

APPLYING THE CODE FOR SUSTAINABLE HOMES ON THE BRE INNOVATION PARK

Lessons learnt about water use, harvesting, recycling and drainage

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This Information Paper is the third in a four-part series that looks at the lessons learnt from the BRE Innovation Park concerning compliance with the Code for Sustainable Homes published in November 2006.

- Part 1 deals with building fabric
- Part 2 covers energy sources, overheating and ventilation
- Part 3 deals with water use, harvesting, recycling and drainage
- Part 4 covers architecture, construction and sourcing

The Code for Sustainable Homes was published in November 2006 and between then and the opening of the BRE Offsite07 exhibition in June 2007, four companies (Ecotech^[1], Hanson^[2], Stewart Milne Group^[3] and Kingspan Offsite^[4]) put their reputations on the line to design and build a Code-compliant house on the BRE Innovation Park (see page 8). The Kingspan Lighthouse™ has received its post-construction certificate.

Since May 2008 all new houses in England have been assessed against the Code (or issued with a statement of non-assessment). The Housing Corporation and English Partnerships are specifying achievement of Code Level 3. In 2010 all new homes in England must achieve the Code's energy use as laid out for Level 3. From 2013 Level 4 will apply and from 2016 Level 6.

In Wales, all new social housing should comply with Code Level 4 'as soon as possible' and all new dwellings must be Code Level 5 by 2011.



Figure 1: Measuring flow from a flow-regulated tap

Photography by Peter White and John Griggs, BRE



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STRATEGY

When looking at water use, harvesting and recycling there are three basic strategies that can be combined:

- minimise water use,
- use rainwater,
- use greywater.

Minimising water use is the most obvious and cost-effective first step. The mandatory water consumption levels laid out in the Code for Sustainable Homes (CSH)^[5] of 105 litres per person per day for Code levels 3/4 and 80 litres per person per day for Code levels 5/6 are not generous. All four houses supplement the low-water use items such as dual-flush toilets, flow-regulated or flow-restricted taps (Figure 1) and showers (Figure 2) and low-use white goods with harvested or recycled water.

Greywater reuse, where water is collected from baths and showers to flush toilets can be a regular and predictable source of additional water. However, treatment is required to produce water of suitable consistent quality for WC flushing. Treated greywater is normally only stored for 24 hours.

Unlike greywater reuse systems, rainwater harvesting systems do not need costly water treatment, but they still require some maintenance. However, if there is no rain, then no water is collected. To cope with variations in rainfall, storage volumes for rainwater are much greater than for greywater.

All water reuse systems should be designed, installed and well maintained to robust industry standards to prevent the build-up of deposits and ensure a reliable non-potable water supply. Although all water reuse systems will be provided with a mains back-up supply, the storage volume and collection areas must be correct to minimise the consumption of mains water throughout the year.

The designed and measured water use, harvesting and recycling volumes for each of the houses are compared in Table 1. The table also shows the net water use of



Figure 2: Flow-restricted shower

the dwellings and the resultant number of credits under element *Wat 1* of the Code.

It should be remembered that the Code for Sustainable Homes specifies water flow rates at 3 bar dynamic pressure. No water pressure meters have been installed in the houses so the actual pressure is unknown. Therefore, the measurements may vary from those specified in the design. Having said that, it is clear that some of the taps that have been supplied with non-integrated flow restrictors, have had these restrictors omitted during installation.

Some of the differences between design and measured water usage for the white goods are because the white goods actually installed, were not those specified. Other differences may be due to the mis-reading of manufacturers' information (see Table 2).

At the time of writing, only Kingspan Offsite had completed a post-construction review and therefore for the other houses there will still be the opportunity to make modifications.

Minimising water use

A number of products were specified to minimise water use. According to Cyril Sweett the 6 litres/min showers are probably at the low end of customer acceptability^[6]. Kingspan Offsite specified 8 litres/min. All the baths are small compared with a standard size of 225 litres. The smallest bath, a Betteform Low-line^[7] (Figure 3), is in the Ecotech Organics™ House. The largest bath (Figure 4) of the four is in the Hanson Ecohouse™. Hanson have in part compensated for a larger bath by using rainwater harvesting to reduce overall water use.

The flow from taps specified at 2 litres/min (or less than 2 litres/min) work well in bathrooms but when used in kitchens they are obviously slow to fill when using containers such as pans and kettles, compared with the standard flow rate of 12 litres/min. This has been addressed in subsequent versions of the Code which now allows for the use of taps that have a water brake at the mid-range of the flow. These are sometimes called 'click taps' or 'two-stage mixer taps'. The rate used for such taps in the BRE water calculator^[8] is the maximum flow of the lower range, which is normally 50% of the maximum flow rate.

Care should be taken to ensure that the risk of creating conditions ideal for growth of legionella is minimised. Water in conventional 15 mm and 22 mm pipes may be kept at ambient temperature (ie warm) for a long time if the turnover of water is low. This creates a potential environment for legionella and similar bacteria to multiply. Spray outlets can then create atomised droplets which could be inhaled and could infect vulnerable people. These risks are reduced by appropriate pipe layouts, including small-bore insulated pipework and high-use sentinel fittings*, such as WCs. Under more recent versions of the Code, risk assessments for this are now required. Further information on controlling legionella in water systems^[9] can be found in *Further sources of information* on page 7.

* A sentinel fitting is the last item on the end of a pipe run.

Table 1: Water use, harvesting and recycling volumes

	Ecotech		Hanson		Stewart Milne Group		Kingspan Offsite	
	Design	Measured by BRE*	Design	Measured by BRE*	Design	Measured by BRE*	Design	Measured by BRE*
WC (litre)	6/4	6/4.5	6/4	6/4	6/4	6/4	6/4	4/2
Taps (litre/min)	2	1.75	2	15, 11.5, 16	1.7	14, 7.5, 13, 5	2	2, 3
Shower(s) (litre/min)	6	5	6	8.5	6	6, 5.5, 5	8	9
Bath capacity (litres)	116	116	195	Not determined	167	Not determined	160	Not determined
Washing machine (litres/use)	49	Manufacturer states 49 on web site (only 5.0 kg max load)	52	No machine installed hence default value of 49 should be used	40	Manufacturer states 40 on web site (only 4.5 kg max load)	45	Manufacturer states 47 6 kg max load
Dishwasher (litres/use)	13	Manufacturer states 14 on web site (only 9 place settings, so default value of 13 used)	None	Manufacturer states 16 on machine label	10	Manufacturer states 15 in manual	10	Manufacturer states 11 on web site
Saving from collecting rainwater (litres/day)	N/A	24	24	Assumes WCs are flushed	N/A	15.3	Assumes washing machine is used	
Saving from recycling greywater (litres/day)	22.4	Assumes WCs are flushed	N/A	22.4	Assumes WCs are flushed	22.4	22.4	Only 12.76 litres can be saved with a 4/2 WC**
Net water use (litres/day)	≤80	≤90	≤80	≤80	≤80	≤80	≤80	
Wat 1 (maximum 5 credits)	5	4	5	5	5	5	5	

* The Code for Sustainable Homes specifies water flow rates for 3 bar dynamic pressure. No water pressure instruments have been installed in the houses so the measured pressure is unknown. Therefore, the measurements may vary from those specified in the design.

** When taking this into account the house would still use less than 80 litres/day.



Figure 3: Betteform Low-line bath in the Ecotech Organics™ house. Photo gives an indication of the height of the overflow



Figure 4: Bath in the Hanson Ecohouse™

The use of small-capacity washing machines and dishwashers are an effective way of enabling a low target consumption to be achieved under the Code, however, they may require the occupants of the home to increase the frequency of use of such appliances.

It is also worth remembering that the consumption values used for the dishwashers and washing machines only relate to one specific program. To put this in perspective, Table 2 is an extract from the Bosch washing machine instruction manual. Here, it can be seen that not only does water consumption vary with the program, but the capacity for each load ranges from 4.5 kg to only 2 kg. The difference between the ‘designed’ water use and the ‘measured’ water use is not something that will be revealed in a post-construction inspection under the Code as the inspection is purely visual.

What is also clear is that it is possible to find new washing machines and dishwashers with significantly better performance than the default case allowed for in the Code with a consequent improvement in results in the water calculations. Low-water-use products and further advice can be found on the Waterwise website^[10].

Rainwater harvesting

The obvious question to be asked with rainwater harvesting is: How much rain will fall? There are then related questions, ie How much can be collected? What volume of storage should be used? Although such systems do not require significant water treatment they are not ‘fit and forget’ systems and will normally require inspection of filters and pumps and occasional tank cleaning.

Ecotech and Stewart Milne Group have adopted greywater recycling for internal use inside their houses, as well as rainwater harvesting for their gardens, involving the installation of a water butt (Figure 5). Although the butts will collect rainwater efficiently, they have not been installed with overflows and this would need to be rectified as part of the post-construction review. These sorts of simple systems achieve the one credit available in Wat 2 of the Code for garden irrigation.

Hanson and Kingspan Offsite have adopted more sophisticated systems.

Table 2: Example of washing machine program consumption value variations (Source: Modified from Bosch washing machine manual)

Programme	Additional function	Load (kg)	Current** (kWh)	Water** (litres)	Programme duration** (hours)
Cottons, 40 °C*	Wash Plus	4.5	0.55	50	2:10
Cottons, 60 °C	—	4.5	1.00	55	1:20
Stains, 60 °C*	Wash Plus	4.5	0.76	40	2:15
Cottons, 90 °C	Wash Plus	4.5	1.40	59	2:10
Easy Care, 40 °C*	Wash Plus	2.5	0.45	50	1:31
Easy Care, 40 °C (Also suitable as short programme)	—	2.5	0.45	40	0:55
Mixed Load (Whites and Coloureds)	—	2	0.60	30	0:50
Delicates, 30 °C	—	2	0.20	36	0:30
Woollens, 30 °C*	—	2	0.13	30	0:40

* Programme setting with Wash Plus option and maximum spin speed for testing according to or in accordance with EN 60456^[15] and IEC 60456.

** The values deviate from the indicated values depending on water pressure, water hardness, water inlet temperature, room temperature, type and amount of washing and degree of soiling, utilised detergent, fluctuations in the mains voltage and selected additional functions.



Figure 5: Water butt

The Kingspan Lighthouse™

Rainwater is collected from the roof of the Kingspan Lighthouse™ and is stored in an underground tank (Figure 6) for use in the washing machine. The system was supplied by Envireau^[11]. Assuming local rainfall to be 800 mm per year, according to the BRE water calculator^[12], the system will deliver savings of 15.3 litres/day.

One problem has been encountered with the sweet-chestnut timber cladding on the roof which contains unusually high amounts of tannin which has been turning the collected water brown. This unintended consequence highlights an additional consideration when specifying roof claddings, gutters, downpipes, etc.

Another problem with the harvesting system has been caused by the poor installation of a drainage chain instead of a conventional downpipe. The chain results in the loss of water between the gutter and the gully and has become rusty over time which is now also contributing to the brown coloration of the water. The presence of iron may cause staining when the water is used for washing clothes.



Figure 6: Envireau^[11] underground water tank being installed at the Kingspan Lighthouse™

It should be noted that when specifying washing machines that some manufacturers are perfectly content to allow rainwater to be used in their machines, but others are concerned about potential contamination and, in particular, faecal material. This could cause a guarantee to be void.

The Hanson Ecohouse™

Rainwater is collected from the roof of the Hanson Ecohouse™ and the roofs of adjacent properties and through the permeable paving surrounding the Ecohouse™, ie providing part of a sustainable drainage system (SUDS) solution as well as a harvesting solution (Figure 7a). The membrane beneath the paving is claimed to trap and degrade nearly all oils, metals and herbicides. In total, the system has a capacity of 3500 litres (Figure 7b) which as well as supplying water for the toilets and garden irrigation also provides a location for the external pipe runs for the ground source heat pump.

Assuming local rainfall to be 800 mm per year, according to the BRE water calculator^[12], the system will deliver savings of 24 litres/day. This permeable paving system is sold by Hanson under the Formpave brand^[13].

By providing water for irrigation from their rainwater harvesting systems, Kingspan Offsite and Hanson were able to achieve the one available credit for Wat 2 under the Code.

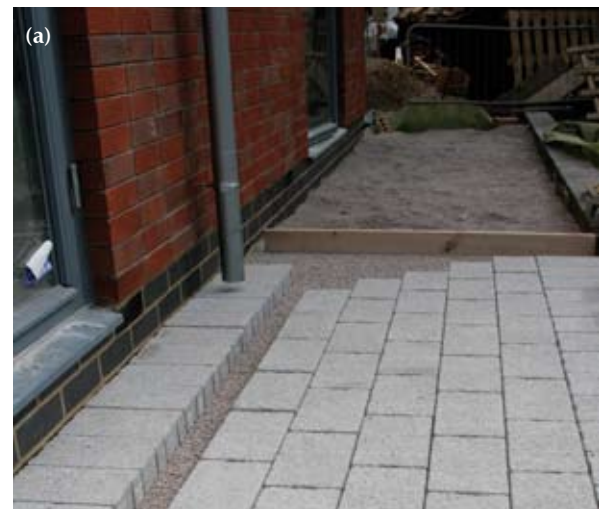


Figure 7: (a) Laying permeable paving, (b) rainwater storage tanks for installation under the paving at the Hanson Ecohouse™

Greywater recycling

Greywater recycling systems normally require more maintenance than rainwater systems, including recommendations for an annual visit by a specialist. As a result, they are often installed on a communal basis and can be managed by an appropriate contractor or service provider. It is commonly believed that poor water quality is more likely to arise from the re-use of greywater than from the re-use of rainwater.

The Polypipe Ecoplay^[14] greywater system (Figure 8) that has been installed in the Kingspan and Stewart Milne houses is more compact than traditional greywater systems. It stores water from showers, baths and sinks in tanks above the WC. One system can supply up to two WCs. The system avoids filters by using two tanks and separation by density. In the first tank, called the 'cleaning' tank, any light material is skimmed off from the top and heavier materials sink to the bottom. The cleaner water from the middle of the tank is transferred to a storage tank for flushing. The contaminated water containing the heavier material goes directly to waste. If the WC is not used for a long period the tanks are automatically flushed out with mains water.

Ecotech have adopted a more conventional approach by installing a Brac^[15] greywater recycling system (Figure 9) in the cycle store by the side of the house.

Both the Ecoplay and Brac systems are calculated to save 22.5 litres/day when used with 6/4 litre WCs.

The colour of water in these systems is worth noting. It often has a grey hue so end-users need to be prepared for this. In addition, it is also possible for the water to be contaminated, which is more likely if systems collect 'sullage', ie water from kitchen or utility room sinks. Examples of contamination in greywater on the BRE Innovation Park have included coffee granules, which have turned the water brown for a brief period and, more seriously, paint from the washing of brushes. This sort of contamination would be less likely if the greywater came only from baths and showers as is generally recommended.



Figure 8: Internal components of a Polypipe Ecoplay^[14] greywater recycling unit



Figure 9: Brac^[15] greywater harvesting system

MAINTENANCE AND NOISE

Occasionally, some water-using, harvesting and recycling products will break down. Therefore, it is important that provision is made to enable appliances and terminal fittings to be isolated individually and to be accessible for maintenance (ie not tiled in).

Where pumps are used, these have an operational noise and although reliable they need to be maintained. It may be appropriate to consider locating them in accessible places outside the dwelling.

LESSONS LEARNT

The lessons learnt about water use, harvesting, recycling and drainage of these four houses on the BRE Innovation Park in relation to the Code for Sustainable Homes can be summarised as follows.

Minimising water use

- Use aerated showers to increase perceived flow rate without increasing water use.
- Use kitchen taps that have a water brake at the mid-flow. These are sometimes called 'click taps' or 'two-stage mixer taps'.
- Where flow restrictors have been fitted to tapware, ensure that they have been installed and set correctly.
- The specification of small-load-capacity washing machines and dishwashers will appear to result in lower water usage in the water calculator, even if this is not the case in practice.
- A wide range of white goods use less water than the default cases in the water calculator and therefore installing them could potentially achieve a better classification under the CSH water calculator^[8].
- Care must be taken that what is specified is installed.
- Low-water-use white goods can be found ranked on the Waterwise website^[10].

- Only use rainwater harvesting and/or greywater recycling in conjunction with water use minimisation devices as part of a coordinated strategy.
- Risk assessments will be required with regard to potential environments in which legionella and similar bacteria may multiply.
- Water supply pipework should be sized and designed to minimise dead-legs and run-off times.
- Be careful to enter the correct values into the water calculator for white goods. For washing machines this will be the water use for a 60 °C cotton wash in accordance with EN 60456^[16]. For a dishwasher it will be the water use for a cycle in accordance with EN 50242^[17].

Rainwater harvesting

- Rainwater harvesting systems need to collect water that can be used to irrigate the garden (if there is one) to obtain credits under CSH Wat 2.
- Water butts that collect water from the roof are an easy and effective way of obtaining credits under CSH Wat 2, but must be fitted with functioning overflows.
- Rainwater harvesting solutions can simultaneously be part of a SUDS solution for a development.
- Rainwater from roofs should be taken directly to storage tanks without using open or grated gullies.
- Surfaces that are to be used to collect rain for harvesting systems need to be colourfast, non-rusting and free draining.
- Only some manufacturers permit rainwater to be used in their washing machines.

Greywater recycling

- Consideration should be given to communal water reuse systems that can be maintained by an outside contractor.
- Self-contained water-reuse systems offer a single dwelling solution.
- Sinks should not provide water for reuse.

Maintenance

- Consider putting pumps outside to limit noise and to make access for maintenance easier.
- Make provision for appliances and terminal fittings to be isolated individually and to be accessible for maintenance.

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FURTHER SOURCES OF INFORMATION

- [1] www.eco-techgroup.com/
- [2] www.hanson.co.uk/713/buildingsystemsandmmc/hansonecohouse.html
- [3] www.stewartmilne.com/
- [4] www.kingspanoffsite.com/kingspan/case_study/market/housing?case=lighthouse
- [5] **Communities and Local Government (CLG)**. The Code for Sustainable Homes. Available from www.communities.gov.uk/thecode
- [6] **Cyril Sweett**. A cost review of the Code for Sustainable Homes. Report for English Partnerships and the Housing Corporation. April 2007. London, Cyril Sweett. Available from www.cyrilsweett.com/news/researchandlit.htm
- [7] www.bette.de/
- [8] **Department for Communities and Local Government**. The Code for Sustainable Homes. Technical Guide. April 2008. BRE water calculator, Table 1, page 104
- [9] **Health and Safety Executive (HSE)**. Legionnaires' disease: The control of legionella bacteria in water systems. Approved Code of Practice and guidance. L8. London, HSE, 2000
- [10] www.waterwise.org.uk
- [11] www.envireau.co.uk/
- [12] **Department for Communities and Local Government**. The Code for Sustainable Homes. Technical Guide. April 2008. BRE water calculator, Table 2, page 107
- [13] www.hanson.co.uk/859/formpavehomepavingandsuds/
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- [15] www.bracsystems.com/
- [16] **British Standards Institution**. BS EN 60456: 2005 Clothes washing machines for household use. Methods for measuring the performance. London, BSI, 2005
- [17] **British Standards Institution**. BS EN 50242: 1999 Electric dishwashers for household use. Test methods for measuring the performance. London, BSI, 2005
- [18] www.planningportal.gov.uk/
- [19] www.sbsa.gov.uk/
- [20] www.dfpni.gov.uk/

Water regulations

The Water Supply (Water Fittings) Regulations 1999. London, The Stationery Office. See www.opsi.gov.uk/si/si1999/19991148.htm
Water Supply (Water Fittings) Regulations 1999. Guidance Document. See www.defra.gov.uk/environment/water/industry/wsregs99/guide/index.htm

Building regulations

The Code for Sustainable Homes has been adopted in England & Wales only^[5]. See also planningportal.gov.uk/uploads/code_for_sustainable_homes_techguide.pdf
The Building Regulations 2000 Drainage and waste disposal. Approved Document H (2002 edition)^[18]

To comply with building regulations in Scotland and Northern Ireland see:

The Building (Scotland) Regulations 2008. Section 3: Environment, Domestic Technical Handbook^[19]
Building Regulations (Northern Ireland) 2000. Technical Booklet N 1990 Drainage^[20]



① Ecotech^[1] built the Organics™ house, a Swedish timber-frame 2-storey house on top of a 1-storey flat, both with ‘compact service units’ (containing an air source heat pump, a mechanical ventilation unit and a hot water cylinder), solar thermal panels and greywater recycling. They were designed to Code Level 4.

② Hanson^[2] built the Ecohouse™, an offsite-produced masonry house in which traditional mortar was replaced with adhesive. It was built to utilise thermal mass and natural ventilation. Heating and hot water are supplied by a ground source heat pump and solar thermal panels. Rainwater recycling has been used. It was designed to Code Level 4.

③ The Sigma™ Home by Stewart Milne Group^[3] was built with a closed panel timber frame, photovoltaics, solar thermal panels, wind turbines, greywater recycling and rainwater harvesting. It was designed to Code Level 5.

④ Kingspan Offsite^[4] built the Lighthouse™ using SIP panels with a biomass boiler, solar thermal, photovoltaics, greywater recycling and rainwater harvesting. It was designed to Code Level 6 and has received its post-construction certificate.

1 www.eco-techgroup.co.uk

2 www.hanson.co.uk/713/buildingsystemsandmmc/hansonecohouse.html

3 www.stewartmilne.com

4 www.kingspanoffsite.com/kingspan/case_study/market/housing?case=lighthouse

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