

BioRegional

solutions for sustainability

BedZED seven years on

The impact of the UK's best known eco-village and its residents



About BedZED

The Beddington Zero Energy Development, or BedZED, is the UK's best-known eco-village. The multi-award winning development is one of the most coherent examples of sustainable living in the UK.

BedZED was initiated by BioRegional and developed by Peabody in partnership with BioRegional and designed by Bill Dunster Architects (now BDa ZEDfactory). BedZED is owned and managed by Peabody.

Located in Hackbridge, south London, BedZED comprises 100 homes, community facilities and enough work-space for 100 people. Residents have been living at BedZED since March 2002.

Many thanks to all of the residents who took part in the monitoring by answering questions and allowing us access to their meters. Without their continued input we would be unable to gauge successes or recommend improvements, for BedZED and for future developments.

BioRegional

solutions for sustainability

About BioRegional

This report was written by Jessica Hodge of BioRegional and Julia Haltrecht an environmental consultant with experience in post occupancy evaluation.

BioRegional is an entrepreneurial charity, which invents and delivers a wide range of practical solutions for sustainability. We are perhaps best known for our work on BedZED.

Our role at BedZED during the planning and construction stages was to ensure that sustainability was considered at every step. We particularly focussed on the green transport plan, energy strategy, sustainable construction materials strategy and the green lifestyles programme.

BioRegional has had its offices at BedZED since the site was completed and we run a visitor centre including a show home, guided tours and training.

www.bioregional.com



PEABODY

About Peabody

Founded in 1862, Peabody is one of London's best known and largest housing associations. Peabody owns or manages over 19,000 properties housing some 50,000 people. As well as providing affordable housing it offers a range of learning, volunteering, personal development and community activities. Peabody's mission is to make London a city of opportunity for all by ensuring as many people as possible have a good home, a real sense of purpose and a strong feeling of belonging.

www.peabody.org.uk

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Foreword



Steve Howlett,
Chief Executive, Peabody

We are very proud of what we achieved with our partners BioRegional and architect Bill Dunster when BedZED was completed in 2002. We believe it was truly groundbreaking and this has been confirmed by the continued international interest from architects, engineers, housing practitioners and environmentalists.

This report provides a valuable contribution to the on-going conversation about BedZED and underlines its wider significance. As we work to meet statutory targets and cut carbon emissions by 60% by 2025, we can and must apply lessons learned at BedZED across the entire social housing sector.

BedZED was an innovative project realised by a committed team with a strong vision. The technology was ahead of its time and as with many innovations, there have been challenges as well as successes along the way.

Among the successes is the continued low energy use of homeowners at BedZED – 45% lower electricity and 81% less hot water than the borough average – reducing carbon emissions as well as residents' fuel costs. BedZED has also successfully fostered a strong and committed community where residents have a real sense of belonging and pride

in their estate. This development reminds us that it is possible to build homes that are both socially and environmentally sustainable.

This report also accurately draws out the challenges at BedZED, the most significant being those associated with the biomass combined heat and power (CHP) plant. With residents and our partners Peabody is now finalising a heating system solution that will strike the right balance between residents' needs and the original vision for a low-carbon estate.

However, if social landlords are to realise this vision on a meaningful, sector-wide scale we must have more government support. Our experience at BedZED has shown just how difficult it will be to influence positively people's choices in these areas without the right policies in place. It is now clear that the need to make all homes greener, whether existing or new build, can only be met by powerful partnerships between social landlords, the government, utility firms and residents themselves.

But the good news is that we have demonstrated with BedZED that the technology to build and retrofit low environmental impact homes already exists. It is imperative now that we make it widely available for the benefit of all.

Lessons from BedZED



Sue Riddlestone

Director and co-founder, BioRegional

Seven years after it was built BedZED still attracts a lot of interest and the lessons learned from examining how things have worked in practice are important to pass on. That is why we have carried out the monitoring and analysis contained within the main body of this report.

BedZED was influential in the genesis of the UK government policy that all new homes must be zero carbon by 2016. This policy has been incorporated into the code for sustainable homes, a voluntary standard which will become mandatory within a few years. There is broad agreement that the detail of these policies need to be made more workable and that we need to make zero carbon and sustainable homes more cost effective. It is important to consider the lessons of BedZED at a time when this policy is being re-examined by the UK government.

Zero carbon lessons

One key discussion point is how much renewable energy should be generated on-site? At BedZED the aim was to have a demonstration project which would show how we can live sustainably in the future. Simply put, the zero carbon strategy was to reduce energy demand in the buildings for example through: insulation and air tightness, fitting homes with low energy appliances and trying to influence

residents' energy use behaviour by having the meters on show. Then, having reduced demand, to supply the remainder of the energy required with renewables. At BedZED the idea was to demonstrate this all on-site, but of course that doesn't mean that on-site energy generation is necessary for all homes in the future.

BedZED's renewable energy was to be generated by a CHP plant using locally sourced woodchip to generate both heat for hot water and electricity. The plant was operational for long periods but is now famously idle whilst Peabody consider the options for replacement. The main reason it didn't work is that it is too small scale to justify the maintenance needed to keep it operating. This is further explained within this report. However, currently around 20% of BedZED's electrical demand is met by on-site photovoltaics. They were originally installed to power electric cars but since the market hasn't taken off yet this energy is being used in the buildings.

It is likely that the BedZED CHP plant will be replaced in the coming year with an alternative system. One promising solution would be a wood heat unit - well proven and simple technology - to supply hot water through the district heating and hot water system. The remainder of the renewable electricity can then



Photo 1 South facing conservatories, credit: Marcus Lyon

be purchased from off-site sources. BedZED would then show a workable renewable energy strategy for communities of a similar scale in a similar type of suburban location. Of course, technology develops all the time, but for now the lesson is that it is not sensible to say that all energy should be generated on-site in all cases. What is possible, technically and economically, will vary by location, type and scale of the buildings. We have come to see how important it will be for the government and utility providers to take responsibility for developing a workable renewable electricity grid. With local, decentralised electricity generation to be considered and introduced as an important part of this strategy.

Encouraging sustainable lifestyles

Another key lesson from BedZED is the importance of considering not just the buildings but how to design communities to help residents live sustainable lifestyles. The importance of this, although it has gained support, is still not appreciated widely enough. BioRegional's carbon neutral toolkit, published in 2003, showed that at BedZED the sustainable lifestyle strategies were a very cost effective way to reduce impacts compared to expensive infrastructure.

Ecological footprinting shows us that if everyone in the world lived as we do in the UK we would need

three planets to support us. We therefore need to reduce our ecological footprint by two thirds, which would include a 90% reduction in carbon emissions. When designing sustainable communities BioRegional thinks about it from the perspective of who is going to live or work there and considers all aspects of a person's lifestyle impacts, using ecological and carbon footprinting. We call this approach "one planet living" and have developed ten principles of sustainability which we use as a framework to design sustainable communities and lifestyles. This one planet approach can be used by individuals and organisations as well as for projects.

We have found that it is important to make it easy and convenient for people to take sustainable actions and difficult for them to take unsustainable ones. The monitoring consistently shows that sustainable lifestyles account for around half the eco-savings at BedZED, and putting them in place when the community is built is key.

The energy used from car driving can be as high as the energy impact of running a home, so the need to avoid using fossil fuelled cars is a major consideration. Once thinking like a resident who is trying to avoid driving, the thought process naturally leads to an acceptance of the need for higher density living. This would make the provision of facilities like shops, schools and public transport viable within convenient walking and cycling distances. This in turn leads to the re-creation of our communities and to a sense of well being and happiness for residents. At BedZED the dominance of the car was de-emphasised with the road and parking placed at the edge of the community and pedestrianised areas in the centre. Children can safely play outside and as residents walk about they can meet and chat with their neighbours without having to compete with traffic noise.

Residents at BedZED consistently say that they like the sense of community, and the monitoring shows that on average they know twenty of their neighbours, compared to the local average of eight. Research shows that people who are engaged in society in this way are more likely to be happier and healthier.



Photo 2 A high level view of BedZED

Service provision and management

BedZED also highlighted the opportunity for, and the importance of, the new service companies and systems we will need to keep our sustainable communities running smoothly. The car club at BedZED which allows residents to use a car when they need one is a crucial part of the transport strategy which has led to a sixty five per cent reduction in fossil fuel car miles driven at BedZED. In 2002 we had London's first car club, now the network and availability of them is growing across London and the UK.

The idea of using an energy services company (ESCO) or multi utility company (MUSCO) to operate the local energy and water treatment systems was not totally clear when BedZED was built. But it has certainly become clear how necessary these companies are in retrospect. They are a different business model from developers of private homes who tend to build homes and move on. They are also quite different to the model of large utility providers. These businesses are

opportunities for job creation. They are much talked about but we have found they are only on the cusp of happening in practice.

A third area of service provision is the development of facilities management to include sustainability - green facilities management. All of these should ideally be developed and set up at the design stage.

Next generation sustainable communities

Sustainable communities development company, BioRegional Quintain Ltd, is now developing new models for facilities management and community management as part of its One Brighton sustainable community. Residents will move in later this year. I am sure the innovations there will prove as useful and groundbreaking as those of BedZED as well as being a great place to live. One major innovation is that BioRegional Quintain has been able to build to zero carbon and one planet living standards within the normal range of build costs. The zero carbon strategy includes on-site wood heat but also new off-site renewable electricity. One Brighton starts to

show how sustainable communities could become a reality across the UK.

BioRegional is working with developers in other parts of the world who are building larger One Planet Communities. They include Coddling Enterprises' Sonoma Mountain Village, near to San Francisco in the USA, where existing buildings are being retrofitted in combination with all new buildings developed to zero carbon and one planet living standards. Back in the UK, the London Borough of Sutton, who nurtured the development of BedZED, have committed to work with BioRegional and make Sutton a One Planet borough. With a target to make all buildings across Sutton zero carbon by 2025. This has led us to investigate community retrofit and renewable energy generation. The lessons learned from BedZED and these other projects have also informed the UK government's new eco-towns through my involvement on the eco-towns challenge panel.

Is BedZED a success?

In conclusion the monitoring figures contained in this report show that a resident at BedZED, if taking advantage of all the green lifestyle features, can reduce their impact from 3 planets down to 1.9 planets and down to 1.7 planets once the renewable energy system has been fixed. The average is higher at 2.6 or 2.4 planets respectively. This is primarily due to the amount of holiday flights residents take, a point which was highlighted to residents when the monitoring results were presented to them earlier

this year. Residents were surprised by this and it will be interesting to see if this information changes behaviour the next time we carry out the monitoring. As explained in this report, residents cannot lead one planet lifestyles in a relatively small demonstration project like BedZED. This is because the minute they step off site they are participating in the "three planet" higher impact world and using the facilities we all share, such as the health service, roads, shops and government services.

Some people ask if BedZED really has been a success. The CHP doesn't work and the original on-site water treatment system was decommissioned, and didn't it cost too much?

I would say that the fact that residents here can reduce their ecological footprint by around half and yet improve the quality of their lives, together with the transferable and useful lessons learned, show that, yes, BedZED has been a success and has achieved what we set out to do. It holds up a light which shows where our impacts arise and shows what can be achieved. Another marker of success is that the lessons learned are now being developed and refined in follow-on projects. It is to the credit of Peabody that it had the courage to lead by example.

Living and working at BedZED as I do, I can say at first it was like moving into the future, but after a couple of weeks it just became normal. I am very happy here. It is the nicest place I have ever lived and my children think so too.



Photo 3 A tour group visits BedZED

Summary of monitoring results

BedZED was designed to minimise its ecological impact, both in construction and operation, to help residents live within their fair share of the earth's resources. Monitoring progress towards achieving these targets is vital in order to assess the effectiveness of the development, identify areas for further improvement and highlight lessons that can be learnt and applied to future developments.

During 2007, BioRegional interviewed 71 households (out of 100) about food, transport and waste habits, and their feelings about living at BedZED. We took meter readings to record water, electricity and heat consumption and carried out waste audits.

Energy and water use

We found that BedZED households use 2,579 kWh of electricity per year which is 45% lower than the average in Sutton. While the biomass Combined Heat and Power (CHP) plant is not in use, BedZED uses gas to power the district heating system. On average, households use 3,526 kWh of heat (from gas) per year – 81% less than the average in Sutton.

We found that residents only use 72 litres of mains water per day, topped up by 15 litres of recycled or rainwater. This is less than half of the local average.

Green lifestyles

86% of BedZED residents buy organic food and 39% grow some of their own food and although this is encouraging, there is scope to build on this. While BedZED residents have much lower car ownership and drive far fewer miles, they also fly more so the overall impact of transport is slightly higher than for the average resident in Sutton. Through waste audits with ten households, we found that 60% of waste by weight is recycled or composted, but this rate is likely to be lower for all households – people tend to try harder to recycle and compost while they are being audited.

Quality of Life

When we asked residents to name one or two things they particularly like about BedZED the sense of community was the most popular answer, followed by the design, sustainability and a sense of wellbeing

(quietness, quality of light and the feeling of space were all mentioned).

84% of residents felt that the community facilities were better here than in previous neighbourhoods and only one resident, out of 70 who answered this question, felt they were worse.

People living at BedZED know an average of 20 of their fellow residents by name and one resident was able to name 150 of her neighbours! This is significantly higher than for Hackbridge (excluding BedZED) where the average is eight.

Ecological and carbon footprint

The ecological footprint of the 'average' BedZED resident is 4.67 global hectares (equivalent to needing 2.6 planets of resources if everyone in the world lived like this) and a carbon footprint of 9.9 tonnes (for truly sustainable living this would need to be 1.1 tonnes by 2050). If the biomass CHP was working and BedZED was zero carbon as designed, the average resident would have an ecological footprint of 4.32 global hectares (2.4 planets' worth) and a carbon footprint of 8.9 tonnes. A keen resident, who made significant efforts to reduce their impact, could achieve an ecological footprint of three global hectares (equivalent to 1.7 planets) and a carbon footprint of 6 tonnes.

While this is a significant decrease in ecological and carbon footprint compared to the UK average, it is still not sustainable. The limiting factor is that so much of BedZED residents' impact occurs outside of the estate: their schools, workplaces and the goods and food that they buy for example, and we have not so far been able to influence this. In 2005, Sutton Council committed to becoming a 'One Planet Borough'¹ by 2025, and will be working with BioRegional to reduce the footprint of the whole borough. By working at this scale, and applying lessons learnt from BedZED to the whole borough, we hope that that we can make significant reductions in ecological and carbon footprint, for BedZED and for all Sutton residents.

1. BioRegional's One Planet programme is a global initiative. It is based on 10 principles of sustainability developed by BioRegional and WWF

What we measured

This report gives an insight into how BedZED is performing. We look at BedZED's technology as well as the lifestyles of the people who live here. This report does not look at the businesses on-site, but for one example of how a BedZED office performs, refer to BioRegional's One Planet Action Plan¹ which includes energy and water consumption and ecological footprint.

BedZED was designed to minimise its ecological impact both in construction and operation – to help residents live within their fair share of the earth's resources. Some of the key operational aims were as follows:

- reduce water consumption compared to the UK average by 33%
- reduce electricity consumption compared to the UK average by 33%
- reducing space heating needs compared to the UK average by 90%
- reduce private fossil fuel car mileage to 50% of UK average
- eliminate carbon emissions due to energy consumption.

Monitoring progress towards achieving these targets is vital in order to assess the effectiveness of the development, identify areas for further improvement and highlight lessons that can be learnt and applied to future developments.

Where we look at consumption of natural resources, energy and water for example, we compare the findings to local (Hackbridge or Sutton) or UK averages, as well as to current and future building regulations, and to past BedZED monitoring. BedZED is much written about in theses, books, reports, and on the internet – putting BedZED into a search engine returns over 48,000 results – yet there is very little written about performance. The monitoring reports we use for comparisons in this report were both written by people employed by BioRegional or Peabody at the time of writing, and are detailed in the following paragraphs:

Toolkit for Carbon Neutral Developments Part 2, October 2003, Nicole Lazurus, BioRegional. The toolkit is a practical guide to producing carbon neutral developments and how to afford them. It is based on the achievements at BedZED, describing measures taken in the scheme to reduce environmental impact. It includes technical descriptions, monitoring results and financial mechanisms that have allowed the innovations at BedZED to become a reality.

The toolkits (Part 1 is the BedZED Construction Materials Report) are available from BioRegional www.bioregional.com or tel +44 (0) 20 8404 4880.

The BedZED lessons (Thesis) MSc Architecture: Advanced Environmental and Energy Studies, University of East London, November 2005, Simon Corbey.

A post construction review of BedZED conducted in 2004 which then draws on this review and other research to conclude the BedZED lessons – the achievements and limitations of the development and the subsequent ramifications of these conclusions. The thesis then makes recommendations for future developments. 22 questionnaires were completed.

To request a copy of this thesis please email simon.corbey@cutthecarbon.com.

BedZED Resident Satisfaction Survey Report, Rachel Ellis, Peabody, May 2004

This report details BedZED residents likes and dislikes of living at BedZED, and includes feedback on satisfaction with their home, the location and neighborhood, refuse and recycling facilities, energy use, facilities at BedZED, personal transport and sense of community. 38 surveys were completed.

To request a copy of this report please contact Peabody www.peabody.org.uk.

1. Available on BioRegional's web site and updated annually www.bioregional.com/actionplan

Methodology

The research was conducted between January 2007 and January 2008 and comprised waste audits, questionnaires and meter readings.

Waste Audits

Carrying out waste audits entailed a household saving a week’s worth of rubbish. The waste was then removed from the bag and its constituent parts weighed separately according to waste and recycling guidelines.

Residents were reluctant to save a week’s worth of waste up as they were worried about the smell and attracting pests and so in some cases we collected daily. This is only possible because BioRegional’s offices are at BedZED and would have been untenable otherwise.

We aimed to audit the waste produced during a week for ten households and to carry this out 4 times during the year. In fact just over half of this was achieved. However, the information collected was valuable in creating a picture of household waste habits.

Because the waste audits are not a neutral method of monitoring (i.e. they can influence resident behaviour), we chose to see them as a positive tool for change and gave feedback to the residents taking part if they had contaminated waste streams, or left recyclable materials in the bin.

Questionnaires

The questionnaire formed a significant part of our research and was developed using questions from the ecological footprint calculator, from previous BedZED monitoring, and also included some questions devised by an environmental consultant with experience in post occupancy evaluation.



Photo 4 Interviewing a BedZED resident

Residents were sent letters inviting them to participate in the monitoring program. Face-to-face interviews were considered the most appropriate method for data collection, as potentially, residents would feel most comfortable expressing their opinions in their own homes, at a time that most suited them. Towards the end of the monitoring process some telephone interviews took place for expediency. The interviews lasted around 15 minutes each.

The survey composed of open and closed questions. It was divided into sections:

- A. Your home
- B. Food
- C. Travel and Transport
- D. Shelter and Thermal Comfort
- E. Goods and Services
- F. Waste
- G. Community and Amenities

There was an enthusiastic response within the first half of the year and then it became progressively harder to make appointments, or for some of the residents to keep them. During the monitoring period we completed questionnaires with 71 out of 100 households.

In an effort to gain representative results, we were careful to ensure that the tenure of the households completing questionnaires matched actual current tenure, shown here in **Table 1**.

	Questionnaire	Actual ¹
Social Housing	25%	25%
Shared ownership	24%	24%
Owner occupied	45%	51%
Private rent	6%	

1. Information on current tenure supplied by Peabody, May 2008

Meter Readings



Photo 5 Meters in BedZED house, credit: Christian Lewis Searle

It was not possible to get meter readings for a complete year from the utilities company due to data protection requirements. Furthermore, many meters have been out of action for periods of time and replaced. In BioRegional’s office one meter had been replaced three times during our occupancy. Therefore the remote readings are not always accurate. We read the meters in those households that wanted to take part in the monitoring and who were in when we called. We then disregarded any that were replaced in the monitoring period.

Meters were read at the beginning and end of the monitoring period, though due to time and resource constraints it was not possible to get all of the readings in one go. The majority of meters were read between January and March 2007, and again between November and January 2008. Each unit was monitored for between 126 and 434 days.

Calculations

The total units (of electricity, water or heat¹) consumed for each dwelling were divided by the number of monitored days to get the mean consumption per day, and multiplied by 365 to get an average per annum, then divided by the number of inhabitants or m² in that dwelling. The sum of the averages per dwelling, or per person in a dwelling, or m² in a dwelling, is calculated and divided by the number of monitored dwellings. The calculation is shown in Table 2.

Table 2 Calculation example (random sample, not indicative)

monitored days	ΔElec kWh	kWh per day	people per dwelling	person per day
310	3184.4	10.3	4	2.6
311	2287.4	7.4	2	3.7
312	1050.1	3.4	1	3.4
322	855.7	2.7	1	2.7
326	3386.0	10.4	3	3.5
329	3662.2	11.1	3	3.7
348	2172.2	6.2	2	3.1
434	3364.6	7.8	2	3.9
	Total	59	18	26
	Average	7	2	3

1. Whereas most households are billed by kWh of gas delivered to the meter point, at BedZED residents are billed per kWh of heat delivered from the district heating/ hot water system

Energy to CO₂ conversion factors

The conversion factors for electricity have been taken from the guidelines to Defra's greenhouse gas conversion factors for company reporting, June 2007. We have used the 5-year rolling average figure of 0.523 kg CO₂ per kWh electricity, shown in Table 3, rather than 0.43 kg CO₂ per kWh that Defra recommends for using for projections of a decade or more.

Table 3 Defra's electricity conversion factors

Electricity conversion factors from 1990 to 2005	
Year	kg CO ₂ per kWh
1990	0.77
1991	0.75
1992	0.7
1993	0.62
1994	0.61
1995	0.58
1996	0.56616
1997	0.51935
1998	0.51808
1999	0.48291
2000	0.51022
2001	0.52581
2002	0.50974
2003	0.52628
2004	0.52659
2005	0.52657
Rolling average	
Rolling average	0.523
Long term marginal factor	0.43
Electricity from CHP	0.295
Renewables	0

From the same document we have taken the conversion factor of 0.185 kg CO₂ per kWh natural gas. This is the Gross Calorific Value basis, commonly used in the UK. This is not consistent with the European Union Emission Trading Scheme (EUETS) for CO₂ emissions which uses a Net Calorific Value which would result in a conversion factor of 0.206 kg CO₂ per kWh natural gas.

Ecological footprint

Ecological footprinting is an accounting methodology that tracks our supply and use of natural resources. The methodology is able to document the area of biologically productive land and sea a given population requires to produce the resources it consumes and to assimilate the waste it generates (thus calculating its ecological 'footprint'), using prevailing technology. The methodology can then be used to compare the calculated ecological footprint with the actual total area of biologically productive land and sea available on earth; this can tell us if we are living within the earth's regenerative capacity. The tool enables the environmental impacts of a process, product, community, region, organisation or an individual's lifestyle to be measured.

Ecological footprinting data from the Living Planet Report¹ show that if everyone on the planet consumed as much as the average person in Western Europe, we would need three planet earths to support us.

The ecological footprint of the 'average' BedZED resident is calculated using the Resources and Energy Analysis Programme (REAP carbon and ecological footprint accounting software). For this we rely on residents to report their consumption of natural resources, but it is very hard for residents to estimate, for example, the proportion of meat and dairy in their diet. However, it does give us a fairly good indication of what residents' major impacts are and where more work is needed.

1. Living Planet Report, WWF, October 2008

Energy

BedZED, or Beddington Zero (Fossil) Energy Development, was designed to be carbon neutral, to generate as much or more renewable energy on-site than was used in the buildings for heating, hot water and electrical appliances. Energy use has been reduced considerably and the remaining demand was designed to be met by a CHP plant fed by locally-produced waste wood. However, this is not currently in operation and so hot water is produced by an efficient gas condensing boiler. Most of the electricity is supplied from the national grid with a proportion of renewable electricity being generated on-site by photovoltaic panels.

Background

Government figures show that the UK was responsible for 560.7m tonnes of UK CO₂ in 2005¹ (This figure excludes international aviation, shipping and Britons' impact abroad (foreign holidays for example). If these sectors are included the estimated total emissions increase to 602.9m tonnes of CO₂).

If we include the full 'basket' of green house gases as CO₂ equivalent² (CO₂e) the total is 656m tonnes of UK CO₂e 2005 (Or 733m tonnes CO₂e³ including international aviation, shipping and Britain's impact abroad).

Energy use in the domestic sector accounts for approximately 27% of the total CO₂e and although this figure does include embodied energy, the majority is from household energy consumption for appliances, lighting, cooking, heating and hot water.

Household energy consumption is increasing by 1.5% per year and will need to fall by 2.4% per year to deliver the UK's target of an 80% reduction in emissions by 2050⁴. Defra also reports that although energy efficiency has historically improved by 1% per year, over the next decade household energy consumption is expected to increase by 2% per year resulting in no net reduction in emissions.⁵

The UK's Climate Change Act sets a legally binding target to reduce CO₂e emissions by 80%, compared to 1990 levels, by 2050. As it is impossible to achieve this reduction in all sections of our CO₂ footprint – transport for example⁶ – we need to go much further

with our housing stock and should be aiming for all existing and new buildings to be zero carbon.

Electricity consumption

BedZED Aim - reduced electrical demand:

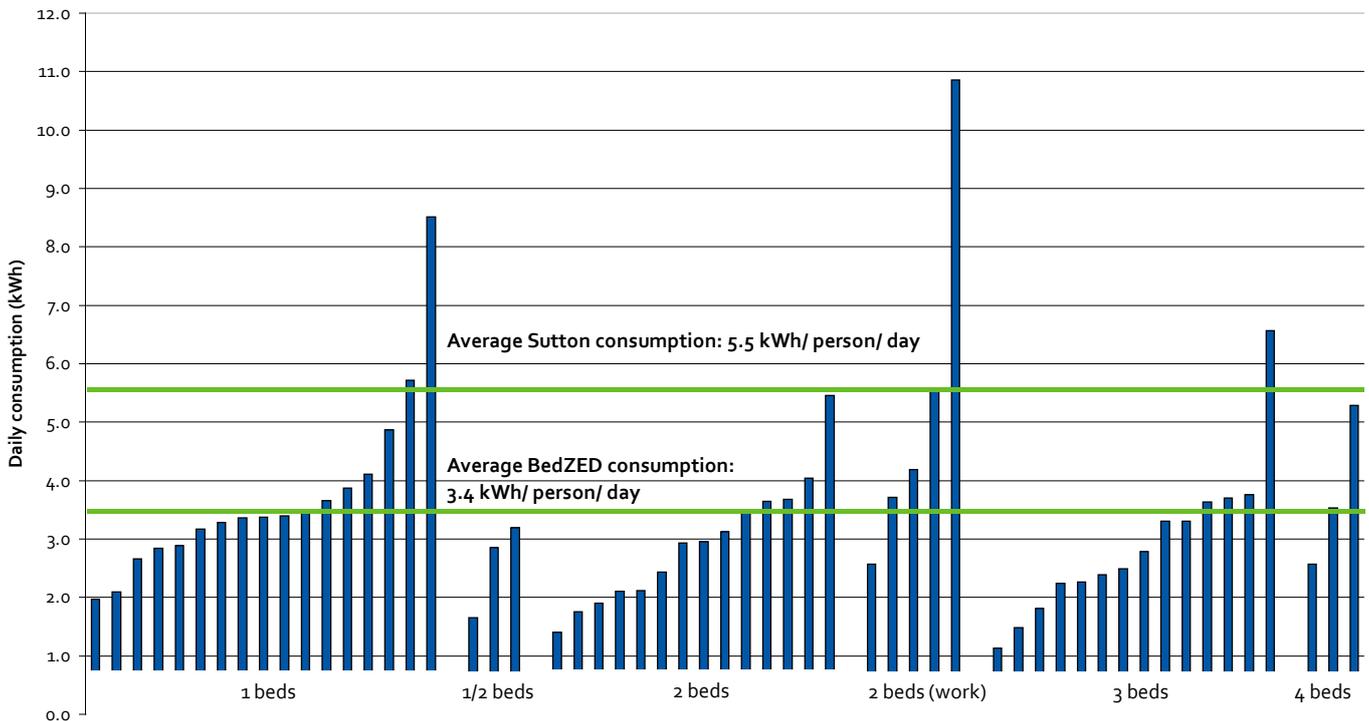
- Homes fitted with energy efficient appliances:
 - 20 watt compact fluorescent light bulb
 - A-rated fridge/ freezer and washing machine
- Visible meters (Photo 5) to make residents more aware of consumption
- Good daylight design reducing the need for electric lighting
- Passive ventilation removing the need for electric ventilation or fans
- Aerated showers, removing need for power showers

1. www.nao.org.uk/publications/0708_greenhouse_gas_emissions.pdf
2. CO₂ equivalent figure comprises the six main gases with a direct greenhouse effect: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF₆)
3. Figures extrapolated from Home Truths: A low-carbon strategy to reduce UK housing emissions by 80% by 2050, Brenda Boardman, University of Oxford's Environmental Change Institute, November 2007
4. www.defra.gov.uk/corporate/consult/cert2008-11/index.htm
5. UK Climate Change Programme: Annual Report to Parliament, July 2007
6. The impact of transport, Sustainable transport report October 2008, BioRegional

BedZED monitoring results – kWh and CO₂ from electricity

Figure 1 shows monitored electricity consumption for 56 BedZED dwellings for all delivered electricity. 66 sets of readings had been taken but ten had to be discounted because the meter had been replaced during the monitoring period, or there was a clear error.

Figure 1



Electricity Consumption 2007

The average electricity consumption during 2007 was:

- 3.4 kWh/ person/ day
- 2579 kWh/ dwelling/ year
- 34.4 kWh/ m²/ year

CO₂ from electricity

Based on a conversion factor of 0.523 kg CO₂ per kWh electricity and assuming a 20% contribution from the PV (see page 18 for further explanation), this equates to:

- 1.4 kg CO₂/ person/ day
- 1,079 kg CO₂/ dwelling/ year
- 14.4 kg CO₂/ m²/ year

If the CHP was in use and reaching designed outputs, BedZED would be CO₂ positive - producing more renewable electricity than we consume.

In Table 4 you can see how electricity consumption breaks down according to tenure and house type, and how the consumption per dwelling compares to Arup's (BedZED's engineers) pre-build predictions¹.

1. Beddington Zero Energy Development Total Energy Strategy including Green Transport Plan 1999

Table 4

	kWh per person/ day	Actual kWh per dwelling/ year	Predicted kWh per dwelling/ year (Arup)	kWh per m ² / year
BedZED average 56 monitored homes	3.4	2579		34.4
Owner occupied 26 monitored homes	3.6	2809		30.3
Shared ownership 15 monitored homes	3.3	2074		32.1
Social housing 15 monitored homes	3.2	2687		43.6
1 bed 17 monitored homes	3.7	1896	1700	34.0
1-2 bed 3 monitored homes	2.9	2770		46.6
2 bed 14 monitored homes	2.9	2662	1900	40.2
2 bed (north-facing) 5 monitored homes	5.4	3400		42.9
3 bed 14 monitored homes	2.9	2680	2700	24.6
4 bed 3 monitored homes	3.8	4040	2800	28.6

Electricity consumption / person / day

Consumption ranges from: 1.1 kWh/ person/ day (a family of five in a 4-bed) to 10.9 kWh/ person/ day (a single person living in a converted workspace which is on the north side of a terrace, who sometimes works from home).

This compares to monitored electricity consumption for 72 BedZED dwellings in 2003¹ of 3.0 kWh/ person/ day. However, in 2003 the electricity consumption was taken from the meter readings and then estimated to exclude the use of temporary space heaters and immersion heaters (this was included in the figures for heat consumption). This was because of delayed commissioning of the CHP which meant that residents were using some electricity for space and water heating. The 2007 results are for all metered electricity which does include some use of electric space heating (see the chapter on Thermal Demand) and emergency use of the immersion when the district heating system was out of action. Therefore the results are not directly comparable.

The average electricity consumption at the meter point per customer in Sutton is 4,652 kWh/ year², with an average of 2.3 people per dwelling in Sutton³, this equates to 5.5 kWh/ person/ day. So the BedZED average of 3.4 kWh/ person/ day for 2007 is 38% lower than the Sutton average.

Electricity consumption / dwelling / year

In 2007 at BedZED, consumption ranged from 721 kWh (a single person living in 1-bed flat) to 5790 kWh (a family of three living in a 4-bed house). Even the highest electricity consumer is lower than Arup's predicted worst-case scenario of 6137 kWh⁴.

The BedZED average of 2,579 kWh/ dwelling/ year at the meter point compares to a Sutton average of 4,652 kWh/ dwelling/ year⁵, a decrease of 45%. However, the average number of people per dwelling at BedZED is also slightly lower than the Sutton average. The UK average is 4,457 kWh.

1. Beddington Zero (Fossil) Energy Development Toolkit for Carbon Neutral Developments – Part II, Nicole Lazurus, BioRegional
 2. Annual Average Domestic Electricity Consumption in 2006 (kWh) BERR
 3. 2001 England and Wales Census
 4. Beddington Zero Energy Development Total Energy Strategy including Green Transport Plan 1999
 5. Annual Average Domestic Electricity Consumption in 2005 (kWh) per meter point BERR

Thermal Demand



Photo 6 BedZED in the snow, credit: Paul Murray

BedZED aim – reduced thermal demand:

- Passive solar gain; dwellings face south with triple-storey conservatories (sun spaces)
- Super insulation; 300mm insulation jacket around each terrace
- 2 skins of double-glazing to south elevation and triple-glazing for all other elevations
- Thermal mass provided by dense concrete blockwork and concrete floor slabs and exposed radiant surfaces to aid heat absorption
- Passive ventilation with heat recovery
- Reduced flow taps and showers
- Visible hot water meter

BedZED monitoring results – kWh and CO₂ from heating and hot water

Table 5 shows monitored hot water consumption for 64 BedZED dwellings. The average heat consumption (for space heating and hot water) during 2007 was:

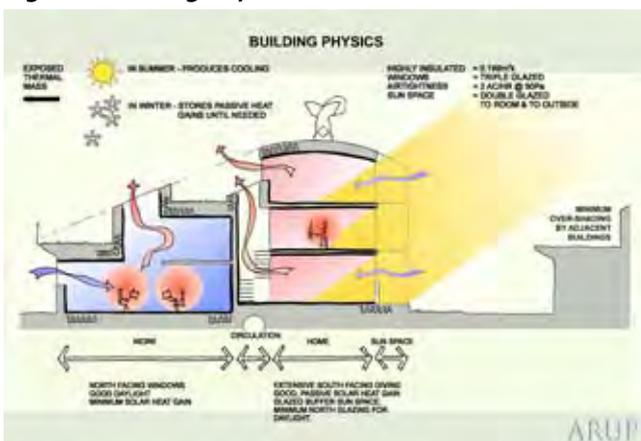
- 5.2 kWh/ person/ day
- 3,525.8 kWh/ dwelling/ year
- 48.0 kWh/ m²/ year

Here you can see how that breaks down according to tenure and house type:

Table 5

Heat Consumption 2007	kWh/ person/ day	kWh/ dwelling/ year	kWh/ m ² / year
BedZED average 64 monitored homes	5.2	3,526	48.0
Owner occupied 30 monitored homes	4.9	3,466	37.1
Shared ownership 17 monitored homes	5.3	3,536	54.0
Social housing 17 monitored homes	5.6	3,621	61.2
1 bed 20 monitored homes	6.7	3,047	56.8
1-2 bed 3 monitored homes	6.3	5,974	100.6
2 bed 14 monitored homes	3.2	2,828	42.8
2 bed (north-facing) 6 monitored homes	7.1	4,011	50.7
3 bed 18 monitored homes	4.5	3,813	34.9
4 bed 3 monitored homes	4.5	4,830	34.2

Figure 2 Building Physics



Efficient supply:

District heating/ hot water system (supplied by woodchip-fuelled CHP or mains gas condensing boilers if the CHP is not in use).

CO₂ from heating and hot water

Based on a conversion factor of 0.185 kg CO₂ per kWh gas, this equates to:

- 1.0 kg CO₂/ person/ day
- 652.3 kg CO₂/ dwelling/ year
- 8.9 kg CO₂/ m²/ year

If the CHP was in operation and using Defra’s conversion factor of 0.025kg/CO₂/kWh biomass (transported less than 30 miles), this equates to:

- 0.1 kg CO₂/ person/ day
- 88.2 kg CO₂/ dwelling/ year
- 1.2 kg CO₂/ m²/ year

Heating and hot water used/ person/ day

Consumption ranges from: 0.4 kWh/ person/ day (2 people in a 2-bed) to 22.2 kWh/ person/ day (a single person living in a converted workspace which is on the north side of a terrace, who sometimes works from home).

The average mains gas consumption at the meter point per customer in Sutton is 18,924 kWh/ year¹ so with an average of 2.3 people per dwelling in Sutton², this equates to 22.5kWh/ person/ day. The BedZED average of 5.2 kWh/ person/ day represents a 77% decrease compared to the Sutton average.

Heating and hot water used/ dwelling/ year

Consumption ranges from: 277 kWh (two people in a 2-bed) to 9424 kWh (three people living in a 2-bed). The BedZED average of 3,526 kWh/ dwelling/ year is 81% lower than the Sutton average of 18,924 kWh. The UK average is 18,241 kWh.

This contradicts Simon Corbey’s 2004 BedZED monitoring³ which estimates that a 3-bed property would consume 7,270 kWh/ year in hot water and space heating. However, this figure was not based on meter readings but on the estimated total site consumption from mains gas boiler and woodchip CHP and apportioned down to a 3-bed dwelling. Therefore the results are not directly comparable.

The 2007 range is much higher than might be expected for two reasons:

1. Some residents have had problems with their connection to the district heating system and

have been using the back-up electric immersion; therefore the reading on the heat meter is very low.

2. The original design had south-facing homes and north-facing workspaces. Some workspaces have since been converted to homes and therefore the heat consumption is much higher than for that of the south-facing homes.

Total energy consumption and CO₂ emissions/ m² (residential)

Table 6

		BedZED 2007 ⁴	BedZED 2007 if CHP in operation ⁵	UK Average (based on dwellings built in 2002)
Heating & hot water	kWh /m ² /yr	48.0	48.0	231.8
	CO ₂ /m ² /yr	9.3	1.2	45
Electrical load	kWh /m ² /yr	34.4	34.4	45.5
	CO ₂ /m ² /yr	10.6	-8.9	18.4
Total energy use	kWh/ m ² /yr	82.4	82.4	275.3
	CO ₂ / m ² /yr	19.9	-7.7	63.3

In Table 6 we have used the emissions factors from Building Regulations 2006 Part L, which for electricity differ from those we have used elsewhere in this report. This enables a comparison of BedZED to more recent developments. The relevant emission factors used are:

- Natural gas: 0.194 kg CO₂/kWh
- Biomass: 0.025 kg CO₂/kWh
- Grid supplied electricity: 0.422 kg CO₂/kWh
- Grid displaced electricity: 0.568 kg CO₂/kWh

1. Domestic Gas Consumption in 2006 (kWh) BERR
 2. 2001 England and Wales Census
 3. MSc Architecture: Advanced Environmental and Energy Studies Thesis, The BedZED lessons, Simon Corbey, December 2005
 4. Assumes 20% contribution to total electricity from photovoltaic panels
 5. Assumes 100% of heating, hot water and electrical demand met by CHP and additional 20% electrical demand supplied by photovoltaic panels.

Ecological footprint of housing

This includes the energy used in a home as well as the area it occupies and a share of construction, maintenance, rentals and estate agency services. BedZED residents use an average of 0.77 global hectares (16% of total ecological footprint) for housing compared to a Sutton average of 1.33 global hectares (25% of total ecological footprint) and this reflects lower energy consumption. It is likely that BedZED residents' ecological footprint for housing is even lower than this but it was not possible to account accurately for a smaller land area per dwelling at BedZED compared to the baseline using the REAP tool.

Thermal comfort and air quality

BedZED homes should not fall below 18°C while they are occupied, as sufficient heat is provided by passive solar gain, human activity and appliances, and residual heat from the hot water cylinder and heated towel rail. If a home is unoccupied the temperature may drop below 18°C, in which case a trickle heat source is automatically activated.

Additional heating and cooling

Results from the questionnaire indicate that 39% of households do use electric fans, on occasion for between one and two months of the year. 42% use some additional electric heating, on average during the coldest two months of the year. This does not imply that residents are using fans/ heaters consistently during that time – it could be only for an hour or two on the very hottest/ coldest days of the year. Furthermore, the low electricity consumption indicates that this is not happening to any great extent.

Internal temperature

We asked the residents to rate the temperature of their homes in summer and winter from 1 (too cold) to 7 (too hot). Responses show that the majority of homes have a comfortable temperature in the winter, with 84% of households giving a rating of 3, 4 or 5 and 44% say it is just right.

However, only 10% feel that the temperature in the summer is just right with 56% giving it a rating of 1 (too hot) or 2.

It is important to note that residents are unable to turn off the heated towel rail in the bathroom and this combined with excess heat from the hot water cylinder, can lead to overheating, meaning that heat is currently being wasted. This is an unforeseen consequence of the original design, which delivers hot water to the towel rail via the district heading system, then back again. Homeowners could retrofit a towel rail on a separate loop to avoid this problem.

Possibly, households do not use the windows and sunspace to cool the house, as they are designed to do. Although this is not something we explored in the questionnaire, many windows are closed when we walk around BedZED in the summer, and anecdotal evidence suggests that this is because residents are worried about security.

BDa Zedfactory have said that for the top level sunspaces there are roof-level opening lights but the opening devices were left off. If these windows could be opened, this would keep the sunspaces cool without compromising security.

BioRegional's experience from its BedZED show-home, which is on the bottom two floors of a block, indicates that if the exterior sunspace windows are opened wide in the summer, and the interior windows closed, the house stays pleasantly cool.

Table 7

Temperature of your home		in winter	in summer
Too hot	1	0%	20%
	2	3%	36%
	3	1%	30%
Just right	4	44%	10%
	5	39%	3%
	6	6%	0%
Too cold	7	7%	0%

We also asked if residents had curtains and blinds in their sunspaces, and if so, if they were for warmth, coolth, privacy, decoration or other reasons. While 71% of households with sunspaces do have curtains or blinds, only 2 households cited temperature control as the primary reason, whereas 90% of those with curtains/blinds in the outer sunspace glazing, and 73% in the inner, cited privacy as their primary reason.



Photo 7 BedZED show home sun space, credit: George Garnier

The questionnaire shows that residents value their sunspace and many commented that it was one of the things they really liked about BedZED. They are certainly well used; we asked the question; *What do you use your sun space for?* (Residents could pick as many responses as were applicable) and the results are as follows:

- Living space 66%
- Growing plants 26%
- Storage 97%
- Other (clothes drying and 'nothing' both mentioned) 7%

This is significantly different to Peabody's findings in 2004, when only 21% of respondents said they used the sunspace for storage, perhaps reflecting their accumulation of possessions in the time between surveys.

Air quality

Figures 3 and 4 show how residents find the air inside in the summer and winter.

Figure 3

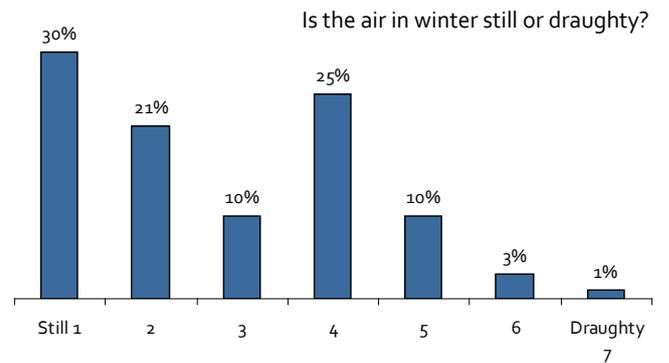
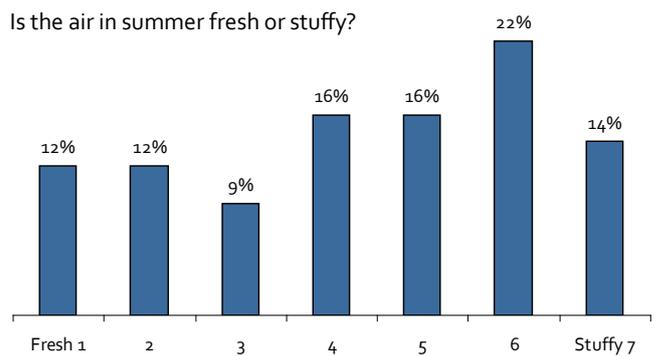


Figure 4



Renewable energy

Wood-fuelled combined heat & power (CHP)

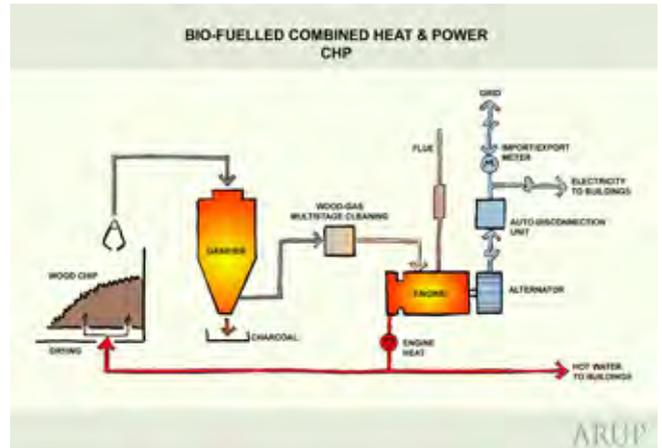
The energy demands of BedZED are dramatically reduced compared to an equivalent conventional development. This reduction should make it realistic to consider small-scale, on-site energy generation. At BedZED, the chosen solution was a biomass CHP plant designed, installed and operated by Exus Energy Ltd (formerly B9 Energy Biomass Ltd). This decision was partly influenced by BioRegional's intention to set up a local operation for processing urban tree surgery waste. The technology is based on downdraft gasification; the process is detailed in the next paragraph.

When the CHP is working, woodchips are fed automatically from a storage area into the drier, which uses waste heat from the engine. Chips are then fed into the gasifier where they are heated in a restricted flow of air, which converts them into a combustible gas (gasification). This wood gas contains hydrogen, carbon monoxide and methane as well as non-combustible CO₂ and nitrogen. The gas is then cleaned, cooled, mixed with air and fed into a spark ignition engine. The engine shaft is coupled to a generator, which produces electricity. When fully operational the CHP is designed to provide 100% of the net electrical load for BedZED's buildings.

Waste heat from the engine jacket and exhaust is tapped by heat exchangers and aims to provide all the hot water and heating needs for BedZED. BedZED's design reduces space heating by 88% (2003 monitoring), so the CHP mainly supplies hot water for washing, for which daily total demand is relatively constant throughout the year. However, across each day the hot water demand fluctuates greatly, so heat storage of some form is needed. This is provided in a simple cost-effective way by large domestic hot water cylinders in each dwelling and workspace so that the CHP can continuously trickle-charge them. The demand fluctuations are again smoothed out by the site's mixed use from homes and offices. The peak site hot water demand is designed to match the peak CHP heat output, so avoiding the cost of a peak load boiler plant.

The CHP heat distribution pipework is sized to need low pumping energy. Hot water cylinder immersion heaters provide a hot water standby facility.

Figure 5



BedZED's prototype CHP unit was designed to be fully automated, with un-manned start up and shut down and strict, automatically controlled operating parameters. The plant is designed to run 24 hours per day, 7 days per week, although at BedZED it ran for 18 hours per day due to noise restrictions of 37dBA at 20m. To reduce noise the engine was enclosed in an acoustic room with silencers on the exhaust and other connections. The acoustic design was tailored to the particular frequency bands that the plant emits. However, on paper it was not possible to meet the stricter noise level requirement that applies between 01.00 am and 04.00 am, so the BedZED CHP was designed to automatically switch off at these times. In practice, noise from the CHP is very low and there have been no complaints.

The plant is equipped with automatic de-ashing. Ideally, weekly attendances are required for receiving woodchip deliveries, checking and filling oil and water levels, and scheduled maintenance should be carried out on a quarterly basis. However, in practice the BedZED CHP required full time manning with frequent downtime for equipment modifications.

The CHP has never consistently reached the agreed outputs of 120 kW of electricity and 250 kW of heat. *"As these targets were never met, EXUS had been bearing the costs of constant staffing and remodelling on-site, to try and develop the CHP to achieve these targets. It did generate 50 kWe during the monitoring period for this thesis but had achieved better results in 2003, with EXUS regularly operating the CHP at 80-90kWe, only 30% from target."*¹ The CHP has not been in operation since 2005.

The main technical problems with the CHP were as follows:

- the design of new, untested equipment such as the automatic ash removal,
- reliability of some equipment that needed to operate continuously, such as the woodchip grabber and slide valves,
- tar condensing from the wood gas, exacerbated by cooling of the plant when shut off at night.

In addition to the technical issues Exus Energy, who operated the CHP on a turn-key contract, ceased trading and the future of the company is uncertain.

BedZED helped to pioneer small-scale biomass gasifying CHP in the UK. However the operating costs of these systems still remain high, and have played a part in the BedZED CHP being decommissioned. Peabody is now working with BioRegional, BDa ZEDfactory, Energy Savings Trust and Building Research Establishment to identify a replacement to the CHP unit. There have been advancements in this technology and Peabody is keen to replace this system with a tried and tested system that will maintain the commitment to a zero carbon development.

Photovoltaics

At BedZED there are 777m² of photovoltaic panels, made up of 1,138 laminates, on the roof tops and in south facing second floor windows. They were originally intended to power 40 electric vehicles (the ten year target). However, uptake of electric vehicles is much slower than hoped and there are only two electric vehicles on-site, belonging to BDa ZEDfactory, BedZED’s architects. Currently the electricity they produce is used by the site as a whole, with any surplus supplied to the grid.

The total size of the array is 108kWp and BP Solar estimated that they would provide 88,000 kWh of electricity per annum. BP Solar’s estimate accounts for 30% of the whole site consumption (estimated at 297,000 kWh²). As previous readings of the PV display use have been lower than this, and because the output display board is no longer working, for the CO₂ calculations we have assumed a 20% contribution from PV. More monitoring is needed of the efficiency of solar power at BedZED.

For six months in 2006, metering company Pilot Systems monitored import and export electricity for BedZED, shown in table 8. As the CHP was not in use at this time, the exported electricity is all from PV. From this we can estimate annual net grid electricity consumption at 235,703 kWh although it is not possible to estimate PV output as the proportion used on-site, prior to the surplus being exported, is not measured. For the same reason we can not estimate net site consumption of grid and PV electricity. However, if we do assume total consumption at 297,000 kWh, then the PV electricity can be estimated at 20%. However, the readings in table 8 below are from the sunniest half of the year and so the 12 month equivalent figure is likely to be lower, but conversely, there were periods when the PV were not exporting at all, due to a technical fault, and so the 6 month total could, in the future, be much higher.

Table 8

	Electricity imported kWh	Electricity exported kWh	Net grid electricity consumed kWh
May-06	12,312.87	725.95	11,586.92
Jun-06	14,423.06	2,627.71	11,795.35
Jul-06	14,897.27	2,558.72	12,338.55
Aug-06	21,436.51	538.41	20,898.1
Sep-06	22,742.4	273.95	22,468.45
Oct-06	24,115.51	243.04	23,872.47
Nov-06	14,903.52	11.96	14,891.56
Total	124,831.14	6,979.74	117,851.4
12 month equivalent	249,662.28	13,959.48	235,702.8

1 & 2. MSc Architecture: Advanced Environmental and Energy Studies Thesis, The BedZED lessons, Simon Corbey, December 2005

Water

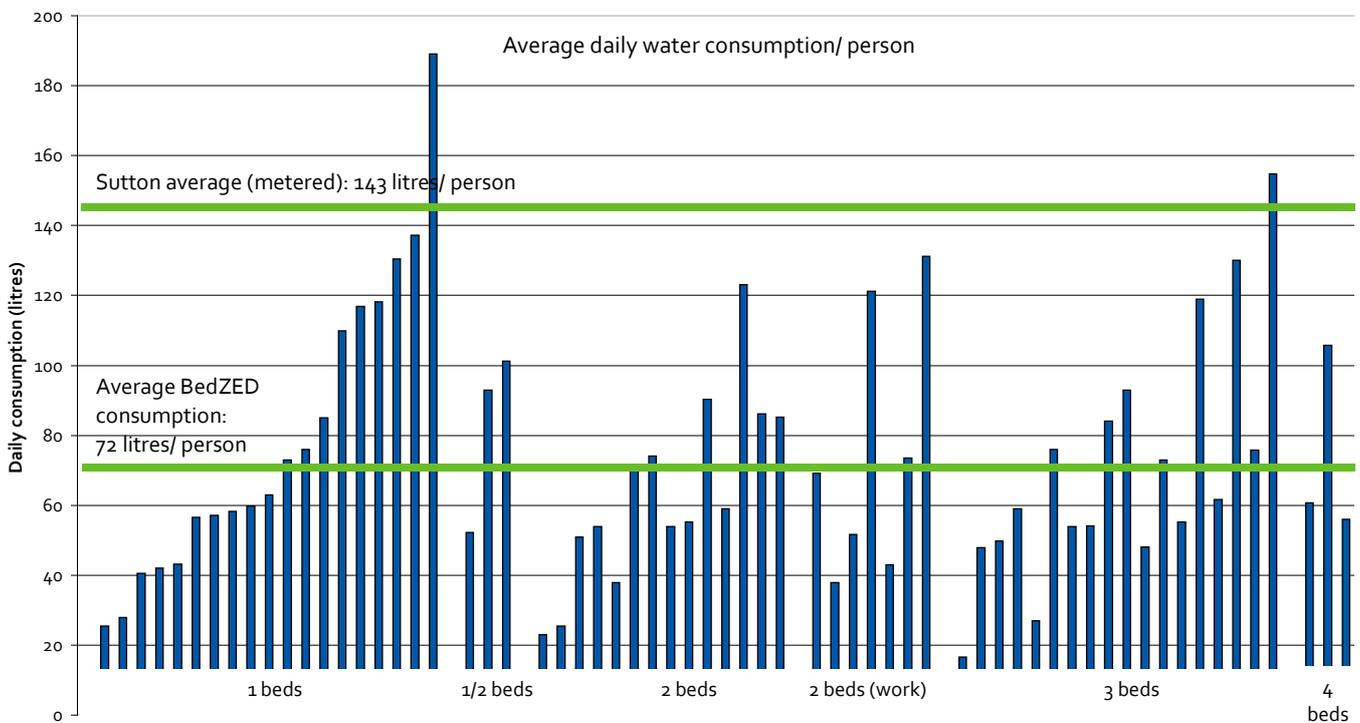
BedZED Aim - reduced mains-water demand:

- Homes fitted with water-saving appliances:
 - Dual flush 2/4 litre flush toilet
 - Reduced flow taps and shower head (basin taps: 3 litres/ minute and shower 11 litres/minute¹)
- Visible meters to make residents more aware of consumption

BedZED monitoring results

- 72 litres/ person/ day
- 162 litres/ dwelling/ day

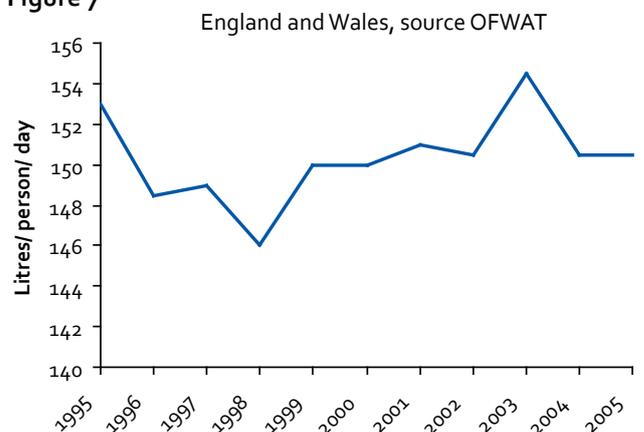
Figure 6



Water used/ person/ day

72 litres/ person/ day is 6% lower than the 76 litres per person per day monitored in 2003. This could be explained by the weather; 2003 was a much hotter and drier summer than 2007 and the graph below shows that 2003 saw higher consumption on average than other recent years throughout England and Wales.

Figure 7



1. Flow rates tested by Sutton and East Surrey Water, March 2008

Simon Corbey's BedZED monitoring in 2004, estimates water consumption at 98 litres/ person/ day, but this figure was calculated by dividing the total quantity of water delivered to the site, less estimated removals and leakages, divided by the estimated number of residents and workers. Therefore the result is not directly comparable with the 2003 or 2007 meter readings.

The 2007 BedZED average of 72 litres/ person, compares to the local average for metered properties of 143 litres¹ (50% reduction) and the local average for all properties of 171 litres² (58% reduction). BedZED residents also use an estimated 15 litres of recycled water or rainwater, bringing the total water consumed to 87 litres per person.

Table 9 Total water consumption summary

BedZED 2003 litres/ person/ day	BedZED 2007 litres/ person/ day	Local average for metered properties litres/ person/ day
91	87	143

Water treatment systems

BedZED's Green Water Treatment Plant GWTP (Photo 8) was designed to clean all of the site's wastewater so that the resulting 'Green Water' effluent could be reused to flush toilets and irrigate gardens, reducing mains water demand. This combined with rain water harvesting has saved another 15 litres of mains water per person per day. Rainwater harvesting has worked well, but the costs associated with operating and maintaining the GWTP could not justify its continued operation on a commercial basis. The plant also uses more energy than conventional sewerage and sewage treatment services. For these reasons, the plant is no longer in use, though it has been useful for research purposes.



Photo 8 Green Water Treatment Plant, credit: David Triggs

Further information and costs for the Green Water Treatment Plant and rain-water harvesting systems can be found in a BioRegional report; Beddington Zero (Fossil) Energy Development Toolkit for Carbon Neutral Developments – Part II.

BedZED Wastewater Reclamation Plant

BedZED is again using recycled water and now hosts the UK's first membrane bioreactor (MBR) for recycling waste water for non-potable domestic use (toilet flushing and irrigation). This has been introduced by Thames Water and Peabody as a three year research project to look into options for using on-site treatment to augment water supply for London, and in part to ascertain if the running and energy costs of on-site water treatment systems can be reduced. The MBR started operating in June 2008, and now processes wastewater from all of the buildings on-site.

Thames Water will be chlorinating the output of their MBR plant which is collected in storage tanks below the BedZED blocks before it is pumped to flush toilets. Although the rainwater is not currently being re-used on-site, it is reverting to the groundwater via soakaway, and this is far better than entering the sewerage system for unnecessary cleaning which is what could happen on a conventional development.

1 & 2. Ofwat 2005/6

Future for on-site water treatment at BedZED

Currently on-site water treatment is not environmentally or financially sustainable. Level six of the Code for Sustainable Homes demands no more than 80 litres of mains water/ resident/ day and this is very difficult to achieve with water efficiency alone – some augmentation of mains water supply is also needed to meet Level six.

The original treatment plant at BedZED used more energy than conventional sewerage and so the environmental benefit is compromised. We do not yet know what the energy use of the MBR will be. Currently, the law only allows water companies to recycle sewage at a local level if it is chemically treated. It would be preferable to find an environmentally safe way that does not resort to chemicals.

On-site water treatment is not currently cost effective (though again, the MBR may prove otherwise). The current price of water generates insufficient income to meet the cost of sewage treatment in small-scale plants and is unsustainable on grounds of energy consumption even before the capital cost is considered. There is no dispensation for making emergency only use of the existing infrastructure, and so there is no cost saving for developers using on-site treatment systems. As water scarcity increases, we will be forced to use more energy intensive methods to recover water. Ironically, the impacts of climate change on water availability may force us to increase the energy consumption of our water systems.

As our monitoring shows an average total water consumption of 87 litres/ person/ day, it does seem like an unnecessary expenditure of money and energy to use water treatment systems to get down to the 80 litres required for Level six of the Code for Sustainable Homes. However, where rainwater harvesting is practical, and the risk of ecoli manageable, this does seem like a sensible option.

A real success here at BedZED is that by fitting fairly standard, affordable water-saving fittings and with minimal behavioural change, BedZED residents have reduced consumption to 87 litres/ person/ day.

Replacing Appliances

Much of the water and energy savings at BedZED can be attributed to efficient appliances, so it is important that residents choose efficient replacements as appliances wear out. 13% of households have replaced appliances or fittings including white goods, taps and light fittings, and of those only one household said they did not specifically choose a water/ energy efficient replacement.

Transport

BedZED aims

The Green Transport Plan at BedZED has three strands; to reduce the need to travel, to promote public transport and to offer alternatives to private car travel. Our aim was to reduce private fossil fuel car mileage to 50% of what would have been expected on a 'conventional' build on the same site. The local average for the London Borough of Sutton was 6,000 miles per person per year¹. For more detailed information about the Green Transport Plan please refer to the BedZED Total Energy Strategy (summary available for free download from www.bioregional.com).

BedZED monitoring results

Transport accounts for 13% of Sutton's ecological footprint or 66 global hectares per capita. Despite achieving significant reductions in car journeys at BedZED there is an overall 13% increase to 0.75 global hectares or 16% of the ecological footprint. This is due to air travel which is higher at BedZED than for Sutton as a whole.

Car ownership

The 2001 census shows that 71% of Sutton households own at least one car, and in Hackbridge (the area around BedZED), our own research² indicates that 84% of households are car owners. At BedZED it is significantly lower at 59%. This may be partially explained by the different proportion of tenure at BedZED compared to Sutton as a whole. At BedZED 83% of owner-occupied households own a car compared to 47% for social housing, 43% for shared ownership and 0% for households that are privately renting. It is likely that tenure is a more important influence on car ownership than any environmental imperative.

Of the 71 households we questioned, four households own two cars, 38 own one car and 29 do not own a car. Average car ownership is 0.6 vehicles per household, significantly lower than the Sutton average of 1.6 cars per household. The average for owner occupiers is 0.9, still far lower than the norm, and the average for social housing tenants is 0.5. The 2003 monitoring also indicated average car ownership of 0.6 vehicles per household.

The role social housing plays in reducing car ownership was recognised in the Green Transport Plan "At least 15 homes at BedZED will be allocated for social housing. Car ownership amongst social housing residents is 50% lower than the average levels in Sutton. The standard allocation of 19.5 spaces for the social housing units can therefore be reduced by 50% to ten spaces."³

Car ownership by type of vehicle (as that household's main vehicle) is as follows:

- Average UK petrol – 31 households
- Average UK diesel – nine households
- Ultra-efficient petrol – one household
- 4x4 – one household
- Liquid Petroleum Gas (LPG) – no households
- Electric – no households

It is significant that none of the households surveyed owned an electric vehicle despite the provision of free 'green' electricity from the photovoltaic panels – essentially free fuel and reduced car parking costs.

At BedZED, residents pay £220 per year (2007) for a car parking space. The charge was intended to make car ownership less attractive but it is very unpopular with residents, as are the clampers in operation. Some residents choose to park for free on the streets surrounding BedZED, which in turn is unpopular with the residents of those streets.

1. National Travel Survey 1999-2001

2. Zero Carbon Sutton – Community Energy Efficiency Fund Report April 2008

3. Beddington Zero Energy Development Total Energy Strategy including Green Transport Plan 1999

Distance travelled by car

Residents found it difficult to estimate car mileage and so the results may be inaccurate.

From the questionnaire we have estimated that on average, BedZED households travel 3,708 kilometres (2,304 miles) per year by car.

We did not ask how many passengers were in the car for each journey and so it is difficult to compare the findings to other studies, many of which look at vehicle kilometres per passenger. Furthermore, we are not convinced that passenger kilometres are as significant as car ownership and vehicle kilometres; by the former method, if a car transports two people rather than one then the emissions per person are halved, even if the passenger would otherwise have travelled by train, or not travelled at all!

However, national car occupancy is estimated to be 1.6 people per vehicle and if we assume the same, this equates to 2,318 vehicle km/ person at BedZED, 64% lower than the national average of 6,344 km¹/ year. However, we do not know how much of this reduction can be attributed to location and tenure, and how much to resident efforts to live sustainably. Simon Corbey's 2004 monitoring indicated vehicle mileage to be 3,665 miles (5,898 km) per year but this figure includes business travel which we did not account for in our 2007 monitoring (because it is not included in the personal transport category of the REAP ecological footprint). The 2003 monitoring returned a result of 2,061 miles (3,318 km)/ person/ year.

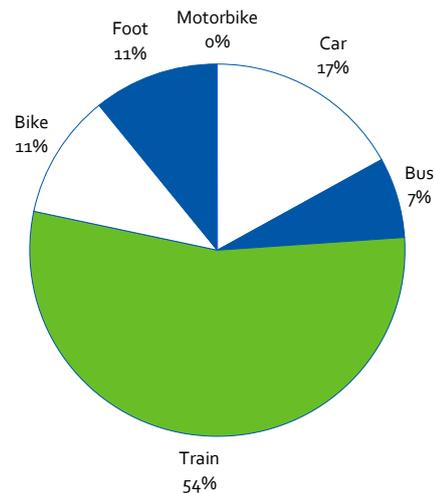


Photo 9 City Car Club at BedZED

Travel to work

Only 17% of BedZED residents travel to work by car (or any motor vehicle), significantly lower than the Sutton average of 49%² and the Hackbridge average of 43%³.

Figure 8 Travel to work



Car club

BedZED hosted London's first car club which is provided by City Car Club. Car club members share the use of a locally based fleet of vehicles. Use of the vehicles is charged on a 'pay-as-you-drive' basis, so members avoid the high overhead costs which encourage car owners to use their car as a default option. Car club members typically halve their annual car mileage, transferring trips to public transport, walking and cycling. Experience shows that one car club vehicle replaces four to six privately owned vehicles.

Nine of the 71 households surveyed have car-club membership. Of those nine, only two households owned a car, far lower car ownership than for BedZED as a whole. This indicates that car clubs do help to reduce car ownership. Three car-share vehicles at BedZED are provided by City Car Club and currently each car is used for about four hours per day on average (based on a seven day week), sometimes more. There are 31 members with an SM6 postcode (Hackbridge). 25 are in BedZED and six near by. For more information, visit www.citycarclub.co.uk.

1. Personal Stepwise powered by Best Foot Forward
2. Smarter Travel Sutton
3. Zero Carbon Sutton – Community Energy Efficiency Fund Report April 2008

Bicycles

Bicycle ownership and storage

49% of the residents we interviewed owned a bicycle. Although BedZED homes are designed with space to store a bicycle indoors and have Sheffield stands and metal rings on the outdoor walls to lock bicycles to, there is clearly a need for more secure bike storage (this was a frequent comment in Peabody's 2004 Resident Satisfaction Survey¹). The 2007 questionnaire shows that residents do not use the Sheffield stands and only one person uses the metal rings in the walkway. 80% of bicycle owners at BedZED use their sunspace or flat for bicycle storage. Peabody has committed to consulting residents about cycle storage options.



Photo 10 Bike lockers

Air travel

This was relatively easy to calculate and should be accurate. We asked the residents to list the start and end points of all the plane trips they had taken (excluding work travel) and then calculated the distances. We found that BedZED residents travel more by air than the average UK resident, though this is not surprising as this is true of Londoners generally.

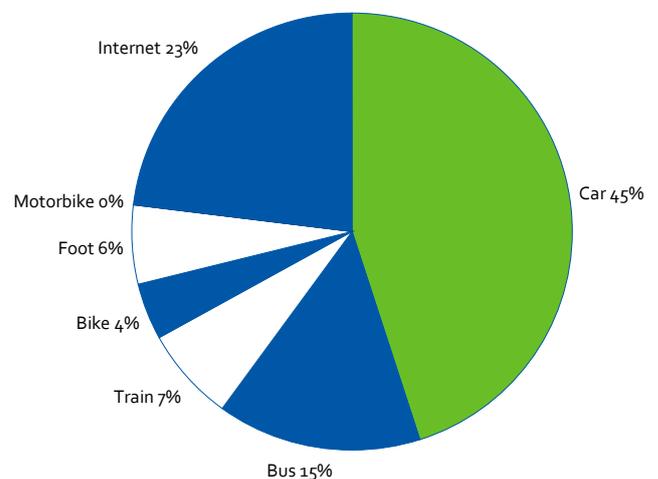
In one year the average BedZED resident flew 10,063 kilometres, roughly a return flight to New York, or three return flights to Spain each. While 27 households didn't fly at all over the year, 44 households totalled 714,504 kilometres, a massive 16,239 kilometres each.

The owner-occupiers flew the most and the social housing tenants the least. But even the social tenants at 3,567 kilometres/ person/ year, are a little over the Sutton average (REAP) of 3,321 km/ year.

We estimate that the average of 10,063 kilometres/ year equates to 1.9 tonnes of CO₂². However, the actual global warming potential is likely to be much worse, as the actual climate change impact of the flights could be 2.5-4 times larger than this due to the emission of water vapour and the altitudes at which gases are emitted. If we aim for an 80% reduction in CO₂ globally by 2050, and split our global allowance equitably among the global population, that gives us 1.1 tonnes of CO₂ each. The CO₂ emitted by BedZED residents for flights already exceeds this.

Travel mode for food shopping

The nearest supermarket to BedZED is around three miles away and local shops do not have a particularly good range, which explains why the car is the primary mode of transport for food shopping, as you can see here in Figure 9.



1. BedZED Resident Satisfaction Survey Report, Rachel Ellis, Peabody Trust Asset Management, May 2004

2. Conversion factor of 0.18g kg CO₂ per km used as we do not know if the flights were long (0.16g kg) or short haul (0.20g)

Food

BedZED aims

At BedZED we wanted to address the impacts of food by encouraging residents to grow their own food and promoting organic fruit and vegetable box delivery schemes. There is no supermarket in walking distance of BedZED though there are several convenience stores. During the monitoring period a fruit and vegetable and grocery market was running on-site twice a week, and residents were able to easily buy UK-produced food.

BedZED monitoring results

Food accounts for 25% of Sutton's ecological footprint (1.31 global hectares per capita) whereas at BedZED there is a 7% reduction to 1.22 global hectares and 26% of the ecological footprint.

Food Growing

28 households, (39%) of the 71 questioned, grow some of their own food but the extent varies from a few pots in the sunspace to a council allotment. This is lower than the average in Hackbridge of 46%. Of those 28 households at BedZED, 20 use their gardens, ten use the on-site allotments (Photo 11) and one has a council allotment¹.

However, at the end of the questionnaire when we asked residents to identify which of the community facilities at BedZED they used, 17 (24%) said they used the allotments, with 14 citing food growing as the reason, two socialising and one with no answer. This indicates that people give different answers according to how a question is phrased but perhaps also that residents associate the allotments more as a community facility (there are seating areas) than a food source.

From regular visits to the allotments it is clear that the quantity of food grown is not significant and many of the troughs are empty for much of the year.



Photo 11 Sky garden and BedZED allotments

1. Although anecdotal evidence from one allotment user suggests at least seven BedZED households have off-site allotments

Organic Food

Of the 71 households asked, 60 (86%) choose to buy organic food over non-organic if the cost is the same, and 31 (44%) choose organic produce even if the cost is higher.

On average, residents estimate that 25% of the food they consume (by weight) is organic. This varies from 0% for 11 households to 85% for one household.

The Cooperative Bank Ethical Consumerism Report 2007 shows an 18% increase in spending on organic food in 2006 compared to the previous year, and we would expect BedZED to follow this trend. Yet in 2004¹, when residents were asked if they bought organic even if it was more expensive 55% said yes, more than in 2007. However, they were not asked what their choice was when the cost was the same. Also, only 22 residents completed surveys in 2004, and so the results can not be seen as statistically significant.

Food deliveries

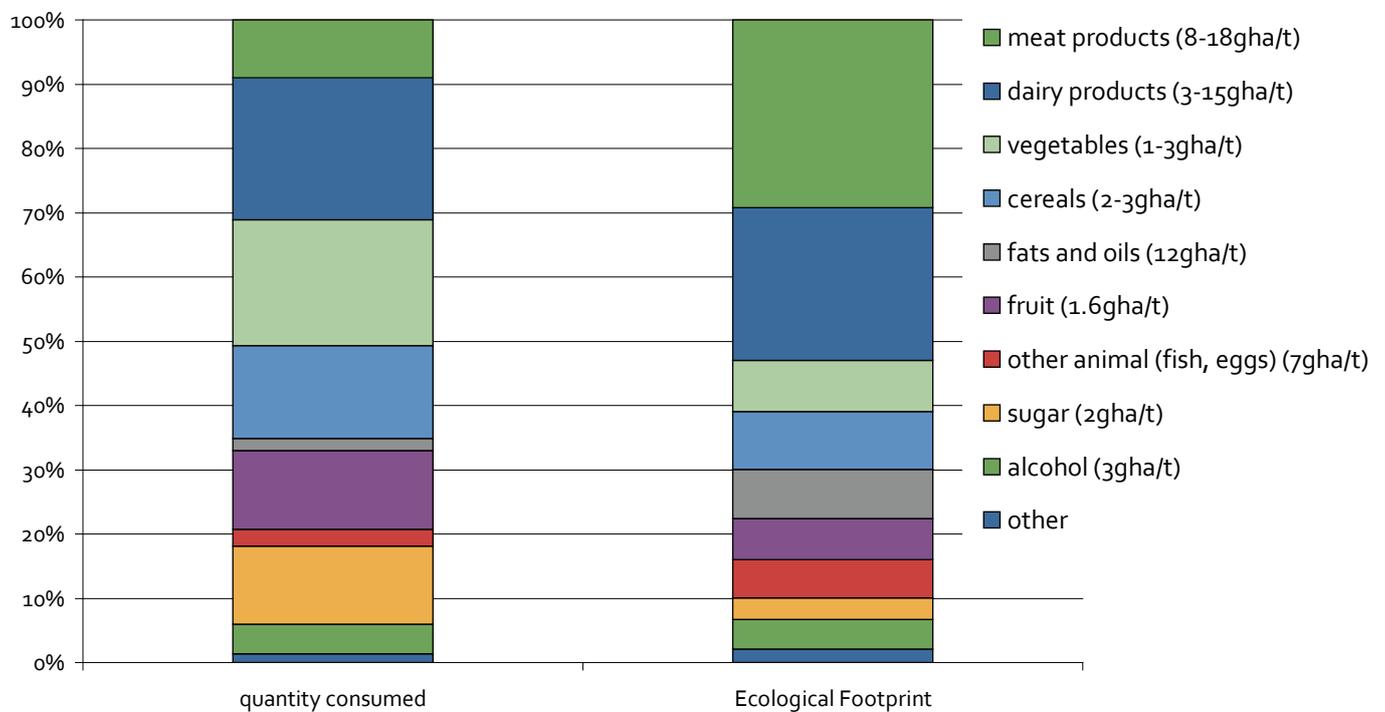
In 2004 25% of households said they had an organic box delivered and 6% had a regular supermarket delivery. In 2007 the questionnaire results show that 25% have an organic box and 18% have a regular supermarket delivery. This trend reflects the increasing popularity of these methods of shopping.

Recommendations for BedZED

In order to achieve a bigger reduction in ecological footprint it would have been beneficial to have tackled food waste (UK consumers throw away approximately one third of the food they buy) and meat and dairy consumption.

Figure 10 shows the estimated ecological footprint of the average UK diet; it is evident that meat and dairy have the highest impacts; whilst animal products comprise 30% of our diet, they account for over 50% of our diet's impact, due to the energy needed to produce them.

Figure 10²



1. MSc Architecture: Advanced Environmental and Energy Studies Thesis, The BedZED lessons, Simon Corbey, December 2005
 2. Sutton Local Food Guide, Anna Francis, BioRegional Consulting Ltd 2007

Waste

BedZED aim

60% recycling rate by weight of waste (including green waste). In theory 70% of the current waste stream is recyclable or compostable so a 60% rate of diversion from landfill should be possible at BedZED using the existing infrastructure.

Waste Strategy at BedZED

The aim was to have a kerbside waste and recycling service but the London Borough of Sutton could not offer this. Instead BedZED has bins for different materials around the perimeter of the site as follows (provided by Sutton Council unless otherwise stated):

- Mixed dry recyclables (paper, card, steel and aluminium cans)
- Glass (separate bins for green, clear and brown glass)
- Waste
- White paper recycling bin (provided by Loop Recycling and BioRegional)
- Compost bins (provided by the residents' association)



Photo 12 Composting day

As kitchen and garden waste is bulky and comprises 42% of the waste stream by weight in the UK, it is desirable that it is treated on-site rather than being collected by the local authority. This would save energy in transportation and reduce the volume of material to be processed by the council's waste contractors. Resident volunteers turn the compost and add dry matter such as shredded paper when necessary. They bag it up when it is ready and distribute it back to the residents for use in their gardens or on the communal allotment site.

BedZED kitchens come equipped with divided bins, allowing residents to easily separate and dispose of waste.

The BedZED Residents Manual, Section E, provides contacts for recycling or reusing other items that are not collected regularly by the council such as bulky household items, paint, engine oil and foil.

Additionally the Residents Association has regularly provided guidance on what can or cannot be recycled, through its e-newsletter and through leaflets distributed door to door.



Photo 13 Divided bin in BedZED kitchen

BedZED monitoring results

We completed waste audits for ten households (10%) households. We also asked 71 households which of the waste facilities they use and to estimate their waste arisings by asking them how many shopping bags of rubbish, recycling and compost they threw away each week.

Table 10

2007	Waste audits			Questionnaire	
Waste stream	Kg/ household/ week	Kg/ person/ week	% composition (weight)	% composition (volume)	% households using the bin
mix dry (cans/ fabric / plastic/ card/ paper)	2.4	1.2	30%		90%
green glass	1.0	0.7	12%		80%
brown glass	0.2	0.1	2%		72%
clear glass	0.4	0.2	5%		82%
white paper	0.0	0.0	0%		45%
Total recycling	4.0	2.2	50%	37%	90%
Compost	0.6	0.3	10%	7%	31%
Landfill	3.5	2.0	40%	56%	94%
Total	8.1	4.5	100%	100%	n/a

Discrepancies

Although 45% of households claimed to use the white paper bin, the waste audits show that none of the households separated white paper from other mixed recyclables. Also, 4 households said they did not use the rubbish bins at all, which seems unlikely.

Comparisons

It is difficult to make a comparison of recycling rates with local and national statistics because local and national rates are calculated by weight and we were unable to weigh the whole site’s waste. Even if we had been able to, we would not be able to tell what proportion came from homes, businesses and off-site users of the bins. The waste audits could be misleading as only 10% of households took part and for a maximum of three weeks over the year. We assume that people tend to make a greater effort to recycle if they are being audited. Therefore our results are only indicative and not conclusive.

In Sutton residents throw away 324 kg of residual waste/ person/ year¹, whereas at BedZED the audits show 104 kg of residual waste/ person, a 68% reduction. However flats do tend to produce less

waste than houses and the vast majority of BedZED properties are flats.

At BedZED our audits show that residents recycle 50% of waste, whereas in Sutton the average is 21%. BedZED residents compost another 10% of their waste, whereas the Sutton average is 9%. However, the figure for Sutton includes garden waste collected by the council, whereas at BedZED this service isn’t available and so we weighed the waste that would be composted on-site.

1. Defra, Municipal Waste Statistics 2006/7

Recommendations for BedZED

The questionnaire indicates that only 31% of households compost. It would be beneficial to increase the number of households composting as this is the most effective way of reducing the weight of waste to landfill using the existing infrastructure. It is likely that the number of residents composting has declined over time; Peabody's 2004 survey¹ suggested that 68% of residents composted and a further 8% planned to in the future. This could partly be explained by the smaller sample size in the 2004 survey (38 surveys were completed in 2004 compared to 71 in 2007) but it is also likely that enthusiasm for composting has waned with time and in the absence of a green lifestyles officer (this post was funded for the first 18 months of residents living at BedZED).

A better way of communicating to residents needs to be found. As despite the signs on bins, the information in the Residents Manual and the newsletters, it seems that some residents are still unaware of what can be recycled on-site, for example, many residents did not know that BedZED has white paper recycling or composting. There was also confusion over the kinds of plastic that can be recycled.

Ideally BedZED residents would have a door-to-door waste collection service; as currently it is difficult to identify the residents who are not participating and there also problems with contamination and fly tipping.

If the bring sites are kept, as is most likely, either capacity at the pedestrian entrance to the site should be increased, or the frequency of pick-ups at that point should be increased, as these bins get used the most and are frequently overflowing with bags left by the side of the bins if they are too full.

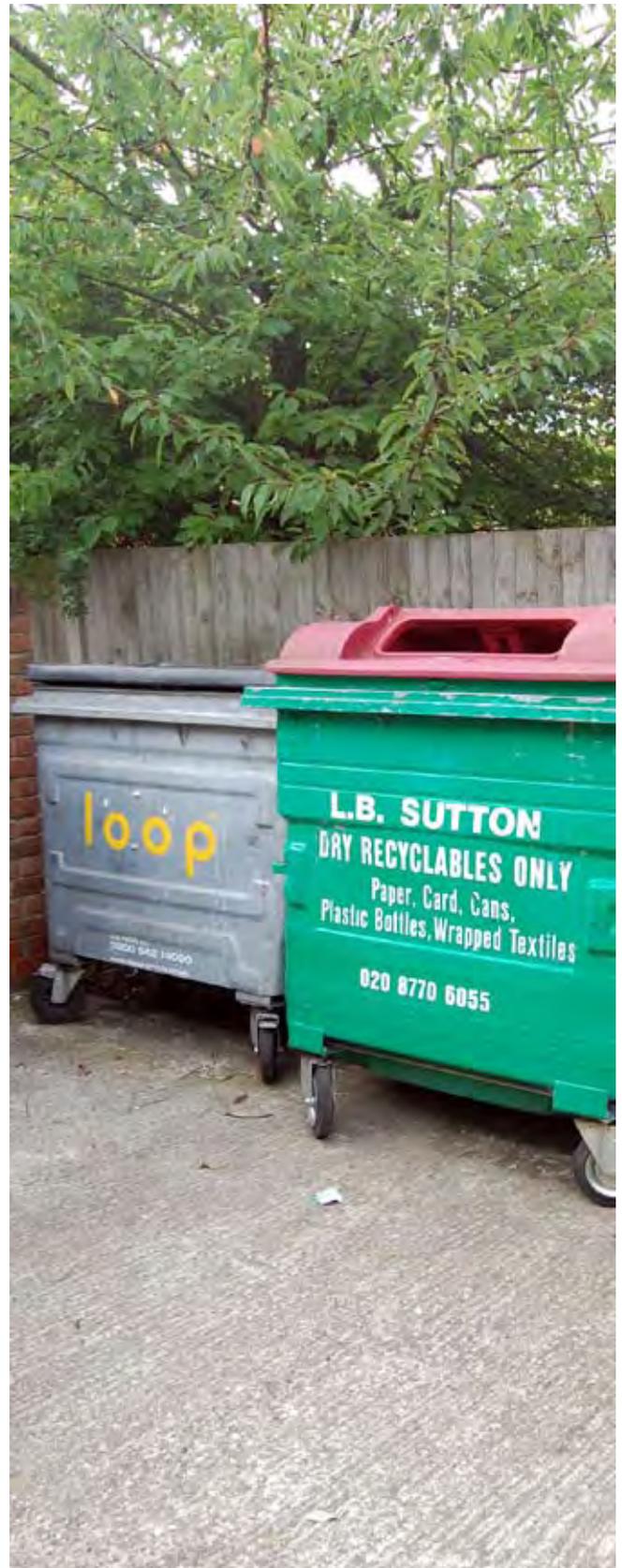


Photo 14 Council recycling bin and white paper bin

1. BedZED Resident Satisfaction Survey Report, Rachel Ellis, Peabody Asset Management, May 2004

Quality of life

On average, residents that we interviewed had lived at BedZED for 40 months or just over three years.

People living at BedZED know an average of 20 of their fellow residents by name. Three residents didn't know anyone but 29 knew 20 or more and one resident was able to name 150 of her neighbours! This is significantly higher than for Hackbridge¹ (excluding BedZED) where the average is eight and the range from 0 to 35.

Table 11 Neighbours known by name at BedZED

Less than 4	16%
4-9	22%
10+	62%
Average	20
Range	0-150

65% of residents said that they knew more people here than in previous neighbourhoods, 18% felt they knew about the same number of people and 17% said they knew less people at BedZED. This is significant as people who are engaged in society are more likely to be happier and healthier².

Community facilities

84% of residents felt that the community facilities were better here than in previous neighbourhoods and only one resident out of 70 who answered this question felt they were worse.

Allotments

BedZED is built on a former sewage works and the land has some heavy metal contamination. For this reason the 'allotments' are a series of metal troughs which have been filled with imported soil and compost. Over the monitoring period the site was leased from the London Borough of Sutton at a cost of £100 per annum.

The allotments have suffered vandalism; plants have been ripped out and in April 2007 the wooden seats that residents had constructed were burnt by arsonists. This is very likely to have a negative effect on the number of residents using the allotments.

However, 24% of households use the allotments for a variety of activities; growing food, socialising, sitting chatting, and playing with kids.

Nursery

On-site nursery, Sunnyfields Day Nursery, closed down during the monitoring period but when it was open only 2 households surveyed said they used it. The unit is now being let by Peabody to a local college.

Village square

31% of households use the village square, mainly for social reasons such as 'hanging out', 'sitting chatting'/ talking to neighbours and barbecues. Bring and buy sales, playing with the kids, petanque, and bike maintenance were also mentioned.

Pavilion (community centre) and sports field

The Pavilion (which includes changing rooms and showers) and sports field were provided by Peabody as part of a Section 106 agreement, as they were requested by Hackbridge residents during the community consultation. The Pavilion is the most popular facility with 66% of households attending events there. The Pavilion is used by residents for exercise classes (dance, aerobics and yoga), social events (parties, quiz and film nights), for meetings and as a café and food market.

Although the sports field is used on an ad-hoc basis by residents, it is not used as an 'official' sports facility. 30% of households use the field and the uses given were: playing football and tennis, mucking about, playing with the kids, sitting in the sun, aerobics and meditation. Peabody and the tenant-led New Possibility Committee now plan to develop this facility as a general amenity space.

1. Zero Carbon Sutton – Community Energy Efficiency Fund Report April 2008

2. Healthy Futures: food and sustainable Development, NHS, March 2004



Photo 15 The Pavilion

Likes and dislikes

We asked residents to name one or two things they liked about BedZED as well as things they particularly disliked.

Summary of likes (In order of popularity)

This was an open question and answers were then assigned to categories by us; some interpretation is needed, for example if a resident had commented that they liked the insulation it could mean that they primarily like the insulation itself (design), or the warmth (wellbeing), lower bills (cost) or lower energy consumption (sustainability). We put gardens and sunspaces (very much like a conservatory in style, though there more for thermal performance) in the same category.

Most answers fell into the following categories (shown in order of frequency and number of interviewees who mentioned it):

- BedZED community (32)
- Architecture/ design (28)
- Sustainability (21)
- Wellbeing (feeling of space, light, quiet, health...) (19)
- Garden and sunspace (13)
- Cost (5)
- Location (5)
- Other (uniqueness, modernity...) (4)
- Facilities (community centre, car club, showers...) (3)
- Size (3)

The most frequent answers related to the sense of community with 32 households making comments like “social side is spectacularly good”, “nice community spirit, non-isolating” and “like my neighbours”. 26 households said that they liked the design and comments included “house is aesthetically pleasing and function built into form”, “I like the look and design of it” and “I love that the design of the house is different to most houses in the UK”.

The next most frequently mentioned category was sustainability. Comments include “love eco friendly design, I’m passionate about the environment”, “recycling close by” and “theoretically small footprint”.

The fourth most popular category was wellbeing, and comments include “air quality in house”, “environmental comfort of the house (cool in summer, warm in winter)” and “quiet even though main road is there”.

Our summary of residents likes in 2007 is broadly similar to those summarised in Peabody’s 2004¹, “Residents were asked what they liked most about their homes and living at BedZED. They made a wide variety of comments, with the design of homes, the sense of community, the garden and sunspace, the green features of homes, and the reduced energy bills being the most frequently mentioned.”

1. BedZED Resident Satisfaction Survey Report, Rachel Ellis, Peabody Asset Management, May 2004

Summary of dislikes

Most answers fell into the following categories (shown in order of frequency and number of interviewees who mentioned it):

- Location (15)
- Lack of wellbeing (temperature, noise...) (14)
- Things not working (CHP, hot water, repairs needed...) (13)
- Management (11)
- Size (9)
- Nothing (8)
- Crime/ fear of crime (7)
- Parking (6)
- BedZED community (5)
- Design (5)
- Intrusion from visitors (3)
- Sustainability (2)

Location came up the most frequently and comments include "Area is isolated, suburban feeling", "lack of local amenities" and "Not keen on the area". Lack of wellbeing was next; with the majority of comments relating to temperature and noise though smells were also mentioned (BedZED is close to a sewage works and landfill site). Maintenance was also a key issue with repairs needed inside the flats, although in some cases these are the responsibility of leaseholders, as well as estate-wide problems such as the CHP not working or problems with the hot water supply. In terms of management, customer service, the service charge and general management of the estate were also mentioned.

Again the dislikes are broadly similar to those found in Peabody's 2004 survey; "Residents were also asked to identify what they disliked about BedZED. The main dislikes mentioned were problems with the heating system, noise transference between properties (which has been reduced by sound proofing wind-cowl vents), defects and problems with their resolution, and the parking facilities."

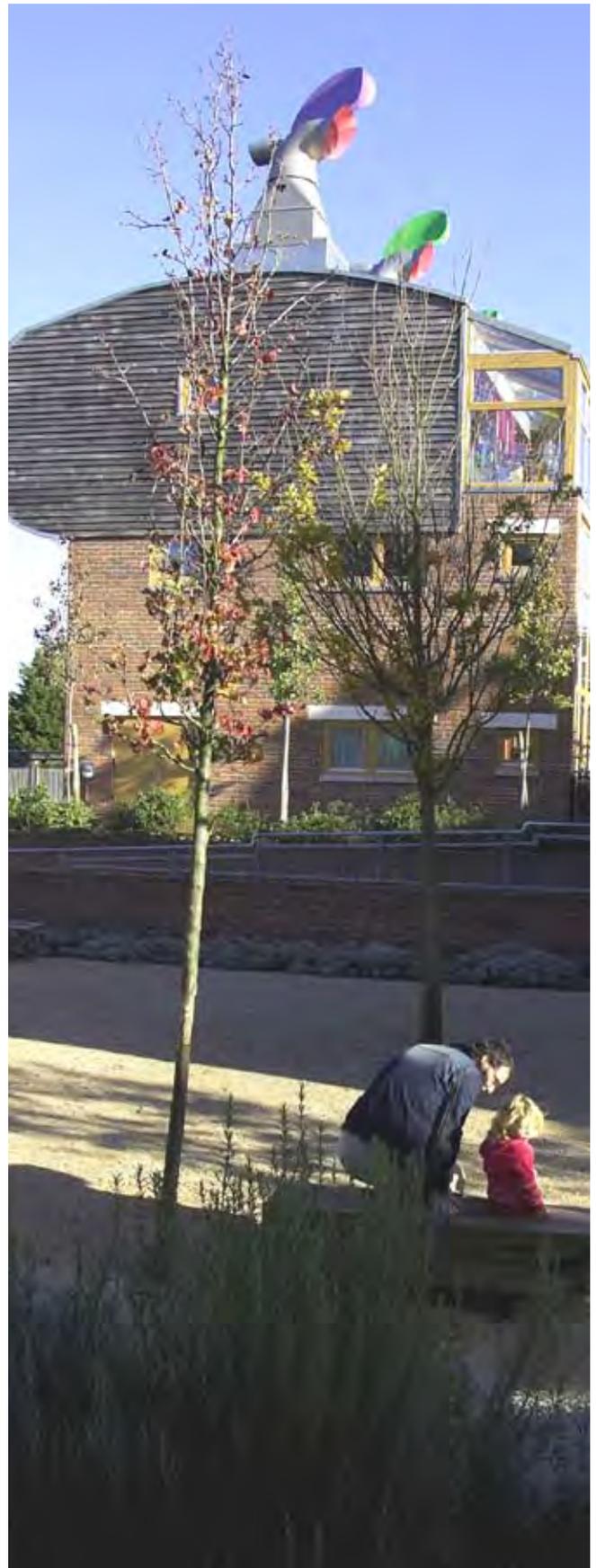


Photo 16 BedZED's village square, credit: Marcus Lyon

Ecological footprint and CO₂ emissions of BedZED residents

What is our fair share?

CO₂

The UK's Climate Change Act 2008, sets an 80% CO₂ reduction target by 2050 against a 1990 baseline. This is intended to help limit global warming to 2°C or less. However, this does not include international aviation and shipping, CO₂ emissions from which continue to rise. However, in a globalised economy when so much of UK residents' impacts occur abroad, it does not always make sense to look at a nation's CO₂ emissions when measuring individual residents' impact. It can be more helpful to view emissions in terms of a per capita global fair share.

Research published by scientists at the Met Office, predicts that the biocapacity of the earth for absorbing carbon dioxide emissions is decreasing.¹ This, coupled with a projected growth in the global population, means that carbon emissions/ person will probably need to be reduced even further over time.

Among environmental experts it is generally held that industrialised countries such as the UK need to contract their emissions whilst the emissions of developing countries should be allowed to increase until a point where every country's per capita CO₂ emissions are equal. This framework is commonly referred to as 'Contraction and Convergence'. For truly sustainable living this would need to be 1.1 tonnes per person by 2050.

Ecological footprint

The Global Footprint Network estimates that there are currently 1.8 global hectares of productive land available for every person on the earth (11.7 billion gha in total). Given global population increase and assuming 20% of land is left for wildlife and wilderness, it is estimated that there will be 1.2 gha available/ person by 2050.

BedZED residents' ecological footprint

This chapter is taken from a report on Ecological Footprinting for Communities written by BioRegional in April 2008². The full report is available from www.bioregional.com.

The baseline data used are the reference values within the REAP carbon and ecological footprinting accounting tool. The data are modified to results in an ecological footprint that should be representative of an average BedZED resident. This is based on current operating conditions (i.e. the CHP is not running, hot water is provided by a district heating system using a natural gas boiler).

Here we have looked at the Sutton average compared to the BedZED average, but also what could be achieved at BedZED by a 'keen' resident and if the CHP was in use.

1. Chris D. Jones et al., Strong Carbon Cycle Feedbacks in a Climate Model with Interactive CO₂ and Sulphate Aerosols Geophysical Research Letters, Vol 30 (9 May 2003), p 1479

2. Ecological Footprinting Methods for Communities, BioRegional, April 2008

Table 12 BedZED ecological and carbon footprint scenarios (REAP)

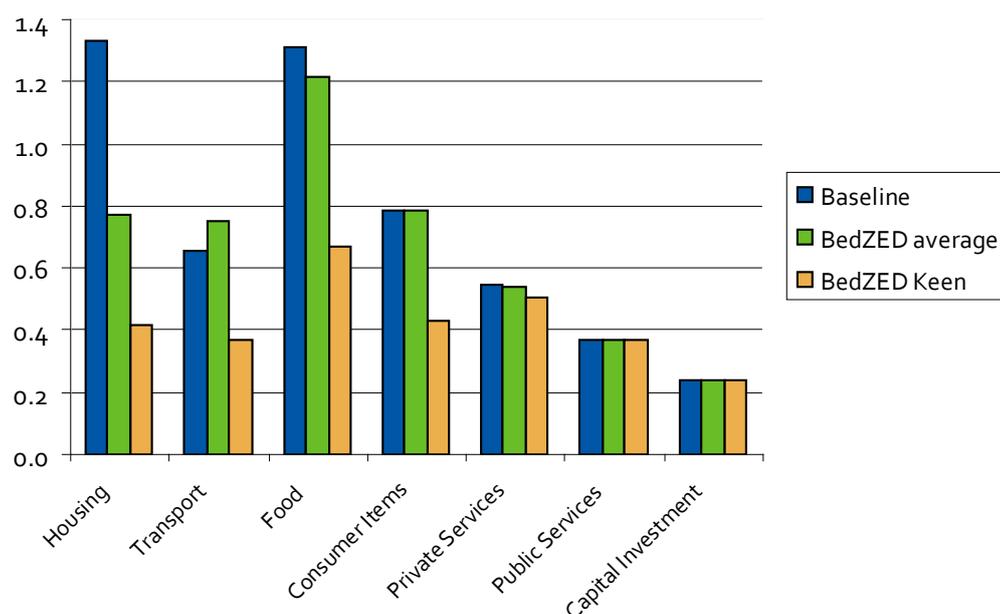
Item	'Sutton average'	'BedZED average'	'BedZED keen'
	Average data from the REAP software	Data acquired through the 2007 monitoring period	BedZED average data modified to assume a resident making a significant effort to reduce impact. Also modified to represent the energy supply as originally intended.
Energy and home	Electricity 3.9kWh pp per day Other fuel 18.2 kWh per day	Electricity: 3.4 kWh pp per day 20% electricity from PV Heat and hot water: 5.2 kWh pp per day	Energy demand classed as zero due to planned renewables meeting all capacity.
Personal travel in private car	5,282 km/year	2,015 km/year	0 km/year Also 0 km/year by taxi
Private vehicle ownership	1.6 cars per household	0.6 cars per household	0 cars per household
Train	897 km/year	4992 km/year	4992 km/year
Bus	465 km/year	676 km/year	676 km/year
Air travel	3,245 km/year	10,063 km/year	0 km/year
Consumable items Includes clothing, furniture, tools, appliances, personal care etc.	100% of UK typical consumption. <i>Reflects 'typical western style' consumption patterns.</i>	100% of UK typical consumption. <i>Replacing clothes and other items when they are worn out and need replacing as well as occasional other purchases.</i>	41% of UK typical consumption <i>Replacing clothes and other items when they are worn out and need replacing.</i> - tobacco and jewellery to zero - audio-visual equipment reduced by 75% - clothing, furniture, textiles & personal care reduced by 50% - household appliances, tools, utensils, maintenance, and recreational items reduced by 20%
Diet	Typical diet from REAP	25% of veg, fruit, meat and dairy are organic	Healthy vegetarian diet, further reduction calculated in line with SEI food report.
Food waste	0% reduction compared to average UK consumption.	20% reduction in fruit and veg compared to average UK consumption	30% reduction compared to average UK consumption.
Private services Includes hospitals, clinics, postal services, water supply, education, catering etc.	100% of UK typical use Water services Sutton average 171 litres per day	100% of UK typical use. Water services reduced to 87 litres per day	100% of UK typical use apart from specified categories: - Water services reduced to 65 litres per day - Mobile phone bills & eating out reduced by 50% - Private medical treatment reduced to zero
Government and capital investment	100% of UK typical	100% of UK typical	100% of UK typical
Carbon footprint	11.2	9.9	6

The results show that the average ecological footprint of a BedZED resident is 4.67 global hectares (2.6 planets), which is 89% of the baseline. This would reduce to 4.32 global hectares (2.4 planets) if the energy was all zero carbon. However, a keen resident at BedZED (if the CHP was working) could achieve an ecological footprint of 3.0 global hectares (1.7 planets) which is 57% of the average. This modelling is invaluable as it shows us where the real opportunities for affecting change lie. The results also show a clear link between affluence and ecological footprint; the average ecological footprint for social tenants is 0.48gha (10%) lower than for owner occupiers.

Table 13 Results from BedZED Scenarios

Ecological footprint (gha)	Sutton Baseline	BedZED average	BedZED Keen	BedZED Social	BedZED Private	One planet living by 2050
Housing	1.33	0.77	0.42	0.77	0.77	
Transport	0.66	0.75	0.37	0.50	0.98	
Food	1.31	1.22	0.67	1.22	1.22	
Consumer Items	0.79	0.79	0.43	0.79	0.79	
Private Services	0.55	0.54	0.51	0.54	0.54	
Public Services	0.37	0.37	0.37	0.37	0.37	
Capital Investment	0.24	0.24	0.24	0.24	0.24	
TOTAL	5.24	4.67	3.0	4.42	4.90	1.2
Planet equivalents	2.9	2.6	1.7	2.5	2.7	1
Reduction from baseline	-	11%	43%	16%	7%	66%
Carbon footprint (tonnes)	11.2	9.9	6			1.1

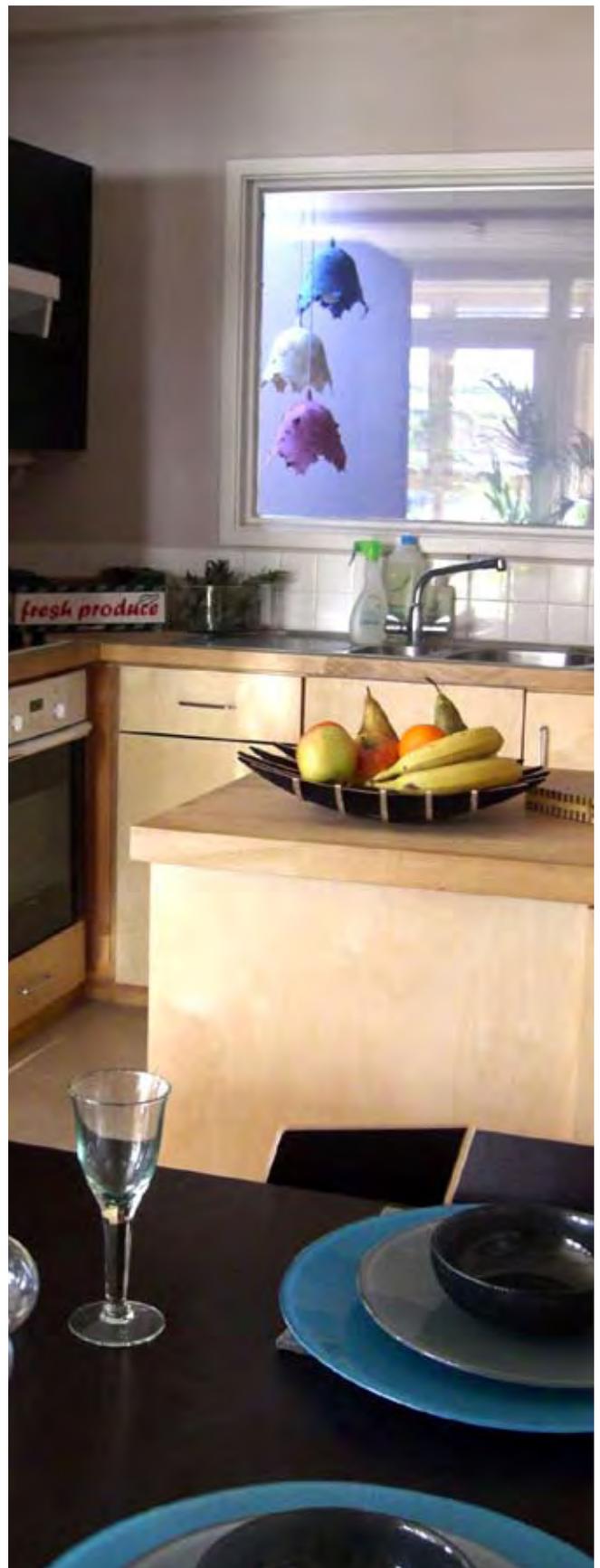
Figure 11 Results from REAP BedZED scenarios



BedZED seven years on

The results clearly show that residents living in BedZED are unable to get to a one planet living level. Although the energy consumption in the homes is much lower than average it is still important that the gas fuel for the heating and hot water is replaced with a biomass source for the residents to achieve CO₂ reductions of a large enough magnitude. Transport is actually higher than average for Sutton, which presents a real challenge for communities to deal with in the future. Food is an area that did not have significant quantities of data to provide a high level of certainty in the modelling. However, residents can achieve significant reductions.

The BedZED community is not large enough to reduce its impacts from public services and capital investment, which make up 21% of the UK average ecological footprint. This is one of the key drivers for One Planet Communities¹ to be larger developments than BedZED. If we develop communities that are large enough to support local infrastructure such as medical centres and schools (also built to one planet living standards) then we can start to have an influence on these areas of the ecological footprint.



1. BioRegional's One Planet programme is a global initiative. It is based on 10 principles of sustainability developed by BioRegional and WWF. www.bioregional.com/oneplanetliving. A key aim is to build a world-wide network of *One Planet Communities* and other exemplary projects to demonstrate *one planet living* in action.

Photo 17 BioRegional's BedZED show home

Glossary

Aerated Showers	Showers that mix air with water for water efficiency.
Biomass	Any plant derived material.
BedZED Residents Manual	A guide to living at BedZED, given to each household upon moving in, it should be handed over to new tenants/owners as occupants change.
Biocapacity	The capacity of a given biologically productive area to generate an on-going supply of renewable resources and to absorb pollutants.
Bring sites	Communal waste and recycling collection sites.
2008 UK Climate Change Act	The Act sets a net UK carbon account for the year 2050 to be at least 80% lower than the 1990 baseline.
Car Club	A business that hires cars on a pay-as-you-drive basis to its members. They are set up for short term hire. Statistically each hire car takes 4 to 6 privately owned cars off the road because members consider the best transport option for their journey rather than automatically choosing a car every time.
Code for Sustainable Homes	The Code measures the sustainability of a new home against categories of sustainable design. The Code uses a 1 to 6 star rating system to communicate the overall sustainability performance of a new home. It is mandatory for new homes to be rated.
Combined heat and power plant (CHP)	A power plant that generates both electricity and heat.
Ecological footprinting	Ecological footprinting measures the amount of productive land and water, such as forests, farmland and fishing areas that a person, project or product needs to produce all the resources that they/it consumes and to absorb the waste they/it generates.
Embodied energy	The quantity of energy required to manufacture, and supply to the point of use, a product, material or service.
ESCO	A business providing a range of energy solutions including design and implementation of energy savings projects, energy infrastructure outsourcing, power generation and energy supply, and risk management. The ESCO will install and maintain the system to ensure energy savings during the payback period. If the project does not provide returns on the investment, the ESCO is often responsible for paying the difference.
Greenhouse gas conversion factors	In this report: the factors used to work out how much CO ₂ is emitted from gas and electricity.
Green Water Treatment Plant (GWTP)	An effluent treatment facility used to clean effluent to a standard whereby it can be used for toilet flushing and irrigation. The BedZED system comprises two underground septic tanks followed by a series of treatment tanks that treat the water biologically.
kWh	kilowatt hour – a standard unit of electricity or consumption equal to 1000 watts over one hour.

kWp	kilowatt peak – The photovoltaic generator’s peak power at maximum solar radiation under standard test conditions.
Membrane bioreactor (MBR)	An effluent treatment system. At BedZED solids are first settled, the remaining effluent is then treated through several processes including a membrane, carbon filtration and disinfection (using chlorine).
MUCSO	As an ESCO but offers multiple utility services.
Passive ventilation with heat recovery	Wind powered ventilation system whereby the heat from the outgoing air is used to warm the fresh air coming in.
Photovoltaic panels	Solar panels that generate electricity.
Potable water	Drinking water.
Resources and Energy Analysis Programme (REAP)	Carbon and ecological footprinting software.
Section 106 agreement	A section of the 1990 planning act relates to monies paid by developers to Local Planning Authorities in order to offset the costs of the external effects of development. For example, if a developer were to build 100 new houses, there would be effects on local schools, roads etc., which the Local Authority would have to deal with. In that situation there might be a Section 106 agreement as part of the granting of planning permission. The developer might agree to make a contribution towards the provision of new schools.
Super-insulation	There is no set definition of superinsulation but super-insulated buildings often include very thick and detailed insulation and airtight construction.
Sheffield stands	A type of bicycle stand consisting of a single inverted U-shaped metal bar mounted onto or embedded into the ground.
Natural gas	A gaseous mixture, consisting mainly of methane, found below ground; used widely as a fuel.
Wind cowls	BedZED’s wind cowls are part of the passive ventilation system. They are the colourful cowls located on the roofs. They bring in fresh air through one duct and expell it through the other.

BedZED seven years on

This report looks at the pioneering BedZED development seven years after completion, and examines the lessons for other zero carbon developments. At the cutting edge of sustainable design when it was built, which of BedZED's catalogue of low-carbon solutions are the most practical and cost-effective in the long term?

About BioRegional

BioRegional is an entrepreneurial charity, which initiates practical sustainability solutions, and then delivers them by setting up new enterprises and partnerships around the world. We assist and encourage others to achieve sustainability through consultancy, education and informing policy.

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