

# Beddington Zero (Fossil) Energy Development



## Toolkit for Carbon Neutral Developments – Part II

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Funded by  Partners in Innovation



BedZED village square

## BioRegional

### BioRegional Development Group

BioRegional Development Group is an independent environmental organisation working with industry, retail and public sectors to bring sustainable practice into the mainstream. Established in 1994, BioRegional work in housing, construction, forestry, paper, textiles, energy and food industries to create sustainable living solutions that are easy, attractive and affordable. By using local resources wisely, we can increase our quality of life whilst leaving space for wildlife and wilderness.

This report is intended to be of practical use in reducing the environmental impacts of new developments. BioRegional will be glad to hear from any readers with feedback and examples of its application.

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### Acknowledgements

This report has been written with the essential input of the BedZED Project Team:



Peabody Trust



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Ove Arup, Consulting Engineers



Gardiner & Theobald, Quantity Surveyors  
Gardiner & Theobald, Construction Management

### Zedfactory

Zedfactory is an initiative by Bill Dunster Architects to produce carbon neutral buildings as a standardised product. ZED homes, workspaces or public buildings can be ordered "off the shelf" with standard designs and a guaranteed maximum price, just like buying a car. The **ZED in a Box** standard products are the new generation designs, based on BedZED but improved to take advantage of lessons learnt in buildability, value engineering and customer satisfaction. The **ZEDteam** are working with suppliers and contractors to produce a range of **ZEDproducts**, specialised components and trade packages that maximise environmental performance but achieve assured quality and volume discounts through standardisation and repetition.

The **ZED on a Sheet** spreadsheet package makes quantified environmental benefits, build densities and build costs instantly transparent and can be used as an open book planning tool by local authorities or developers to trade environmental savings for planning gain.

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## Introduction

This is a practical guide to producing carbon neutral developments and how to afford them. It is based on the achievements at the Beddington Zero (Fossil) Energy Development (BedZED), describing measures taken on that 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.

This Toolkit is produced in conjunction with a ZEDfactory publication, "From A to ZED", which introduces the new "ZED in a box" design and the new range of ZEDproducts and ZEDtools.

The development of BedZED and "ZED in a Box", has given the ZEDteam a vast bank of knowledge and practical experience in producing carbon neutral developments. These reports are designed to encapsulate that knowledge and to save others time.

### BedZED

BedZED is a mixed-use scheme in South London initiated by BioRegional Development Group and Bill Dunster Architects. BedZED has been developed by London's largest housing association, the Peabody Trust. The scheme comprises 82 homes and 2,500m<sup>2</sup> of commercial or live/work space. The scheme was completed and occupied in 2002.

The scheme helps people to live more sustainably, perhaps even within their share of the earth's renewable resources, without sacrificing a modern, urban and mobile lifestyle. It challenges conventional approaches to housing by tackling sustainability in every area from the outset.

Heat, electricity and water demands are greatly reduced. Facilities and services are designed to make it easy to reduce waste to landfill, to recycle waste and to reduce car use. BedZED achieves the high densities recommended in the Urban Task

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Force report whilst still providing a healthy internal environment with generous access to green space and sunlight.

In addition to the sustainability of the finished BedZED product, every aspect of construction was considered in terms of its environmental impact. Materials used in construction were carefully selected for low environmental impact, sourcing locally where possible and sourcing reclaimed and recycled materials where possible.

This approach at construction stage succeeded in reducing the embodied environmental impact of BedZED by some 20-30%. It is documented in The Construction Materials Report available from BioRegional.

## Structure of this report

Following the Introduction and Summary, chapter 3 looks at the need for Carbon Neutral Developments. Then the report looks at the following “areas of innovation” with a chapter on each:

- 4 Planning gain
- 5 Thermal demand
- 6 Electrical demand
- 7 Water demand
- 8 Transport
- 9 Renewable energy supply

Each chapter describes the measures taken to improve environmental performance in that area. Monitoring results from the first year of operation at BedZED are reported. The costs, savings and benefits associated with each measure are quantified.

There is an additional chapter 10 discussing all the factors that affect the Quality of Life of ZED occupants. Based on interviews and monitored lifestyle habits at BedZED, this identifies all the benefits of living there, attempting to place a value on these benefits and assessing how much of that value can actually be returned to the developer in the form of increased property value.

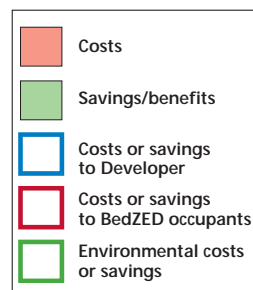
The total costs, savings and benefits from each area are brought together in the Project Balance Sheet and Conclusion.

This report is funded by the DTI's Partners in Innovation programme. Data from this report has also informed an eco-footprinting analysis, funded by WWF-International.

## Methodology

The study that has led to this Toolkit set out to analyse the relative costs and benefits of the various measures taken at BedZED to improve sustainability. From the developer's point of view, the study has looked at the additional build costs as compared with the added revenue achievable through planning gain and property prices. From the occupier's point of view, it looks at financial savings in the form of lower bills and also looks at whether occupants value the features as enhancing their quality of life. From the environmental point of view, the study also reports savings that benefit the wider community such as reduced CO<sub>2</sub> emissions and water savings.

All of these costs and savings to different parties are summarised in colour coded diagrams. Red and green boxes show costs and savings respectively. Blue, red and green borders to the boxes show which party experiences the cost or the saving, the developer, the occupant or the “Environment” respectively.



All figures are based on experience at BedZED. Build costs are supplied by Gardiner & Theobald quantity surveyors, the cost consultants for BedZED. Rates are taken directly from BedZED construction costs but do not include additional expenses that were part of BedZED's research and development.

The information is intended to be applicable to future developments of any size. To make the information transferable, all figures are converted into apportioned costs and savings for a terrace of six plots containing 18 units of 1,2 and 3-bedrooms. The reader must use his or her discretion in applying these figures to different sized developments. Bulk buying affects material costs significantly and for much larger developments, economies of scale will be possible for renewable energy solutions and for on site wastewater treatment. Similarly, a green lifestyles programme benefits from a larger scale development as many facilities become more viable and cheaper for residents.

All costs and savings are given relative to a “conventional” development. Costs are compared with buildings compliant with 2000 Building Regulations, supplied by Gardiner & Theobald Quantity Surveyors. All bill savings and environmental savings are compared with typical UK average except for thermal performance. New build homes are now theoretically 44% more thermally efficient than typical UK housing stock so savings are reported in comparison with both new 2000 Building Regulations and with UK average housing stock.

All environmental savings are monitored savings after 1 complete year of occupation. The only exception to this is the renewable energy section where predicted CO<sub>2</sub> savings are quoted.

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## Summary

Carbon neutral developments are needed both for political reasons to reduce pressure on fossil fuel reserves and because of very clear evidence about the affects of carbon emissions on climate change. To meet the Royal Commission's recommended carbon reductions will require radical measures in all areas. New built developments need to be designed holistically with mixed use functions, integrated transport solutions and on-going viable green lifestyle initiatives.

With a carbon neutral commitment from the start, a new development's carbon emissions can be reduced in all aspects of people's domestic and working lives without sacrificing convenience or mobility. In fact on the contrary, BedZED has shown how environmental savings can go hand in hand with an improved quality of life.

Low fuel bills accompany the carbon savings. Reduced car dependence is not only cheaper but frees up time for other activities. The car-free streetscape at BedZED is peaceful and conducive to neighbourly chat and children playing. Through its imaginative, practical community schemes, BedZED has created real community spirit and happy living and working environments.

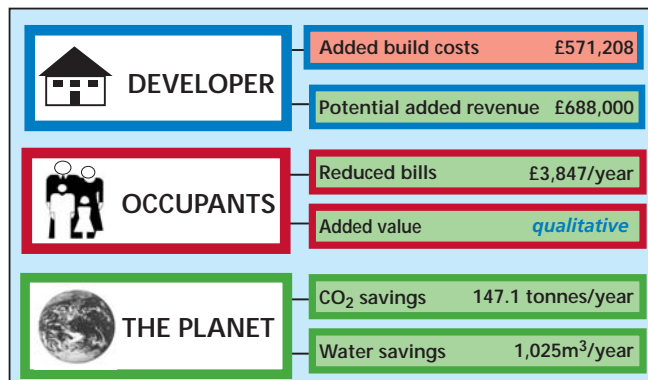
Monitoring results from BedZED's first year of occupation show that building performance and transport patterns have been very much as predicted. Table 2.1 shows comparisons with the national average and, for space heating and hot water, with new homes built to 2000 Building Regulations (in brackets).

	Monitored reduction	Target reduction
Space heating	88% (73%)	90%
Hot water	57% (44%)	33%
Electricity	25%	33%
Mains water	50%	33%
Fossil fuel car mileage	65%	50%

Table 2.1

Carbon neutral buildings do cost more to build. Facilitating carbon neutral lifestyles requires investment in infrastructure and on-going initiatives. For a ZED specification 6-plot terrace, with 100% renewables, 100% waste water recycling and full Green Transport Plan, this report

has calculated costs and savings compared with new homes built to 2000 Building Regulations:



If carbon neutral developments are rolled out on a significant scale, the build costs will be greatly reduced through bulk buying of specialist components and through a build up of on-site skills. Until these economies of scale are achieved, the added costs can be recovered through planning gain and market opportunities for added value.

In housing, the market for sustainable buildings has been clearly demonstrated at BedZED. FPDSavails have showed that buyers are willing to pay up to 20% premium for innovative design and "green" features such as those at BedZED (see Table 2.2).

Unit type	Average current sales figures (Aug 2003)		% Difference
	Local market	BEDZED (estimated)	
1 bed flat	£125,000	£150,000	20.00%
2 bed flat	£175,000	£190,000	8.57%
3 bed flats/ terraced houses	£225,000	£265,000	17.78%
4 bed semi	£300,000	£350,000	17.78%
Average	£206,250	£238,750	15.75%

Table 2.2

Readers of this Toolkit can cherry pick ideas and introduce "green add-ons" to their work or, even better, you can go all the way for a carbon neutral specification and reap the rewards of added value. Read this Toolkit in conjunction with ZEDfactory's "From A to ZED" publication and BioRegional's Construction Materials Report and you should have all the information and contacts you need to produce Carbon Neutral Developments.

Good luck  
Nicole Lazarus

## Need for carbon-neutral developments

If everyone in the world enjoyed the same level of natural resource consumption as a typical UK citizen, we would need three planets to support us<sup>1</sup>. This is clearly unsustainable.



The UK has only fifteen years of North Sea gas left. Once this is gone we will be reliant on fuel reserves from potentially insecure sources. Political instability has led to expensive military resources being committed in the Middle East where fossil fuel supplies are most at risk. War is both an environmental disaster and a major loss of human life. Somehow an increasing human global population competing for limited resources needs to avert more violent conflict in the 21st century.

The reality of climate change and global warming will make fossil fuel use increasingly unacceptable. Renewable energy sources will be initially more expensive until they attain the economies of scale needed to achieve lower manufacturing costs.

Renewable energy sources can only provide a useful percentage of our annual energy demands if we can reduce the amount of energy we need

to run our lives. This means we can only wean ourselves off fossil fuels if we reduce demand for energy to a point where it can be met by renewable energy sources.

One fifth of the UK's CO<sub>2</sub> is generated by foodmiles, with the average UK meal having travelled over 2000 miles from farm to dinner plate. Making green lifestyles easy for people is as important as running homes and workplaces off renewable energy. As well as green buildings, we need local food initiatives that are good value and more convenient than the supermarket.

The environmental impacts of individual residents make up only 60% of the UK's total impact. Some 40% of the UK's carbon emissions are associated with "shared" infrastructure and services, and by-products consumed in the commercial sector. These broad "shared" headings include the emissions from all facilities except homes eg. hospitals, schools, offices, factories, government buildings and retail centres. Just like homes, all these buildings can be built to a high environmental specification and can drastically reduce their CO<sub>2</sub> emissions. For example, the office units at BedZED use only 60% of the energy consumption of a typical office.

### UK Carbon Emissions

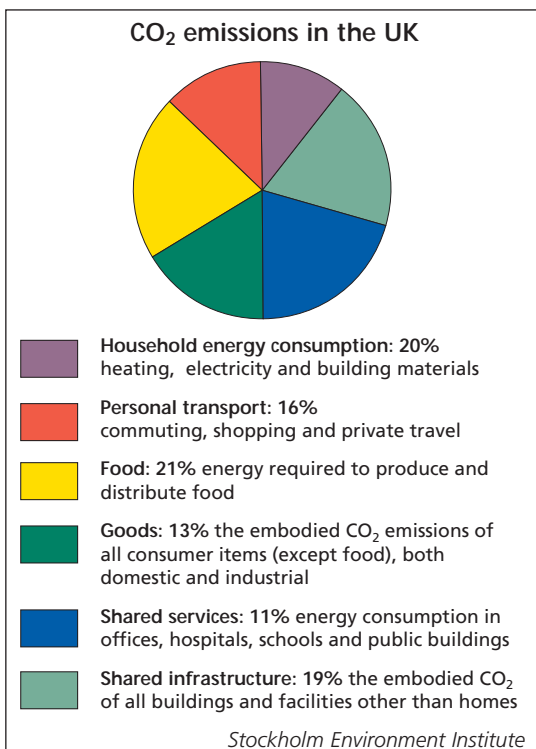
Global climate change is caused by human-induced emissions of carbon dioxide and other greenhouse gases. Global temperatures have already risen by 0.6°C and are predicted to rise between 1.4°C and 5.8°C by 2100.



The average UK citizen is currently responsible for 12.3 tonnes of CO<sub>2</sub> emissions per year<sup>2</sup>. CO<sub>2</sub> emissions from fossil fuel burning make up 80% of UK greenhouse gas emissions. The next most significant contributor is methane.

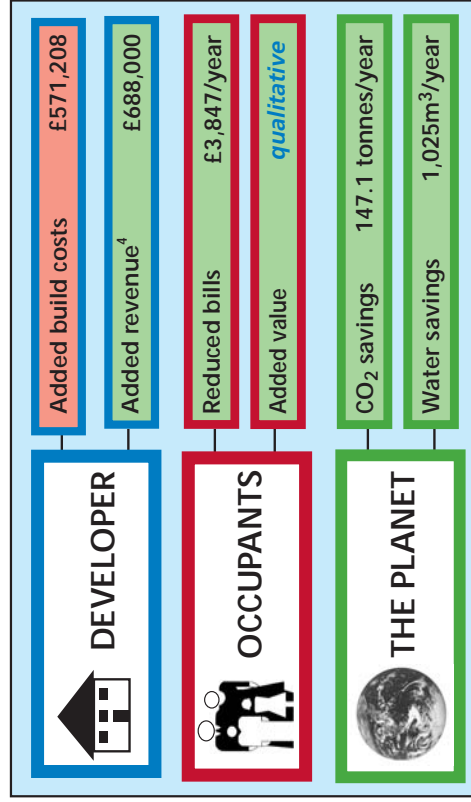
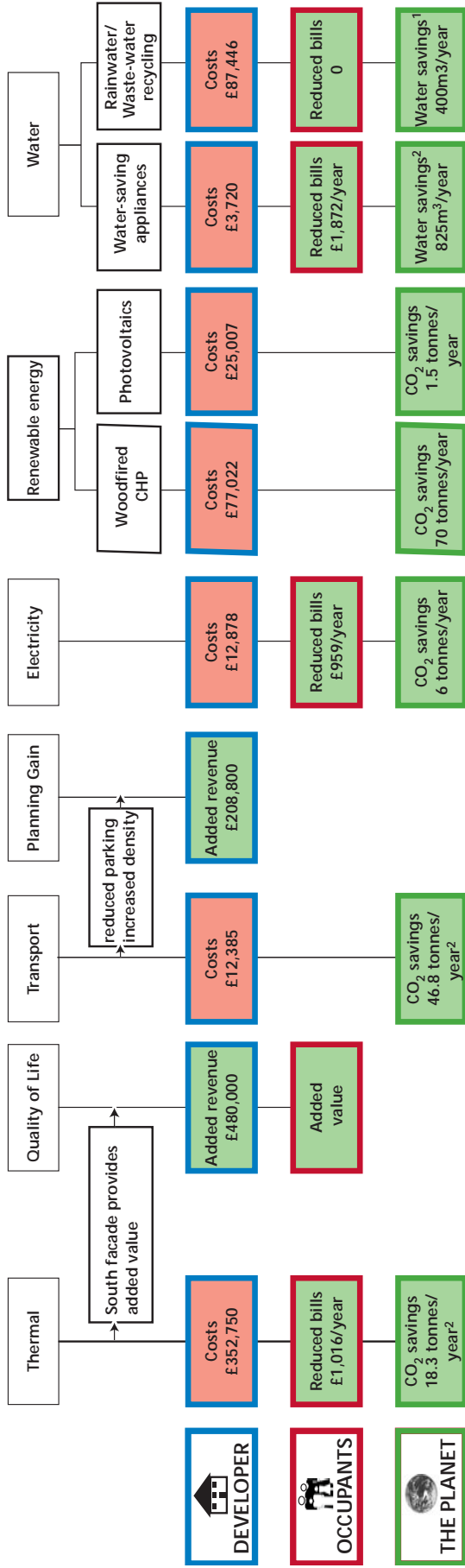
The UK's Royal Commission on Environmental Pollution has recommended that we reduce our CO<sub>2</sub> emissions by 60% by 2050 compared with 1997 levels. This is an ambitious target and to meet it, all sectors will need to contribute to the reduction.

Under the Kyoto agreement, the UK has a greenhouse gas reduction target of 12.5% by 2010. In addition, the current UK Labour government has committed to a target of 20% CO<sub>2</sub> reduction from 1990 levels by 2010.



# Project Balance Sheet

Cost/benefit analysis for a 6-plot terrace



- Costs
- Savings/benefits
- Costs or savings to Developer
- Costs or savings to BedZED occupants
- Environmental costs or savings

1 assuming washing machines use green water  
 2 monitored savings  
 3 predicted when CHP fully commissioned  
 4 from planning gain and added value

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## Conclusion

### Overall

Building a 6 plot terrace to a ZED specification costs a predicted extra £571,208 or £34/ft<sup>2</sup>, compared with a conventional development built to 2000 Building Regulations. However, for each terrace, the ZED planning gain tool allows a developer to generate an extra £208,800 in extra profit. Also, the added value of the light, spacious dwellings with sky gardens and on-site services combined with the attraction of significant bill savings have the potential to bring the developer a further £480,000 in added value. Developers can therefore choose to design for very considerable environmental savings and still recover their costs.

### Monitoring results

BedZED has performed very much as predicted, with radical savings in carbon emissions in all areas. The monitoring results are summarised in the table below showing average reduced consumption across the development compared with the national average. Numbers in brackets show a reduction compared with new 2000 Building Regulations. Results are shown against the original aspirations and targets set out when the BedZED scheme was initiated in 1997.

	Monitored reduction	Target reduction
Space heating	88% <sup>1</sup> (73%)	90%
Hot water	57% <sup>1</sup> (44%)	33%
Electricity	25% <sup>1</sup>	33%
Mains water	50%	33%
Fossil fuel car mileage	65%	50%

<sup>1</sup>Temporary electric space heaters and immersion heaters are accounted for under space heating and hot water.

### Thermal Performance

The building fabric specification which is accounted for in the Thermal chapter adds an extra £342,615 to the build costs of a 6-plot terrace, or £20/ft<sup>2</sup>. This makes up 60% of the additional build costs. The building fabric is however designed for a 120 year design life and, with proper maintenance, will deliver annual carbon savings throughout that time.

Of this, some £285,000 is from the glazed south façade and the roof lights. The daylight design of

the ZED properties is one of the main features that bring added value, so this build cost element must not be considered for CO<sub>2</sub> savings alone. It must be offset against the potential added value, demonstrated by FPDSavills in chapter 10.

### Transport

The Green Transport Plan in a ZED development costs only £12,385 for a 6 plot terrace, but results in 46.8 tonnes of CO<sub>2</sub> savings per year. In terms of lifetime, it is difficult to predict over how long these carbon savings will be delivered as they are dependent on individuals and their lifestyle choices. On the one hand, enthusiasm could peter out after just a few years and people could get back to using their cars in line with the national average. Alternatively, congestion charging, fuel price rises and the rapid growth in car clubs we are currently seeing could mean that these savings go on being delivered for decades.

The Green Transport Plan is essential for the planning gain tool. At BedZED, every square metre that was saved in parking or road space, due to green transport measures, was built on and used to generate the added revenue that balances the added build costs.

### White Appliances

For a very modest £12,878, a terrace can be fitted out with the most efficient electrical appliances, saving residents £959/year and cutting CO<sub>2</sub> emissions by 6 tonnes/year. Similarly, water saving appliances cost a modest £3,720 and save residents £1,872/year and 825m<sup>3</sup> of water/year. These measures are easy and off-the-shelf but they only deliver savings over the lifetime of the appliance ie. around 5 years. To fit out homes with the best A-rated appliances requires no specialist expertise and hardly any effort. A simple websearch using the details in this report to find the best current models is all that is required to make these significant savings.



## Water

Rainwater and wastewater recycling facilities added £87,446 to the cost of a 6-plot terrace at BedZED. They do not result in any bill savings to residents but they could save some 400m<sup>3</sup> of mains water every year over the lifetime of the plant. There is significant potential to reduce the added build costs for these items. For example, a developer may choose to opt only for waste water treatment and recycling and omit the rainwater collection. This would save on rainwater harvesting equipment. It would also mean the storage tanks could be much smaller. They would be designed for steady flow instead of erratic rainfall patterns, so the large volume storage function would be removed. Alternatively, a developer could design for rainwater harvesting and storage and omit the wastewater treatment and recycling. Conventional mains sewage is very energy efficient compared to small scale treatment plants and where mains sewage connection is cheap and convenient, it is difficult to justify the extra expenditure of a small scale plant on environmental grounds.

## Renewable Energy

The renewable energy generating equipment at BedZED adds £102,029 capital costs but also saves 76 tonnes of CO<sub>2</sub> per year. This annual carbon saving will be delivered for the design life of the CHP and the PV panels (20 years). As renewable energy solutions develop and achieve economies of scale, they will be cheaper and will reduce in risk. Developers should take advantage of the many grant funding opportunities available in this area when choosing the best solution. ZEDproduct R in the "From A to ZED" offers a number of options for this, including solar hot water systems and wood pellet boilers as well as the wood-fired CHP and photovoltaics used on BedZED. In the future, it is hoped that as energy prices rise and volume production of these technologies bring capital costs down, these will be self-financing, paying back their capital cost investment with revenue from energy sales.