The Merton Rule

A review of the practical, environmental and economic effects

NHBC Foundation

Housing research & development in partnership with BRE Trust

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FOREWORD

Since its introduction in 2003, the Merton Rule has been a focus of controversy. While some call it 'ground-breaking', and view it as having a positive impact on the renewables industry, others believe that it encourages a 'bolt-on' approach to energy efficiency and can be a financial burden on developers. To add a further complication there is evidence that it has been interpreted in a myriad of ways. So, how best to measure the impact of the Merton Rule?

In an attempt to consider the evidence, and understand what prompts the differing standpoints, this review looks at various scenarios and case studies and comes to conclusions regarding the effect the Merton Rule has had to date and its impact on the housebuilding industry, renewables and energy efficiency.

The NHBC Foundation aims to commission and promote research which will be of value to the housebuilding industry with a particular focus on terms of sustainability. This review highlights the varying effects of the Merton Rule and demonstrates the potential ramifications in terms of the economic and environmental impact.

It concludes that the Merton Rule was ground-breaking in its approach but, as with similar introductions, the benefits of innovation were accompanied by mistakes arising from inexperience. As with other innovative policies, lessons can be learned and these are highlighted in this review.

Hopefully this review will help inform the on-going debate not just on the future of but above all on delivering the 2016 zero carbon targets and planning for a sustainable future.

I hope you find this review relevant, informative and stimulating.

Rt. Hon. Nick Raynsford MP

Chairman, NHBC Foundation

PREFACE

The Merton Rule is the name given to a policy first implemented by Merton Borough Council, in south London, requiring specific new-build developments to provide 10% of their energy use from renewable sources. Since its introduction in 2003, it has engendered strong debate amongst those who have crossed its path. It has its advocates, who extol its virtues in terms of the positive impact it has on the development of the renewables industry. It also has its detractors: those who believe that it encourages a 'bolt-on' approach to energy efficiency or that the financial burden it brings to bear on developers is too great – and, furthermore, that it is not applied on a level playing field. Indeed, many local authorities have interpreted and applied the Merton Rule in divergent ways, some requiring higher or lower percentages or recommending that energy efficiency be implemented as a first step to achieving CO_2 emissions reductions, and some insisting solely on a requirement of 10% of energy from renewables.

This review is an attempt to evaluate the claims of those with differing standpoints, to show which of the various scenarios produces the greatest long-term reduction in emissions, and to assess some practical measures which could be used to achieve these. It will provide an economic assessment of the applied options in order to quantify the financial impact on residential developers of complying with requirements of this nature. It will also assess the short- and long-term costs per tonne of CO_2 saved.

The review additionally takes a look back at the effects the Merton Rule has had to date, based on a survey of developers and anecdotal evidence from industry. Has it kick-started the renewables industry? Have developers applied it in isolation, without attention to reducing energy demand in the first place – or is the opposite the case? An attempt will be made to interpret what effect it has had, as a Code for Sustainable Homes rating has become mandatory in England* and the construction industry stands at a pivotal point in the quest towards the 'Holy Grail' of providing 100% zero-carbon homes by 2016. Will the Merton Rule have helped or hindered in the drive towards meeting this objective?

* Although a nil-rated certificate can be downloaded and an assessment is not currently required.

CONTENTS

ABOUT THE NHBC FOUNDATION

The NHBC Foundation was established in 2006 by NHBC in partnership with the BRE Trust. Its purpose is to deliver high-quality research and practical guidance to help the industry meet its considerable challenges.

Since its inception, the NHBC Foundation's work has focused primarily on the sustainability agenda and the challenges of the government's 2016 zero carbon homes target. Research has included a review of microgeneration and renewable energy techniques and the groundbreaking research on zero carbon and what it means to homeowners and housebuilders.

The NHBC Foundation is also involved in a programme of positive engagement with government, development agencies, academics and other key stakeholders, focusing on current and pressing issues relevant to the industry.

Further details on the latest output from the NHBC Foundation can be found at www.nhbcfoundation.org.

EXECUTIVE SUMMARY

In compiling this review, an evaluation was required of the respective costs of achieving a 10% reduction in energy use by means of improvements to the building envelope and services, or by solely adding renewable energy installations – and of which approach achieved the greater reduction in CO_2 emissions.

An industry survey was carried out, which showed that implementation of Merton Rule-type policies does seem to have brought about a greater use of renewable energy in new-build housing. However, there does not seem to have been a corresponding improvement in implementation of energy-efficiency measures to the building envelope. The survey informed the selection and development of three scenarios, which were then tested by being modelled on a hypothetical development:

1. Approximately 10% reduction in energy use using building-fabric and services improvements
2. Approximately 10% reduction in energy use using renewable energy
3. The combined effect of the first two scenarios.

The modelling clearly showed that the most cost effective way of reducing energy use by about 10% was by improving the fabric of the building envelope and the efficiencies of its services. Although the greatest lifetime reduction in CO_2 emissions was achieved from renewables, this was 4.2 times higher in cost per tonne of CO_2 saved for only an additional 1.1% reduction.

Combining fabric and services improvements with renewables to achieve a reduction of about 20% in energy use was cheaper per tonne of CO_2 emissions reduced than achieving a 10% reduction by using renewables alone.

This review therefore concludes that built-fabric envelope and services improvements are the most cost-effective first-line approach – with additional renewable energy installation after this measure bringing about the greatest CO_2 savings and most cost-effective holistic solution for achieving the energy targets of the higher levels of the Code for Sustainable Homes.

It should be noted that energy prices have risen since the modelling was carried out for this review, which may have an impact on payback periods for renewable energy installations.

The main findings are reproduced in Table 1.

TABLE 1

Main findings – costs and CO_2 savings

Scenario	Initial 20-year CO_2 saving (tonnes)	60-year CO_2 saving (tonnes)	Immediate cost (£)	60-year cost (£)	Cost per tonne of CO_2 saved (£)
Built-fabric improvements only	163 (10.9%)	488 (10.9%)	47 787	60 546	124
Renewables only	180 (12%)	540 (12%)	101 198	283 593	525
Built-fabric improvements and renewables combined	343 (22.9%)	1028 (22.9%)	148 984	344 138	335

Recommendations

The review recommends that the emphasis in policies designed to reduce CO_2 emissions be placed firmly on improving the thermal performance of the building fabric first for future-proofing and for cost-effectiveness. Additional renewables requirements for meeting higher standards will then bring about maximum emissions reductions with lower long-term costs for the construction industry.[1]

1 Background

1.1 History, background and objectives

The Merton Rule takes its name from a requirement introduced by Merton Borough Council. The policy text, introduced in October 2003, states:

> *The council will encourage the energy efficient design of buildings and their layout and orientation on site. All new non residential developments above a threshold of 1,000sqm will be expected to incorporate renewable energy production equipment to provide at least 10% of predicted energy requirements.*
>
> *The use of sustainable building materials and the re-use of materials will also be encouraged, as will the use of recycled aggregates in the construction of buildings. This will be subject to the impact on the amenity of the local environment, taking into account the existing character of the area.*

The policy was included in Merton's Unitary Development Plan, thus giving it high status and a certain amount of legislative weight. The 10% figure for renewables tends to stick in people's minds, however, while other parts of the policy are often forgotten.

The original requirement stemmed from global environmental awareness gained through Local Agenda 21 work. Local Agenda 21 emerged from the Agenda 21 programme agreed at the United Nations Earth Summit in Rio de Janeiro in 1992. Endorsed by the government every local authority had to produce a Local Agenda 21 strategy by the end of 2000. The Merton Rule was intended to reduce energy bills for start-up businesses, reduce fossil-fuel use and kick-start the renewables industry. Although the wording of the original policy statement expresses the reduction in terms of energy requirements, the guidelines for calculation purposes have always relied on a conversion of energy requirement to CO_2 emissions as in the current Merton Rule guidance. Adrian Hewitt, principal environmental officer at Merton Borough Council at the time of the introduction of the Merton Rule, confirmed that the reason for this was to discourage the use of electricity as a heating fuel – an approach which could have been exploited as a loophole for compliance. The calculation methodology for conversion of the energy requirement to CO_2 emissions arises from the fact that the Merton Rule was originally intended for non-residential developments. A calculation for residential purposes would be unnecessary, since the CO_2 emissions are already given in the Standard Assessment Procedure (SAP) calculation for dwellings. The figures used to establish the percentage requirement were based on the ECON (Energy conservation) benchmarking tool guides produced by the government's Energy Efficiency Best Practice Programme (now managed by the Carbon Trust).

Merton Borough Council has in practice focused less on the implementation of an exact percentage than on evidence of suitable technologies appropriate for the development in question. They do not, for example, grant planning permission without the submission of a detailed energy report. The 10% requirement is calculated for the whole site and not per individual building. Their policy is closely aligned with the original *Integrating renewable energy into new developments: Toolkit for planners, developers and consultants* (the London Renewables Toolkit),[2] and thus emphasises energy efficiency alongside renewables installations. They recognise, however, that the lack of sufficient funding for local authorities and their building-control departments does not aid the monitoring of energy-efficiency measures. Two important potential advances are identified that, if put in place, would aid smoother implementation of the Merton Rule, both in terms of energy efficiency and effective renewables strategies. These are: the insistence on accreditation of building products; and the extensive, sophisticated, post-occupancy monitoring of renewables installations.

Merton Borough Council is developing a web-based tool, based on Geographic Information Systems (GIS) maps, in which real-time energy use of buildings with renewables installations can be viewed. Still in its early stages, this is expected to be a monitoring tool that will give invaluable insights into the nature and effectiveness of different types of renewables. This will feed into the Department for Communities and Local Government requirement for local authorities to produce an annual monitoring report to the Secretary of State, as prescribed in The Planning and Compulsory Purchase Act 2004 Section 35.[3] This report must include information on the extent to which the policies set out in the local development documents are being achieved.

1.2 Other similar initiatives and literature review

The Merton Rule was the first local-authority initiative to specify a percentage requirement for renewable-energy provision. Since its introduction, however, it has been adopted – with variations – by other local authorities, and there have been other initiatives attempting to reduce dependence on fossil fuels.

The Nottingham declaration[4] has seen more than 200 councils sign up to action against climate change since its introduction in 2000. This is more of a statement of intent than an explicit ruling, and there are no specific guidelines for reduction-target figures given.

At the other end of the spectrum is the Greater London Authority (GLA), whose extensive work, building on the Merton Rule, in the London Plan[5] has now seen the introduction of a higher target for 20% renewables following the success of the London Renewables Toolkit.[2] The Toolkit stresses that energy efficiency should be treated with importance as well as renewable energy.

A study by London South Bank University[6] of the impact of the energy policies in the London Plan showed a reduction in CO_2 emissions in new developments of approximately 26%. This reduction has increased over the life of the policy, with two significant factors having a marked effect. The first was the introduction of the London Renewables Toolkit[2] and the second was the employment and training of more GLA staff to deal with implementation of the policy. Savings reported were in the order of 21% resulting from energy efficiency measures, with a further 5.8% being attributable to renewables.

English Partnerships' document *Review of planning and climate change*[7] gives a useful overview of those councils adopting Merton-type policies. It illustrates how some local authorities have implemented their own version of the Merton Rule stating CO_2 emissions reductions as a target. The study, which was carried out by Arup, also makes recommendations regarding implementation of renewables requirements. It suggests that implementing national targets would provide clarity and certainty for developers and their supply chains, expand the market for low- and zero-carbon technologies in order to encourage investment in the sector, and allow planning decisions to take targets into account if they were included in a Planning Policy Statement (PPS). Merton Borough Council also keeps an ad hoc list of other councils using comparable policies, which can be found on the website http://themertonrule.org.

Despite media speculation that the Merton Rule may have been abandoned, Yvette Cooper, the then Minister for Housing, spoke out in favour of the Merton Rule in 2006, further endorsing its use by local authorities. The Department of Business Enterprise and Regulatory Reform (BERR)[8] reported that the UK was not on target to meet its CO_2 emissions-reductions target of 60% by 2050, and that more will have to be done to get the country back on course. This may have been a significant factor in the Minister's autumn 2007 reiteration of the message that she would keep the Merton Rule and wanted to develop it further with the intention of delivering further carbon savings.

The government has now raised this target to 80% following recommendation from its climate change committee.

Adrian Hewitt, formerly of Merton Borough Council has expressed the view that if the policy were extended nationwide, then a renewables industry worth over £1 billion would be created, ensuring a secure environment for research and development and producing economies of scale.

The Stern Review (2006),[9] a report on the economics of climate change led by the government's chief economic adviser, also predicts that spending 1% of the UK's GDP to reduce CO_2 emissions now will avoid the necessity of spending between 5% and 20% of GDP every year in the future.

The Renewables Advisory Board (2008),[10] in their working groups looking at how to achieve the UK target of 15% of energy use from renewables by 2020, have emphasised that, "business as usual or a small extension of it would fall well short of the target". They also emphasise the importance of a 'stable and growing market' – in this case to maximise national wealth creation from renewables.

Another Renewables Advisory Board report, *The role of onsite energy generation in delivering zero carbon homes*,[11] states its central recommendation as being, "that Government finds new ways of bringing forward demand for renewables before 2016".

1.3 Review of guidance available to home builders

There have been attempts to help home builders meet the renewables requirements demanded of them. Indeed, some local authorities provide a level of guidance through the planning process, as is clearly demonstrated in the London Plan. Contained within some authorities' guidance documents are recommendations that energy-efficiency measures should be considered as a first step or in addition to the installation of renewable technologies. The nature of such guidance is varied, and energy-efficiency measures are often either undefined or referred to in simplistic terms.

1.3.1 Planning guidance

Planning Policy Statement 22 (PPS 22),[12] which sets out the regulations for implementation of renewable-energy provision, makes the following statement:

> *Local planning authorities may include policies … that require a percentage of the energy to be used in new residential, commercial or industrial developments to come from on-site renewable energy developments.*

Further on in the same document, PPS 22 advises that local authorities should specifically encourage such schemes.

The Department for Communities and Local Government (CLG) document Planning Policy Statement *Planning and climate change*[13] takes a slightly stronger stance, influenced by and moving more in line with the Merton Rule, and states that CLG: "expect a proportion of the energy supply of new development to be secured from decentralised and renewable or low-carbon energy sources." The exact proportion, however, is still not specified.

The impact assessment of PPS 22[14] shows the considered positive impacts to developers of the PPS on planning and climate change to be:

- increased scope for sustainable development and renewable, low-carbon and decentralised energy projects
- an increase in the value of developments
- greater clarity regarding expectations for addressing climate change.

Negative perceived impacts are reported as being:

- slightly increased reporting requirements as part of the planning process
- increased cost of implementing renewable and low-carbon energy technologies.

It also includes, amongst wider stakeholder interests, lower costs for adaptation to climate change in the future.

1.3.2 Other guidance

There are several publications from industry advisory organisations giving guidance on the use of renewable energy. The *NHBC guide to renewable energy*[15] gives clear advice covering on-site options. This guide is only designed to look at technologies, however, not at reducing the initial demand load through fabric improvements. A further NHBC Foundation guide *A review of microgeneration and renewable energy technologies*[16] advises on choosing suitable technologies for specific situations.

The Energy Saving Trust guide CE190[17] entitled *Meeting the 10 per cent target for renewable energy in housing – a guide for developers and planners*, produced under the Energy Efficiency Best Practice in Housing (EEBPH) Programme, illustrates how to address Merton-Rule type requirements. This guide provides a section of advice on utilising solar gain and increasing the thermal efficiency of dwellings, but it was beyond the scope of this review to provide fabric specifications for reduced heat loss.

The most comprehensive guide, including fabric energy efficiency, seems to be The London Renewables Toolkit[2] mentioned above. In this guide the Mayor's energy hierarchy is clearly stated, with the first measure being energy efficiency. The different considerations for energy efficiency are presented, including standards where relevant.

2 Case study preparation

2.1 Study of home builders

A study was undertaken to determine to what extent home builders have implemented energy-efficiency measures in order to reduce the level of renewables required.

This was achieved through a survey of home builders to establish some guidelines for the development of a hypothetical site, which could be used for modelling the effects of built-fabric energy efficiency compared to renewables. Ten home building organisations of differing sizes provided information for the study.

The study was also used to cross-check the findings of the modelling carried out. Areas covered by the study included:

- an assessment of the size of the organisation surveyed
- local authority requirements in force in the location of the development
- an assessment of the extent to which built-fabric energy-efficiency measures had been applied over and above the company's normal practice to sites which were required to meet renewables requirements
- the percentage of energy demand met by renewables on the site
- typical U-values achieved by the dwellings for: walls, roofs, windows and floors
- the type of heating system used, and its percentage efficiency/SEDBUK rating
- the estimated extra cost per dwelling unit for fabric improvements and for renewables
- the percentage build-cost increase per dwelling due to energy efficiency measures/renewables that was felt to be acceptable by the home builder.

2.1.1 Limitations of the study

This study was used as a basis for developing scenarios for further modelling and as a cross-check with real-life situations for the findings of that modelling exercise. Full information for every site was not available but enough good quality data was gathered to form a good picture of a range of issues.

The level of detail contained in the responses did not provide sufficient information for an analysis of different construction methods used to meet certain U-values, nor which renewable technologies were implemented in every case – although some assumptions/exclusions for the latter could be made based on costs given.

2.1.2 Implementation of built-fabric efficiency measures and typical extra costs

Amongst the responses received, those developers who had implemented built-fabric efficiency before renewable energy installations were in the minority. A need for education on the distinction between fabric energy efficiency and renewable installations such as solar hot water panels was observed. Boiler efficiency increases were also quoted as fabric improvements in several responses, and they have been accepted as such in our modelling scenarios.

For the purposes of the CO_2 emissions modelling, it has been decided to include increasing boiler efficiency in built-fabric measures in this review for two reasons. Firstly, it was the most common improvement displayed by home builders before the implementation of renewable technologies; and secondly, it was felt that, over time, less efficient boilers would not be available, meaning that there was little danger of a lower efficiency replacement boiler being fitted at a later stage.

Built-fabric U-values were mostly seen to follow typical values that would aid overall compliance with Building Regulations Approved Document L1A,[18] with the averages being as follows:

- Walls 0.30 W/m^2 K
- Roof 0.16 W/m^2 K
- Floors 0.18–0.22 W/m^2 K
- Windows 1.80 W/m^2 K.

The range of U-values displayed in the responses received was fairly narrow, except where a 20% renewables requirement was specified. In this case, significant improvements to the fabric were observed and the extra cost required to reduce U-values was estimated to be comparable to the cost of installing solar hot water panels in other examples, in which only a 10% requirement was asked for and no fabric improvement was made.

The highest extra costs for meeting the 10% requirement were seen to correlate closely with the worst quoted U-values for the fabric envelope of the building. These were (averaged):

- Walls 0.35 W/m^2 K
- Roof 0.25 W/m^2 K
- Floors 0.25 W/m^2 K
- Windows 2.2 W/m^2 K.

Unfortunately boiler efficiencies could not be established in every case, so it was not possible to ascertain whether poor efficiency of the heating system may also have been a factor. From the evidence obtained it seems that larger organisations are able to achieve compliance at a lower cost than smaller builders.

Looking at those sites subject only to a 10% renewables requirement, the following cost ranges per dwelling unit were observed:

- Range of costs for fabric (including boiler) improvement £1000–£3000
- Range of costs for renewables without fabric improvements £3000–£15 000
- Range of costs for renewables additional to fabric improvements £0–£3000.

2.1.3 Acceptable cost increase

Although there were some developers, in particular amongst affordable housing providers, who felt that any increase in delivery cost affects the viability of the site, the most common range of acceptable cost increase per home or dwelling unit was quoted as being between 3 and 5%.

2.1.4 Impact on suppliers

Although it is beyond the scope of this study to analyse in any depth the economic effect of the Merton Rule on either the renewables industry or on insulation suppliers, some leading industry figures from each have kindly given their thoughts on the matter.

David Matthews, chief executive of the Solar Trade Association & Ground Source Heat Pump Association, expressed the view that above level 3 of the Code for Sustainable Homes renewables will be necessary, and that the renewables industry will not be able to simply 'switch on' in order to meet this demand. It will be necessary for the industry to grow year on year to be able to match the demand when it arises. Matthews believes the availability of installers will be the key. He also gave anecdotal evidence that the Merton Rule has certainly had the desired effect of kick-starting the renewables industry. He tells of the whole ethos changing, following its initial introduction, and of the almost tangible atmosphere of expectation. This initial excitement seems to have translated into increased sales figures – although further research would be necessary to establish and quantify the precise causes, since sales were already beginning to increase before the introduction of the Merton Rule. The UK home sales of solar collectors are shown in Table 2.

TABLE 2

Sales of solar-thermal collectors (extracted from European Solar Thermal Industry Federation[ESTIF] market data, as supplied by the Solar Trade Association [STA])[19]

Year	Glazed collector sales by m^2	Annual increase (%)	Increase over 2003 (%)
2003	22 000	–	–
2004	25 000	13.6	13.6
2005	28 000	12	27.3
2006	54 000	92.9	145.5

Another factor, just as important as overall sales, is the growth in employment in the solar industry. The 2003 market data report, based on previous figures, showed 491 employees in full-time jobs in the sector. An astoundingly small figure of nine full-time installers is quoted. Clearly, as the use of renewables is unavoidable in order to meet the higher levels of the Code for Sustainable Homes, the presence of adequate numbers of trained staff will be an important factor in the UK's ability to meet the 2016 zero-carbon target.

The National Insulation Association's Head of Policy and Communications, John Mason, commented that the Merton Rule has not been demonstrated to have had a detrimental effect on insulation sales. He felt that since the Building Regulations have to be met, and that they are incrementally raised on a regular basis, there will always be a demand for insulation products to meet the standards required. There were some concerns that the Merton Rule could be instrumental in focusing developers' attention on renewables at the expense of energy efficiency, although this was seen to be more of a problem with the way in which the Merton Rule is applied at local authority level. Mason felt that any future extensions of the Merton Rule should be integrated firmly with fabric-efficiency standards to avoid this situation. The holistic approach that the Code for Sustainable Homes takes in encouraging both energy efficiency and renewables is viewed favourably, but there is a concern that the background presence of a Merton-Rule type requirement could send contradictory messages to some local authorities. Overall, the view was that an over-emphasis on either one of these two approaches could prevent the most cost-effective solution being achieved.

2.2 Development of a hypothetical site

The site used to illustrate the various modelling scenarios was taken from a design guide, and is reproduced with kind permission from English Partnerships (Figure 1). Certain generic house 'types' were then assigned to the site to give a representative mix of a typical layout of 51 dwellings, which included detached, semi-detached and terraced houses as well as flats.

Figure 1 The hypothetical site used for modelling *(courtesy of Ed Warwick, English Partnerships)*.

The site comprises:

- 24 two bedroom flats
- 4 four bedroom detached houses
- 10 three bedroom semi-detached houses
- 4 three bedroom end-terrace houses
- 6 three bedroom mid-terrace houses
- 2 two bedroom end-terrace houses
- 1 two bedroom mid-terrace house

For the baseline-case modelling, it was assumed that 15 of the dwelling units (29%) were affordable housing and had a minimum design requirement of Code for Sustainable Homes level 3. The rest of the house types were assumed to be Building Regulations Approved Document L1A compliant.[18]

2.3 Formulation of scenarios for assessment on the hypothetical site

For the purposes of this review, and following comments from home builders, we have used the following definitions for discussion and modelling purposes.

2.3.1 Fabric energy efficiency measures

Improvements over and above any elements described in Building Regulations Approved Document L1A (2006 edition)[18] for prevention of heat loss in buildings, including:

- insulation
- glazing
- air-tightness
- thermal bridging
- conventional boiler systems.

2.3.2 Renewable energy

The installation of any form of energy provision which is either infinitely renewable, releases only as much carbon in its combustion as it absorbs in its growth, or extracts useful heat from the ground and boosts it by means of another fuel to give an overall reduction in CO_2 emissions of at least 10%.[20] These include:

- solar hot water panels or evacuated tubes
- photovoltaic (PV) panels
- wind turbines
- biomass heating
- biomass combined heat and power (CHP)
- ground-source heat pumps (credits awarded under Ene 7 Code for Sustainable Homes for low- or zero-carbon technologies).

2.3.3 Limitations to renewable scenarios

In the case of renewable energy provision private-wired to a development, the commercial variants were considered too numerous to be feasible within the scope of this study. An analysis of grid-based renewable energy options was excluded, as they are not, at the time of writing, given credit in the Code for Sustainable Homes and raise wider issues regarding the source of the renewable energy. The Code for Sustainable Homes is undergoing continual review to make it more robust and workable, and a consultation on the definition of zero carbon and the implications for sources of provision of renewable energy is imminent. Larger scale renewables may have a significant impact on reducing the costs involved in compliance with Merton Rule-type requirements.

3 Case study results

3.1 Impact of energy efficiency and renewables on the CO_2 emissions from the site

SAP modelling was undertaken for the following three scenarios, which involved reducing the primary energy use of a development by:

- 10% through fabric improvements
- 10% through renewable energy generation
- 20% through a combination of fabric and renewable strategies.

Before these scenarios could be tested, however, it was first necessary to model the baseline case of the development that achieves compliance with Approved Document L1A (2006 edition)[18] of the Building Regulations (as amended) 2000.

It should be noted that all the modelling undertaken to assess the CO_2 emissions from the site uses illustrative scenarios. These are not the only way of achieving the requirements. Additionally, it is not the intention of this review to imply that these solutions are backed up by a design feasibility study. Home builders wishing to follow examples from this review should undertake their own design and assessment process.

3.1.1 Approved Document L1A baseline case

For Building Regulation compliance, all dwellings on a development have to achieve a dwelling CO_2 emission rate (DER) that is not more than its own target CO_2 emission rate (TER) based on a standard dwelling with the same dimensions and heating system. To meet this requirement for the entire development, it is necessary to first determine which dwelling has the highest DER that still complies with Approved Document L1A, ie its DER is closest to its TER but still below its TER. Since the construction will then be the same for all dwellings this inevitably means that all dwellings will have a DER that will be less than their TER, and in some cases this could be considerably less.

In this baseline case, plot 17 which is a 4-bed detached unit whose entrance faces south (and hence has an excess of glazing facing north), has a DER which is 0.1% below its TER when using the following typical built-fabric U-values and design features – and hence its design dictates the design of the remainder of the development.

Built-fabric U-values

Walls	0.30 W/m^2 K
Roof	0.16 W/m^2 K
Floors*	0.18–0.22 W/m^2 K
Windows	1.80 W/m^2 K (double glazed, argon filled, soft low-E glazing, 16 mm air gap)
Doors	3 W/m^2 K (solid timber door).

Other features

Boiler efficiency 89%, minimum controls for compliance

Air-tightness 7 m^3/hm^2 @ 50 Pa

Natural ventilation with intermittent extract fans

Accredited construction details (heat-loss factor, y = 0.08)

50 mm insulated hot water storage tank.

The majority of the other dwellings show a reduction in their DER of 1–4%, while the flats (because they do not all have all three thermal elements), achieve a reduction of about 10% (for ground-floor locations), about 8% (mid floor) and about 7% (top floor). A typical construction that can achieve these fabric U-values is outlined below.

Typical Approved Document L1A 2006 constructions

Walls	105 mm brickwork
	100 mm full-fill mineral wool, thermal conductivity: λ = 0.038 W/m K
	100 mm lightweight blockwork, λ = 0.19 W/m K
	15 mm dab airspace
	12.5 mm plasterboard
Roof	12.5 mm plasterboard
	100 mm mineral wool, λ = 0.040 W/m K, between trusses, with
	150 mm mineral wool, λ = 0.040 W/m K, laid over trusses (at ceiling level)
Floor	65 mm concrete screed
	100 mm expanded polystyrene, λ = 0.037 W/m K
	100 mm concrete slab
	50 mm expanded polystyrene, λ = 0.037 W/m K, upstand to perimeter.

In addition to a development achieving Building Regulation compliance, there is also a requirement to achieve a certain percentage of affordable housing on a development, dependent on local authority requirements. It was decided to choose six 3-bed semi-detached/terraced houses and three of the blocks of flats, ie 15 units in total (29% of the development). These affordable units would typically be required to achieve Code for Sustainable Homes level 3 for energy, which requires a reduction in the DER over the TER of at least 25%. Energy averaging could be used, which means that not every unit needed to achieve 25%, but the floor-area-weighted average of a block of flats should achieve 25%.

*Although the same ground-floor construction will be used in all dwellings, the actual U-value this achieves differs from one dwelling type to another, because they have different perimeter/area ratios.

Therefore, for these 15 units the following improved built-fabric design and features are used.

Built-fabric U-values

Walls	0.23 W/m^2 K
Roof	0.13 W/m^2 K
Floors	0.15–0.17 W/m^2 K
Windows	1.40 W/m^2 K (triple glazed, argon filled, soft low-E glazing, 16 mm air gap)
Doors	2.45 W/m^2 K (half double glazed, air filled, soft low-E glazing, 16 mm air gap).

Other features

Boiler efficiency 89%, minimum controls for compliance

Air-tightness 3 m^3/hm^2 @ 50 Pa

Mechanical ventilation with heat recovery – efficiency 93%, specific fan power 0.58 W/l/s

Energy Saving Trust enhanced construction details (y = 0.04)[21]

80 mm insulated hot water storage tank.

The following Energy Saving Trust enhanced constructions, as outlined below, are used to achieve these lower fabric U-values. Again, although the same ground-floor construction will be used in all dwellings, the actual U-value achieved from one dwelling type to another varies.

Energy Saving Trust enhanced constructions

Walls	105 mm brickwork
	100 mm full-fill mineral wool, λ = 0.038 W/m K
	100 mm lightweight blockwork, λ = 0.19 W/m K
	10 mm parge coat
	15 mm dab airspace
	12.5 mm plasterboard laminated with 30mm PU, λ = 0.023 W/m K.
Roof	12.5 mm plasterboard
	50 mm airspace/service void
	30 mm PU, λ = 0.023 W/m K, below trusses
	100 mm mineral wool, λ = 0.040 W/m K, between trusses, with
	150 mm mineral wool, λ = 0.040 W/m K, laid over trusses (at ceiling level).
Floor	65 mm concrete screed
	90 mm PU, λ = 0.023 W/m K
	100 mm concrete slab
	70 mm PU, λ = 0.023 W/m K, upstand to perimeter.

This combination of specifications for the Approved Document L1A-compliant dwellings, and the affordable housing, leads to an estimate for the primary energy demand from SAP 2005 for the development as a whole of some 454 280 kWh/year. Thus, imposing the Merton Rule would require this to be reduced by at least 10%, ie by 45 428 kWh/year, to a maximum of 408 852 kWh/year.

3.1.2 Scenario 1: Proposed built-fabric changes

As a first step for the proposed built-fabric improvements, it was decided to apply a maximum heat loss parameter (HLP) of 1.3 for all dwellings. The HLP is a measure of the total fabric and ventilation heat losses, expressed in terms of the dwelling's floor area. As such, it is house-type specific and is not affected by any internal or external heat gains.

The value of 1.3 was selected as this achieves a credit point, under Ene 2, in the Code for Sustainable Homes. The starting point for achieving this was to use the same constructions, and hence the same U-values, as those used for the affordable housing element of the Approved Document L1A baseline case. This would mean that all dwellings now share the same construction across the entire development. However, the dwellings which do not need to achieve the 'affordable' status would still be fitted with double glazing but they would not have mechanical ventilation with heat recovery installed, as special effort would not be made to improve their air-tightness (although the thermal principles for the Energy Saving Trust enhanced constructions would still be used).

Some additional minor changes included the use of 'load/weather compensators' and 'delayed start' controls on the boiler system in order to increase its efficiency, together with the use of 80 mm insulated water storage tanks throughout.

These services upgrades are considered to be 'fabric' improvements as they do not involve any renewable-energy generation.

A summary of these improvements is included below.

Fabric U-values

Walls	0.23 W/m^2 K
Roof	0.13 W/m^2 K
Floors	0.15–0.17 W/m^2 K
Windows	1.80 W/m^2 K (double glazed, argon filled, soft low-E glazing, 16 mm air gap), or:
Windows	1.40 W/m^2 K (triple glazed, argon filled, soft low-E glazing, 16 mm air gap) – affordable housing only
Doors	2.45 W/m^2 K (half double glazed, air filled, soft low-E glazing, 16 mm air gap).

Other features

Boiler efficiency 89%, full controls

Air tightness 7/3 m^3/hm^2 @ 50 Pa

Extract fans/mechanical ventilation with heat recovery

Energy Saving Trust enhanced constructions details (y = 0.04)

80 mm insulated hot water storage tank.

Built-fabric improved constructions

Walls	105 mm brickwork
	100 mm full-fill mineral wool, λ = 0.038 W/m K
	100 mm lightweight blockwork, λ = 0.19 W/m K
	10 mm parge coat (affordable houses only)
	15 mm dab airspace
	12.5 mm plasterboard laminated with 30mm PU, λ = 0.023 W/m K.

Roof	12.5 mm plasterboard
	50 mm airspace/service void
	30 mm PU, λ = 0.023 W/m K, below trusses
	100 mm mineral wool, λ = 0.040 W/m K, between trusses, with
	15 mm mineral wool, λ = 0.040 W/m K, laid over trusses (at ceiling level).
Floor	65 mm concrete screed
	90 mm PU, λ = 0.023 W/m K
	100 mm concrete slab
	70 mm PU, λ = 0.023 W/m K, upstand to perimeter.

The effect of this 'fabric' improvement strategy is to reduce the energy demand for the development by 48 346 kWh/yr representing a reduction of 10.6% over the Approved Document L1A plus 29% of properties to Code for Sustainable Homes level 3 baseline scenario. The reduction in actual CO_2 emissions from this strategy would be 10.9% compared to the emissions of the Approved Document L1A plus 29% baseline.

In reality, achieving precisely the 10% saving is often more trouble than a 'near as makes no difference' approach. Standardising construction methods often makes more sense than trying to artificially pare down the odd percentage point.

3.1.3 Scenario 2: Proposed renewables strategy

In a renewables strategy, it is not necessary to improve every dwelling on a development; indeed, some dwellings may not be suitable for some types of renewables – such as solar thermal or solar PV if the orientation of the dwelling is, for instance, east-west.

For a successful renewables strategy, it makes sense to target those dwellings with the largest energy use first, ie the houses rather than the flats. To this end, it was decided that each of the 4-bed detached dwellings would be provided with a ground-source heat pump (GSHP)[22] (SAP 2005 default efficiency of 320%), and each of the 3 and 2-bed semi/terraced houses (as long as they had a roof slope that was orientated within a south-west to south-east swath) would be provided with 2 m^2 of solar thermal panels (evacuated tube – SAP 2005 default).

In addition to the above renewables, it was decided to provide each of the nine affordable flats with a 1 kWp array of solar PV. Finally, the four detached dwellings were provided with a 0.6 kWp array of solar PV, as this was calculated to be sufficient to achieve the same 10.6% reduction of primary energy demand for the development that was achieved by the built-fabric improvements strategy. The savings in actual CO_2 emissions from this total strategy would be 13% over the emissions of the baseline case.

At first glance it appeared that a renewables strategy would produce a significantly larger reduction in actual CO_2 emissions compared to built-fabric improvements alone. However, this estimate for the reduction in actual CO_2 emissions assumes that the renewable technologies will operate at 100% optimal levels throughout their life expectancy. Furthermore, it takes no account of the replacement and maintenance of systems. On the other hand, fabric improvements should remain at their optimal level for the entire lifetime of the dwelling.

When compiling the projection of CO_2 emissions reductions over a building life expectancy of 60 years, it would have been ideal to adjust the savings by subtracting the embodied carbon arising from the energy involved in the production of each renewable installation, including replacement installations, ie every 25 years for solar installations and every 15 years for GSHPs.[23] Owing to the absence of data for solar thermal and GSHP, this was only possible in the case of the PV installations. A life-cycle-analysis study by Bankier and Gale[24] estimates the energy payback (ie how long it takes for the embodied energy in production to be repaid by energy savings in use in terms of CO_2 emissions) of the average domestic roof-mounted PV array to be four years. To take account of this the carbon savings arising from PV panels were reduced by 16% (the four years taken to payback the embodied carbon divided by the expected lifetime of a PV array of 25 years).

Unfortunately, no reliable life-cycle analysis data could be found that included CO_2 from embodied energy for solar thermal or GSHP installations. It can therefore only be assumed that inclusion of these, after normalising for replacement of the gas boiler under the built-fabric only scenario, would further close the gap between CO_2 savings from fabric measures and those from renewables.

3.1.4 Scenario 3: Proposed combined fabric and renewables strategy

The final scenario modelled was the combined effect of applying first scenario 1 and then scenario 2, as outlined above, to the development. The overall effect of combining the built-fabric improvement with the renewables strategy is to achieve a 20.1% reduction in primary energy demand, which in turn achieves a 22.9% reduction in actual CO_2 emissions. It may seem odd that the combined effect of both scenarios does not achieve a 21.2% (10.6% plus 10.6%) reduction in primary energy demand, and a 23.9% (10.9% plus 13.0%) reduction in actual CO_2 emissions. This is due to the varying types of renewable-energy generation strategies (GSHP and solar thermal) being used to heat water for use in the space heating system. However, as the built-fabric improvements mean that there is a reduction in the energy demand from the heating system, these renewable sources provide a proportionally higher part of the revised heat demand. The modelling undertaken for this study was not extended to account for this. In real terms, however, this may mean that in some cases the installations modelled in scenario 3 were actually oversized for their respective applications.

3.2 Conclusions to CO_2 emissions modelling

Both the built-fabric only and renewables-only scenarios achieve a 10.6% reduction in primary energy demand. The renewables strategy produced the larger reduction in CO_2 emissions: 13% below the baseline case before allowing for embodied carbon of equipment. The built-fabric-only scenario achieved a reduction of 10.9% in CO_2 emissions.

The gap narrows over a lifetime prediction of 60 years, taking into account only the replacement of PV panels to give a 12% reduction in emissions against the fabric reduction of 10.9%. This gap might have been further narrowed if reliable data had been available to model the embodied energy of solar thermal and GSHP installations. A further reduction might have been seen if the effects of reduced efficiency from degradation of equipment could have been modelled, but again no reliable data was available.

The combined scenario of built-fabric improvements and renewables produced a 20.1% reduction in primary energy demand for the development, and this would achieve an initial 22.9% reduction in CO_2 emissions (ie one year's emissions reductions).

These results are set out in Table 3, which includes the total amount of CO_2 saved (in tonnes) by each scenario over 20-, 40- and 60-year time periods, without taking into account any embodied carbon or degradation of renewables installations.

TABLE 3

Lifetime CO_2 savings excluding embodied carbon

Scenario	Tonnes of CO_2 saved over		
	20 years	40 years	60 years
Built-fabric improvements only	162.7	325.4	488.2
Renewables only	193.6	387.1	580.7
Built-fabric improvements and renewables combined	356.3	712.6	1068.8

The CO_2 savings for the renewables-only and the combined built-fabric improvements and renewables scenarios are both based on the renewable-energy technologies maintaining optimal levels throughout these time periods.

The CO_2 savings taking into account the embodied carbon in PV panels assuming a 25-year average lifetime are shown in Table 4.

TABLE 4

Lifetime CO_2 savings including embodied carbon for PV panels only

Scenario	Tonnes of CO_2 saved over		
	20 years	40 years	60 years
Built-fabric improvements only	162.7	325.4	488.2
Renewables only	180.0	360.0	540.0
Built-fabric improvements and renewables combined	342.7	685.5	1028.3

The cost per tonne of CO_2 saved during the lifetime for each scenario is as follows.

3.2.1 Built-fabric improvements only

Total lifetime costs = £60 546

Total CO_2 saved = 488.2 tonnes

Cost per tonne of CO_2 saved = £60 546/488.2 = £124/tonne.

3.2.2 Renewables only

Total lifetime costs = £283 593

Total CO_2 saved = 540.0 tonnes

Cost per tonne of CO_2 saved = 283 593/540.0 = £525/tonne.

3.2.3 Combined built-fabric improvements and renewables

Total lifetime costs = £344 138

Total CO_2 saved = 1028.3 tonnes

Cost per tonne of CO_2 saved = £344 138/1028.3 = £335/tonne.

TABLE 5

Cost per tonne of CO_2 saved over a 60-year period

	Built-fabric improvements only	Renewables only	Built-fabric improvements and renewables combined
Total lifetime costs (£)	60 546	283 593	344 138
Total CO_2 saved (tonnes)	488.2	540.0	1028.2
Cost per tonne of CO_2 saved (£)[25]	124	525	335

Calculations are based on the lifetime costs without applying the discounts of 3.5% and 15% that were calculated in the economic assessment of the different scenarios. Developers, either affordable housing providers or private, can establish costs particular to their own situation by using either the low or the high discounted lifetime costs given in the economic impacts assessment.

3.3 Cost-benefit analysis for the energy-saving scenarios

This section describes the additional cost of achieving energy savings for the three energy-saving scenarios shown above:

- 10% built fabric: A strategy that would achieve approximately 10% reduction in primary energy consumption compared to the base case, through the improved levels of insulation and air-tightness and fitting improved heating controls.
- 10% renewables: A strategy that would achieve approximately 10% reduction in primary energy consumption across the site compared to the base case, through the installation of renewable-energy technologies.
- 10% renewables and 10% built fabric: A strategy where both the built-fabric and renewable packages are implemented across the site.

The building details for the base case for the site and the alternative building details for the first two scenarios have been described in more detail in the earlier sections of this review.

For the built-fabric package, the additional costs relate to upgrading the U-values of the walls, floors, ceiling, windows and doors, installing more effective boiler controls,[26] fitting thicker tank insulation and increased air-tightness levels. In addition to a more airtight construction method, mechanical ventilation with heat recovery (MVHR) will be needed as extractor fans alone will not be sufficient to achieve acceptable indoor air-quality standards.

In order to calculate the marginal cost of these improvements across the site, we researched the typical marginal cost of the improvement and the number of units required. For the fabric insulation measures, typical additional costs were taken from the Part L Regulatory Impact Assessment[27] which provides graphs of the marginal costs per m^2 versus U-value improvement. These graphs were used to determine the typical marginal cost for the U-value changes required here. These were then applied to the total area of built fabric to be upgraded across the site in order to calculate the total cost. The marginal cost of higher levels of tank insulation and of installing MVHR over extractor fans were determined from manufacturers' literature.[28, 29]

For the renewables package, the additional cost of installing the required amount of PV panels, solar hot water systems and the cost of installing GSHPs instead of a conventional boiler system in some homes was required. Cost information for PV panels and solar water-heating systems were taken from recent studies carried out by BRE,[30] and the additional costs of installing GSHPs over a conventional heating system were based on manufacturers' literature.[31]

The unit and total marginal costs for the building improvements required for the three scenarios are shown in Table 6.

TABLE 6

Initial costs associated with energy-saving scenarios

Marginal cost of measures	Cost per unit (£)	Unit	Number of units	Initial cost (£)*
Improved wall U-value	8	m^2	2707	21 652
Improved roof U-value	1.29	m^2	1253	1616
Improved floor U-value	8	m^2	1253	10 020
Improved window U-value	6	m^2	407	2439
Improved door U-value	10	door	72	720
Heating controls	60	house	36	2160
MVHR	250	house	36	9000
Tank insulation	5	house	36	180
			Total cost of built-fabric package	**47 787**
Photovoltaic panels	3088	kWp	11.4	35 198
Heat pump	7000	house	4	28 000
Solar-thermal	2000	house	19	38 000
			Total cost of renewables package	**101 198**
			Total cost of built-fabric and renewables package	**148 984**

*All costs subject to rounding.

The initial cost of implementing the fabric package is around 53% lower than for the renewables package, and therefore provides a cheaper way of achieving a 10% reduction in primary-energy consumption. However, if we look at the savings in terms of the amount of CO_2, rather than energy, saved, the difference narrows somewhat, with the initial fabric package costs being around 48% lower per tonne of CO_2 saved.

The analysis provided here is based on current costs, but it is worth noting that the cost of renewable technologies are expected to fall (relative to conventional measures) over time because of technical advances and increased market volumes. Therefore, the initial cost associated with the 10% renewables scenario may narrow the gap considerably at some point in the future. Similarly, there is uncertainty about the extent of fuel price rises in the future. As energy prices rise payback periods will also become shorter.

The simple payback associated with the costs have been calculated based on (latest available published figures) typical domestic electricity and gas prices of 11.2p and 2.94p/kWh delivered energy, respectively[32] which equate to 4.0p and 2.56p/kWh primary energy.[33] These are shown in Table 7.

TABLE 7

Simple payback associated with energy-saving scenarios

Payback	Initial cost (£)	Annual savings (£ pa)	Simple payback (years)
Built-fabric improvements only	47 787	1236	39
Renewables only	101 198	1534	66
Built-fabric improvements and renewables combined	148 984	2660	56

Therefore the payback times associated with all three scenarios are high, with the built fabric scenario falling within the expected lifetime of the development of 60 years, and the combined built fabric and renewables scenario falling just within this lifetime. So far, this review has only looked at the initial costs associated with the scenarios. To make meaningful comparisons it is necessary to evaluate the total costs over the expected lifetime of the development, which has been assumed to be 60 years.

To consider the marginal costs over the assumed project lifetime, as well as the initial costs associated with each scenario, additional costs incurred for replacement over the lifetime of the development were calculated. Also included were any additional costs associated with maintenance where these were higher than for the base case.[34] The total lifetime costs for the three energy-saving scenarios are shown in Table 8.

TABLE 8

Initial costs associated with energy-saving scenarios

Marginal cost of measures	Initial cost (£)	Measure lifetime	Cost over 60 years (£)
Improved wall U-value	21 652	60	21 652
Improved roof U-value	1616	60	1616
Improved floor U-value	10 020	60	10 020
Improved window U-value	2439	30	4878
Improved door U-value	720	60	720
Heating controls	2160	25	6480
MVHR*	9000	25	15 000
Tank insulation	180	60	180
Total cost of built-fabric package	**47 787**		**60 546**
Photovoltaic panels	35 198	25	105 593
Ground source heat pump**	28 000	15	64 000
Solar-thermal	38 000	25	114 000
Total cost of renewables package	**101 198**		**283 593**
Total cost of built-fabric and renewables package	**148 984**		**344 138**

* Future costs based on replacement of fan unit only

** Future costs based on replacement of heat pump only.

For fabric measures, with the exception of windows, which are assumed to last for 30 years, the lifetime costs will be the same as the initial costs as they are not expected to require additional replacement over the lifetime of the building. For heating controls and the fan units of the mechanical ventilation systems, a typical lifetime of 25 years is also assumed.

There is significant uncertainty about the lifetime of renewable technologies, as they are less well established than traditional ones. The typical lifetimes shown here are consistent with those used by the Low Carbon Buildings Programme. Again, the cost for the combined built-fabric and renewables package is simply the sum of the cost for the other two packages.

Looking at the lifetime costs, it is clear that the renewables package is over four times the cost of the built-fabric package. Consideration of lifetime costs, therefore, has a significant impact on the payback calculation, and takes the cost of the packages that include renewables significantly beyond the anticipated lifetime of the buildings. However, the built-fabric package is cost-effective within the 60-year period based on this measure (Table 9).

TABLE 9

Lifetime payback associated with energy-saving scenarios

Payback	Lifetime costs (£)	Annual savings (£ pa)	Simple payback (years)
Built-fabric improvements only	60 546	1236	49
Renewables only	283 593	1534	185
Built-fabric improvements and renewables combined	344 138	2660	129

This cost information, together with the primary-energy and carbon savings for the site modelled using SAP, was then used to assess the relative cost-effectiveness of the three strategies over the lifetime of the buildings. Discounted cash-flow calculations were carried out for each of the three energy-saving scenarios, and the cost-effectiveness of each option was calculated at 20 years, 40 years and 60 years. These express costs and savings in terms of present values, which take account of the decrease in the value of money over time. The net present value (NPV) is the present value of the savings minus the present value of the costs, so a positive NPV will be cost-effective.

For this study, the cost-effectiveness was calculated at a low discount rate of 3.5% – which is the current Treasury rate, and represents the rate of return which is acceptable to government – and a higher rate of 15%, which reflects a more commercially desirable rate of return.

In layperson's terms, when carrying out this kind of long-term assessment money is considered to be worth less in the future than it is at the moment because it could be invested now in order to gain a return. If it is spent now, then there will be no growth from that investment. The Treasury rate is lower because the government does not invest the money, whereas commercial concerns would look for the best investment growth. Both approaches are valid in this instance, since both affordable housing and private developments are affected.

Because the primary-energy and carbon savings achieved by each of the packages are different, it is more appropriate to compare the savings per unit of carbon (or primary energy). Hence, the cost-effectiveness is also presented in terms of NPV per MWh of primary energy or tonne of CO_2 saved.

The results of the cost-effectiveness analysis at 3.5% and 15% discount rates are shown in Tables 10 and 11, respectively.

TABLE 10

Cost-effectiveness of the energy-saving scenarios calculated at a 3.5% discount rate

Years	Discount rate 3.5%	Present value of costs (£K)	Present value of saving (£K)	NPV (£K)	Primary energy savings (MWh saved)	NPV/unit energy saved (£/MWh)	Lifetime CO_2 savings (tonnes CO_2)	NPV/CO_2 saved (£/tCO_2)
20	Built-fabric improvements only	48	18	-30	967	-31	163	-182
	Renewables only	108	23	-86	963	-89	180	-477
	Built-fabric improvements and renewables combined	156	39	-117	1930	-61	343	-341
40	Built-fabric improvements only	51	27	-24	1934	-12	325	-72
	Renewables only	144	34	-110	1926	-57	360	-305
	Built-fabric improvements and renewables combined	194	61	-133	3860	-35	686	-194
60	Built-fabric improvements only	52	32	-20	2901	-7	488	-41
	Renewables only	159	40	-120	2889	-41	540	-222
	Built-fabric improvements and renewables combined	211	72	-140	5790	-24	1028	-136

TABLE 11

Cost-effectiveness of the energy-saving scenarios calculated at a 15% discount rate

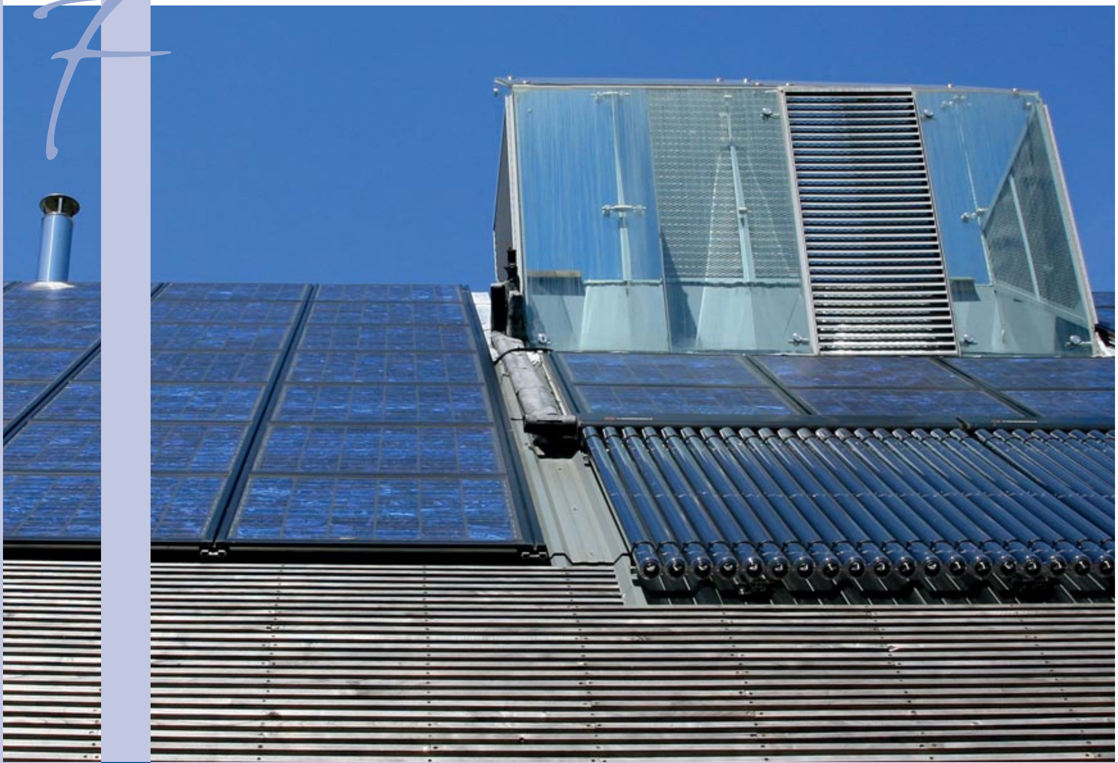
Years	Discount rate 15%	Present value of costs (£K)	Present value of saving (£K)	NPV (£K)	Primary energy savings (MWh saved)	NPV/unit energy saved (£/MWh)	Lifetime CO_2 savings (tonnes CO_2)	NPV/CO_2 saved (£/tCO_2)
20	Built-fabric improvements only	48	9	-39	967	-40	163	-329
	Renewables only	103	11	-92	963	-95	180	-509
	Built-fabric improvements and renewables combined	150	19	-131	1930	-68	343	-383
40	Built-fabric improvements only	48	9	-39	1934	-20	325	-118
	Renewables only	105	12	-93	1926	-48	360	-259
	Built-fabric improvements and renewables combined	153	21	-132	3860	-34	686	-192
60	Built-fabric improvements only	48	9	-39	2901	-13	488	-79
	Renewables only	105	12	-93	2889	-32	540	-173
	Built-fabric improvements and renewables combined	153	21	-132	5790	-23	1028	-128

These results show that none of the energy-saving scenarios is cost-effective – even allowing for a 3.5% discount and considering the investment over the longer time period of 60 years. However, the built-fabric package is shown to be significantly more cost-effective than the renewables package, even at 20 years, and the combined built-fabric/renewables package is a more cost-effective route for achieving carbon savings than renewables alone. The cost-effectiveness with which the combined built-fabric/renewables package saves energy and reduces carbon emissions always falls between those of the separate packages.

It should be noted that the cost analysis modelled is only applicable to the construction methods described. Different construction methods may show greater or lesser cost-effectiveness.

The results calculated at the higher discount rate show a similar picture, but with a narrower gap between the built-fabric and renewables packages, particularly over the longer timescale.

Because these figures are worked out over the life span of the building (an estimated 60 years), the long-term savings will probably be of more interest to developers with a lifetime interest in the buildings, such as housing associations. Private developers, who have no vested interest in the energy provision of the development after the sale of all the properties, are unlikely to factor in the long-term costs unless or until regulations require it.



4 Conclusions and recommendations

4.1 Conclusions

Practical

From the responses received to the industry survey it is clear that Merton-Rule-type requirements have been implemented by residential developers with paramount regard to the renewables requirement and, in all responses excepting where a 20% requirement existed, with less or no regard to the energy efficiency encouragement.

It would therefore seem likely that the Merton Rule, by its wording, has allowed an interpretation placing greater emphasis on renewables (which are expected) than on energy efficiency (which is only encouraged).

According to the modelling carried out on a hypothetical site this would have led to higher costs than necessary being encountered by developers. This is backed up by the cost findings of the industry survey, where results point to a slightly reduced cost of meeting the 10% requirement in cases where demand load was first reduced by means of built-fabric improvements.

There is no evidence from the study to suggest that appropriate guidance was given to developers by planners to illustrate the lower cost of compliance that would have resulted from implementing higher fabric standards to the building envelope in advance of applying the Merton Rule.

There is evidence of a 145.5% increase in sales of solar collectors in the UK home market from 2003, when the Merton Rule was introduced, to 2006. This may be in part attributable to the increasing widespread use of Merton-Rule-type policies, but it was beyond the scope of this review to quantify the actual causes. If this growth in sales of renewable installations continues then the laws of economics dictate that price reductions should follow. This would reduce costs for developers in the long term as higher levels of the Code for Sustainable Homes need to be met by the addition of renewables.

Economic

The cost per tonne of only achieving a 1.1% greater reduction in CO_2 emissions by renewables than from built-fabric-improvement is 4.2 times greater.

Therefore to achieve the most cost-effective options fabric must always be addressed first. Renewables applied without fabric energy efficiency is the most expensive per tonne of the three scenario options considered.

Because residential developers have largely ignored the encouragement for energy efficiency, and planning authorities have failed to give guidance or insist on this, there are likely to have been high costs associated with implementation of the 10% Merton Rule that could have been significantly reduced through more careful wording and better planning control.

Costs per tonne of CO_2 reduced are shown in this modelling to be significantly better value where a 20% reduction has been achieved by using fabric improvements first and then renewables, than by achieving 12% reduction by renewables alone (Table 12). The initial cost of this, however, is more than three times that of using fabric alone but only 47% more than renewables alone.

TABLE 12

Main findings – costs and CO_2 savings

Scenario	60 year cost based on modelling (£)	Cost per tonne of CO_2 saved (£ pa)
Built-fabric improvements only	60 546	124
Renewables only	283 593	525
Built-fabric improvements and renewables combined	344 138	335

Environmental

The lifetime CO_2 savings from modelling of the hypothetical site were 1.1% greater from renewables than from fabric improvements. Over a 60-year life span, this equates to 540.0 tonnes of CO_2 saved by renewables against 488.2 tonnes by built-fabric improvements (Table 13).

TABLE 13

Lifetime CO_2 savings including embodied carbon for photovoltaic panels only

Scenario	Tonnes of CO_2 saved over 60 years and percentage over base case modelling
Built-fabric improvements only	488 (10.9%)
Renewables only	540 (12%)
Built-fabric improvements and renewables combined	1028 (22.9%)

Given the slightly greater reduction in CO_2 emissions from renewables and the fact that built fabric improvements are only capable alone of taking a dwelling to a maximum of Code for Sustainable Homes level 3, renewables will be an important addition to rising built fabric standards over the course of the pathway to the zero carbon goal.

4.2 Recommendations

Consultation on a uniform national requirement should consider that best value can be achieved by insisting on built fabric improvements first, which, if stringent enough, will avoid the need for expensive and inconvenient retro-fitting of energy inefficient houses in the future. This may be achieved by significant raising of Approved Document L1A Building Regulations standards, which would have the added bonus of an established system for control and enforcement. Any renewables requirement could then be satisfied at lowest possible cost.

Planning Policy Statements now expect a proportion of energy in a development to be supplied by renewable and low carbon sources. If a renewables requirement is to be applied, making it uniform across all planning authorities in most circumstances would avoid unfair financial disadvantage to developers building within individually regulated local authorities.

The Merton Rule was ground breaking in its approach and, as with most innovations, it has combined the benefits of innovation with mistakes arising from inexperience. Some lessons can be learned from the research and modelling carried out in this study which may aid the development of any future Merton-Rule-type requirements. As we have shown, the policy must clearly emphasise and insist on the use of the energy hierarchy of built fabric optimisation for energy efficiency and future-proofing of the dwelling. We need to be aware, however, that these fabric improvements can only bring the building to a certain level as far as dwelling and user CO_2 emissions are concerned. Once these measures have been allowed for in the design, a well considered renewables requirement for taking the dwelling or development towards further emissions reductions or zero carbon should take into account all the individual circumstances of the dwelling. It should consider in particular the following:

- The capacity for orientation for solar gain and other micro-renewables within the site layout design
- The opportunities afforded by the local environmental situation for provision of renewable energy on a wider scale than individual dwellings.

Viewing the site holistically will allow for the most cost-effective solution to achieving the greatest CO_2 emissions reductions.

REFERENCES AND NOTES

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20 10% achieves minimum credits in CSH Ene 7. There is some controversy over whether heat pumps should be considered under renewable technology, and research is under way into hitherto-accepted COPs (coefficients of performance). If the fuel used to boost the ground heat comes from a renewable source (eg photovoltaic or wind), these concerns are addressed.

21 Energy Saving Trust enhanced construction details replace the previously used accredited details, which achieved a y-value of 0.08 W/m^2. See ww.energysavingtrust.org.uk/business/Business/Building-Professionals/Helpful-Tools/Enhanced-Construction-Details (accessed 1.12.2008).

22 At first an air-source heat pump (SAP 2005 default efficiency 250%) was also provided to each of the flats, but this actually produced an increase in both primary energy consumption and CO_2 emissions. This is because the air-source heat pump uses electricity, and the TER is therefore adjusted for this fuel type. With this higher TER, the improvement in the DER was significant with the air-source heat pump, but the actual energy use and emissions were higher than the baseline scenario. At the time of writing, the latest version of the Code for Sustainable Homes, released in April 2008, excluded air-source heat pumps in the Ene 7 section on low- and zero-carbon technologies – so air-source heat pumps were subsequently disregarded in this modelling exercise. It has since been clarified that air-source heat pumps are acceptable as low carbon technologies.

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NHBC Foundation publications

A guide to modern methods of construction — **NF1**, December 2006

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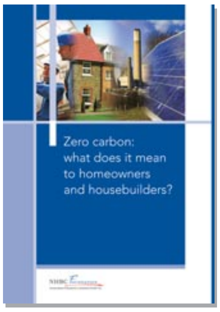

Zero carbon: what does it mean to homeowners and housebuilders?

This report presents the findings of a detailed survey of the views of homeowners and housebuilders on zero carbon homes commissioned by the NHBC Foundation. It reveals current awareness, understanding and attitudes of homeowners towards issues relating to climate change, the Code for Sustainable Homes, airtightness, water conservation and microgeneration.

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NF10, August 2008

NHBC Foundation publications in preparation

- Understanding zero carbon
- Community heating and combined heat and power

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The Merton Rule

A review of the practical, environmental and economic effects

The Merton Rule is the name given to a policy first implemented in 2003 by Merton Borough Council, in south London, requiring specific new-build developments to provide 10% of their energy use from renewable sources. It has its advocates who believe that it can have a positive impact on the renewables industry, and its detractors who believe that it imposes a financial burden on developers. This review evaluates the claims of these different standpoints.

The review also looks at how the Merton Rule has been interpreted, the effect it has had on reductions in CO_2 emissions and how developers have been impacted financially in complying with its requirements. It enables conclusions to be drawn on whether the Merton Rule has proved beneficial in enabling the ultimate goal of 'zero carbon' homes by 2016 to be met.

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The NHBC Foundation has been established by NHBC in partnership with the BRE Trust. It facilitates research and development, technology and knowledge sharing, and the capture of industry best practice. The NHBC Foundation promotes best practice to help builders, developers and the industry as it responds to the country's wider housing needs. The NHBC Foundation carries out practical, high quality research where it is needed most, particularly in areas such as building standards and processes. It also supports house builders in developing strong relationships with their customers.

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