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STAFFORDSHIRE DEVELOPMENT-SPECIFIC SUSTAINABLE ENERGY STRATEGIES - WORKED EXAMPLES

climatechangesolutions

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Executive Summary

This study was undertaken to support the findings of the main Staffordshire County-wide Renewable Energy Study undertaken by Camco. The report for the main study was issued in April 2010, entitled "Staffordshire County-wide Renewable / Low Carbon Energy Study".

Four development site energy strategy studies were conducted to provide 'worked examples' of how a range of schemes would achieve the range of carbon standards set out in the carbon reduction target framework proposed for the study area. The framework is summarised below with a detailed discussion, including the results of the costing tests within the main study report

The objectives of this parallel site energy strategy study were as follows:

- Review the potential for energy efficiency and renewable energy for the four development sites, which were selected as examples that illustrate typical forms of development across the country.
- Test how these example development sites might meet the different carbon standards set out within the recommended targets framework, and consider cost and other implications.
- Highlight the key considerations at the planning stage for compliance against sustainable energy / carbon standards.
- Demonstrate the approach to assessing compliance against carbon standards for new developments. This was achieved through the preparation of Sustainable Energy Strategies (SES) containing the type of information typically required to support planning applications.

The four sites assessed were:

- Lower Milehouse Lane, Newcastle-under-Lyme – a development of circa. 210 houses
- Anker Valley, Tamworth – an urban extension of 900 to 1,150 dwellings
- Holt Lane, Kingsley, Staffordshire Moorlands – 8 semi-detached houses in a rural village
- Tipping Street, Stafford – an office and restaurant/retail development in the centre of Stafford.

Assessment methodology

The target framework for new residential developments proposed by Camco gives three key target levels:

- 25% reduction in regulated emissions, plus 10% of total carbon* reduced by renewable energy
- 44% reduction in regulated emissions, plus 20% of total carbon* reduced by renewable energy
- Zero carbon, providing 70% reduction in regulated emissions, with the remainder of the total carbon emissions offset by allowable solutions.

**both regulated and "unregulated" carbon emissions*

Regulated energy demands are those regulated by Part L of the Building Regulations. It includes heating, hot water, lighting and other building services. It does not include appliance energy demand, for example kitchen equipment and computers. This demand is known as 'unregulated'. The Part L calculation methodology calculates an estimation of regulated demand per year.

The methodology looks at distinct energy efficiency levels for each development, derived from the Energy Saving Trust's 'Best Practice Energy Efficiency' (BPEE) and 'Advanced Practice Energy Efficiency' (APEE) standards. These provide around 15% and 32% reductions in regulated emissions. Combined with a base case of the Part L 2006 Building Regulations standard, this gives three levels of energy efficiency for each development. Cost estimates were made for each of these levels using costs published by the Department for Communities and Local Government. (DCLG).

The three energy efficiency levels are applied to the three key targets (25%, 44% and zero carbon), resulting in nine potential scenarios. For each of these scenarios a 'most suitable' renewable energy option has been suggested, based on Camco's experience with sustainable buildings. The analysis helps identify this option and estimates the capital cost. By combining the cost of energy efficiency with the renewable energy cost a total capital cost is identified. In addition to this, the benefit of the Feed in Tariff and Renewable Heat Incentive have been capitalised, which effectively reduces the capital cost of the renewable energy. This gives an overall 'net capital cost of energy' for each scenario.

Conclusions

The sustainable energy strategy study has shown that each scenario in the proposed target framework for Staffordshire can be achieved. A range of development types have been considered, from a handful of dwellings, to a major urban extension.

Larger developments present a greater range of options for renewable energy, as communal energy systems can be incorporated. Providing a large amount of heat demand from a single source can result in significant economies of scale.

For small developments where communal energy is not feasible, options are limited. For a zero carbon target, photovoltaic panels are often the only option. The estimated capital cost of these panels is up to £14,000 per dwelling, with an additional £5,500 per dwelling required to pay for allowable solutions. With the feed in tariff revenue capitalised, the total cost per dwelling has been estimated at possibly reducing from £19,500 to £16,000. Note that this is a worst case scenario where options for reducing emissions are limited.

The Feed in Tariff (FIT) can provide a long term revenue for renewable energy installations, as can the Renewable Heat Incentive (RHI) if it is implemented as currently planned in April 2011. By capitalising the benefit of this revenue, the net capital cost of the renewable energy can be reduced, for a more realistic comparison against energy efficiency costs. However, this assumes the developer will be able to claim the revenues, which has yet to be proved in practice.

The study has shown that, in most cases, energy efficiency improvements cost more than renewable energy. Hence the cheapest option is not to improve energy efficiency over the Part L 2006 standard, and to instead install more renewable energy. The benefit from FIT/RHI helps make renewable energy more attractive.

However, we would always recommend promoting energy efficiency. The main justification for energy efficiency is that in most cases it involves high levels of insulation, which should last the life of the building. Renewable energy, on the other hand, tends to have a limited life span. Biomass boilers will usually last 15 years, photovoltaic panels perhaps 25 years (they will still generate energy but much lower amounts). There is also greater potential for faults in a complex renewable energy technology, such as inverters burning out. Passive energy efficient design measures have a higher guarantee of long term carbon savings.

A level of energy efficiency beyond Part L 2006 should be promoted for new developments, even if it is shown not to be the most cost effective option. Developers should be encouraged to look at alternative construction methods that could bring the cost of energy efficiency improvements down.

For non-domestic developments, options for energy efficiency and renewable energy will vary greatly depending on the design and site constraints. This study's analysis of Tipping St has shown biomass heating to be the most suitable option. However, this assumes biomass will be available and that the building is designed for a wet heating system.

It is essential for developers to consider energy efficiency and renewable energy targets from the earliest stage of development, to ensure designs can accommodate the most suitable sustainable energy solution.

1 Introduction

As part of the Staffordshire County-wide Renewable Energy Study, analysis of carbon reduction options of four development sites has been conducted. While the report primarily looks at renewable energy generation, energy efficiency is also considered, plus low carbon energy options such as district heating and combined heat and power. New developments in the built environment provide an opportunity to consider all these measures. The analysis of these sites is intended to inform the planning recommendations emerging from the wider study around new development.

The objectives of this study were as follows:

- Review the potential for energy efficiency and renewable energy for development sites, which were selected as examples that illustrate typical forms of development.
- To test how these example development sites might meet the different carbon standards set out within the recommended targets framework, and consider cost and other implications.
- Highlight the key considerations at the planning stage for compliance against sustainable energy / carbon standards.
- Demonstrate the approach to assessing compliance against carbon standards for new developments. This was achieved through the preparation of Sustainable Energy Strategies (SES) containing the type of information typically required to support planning applications.

To achieve these aims, the sites put forward by the project Steering Group have been assessed to show the level of detail typically required and the options available for different scales and types of development.

It is not intended that the results discussed in this report should be used to support any subsequent determination of planning applications for any of the sites considered.

A glossary of common technical terms in included in Appendix I.

2 Description of sites

Table 2-1: Development categories considered

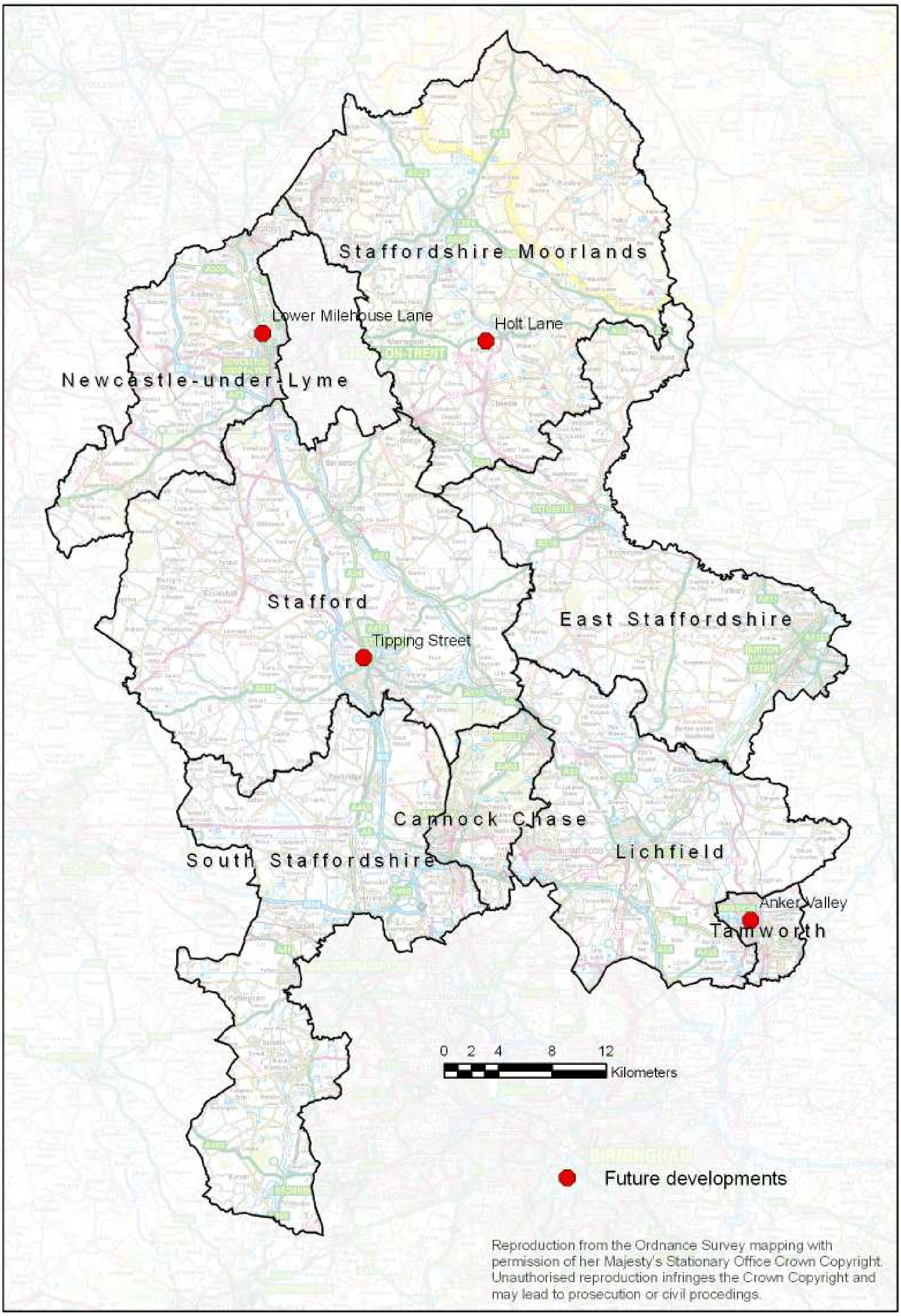
Development categories considered		
Category	**Description**	**Example site for study**
Urban Infill	Small numbers of dwellings (typically 10-100 units) integrated into existing urban environment/settlement framework. Few other building types. High density (50 dwellings/ha).	Holt Lane is in a rural village, but the house types are still typical of an urban infill site (e.g. density exceeds 50/ha).
Town/City Centre development	Development on brownfield sites within a town/city centre. Typically involves demolition of existing buildings to make way for new development	Tipping St
Rural infill	Small numbers of housing units situated within existing settlement framework - ranging from 1 to 100 Medium density (40 dwellings/ha).	Holt Lane
Settlement extension	Up to 1,000 dwellings adjoined to existing town or village with limited mix of other building types. Medium density (40 dwellings/ha).	Lower Milehouse Lane. It could be argued that this site is an Urban Infill as it will need to be integrated into the existing area, but the cleared site allows for infrastructure design that Urban Infill generally doesn’t.
Urban extension	Over 1,000 housing units adjoined to existing town and mix of other building types. Medium density (40 dwellings/ha).	Anker Valley
Large urban extension / new settlement	Large number of housing units adjoined to existing town - up to 4,000 dwellings - and good mix of other building types. High density (50 dwellings/ha).	None of the sites considered in this study fall into this category. Developments of this size are rare.

The four sites assessed were:

1. Lower Milehouse Lane, Newcastle-under-Lyme
2. Anker Valley, Tamworth
3. Holt Lane, Kingsley, Staffordshire Moorlands
4. Tipping Street, Stafford

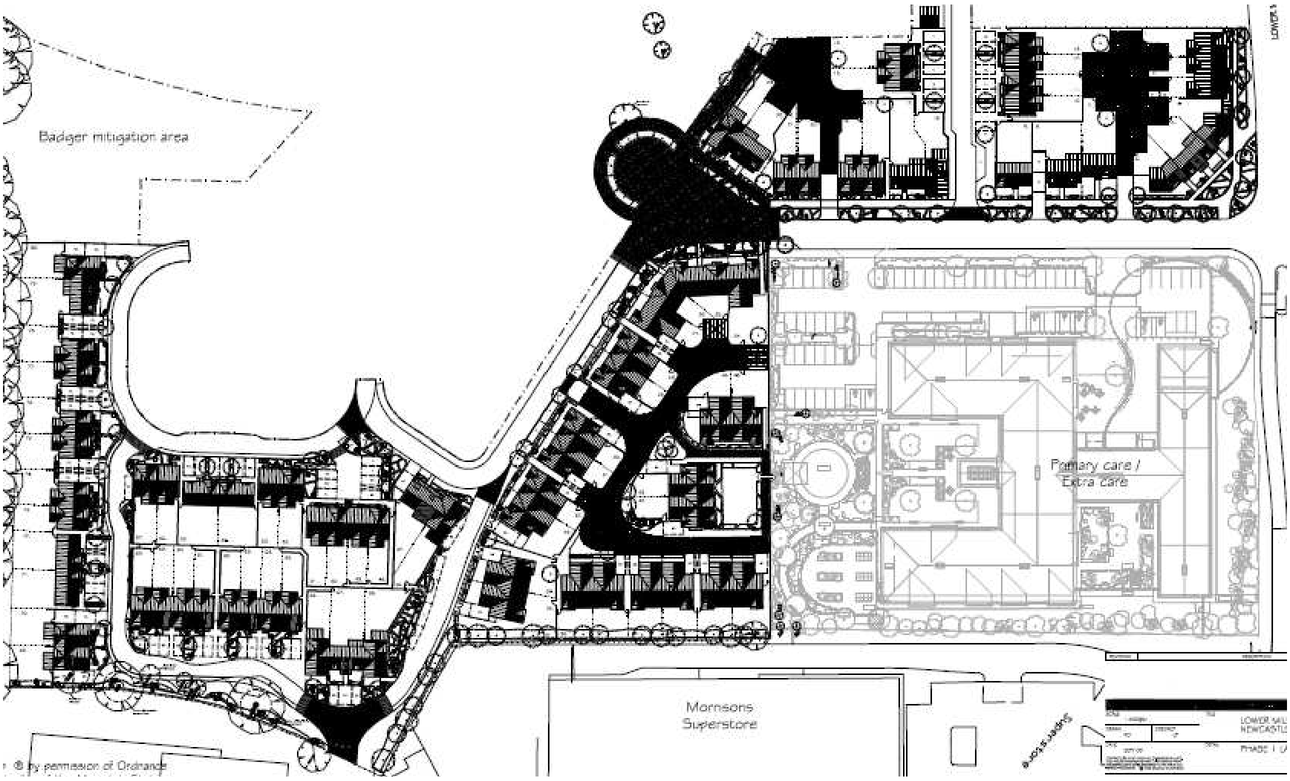
The map on the following page shows their location within Staffordshire.

Figure 2-1: Location of four sites in the study



Lower Milehouse Lane in Newcastle-Under-Lyme is a 210 dwelling site, being developed with support from the Homes and Communities Agency (HCA). The first planning application for 80 houses and a second application for 130 dwellings have both been submitted. All dwellings are being designed to achieve level 3 of the Code for Sustainable Homes, but the planning application gives very little detail about how this will be achieved.

Figure 2-2: Lower Milehouse Lane planning application drawing

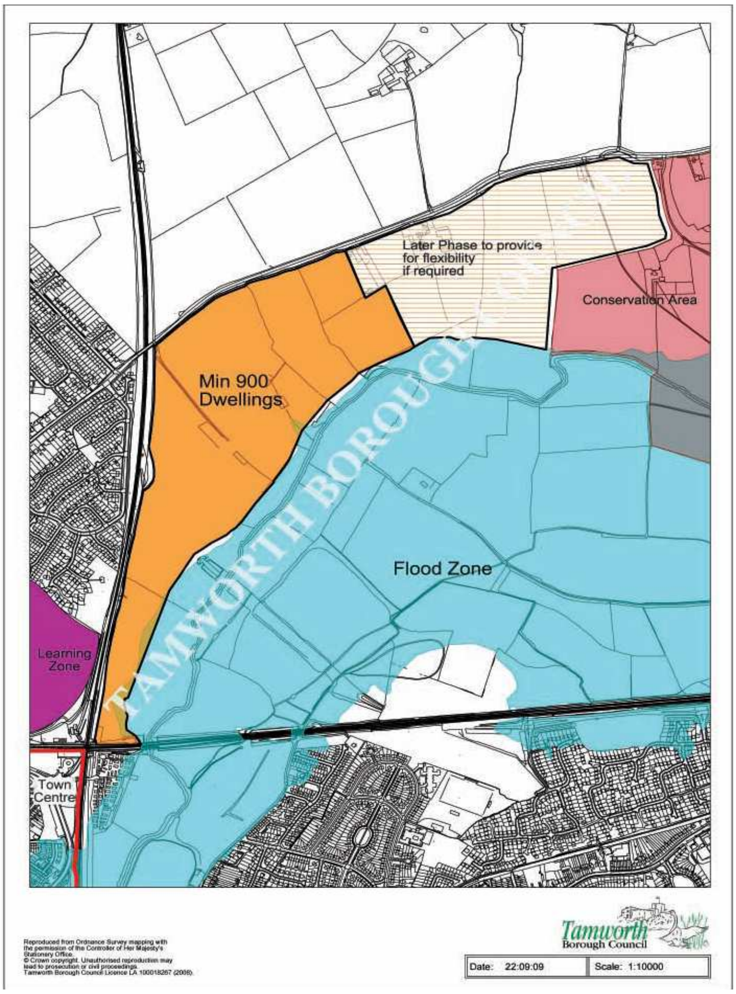


Anker Valley in Tamworth is a large development detailed in the "Core Strategy: Proposed Spatial Strategy"[1] as a minimum of 900 dwellings, but with potential for 1,150. The Council have been looking at the potential of the site for some time. It is an urban extension, but is actually very close to the centre of Tamworth. The development is predicted to be up to 5 years away from starting on site. Viability and infrastructure delivery are key issues for developers at the moment. Tamworth have consulted on this and we understand studies are ongoing.

Provision is also included in the plans for a new local centre incorporating shops, health facilities, a community centre, and a primary or junior school. Considering the need for low cost housing in the area and the proximity to the town centre, it can be assumed that a range of medium to high density housing will be developed. It is expected that this would principally be terraced and semi-detached dwellings, with some 2-3 storey apartments.

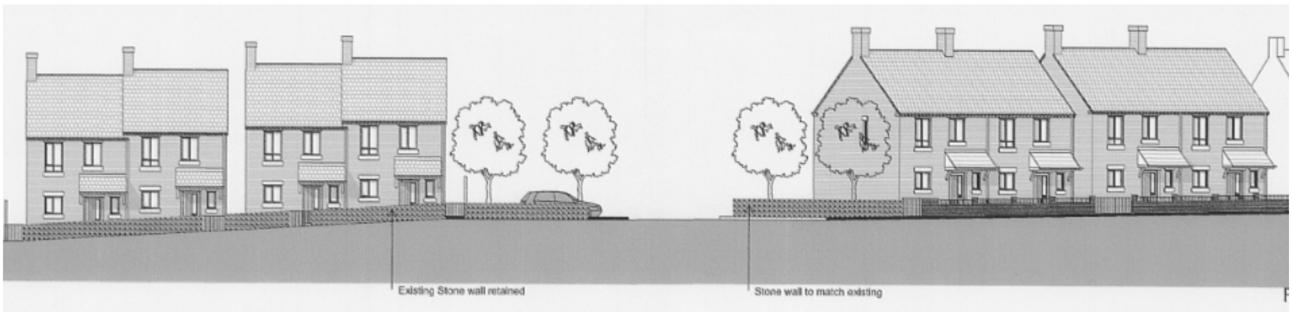
[1] http://www.tamworth.gov.uk/planning/local_development_framework/core_strategy.aspx

Figure 2-3: Anker Valley site (shown in orange)



Holt Lane is a small development of eight semi-detached houses, lying within the centre of the small village of Kingsley (but abutting open countryside), in NE Staffordshire. They are all roughly similar in design, with an open plan ground floor and 2 bedrooms. The houses are now almost complete, but are awaiting formal building control "sign off". Hence at the time of writing none are occupied.

Figure 2-4: Holt Lane planning application drawing



Tipping Street is a new development of two blocks, one four storey and one five storey. It is in the centre of Stafford next to the County Council buildings. The planning application summary is as follows:

> *Erection of two blocks of development comprising one five storey building and one four storey building each with roof top plant to provide Class A1 (retail) Class A2*

(financial and professional services) Class A3 (restaurants and cafes) Class A4 (drinking establishments) Class A5 (hot food take away) and Class B1A (offices) at ground floor (flexible uses under GPDO Part 3 Class E) and Class B1A (offices) on the upper floors. Creation of hard landscaped areas provision of covered cycle storage facility and associated works.

This has been permitted and building work has already started.

The total area of ground floor Class A use is 1,308m^2, with office space totalling 14,543m^2. For benchmark estimates, it has been assumed half the Class A use will be retail and half will be restaurants/cafes. This is in the absence of any further information and in order to approximate the energy demand.

Figure 2-5: Tipping St drawing from the planning application

3 Description of carbon standard scenarios

Rather than simply assessing these developments against prevailing carbon or renewable energy standards each has been considered against a range of possible standards, to help identify the implications of future carbon / renewable energy targets.

The range of the standards considered are shown in Figure 3-1 for residential-led development. See the Camco report “Staffordshire County-wide Renewable / Low Carbon Energy Study”, from April 2010, for further details. By contrast Figure 3-2 shows the current ‘UK zero carbon road map’, which also includes non-domestic development.

The percentage improvements are relative to building regulations Part L 2006. Part L 2006 is the current minimum energy performance standard for new buildings. The government recently consulted on a revised Part L that aims to reduce regulated emissions by 25% from all new buildings. This is planned to be implemented from October 2010. From this point the minimum 25% reduction identified in the acceleration roadmap will be mandatory for residential buildings.

For non-residential buildings, the stages in the road map to achieve zero carbon by 2019 have yet to be set, hence the ranges in carbon reduction shown. Within this report, the potential sustainable energy options for non-domestic buildings have been considered within the four worked examples where it was relevant.

Figure 3-1: Proposed Acceleration – Staffordshire (Domestic)

<table>
<tr><th rowspan="2">Period</th><th colspan="3">Domestic Reductions</th><th rowspan="2">Resulting range in carbon reduction (Regulated emission equivalent)</th></tr>
<tr><th>Regulated (change from Part L 2006)</th><th>Minimum Proportion of Low and Zero Carbon energy generation (against total carbon)*, **</th><th>Un-regulated</th></tr>
<tr><td>2010-13</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Minimum***</td><td>25%</td><td>10%</td><td>0%</td><td>25 – 42%</td></tr>
<tr><td>Maximum[χ]</td><td>44%</td><td>20%</td><td>0%</td><td>44 -78%[χχ]</td></tr>
<tr><td>2013-16</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Minimum***</td><td>44%</td><td>20%</td><td>0%</td><td>44 -78%[χχ]</td></tr>
<tr><td>Maximum[χ]</td><td rowspan="5">100%
(min. 70% Carbon compliance / 30% AS)</td><td rowspan="5">Obsolete at this carbon standard</td><td rowspan="5">100%
(Carbon compliance or AS)</td><td rowspan="5">100 – 150%</td></tr>
<tr><td>2016-19</td></tr>
<tr><td>Minimum***</td></tr>
<tr><td>Maximum[χ]</td></tr>
<tr><td>Post 2019</td></tr>
<tr><td></td><td colspan="3">Zero Carbon</td><td></td></tr>
</table>

*Depending on the technical solutions this may not result in additional carbon savings.

** total carbon = 100% regulated plus 100% unregulated emissions

***To be applied to all housing developments including sub 10 developments to ensure consistency with Code for Sustainable Homes

[χ] where lower costs solutions are available because of technical opportunities, e.g. community heating, biomass heating / CHP, large wind energy, surplus heat or scale of the development

[χχ] unlikely to result in this maximum level of savings since the 44% regulated emissions reduction target will typically require a significant element of renewable energy.

Figure 3-2: Base Case – UK Road Map

<table>
<tr><th rowspan="2">Period</th><th colspan="2">Residential Reductions</th><th colspan="2">Non-domestic</th></tr>
<tr><th>Regulated (from Part L 2006)</th><th>Unregulated</th><th>Regulated (from Part L 2006)</th><th>Unregulated</th></tr>
<tr><td>2010-13</td><td>25%</td><td>0%</td><td>25%</td><td>0%</td></tr>
<tr><td>2013-16</td><td>44%</td><td>0%</td><td>30-44%</td><td>0%</td></tr>
<tr><td>2016-19</td><td rowspan="2">100%
(min. 70% Carbon compliance / 30% AS**)</td><td rowspan="2">100%
(Carbon compliance or AS**)</td><td>37-53%*</td><td>0%</td></tr>
<tr><td>Post 2019</td><td>100%
(44-63% through carbon compliance & reminder through AS**)</td><td>TBC:
Variable or fixed flat rate (0%, 20% or 100%). Through Carbon Compliance or AS**)</td></tr>
<tr><td></td><td colspan="4">Zero Carbon</td></tr>
</table>

*consultation identifies options of the allowable solutions being part of the solution from 2016 for non-domestic buildings

**AS = Allowable solutions

3.1 Public sector funding

A further consideration for developments will be public sector funding. For example, developments with funding from the Homes and Communities Agency (HCA) are currently required to achieve a 25% improvement on building regulations Part L 2006 (equivalent to the carbon standard required by Code for Sustainable Homes level 3). This is expected to rise to 44% when Part L is revised in October 2010. Planning authorities will have to consider on a case by case basis whether or not to require higher targets than those set by the public sector funding agencies.

3.2 Developments with long term phasing

Often developments are phased over a long period. Anker Valley, for example, is likely to be developed over 5-10 years. This means carbon reduction targets will change for different phases of the development. Over such a long timeframe, it is reasonable to expect the cost of energy efficiency and renewable energy to reduce as products become more mainstream. New technologies and products are also likely to become available.

Community energy networks for large developments can often be difficult to include due to phasing. It is hard to justify the upfront cost of an energy centre that will not be fully utilised for several years. However, there are ways of working with the phasing while still achieving a cost effective solution, for example, underwriting infrastructure with public funding. Planning Authorities should be aware of this and encourage developers to consider the long term strategy during masterplanning.

There are several examples of developments that have grown in phases, connecting to community energy networks as they are built. ESCO providers and leading banks are setting up finance mechanisms that take the risk away from the developer. These and other options should be fully explored by the developer of a phased development, to ensure the highest possible standards of carbon performance are being met.

4 Sustainable Energy options and the constraints

Every development presents a range of generic and individual opportunities and constraints for low carbon design. Available options are particularly influenced by site location, existing infrastructure, and the wider aims of the development and ambition of stakeholders.

The main options for low carbon design include:

- Energy efficiency within the building envelope – insulation, airtightness and ventilation
- Optimisation of orientation, window placement and layouts to optimise solar gain and reduce overheating
- Renewable energy within the dwelling boundary – photovoltaics, solar hot water, small scale wind turbines and heat pumps[2]
- Communal heating systems – linking a number of dwellings to a heat network opens up options for gas CHP, biomass boilers and more efficient heat pump systems
- Communal energy services, generating electricity and heat for sale within the new development and beyond. This is an extension of the above, where electricity from CHP is sold on site. If electricity is being generated, it can either be sold directly to residents (at around 14p/kWh) or exported to the grid (for which utility providers will pay around 3p/kWh, plus 5p/kWh for the feed in tariff export price, if applicable). Clearly revenues will be higher if electricity is sold directly to the end user. This increased revenue can make schemes such as biomass CHP cost effective.
- Connection to existing heat sources.
- Use of "allowable solutions" as defined by the Department of Communities and Local Government's consultation on the zero carbon definition[3]

This study has considered these options and constraints for the four sites, which will feed into the energy efficiency and carbon recommendations. It should be recognised that the analyses have been conducted with limited development information. This is possible here as the purpose is to draw out the principles of assessing options and the key differences between development typologies and scales of development, rather than reflect very specific local constraints.

This study makes assumptions regarding the split between energy efficiency and renewable energy. The energy efficiency levels are distinct improvement standards over building regulations, as defined within the Zero Carbon Homes Definition, with renewable energy included to make up the shortfall. This is consistent with the main study. In practice the balance between energy efficiency and renewable energy could be significantly different, particularly if new forms of construction become more widely used. For example developers are starting to make use of more 'modular' construction, in which panels are constructed in a factory and put together on site, reducing the work required on site and in theory overall time and cost[4]. Hence the balance between energy efficiency and renewable energy, as set out in this report, should only be seen as illustrative.

[2] *There are other options for renewable energy that are technically viable for certain sites, but considered unlikely to be suitable for the sites considered here. Hence they have been excluded. Developers may still consider other technologies but would need to provide suitable evidence that they are appropriate.*
[3] *http://www.communities.gov.uk/publications/planningandbuilding/zerocarbondefinition*
[4] *Further details on this and other 'Modern Methods of Construction' can be found at http://www.englishpartnerships.co.uk/mmc.htm*

5 Sustainable energy assessment - methodology

The energy demand of a new development can be estimated, based on typical benchmarks for building types. Camco has developed in-house software to do this based on previous SAP calculations. Accommodation schedules have been estimated where they have not been provided, based on information from sustainable energy strategy experience from other similar developments. This is not as accurate as full SAP calculations (as required for building control purposes), but it gives a good approximation of energy demand where full design details are not available that can be used to assess the level of renewable energy required.

Camco's in-house software produces demand for heating, hot water, pumps, fans and lighting. This is termed as "regulated energy"; as it is regulated under Part L of the Building Regulations. The software also calculates unregulated energy (the estimated demand from appliances and cooking) using standard calculations and benchmarks..

Regulated energy demand for Part L 2006 compliance gives a carbon baseline for each development. The study's analysis then looked at how each development could achieve the carbon / renewable energy targets stated:

- 25% reduction in regulated emissions with* 10% renewable energy
- 44% reduction in regulated emissions with* 10% renewable energy
- 44% reduction in regulated emissions with* 20% renewable energy; and;
- 70% reduction in regulated emissions with "allowable solutions" mitigating the remainder of the total carbon emission to achieve zero carbon.

** meaning that the renewable energy requirement is not necessarily in addition to the carbon reduction target. If, for example, the first case renewable energy is used to achieve the 25% carbon target then further renewable energy may not be required.*

This follows the elevated standards proposed by Camco in the 'Staffordshire County-Wide Renewable Energy Study'.

This analysis is similar to what might be expected of a developer looking to comply with the elevated standards. Camco's in-house tools have been used for the calculations. Developers would be expected to undertake calculations similar to those completed by Camco's tools, based on the National Calculation Methodology (NCM) and relevant industry guidance. The methodology is similar for non-domestic buildings, which also use the NCM.

5.1 Energy efficiency options

There are several ways of reducing energy demand from buildings.

The percentage of total carbon emissions from each energy demand is widely dependent on the building type. In dwellings, regulated emissions are mainly from heating and hot water. In an air conditioned office, energy demand for ventilation and cooling is much higher.

The national calculation methodology (NCM), which includes SAP and SBEM, must be used for building regulations compliance. Through these external software tools it is possible to look at a number of permutations of building layouts, facades, orientations and internal services to achieve a design that meets low carbon ambitions.

For this study, rather than undertaking a detailed analysis, two generic standards from the Energy Saving Trust have been used; **Advanced Practice Energy Efficiency** (APEE) and **Best Practice Energy Efficiency** (BPEE). These two scenarios are used in the zero carbon consultation, from which have been taken the typical carbon reduction and extra over cost estimate.

BPEE and APEE are used for domestic buildings. For non-domestic, the potential for reduction varies greatly, as detailed in the Part L 2010 consultation[5]. The consultation looks at how a range of non-domestic development types might contribute to an overall reduction of 25%, called the aggregate approach. These figures have been used to set the energy efficiency standards for the non-domestic developments in this study. The Part L 2010 consultation also gave cost estimates for energy efficiency improvements, which have been used in this study for the Tipping Street development.

The energy efficiency reductions achieved under these standards for each building type are listed in Table 5-1 below. They are based on what is realistically achievable for each building type, for example a detached house has a larger area for heat loss, so greater potential for reducing heat demand.

For non-residential, only a single energy efficiency reduction target is provided for each building type. These are identified in the Part L 2010 consultation, which considers which building types might be able to achieve greater than 25% carbon reduction, and which might achieve less. Actual site constraints and building design will have a substantial affect on what is achievable.

Holt Lane only has one building type (semi-detached houses) so the standards are simple. The other developments have a range of building types. The emissions for each building type have been averaged to get an overall reduction target. These targets are shown in Table 5-2.

Table 5-1: Best and advanced practice energy efficiency levels

	BPEE	APEE
Apartment/flat	14%	28%
Terrace house	15%	28%
Semi-detached / end-terrace	15%	31%
Detached house	16%	35%
Retail	33%	
Health centre	25%	
School/community centre	23%	
Restaurant/café	33%	
Office	33%	

Table 5-2: Best and advanced practice energy efficiency levels

	BPEE	APEE
Lower Milehouse Lane	16%	32%
Anker Valley	16%	31%
Holt Lane, Kingsley	14%	31%
Tipping Street	33%	33%

5.2 Renewable energy generation solutions

The level of renewable energy required to achieve the target is set by the level of energy efficiency achieved. For example with Lower Milehouse Lane, if BPEE is acheived (16% reduction in regulated emissions, as shown in Table 5-2) then 9% is needed from renewable energy generation to get a 25% reduction overall. However, the development would also have to achieve 10% renewable energy against total carbon emissions (Merton target in Figure 3-2). Effectively, the site has been designed to be more energy efficient than it needs to be, but it cannot use this increased level of efficiency to reduce the percentage of renewable energy required. In this situation, the 10% renewable energy target will dominate, and the percentage reduction against regulated carbon emissions will be higher than 25% (in this case 31% - see section 6.1).

[5] http://www.communities.gov.uk/publications/planningandbuilding/partlf2010consultation

The requirements for each carbon target level and energy efficiency standard are broken down for each development in section 6. With the help of Camco's in-house software, albeit is possible to assess a range of low and zero carbon technologies for each scenario. Table 5-3 shows the technologies assessed.

Table 5-3: Renewable energy technologies considered by Camco

Ground Source Heat Pump (communal)
Ground Source Heat Pump (individual)
Solar Water Heating
Roof Mounted Photovoltaic Panels
Small Scale Wind Turbines
Medium/ Large Scale Wind Turbines
Biomass Heating (communal)
Biomass CHP (communal)

Analysis of air source heat pumps is also possible. However, they have been excluded from the analysis here as they do not, in most applications, result in a carbon saving overall.

Occasionally developments have potential on-site for hydro power and energy from waste. These are very much dependant on the local resource and cannot be assessed in this study, but will be mentioned if follow up might be productive.

Estimating capital cost

Capital costs of renewable energy have been estimated, based on a database of typical projects compiled from producing sustainable energy strategies for new developments. The costs come from a range of sources, including published reports, supplier quotes and completed projects. They represent total capital cost for the technology, which in all cases is assumed to be an extra over cost as Building Regulations are met by energy efficiency. It is the cost before consideration of capitalising long term revenues or ESCO capital.

Feed in Tariff, Renewable Heat Incentive and Energy Services Companies (ESCOs)

A number of scenarios are provided to illustrate how the targets could potentially be met for each site. Capital cost effectiveness is often the main driver, but also considered are: long term revenue from the Feed in Tariff (FIT), the Renewable Heat Incentive (RHI), and ESCOs. FIT and RHI aim to bring the internal rate of return for all technologies to between 5 and 8%. The rate of FIT and RHI varies by technology as shown in Table 5-4, with the result being that whole life costs should be similar and payback periods will be between 10 and 15 years. FIT is currently operational, as of 1st April 2011. RHI is due to become live in 2011, but there are concerns in the industry that the new coalition government will not pursue this policy. RHI was not part of the manifesto, and there has been no official announcement from the Department of Energy and Climate Change on retaining or scrapping it since the May general election.

Camco has undertaken analysis on the long term revenue from FIT, RHI and ESCOs. The analysis 'capitalises' the predicted revenue over 20 years, discounting future years to calculate the present values of these revenues. It should be recognised that these capitalisation discounts are shown, as it may be possible for developers in the future to either use financial services, e.g. from an equipment supplier or an ESCO provider, to reduce the direct investment required, or developers may seek to increase sale prices to account for future lower overall energy costs.

The percentage capitalisation estimated for each technology is shown in Table 5-4. The general principle is that capital costs can be reduced by 25% by capitalising small schemes where an ESCO is not viable. On larger communal schemes where an ESCO is viable, ESCO providers should be able to provide around 50% of the capital cost to support the scheme. This would be agreed on the basis of the ESCO provider managing energy services for 20 years and claiming the

FIT/RHI revenue. These are conservative assumptions to reflect the immaturity of market-based solutions and to partially account for the wide range of projects (and project costs) that can arise. This capitalisation of revenues allows for a comparison of lifetime costs of renewable energy alongside energy efficiency costs.

It should be noted that capitalisation of these revenues effectively means that the developer is 'selling' the FIT/RHI revenue upfront. This means the residents or building occupiers would not be able to claim the FIT/RHI. This should be considered fair, as the system is designed so that the person paying for the renewable energy gets the financial return.

Table 5-4: Potential revenue from the feed-in tariff (FIT) and renewable heat incentive (RHI), including capitalisation percentage of capital costs

Renewable energy technologies	FIT/RHI Revenue (p/kWh)			Capital cost % reduction for capitalisation
	Small	Medium	Large	
Ground Source Heat Pump (individual)	7	5.5	1.5	25%
Solar Water Heating	18	17	17	25%
Roof Mounted Photovoltaic Panels	36.1	31.4	29.3	25%
Small Scale Wind Turbines	26.7	26.7	26.7	25%
Medium/ Large Scale Wind Turbines	18.8	18.8	18.8	50%
Biomass Heating (communal)	9	6.5	2	50%
Biomass CHP (communal)	10	10	10	50%

This study looked at several options before selecting the most appropriate solution. For any site, there are a number of factors that cannot be fairly assessed simply using software solutions. For example proximity of housing, making large scale wind turbines improbable, or development density making communal heating too expensive. This is where Camco's experience with sustainable energy strategies has been used, combined with rules of thumb and industry guidance.

Further analysis beyond this study (such as an appraisal of phasing, key site constraints, dynamic heat and power profiles, etc) would be required to support detailed planning negotiations.

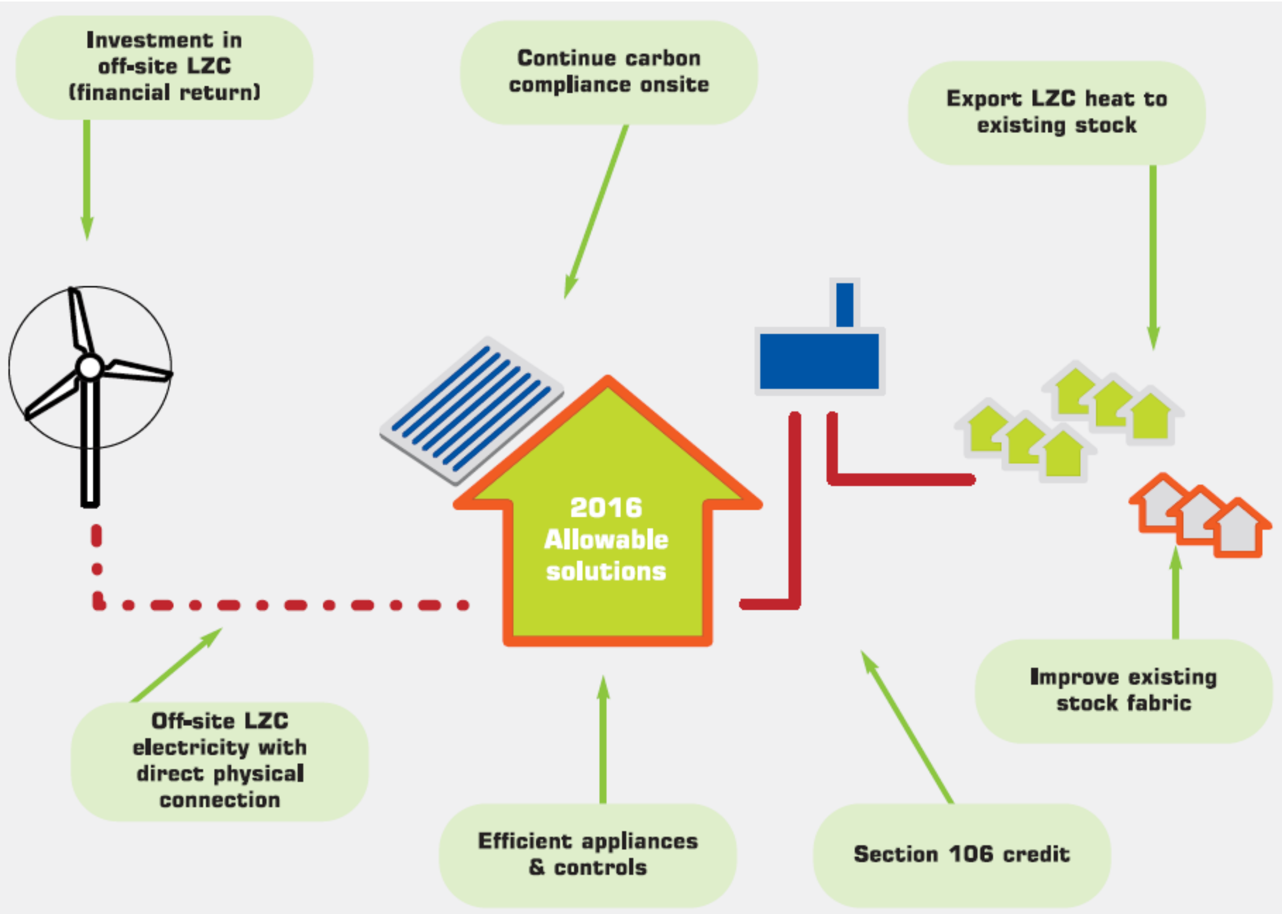
5.3 Off-site generation / Allowable solutions

Allowing off-site renewable energy generation for new developments can improve the technical potential of achieving low to zero carbon development and also substantially reduce the cost of doing so. However, it would raise a number of questions such as how to link the off-site renewable energy generation to the specific development as well as raising important considerations regarding compatibility with the Code for Sustainable Homes and the current consultation of the definition of "zero carbon". Together with energy efficiency and on-site renewables, there are a host of additional possible "allowable solutions" through which zero carbon could be achieved. These measures are listed here and are represented in the figure below:

- Increased energy efficiency / on-site renewables measures beyond stated minimum
- Use of energy efficient appliances or advanced forms of building control
- Export of low carbon or renewable heat (or cooling)
- S106 Planning Obligations paid by the developer towards local LZC energy infrastructure

- Energy efficiency retrofitting works to affect major transformation of the energy efficiency of nearby existing buildings
- Investment in LZC energy infrastructure where the benefits of ownership of that investment are passed to the purchaser of the home
- Offsite renewable electricity, connected to the development
- Any other measures that Government might in future announce

Figure 5-1: Allowable Solutions (Source: Zero Carbon Hub)



The government has suggested that 70% regulated emissions reductions will have to be achieved from energy efficiency, communal heat connection and on-site low carbon energy generation. The remaining emissions, including unregulated, can then be offset by paying for allowable solutions at a total capital cost of £100/tCO_2 per year over 30 years. This figure is from the government's zero carbon proposals.

As an example, a 250 dwelling development would have emissions of roughly 500 tCO_2 regulated and 200 tCO_2 unregulated; the developer would be required to reduce regulated emissions by 70% to 150 tCO_2. They would then have to purchase allowable solutions for (150 + 200) tCO_2 to be considered zero carbon. The capital cost of these allowable solutions would be

$$(150 + 200) \times £100 \times 30 \text{ years} = £1.05\text{m}$$

6 Results of analysis

6.1 Lower Milehouse Lane, Newcastle-Under-Lyme

6.1.1 Schedule of accommodation

A reserved matters planning application for 80 houses in phase 1 has been approved. This contains the split of dwelling types shown below. An outline planning application for a further 130 dwellings in phase 2 has also been submitted. A similar split of dwelling types for this phase has been assumed for the purposes of this study.

Actual dwelling floor areas were not available and so these have been assumed to be equivalent to the English Partnerships Quality standards for new dwellings (these are expected to be adopted by the new Homes and Communities Agency that has replaced English Partnerships). On this basis the assumed accommodation schedule for the site is shown in Table 6-1 below.

Multiplying the figures together gives a total development floor area of 18,290m^2.

Table 6-1: Predicted accommodation schedule for Lower Milehouse Lane, used in calculations

	Phase 1	Phase 2	**Total**	Average floor area
Bungalow	22	35	**57**	77
2 bed house	20	33	**53**	77
3 bed house	23	37	**60**	93
4 bed house	15	25	**40**	106
	80	**130**	**210**	

The above accommodation schedule and Camco's in-house software have been used to get an estimate of the energy demand.

6.1.2 Energy demand and efficiency savings

The development is entirely comprised of houses and they are assumed to be a mixture of semi–detached, detached and terraces. Most energy efficiency savings in houses will come from reducing heat demand. This can be done by a number of measures, including:

- Improved insulation U-values for walls, floors, roofs, doors and windows
- Higher boiler efficiencies, which should also reduce hot water emissions
- More airtight dwellings, which reduces heat loss through infiltration
- Heat recovery ventilation

In a detached house heating demand could make up 60% of the regulated emissions, hence a 50% reduction would be 30% overall. On the other hand, heating demand for an apartment with only one external wall might be only 20% of the regulated emissions. Hence the maximum efficiency saving from an apartment block might only be 10%, whereas a detached house could achieve 30%.

There is little opportunity to reduce electricity demand within the SAP calculation.

It is estimated for this development that BPEE will reduce heat demand by 30% and hot water demand by around 5%, giving an overall carbon saving of 16%.

APEE would require super-insulation, triple glazing, and a level of build quality that is not yet common in UK construction. The low level of airtightness (i.e. below 3 $m^3/m^2/hr$ @50Pa; the building regulations maximum is 10), will require whole house mechanical ventilation, with heat recovery ensuring emissions are reduced. Heat recovery ventilation will actually increase electricity demand as fans run all the time, but overall carbon emissions will go down from the heat saving.

In order to achieve the 32% carbon saving estimated in Table 5-2, this study estimates APEE will have to reduce heat demand by 80% and hot water demand by around 10%.

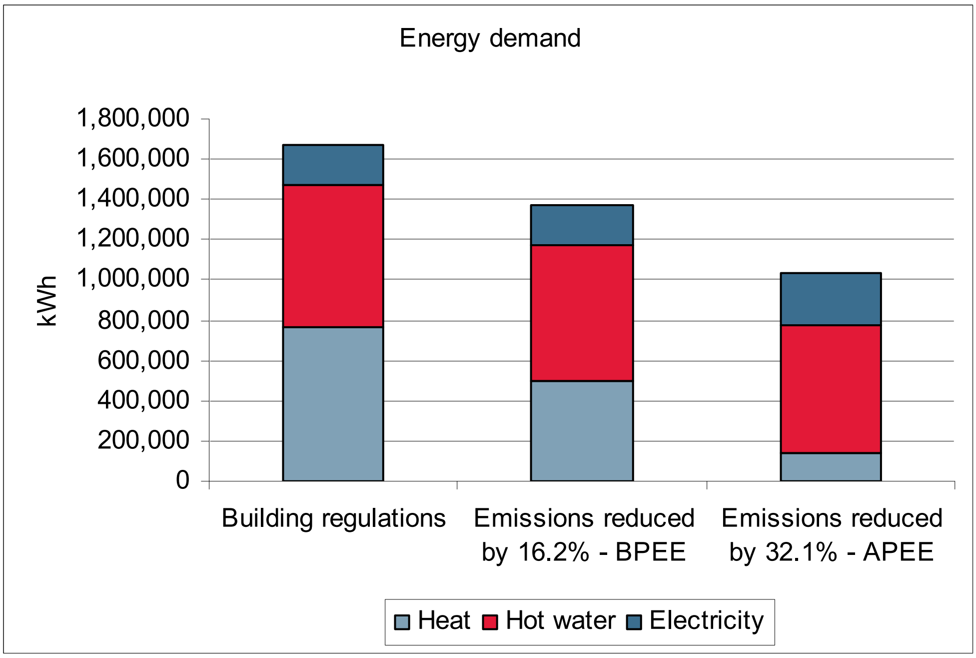
Table 6-2 shows the projected carbon saving and estimated capital costs. The costs are calculated for the Lower Milehouse Lane development based on individual dwellings costs from the CLG Zero Carbon Definition document[6].

Table 6-2: Predicted carbon saving and capital cost of energy efficiency improvements

Energy efficiency standard	Development regulated emissions estimate ($kgCO_2$)	Carbon saving	Capital cost premium	£/tCO_2 saved
Part L 2006	386,920			
Best Practice (BPEE)	324,292	16%	£488,326	£7,797
Advanced Practice (APEE)	262,777	32%	£2,061,327	£16,604

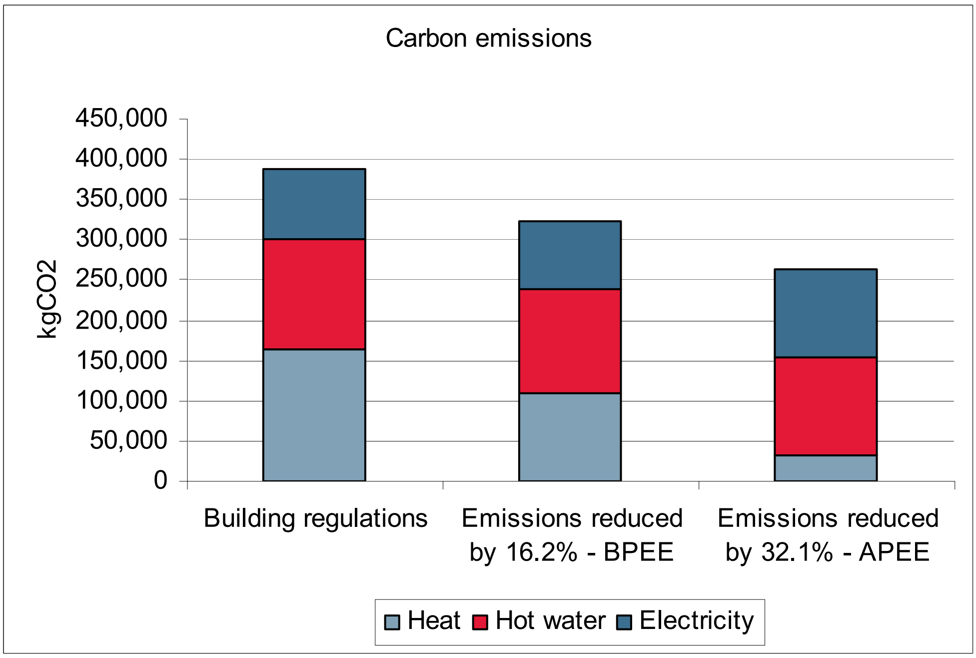
[6] http://www.communities.gov.uk/publications/planningandbuilding/zerocarbondefinition

Figure 6-1: Regulated energy demand for Lower Milehouse Lane broken down for each scenario.



The figure shows heat demand reduces significantly, hot water demand has a small change, but electricity demand increases for APEE due to heat recovery ventilation.

Figure 6-2: Regulated carbon emissions for Lower Milehouse Lane broken down for each scenario.



This mirrors the above figure but for carbon, and shows electricity has a higher carbon impact per kWh than gas.

Figure 6-3: Estimated energy demand for Lower Milehouse Lane, including unregulated demand

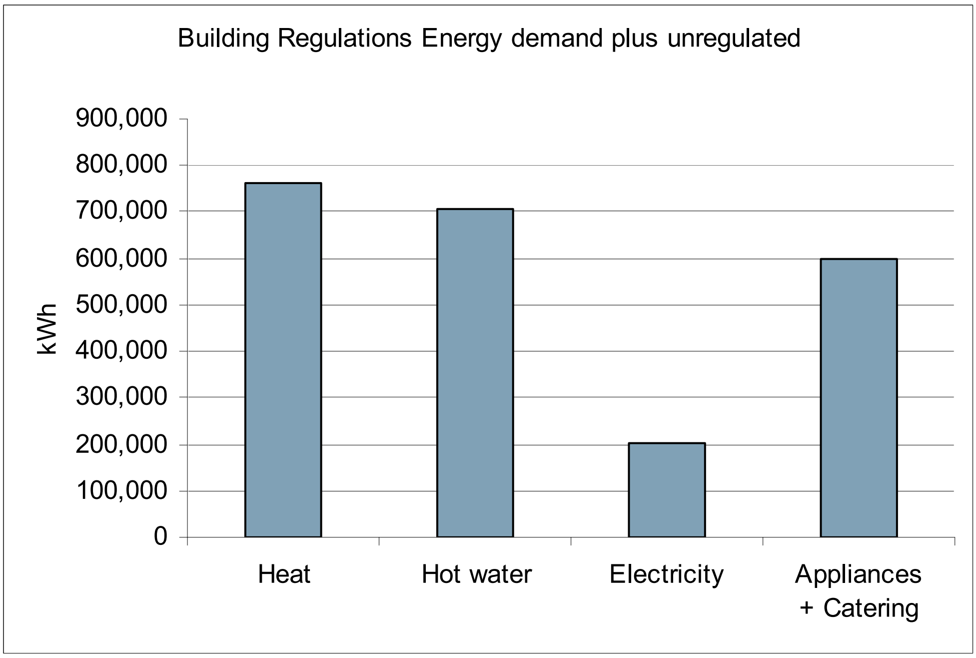
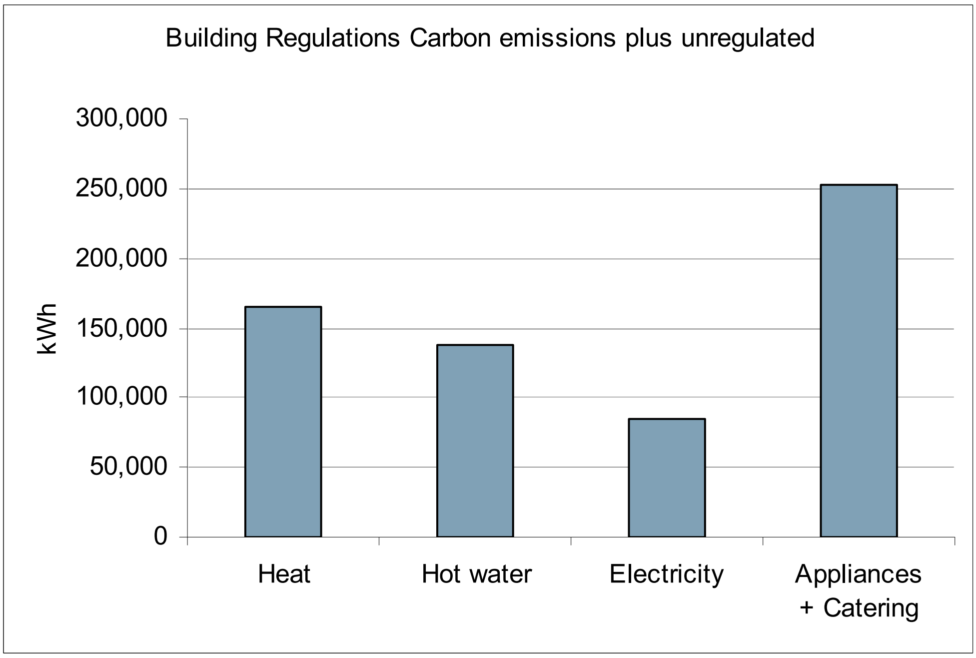


Figure 6-4: Estimated carbon emissions for Lower Milehouse Lane, including unregulated demand



6.1.3 Renewable energy options

With a total of 210 medium to low density dwellings, it is unlikely a communal energy scheme would be viable for this development. This is mainly because the capital cost of connecting dwellings would be high. Also revenues from sale of heat and electricity would not be high enough to sustain an ongoing business model that included administration and maintenance costs.

However, to achieve the higher levels of renewable energy may mean communal heating is required. The business model issues would have to be resolved and could be solved by, for example, adding a gas-fired CHP plant to provide a base revenue.

Biomass has been considered as the only option for communal energy. Ground source heat pumps are unlikely to be sustainable as a long term investment for somebody to manage as part of a community heating scheme (though may be suitable for individual dwellings). There is also not enough demand to make biomass CHP viable, as the smallest engine size currently available is 100kWe.

Also, medium to large scale wind turbines have been discounted. There are too many dwellings and other existing infrastructure in the vicinity of the site to provide a suitable location.

It is worth noting again that the target framework suggests a reduction against regulated emissions (25% and 44%), but the renewable energy reduction is against all remaining emissions plus unregulated. Better energy efficiency means less renewable energy will be required to achieve the percentage renewable energy target.

For a target of 25% regulated emissions reduction and 10% renewable energy, the following three options have been assessed:

1. No energy efficiency improvement over Part L 2006 standard, requiring 15.1% renewable energy to reduce emissions by 96,730 $kgCO_2$.
2. BPEE, requiring 10% renewable energy to reduce emissions by 57,623 $kgCO_2$.
3. APEE, requiring 10% renewable energy to reduce emissions by 51,471 $kgCO_2$.

Solar water heating appears to be the most cost effective option, but will not provide the required 15.1% saving required for Part L 2006 energy efficiency standard. The next best option to provide 15.1% is small scale wind turbines, but in many cases these are not suitable. It is likely for this development that a combination of solar hot water, wind turbines and photovoltaic will be required.

For this analysis it has been assumed that photovoltaic panels are selected for the Part L energy efficiency standard, and solar hot water if a higher level of energy efficiency is achieved.

Table 6-3: Options for 25% regulated emissions reduction, 10% renewable energy, with Part L energy efficiency

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling Size	Per dwelling Capital cost	Per dwelling Annual FIT/RHI revenue
Small Scale Wind Turbines	162	Capacity of turbines (kWe)	15%	£729,349	£45,346	0.8	£3,473	£216
Solar Water Heating	628	Solar panels (m^2)	13%	£549,166	£65,749	3.0	£2,615	£313
Roof Mounted Photovoltaic Panels	1358	PV panels (m^2)	15%	£839,812	£61,311	6.5	£3,999	£292
Ground Source Heat Pump (individual)	457	Heating capacity (kWth)	12%	£239,207	£52,109	2.2	£1,139	£248

Table 6-4: Options for 25% regulated emissions reduction, 10% renewable energy, with BPEE

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling Size	Per dwelling Capital cost	Per dwelling Annual FIT/RHI revenue
Small Scale Wind Turbines	97	Capacity of turbines (kWe)	10%	£435,661	£27,087	0.5	£2,075	£129
Solar Water Heating	439	Solar panels (m^2)	10%	£384,039	£45,979	2.1	£1,829	£219
Roof Mounted Photovoltaic Panels	811	PV panels (m^2)	10%	£501,644	£36,623	3.9	£2,389	£174
Ground Source Heat Pump (individual)	367	Heating capacity (kWth)	9%	£192,126	£40,239	1.7	£915	£192

Table 6-5: Options for 25% regulated emissions reduction, 10% renewable energy, with APEE

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling Size	Per dwelling Capital cost	Per dwelling Annual FIT/RHI revenue
Small Scale Wind Turbines	86	Capacity of turbines (kWe)	10%	£389,153	£24,195	0.4	£1,853	£115
Solar Water Heating	392	Solar panels (m^2)	10%	£343,042	£41,071	1.9	£1,634	£196
Roof Mounted Photovoltaic Panels	725	PV panels (m^2)	10%	£448,092	£32,713	3.5	£2,134	£156
Ground Source Heat Pump (individual)	251	Heating capacity (kWth)	4%	£131,048	£24,676	1.2	£624	£118

For a target of 44% regulated emissions reduction and 20% renewable energy, three options have been assessed:

1. No energy efficiency improvement over Part L 2006 standard, requiring 26.6% renewable energy to reduce emissions by 179,245 $kgCO_2$.
2. BPEE, requiring 20% renewable energy to reduce emissions by 115,246 $kgCO_2$.
3. APEE, requiring 20% renewable energy to reduce emissions by 102,943 $kgCO_2$.

In order to achieve a 44% reduction with BPEE, the level of renewable energy required increases to 28%. The capital cost of the wind and solar options increases, so biomass heating has also been added here. Biomass heating would have a high investment cost for an underground heat network, however this looks to be less than the cost of photovoltaic panels for the Part L 2006 energy efficiency standard. With improved energy efficiency to BPEE and APEE, the amount of renewable energy required is much lower, and photovoltaic panels are now the most cost effective option.

For small scale wind, between 173kW and 286kW is required. This would mean a lot of roof mounted turbines, which would be unlikely to provide the preferred solution.

Additionally, the maximum potential of the solar hot water can be seen. The solar hot water panel size is limited to providing 60% of the hot water demand. Heat pumps have not been included as they serve heating and hot water, but use additional electricity, so savings are limited. Neither technology would be able to achieve the required reduction on its own, but could be combined with photovoltaic panels, for example.

Table 6-6: Options for 44% regulated emissions reduction, 20% renewable energy, with Part L energy efficiency

						Per dwelling		
Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Size	Capital cost	Annual FIT/RHI revenue
Small Scale Wind Turbines	286	Capacity of turbines (kWe)	27%	£1,284,813	£79,882	1.4	£6,118	£380
Solar Water Heating	628	Solar panels (m^2)	13%	£549,166	£65,749	3.0	£2,615	£313
Biomass Heating (communal)	299	Heating capacity (kWth)	27%	£1,441,886	£80,772	1.4	£6,866	£385
Roof Mounted Photovoltaic Panels	2393	PV panels (m^2)	27%	£1,479,404	£108,005	11.4	£7,045	£514

Table 6-7: Options for 44% regulated emissions reduction, 20% renewable energy, with BPEE

						Per dwelling		
Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Size	Capital cost	Annual FIT/RHI revenue
Small Scale Wind Turbines	194	Capacity of turbines (kWe)	20%	£871,323	£54,174	0.9	£4,149	£258
Solar Water Heating	596	Solar panels (m^2)	14%	£521,708	£62,462	2.8	£2,484	£297
Biomass Heating (communal)	203	Heating capacity (kWth)	20%	£1,339,645	£54,778	1.0	£6,379	£261
Roof Mounted Photovoltaic Panels	1623	PV panels (m^2)	20%	£1,003,289	£73,246	7.7	£4,778	£349

Table 6-8: Options for 44% regulated emissions reduction, 20% renewable energy, with APEE

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling Size	Per dwelling Capital cost	Per dwelling Annual FIT/RHI revenue
Small Scale Wind Turbines	173	Capacity of turbines (kWe)	20%	£778,306	£48,390	0.8	£3,706	£230
Solar Water Heating	565	Solar panels (m^2)	14%	£494,250	£59,174	2.7	£2,354	£282
Biomass Heating (communal)	181	Heating capacity (kWth)	20%	£1,316,645	£48,930	0.9	£6,270	£233
Roof Mounted Photovoltaic Panels	1449	PV panels (m^2)	20%	£896,184	£65,427	6.9	£4,268	£312

For a target of zero carbon, three options have been assessed:

1. No energy efficiency improvement over Part L 2006 standard, requiring 42.4% renewable energy to reduce emissions by 270,844 $kgCO_2$.
2. BPEE, requiring 36.1% renewable energy to reduce emissions by 208,215 $kgCO_2$.
3. APEE, requiring 28.5% renewable energy to reduce emissions by 146,701 $kgCO_2$.

Each of these options will give a 70% regulated emissions reduction. To achieve zero carbon, the developer will be required to purchase allowable solutions to offset 368,012 $kgCO_2$, costing £1,104,032.

The options for achieving zero carbon for Milehouse Lane are biomass community heating and photovoltaic panels. The ongoing management and maintenance requirements of a biomass heating system still remain a risk for this development. It would be the cheapest option, but photovoltaic panels would be simpler. If APEE is used to reduce the renewable energy required to 29%, photovoltaic panels become the recommended option.

Table 6-9: Options for zero carbon, with Part L energy efficiency

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling Size	Per dwelling Capital cost	Per dwelling Annual FIT/RHI revenue
Small Scale Wind Turbines	455	Capacity of turbines (kWe)	42%	£2,047,972	£127,330	2.2	£9,752	£606
Solar Water Heating	628	Solar panels (m^2)	13%	£549,166	£65,749	3.0	£2,615	£313
Biomass Heating (communal)	477	Heating capacity (kWth)	42%	£1,630,586	£128,750	2.3	£7,765	£613
Roof Mounted Photovoltaic Panels	3814	PV panels (m^2)	42%	£2,358,148	£172,158	18.2	£11,229	£820

Table 6-10: Options for zero carbon, with BPEE

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling		
						Size	Capital cost	Annual FIT/RHI revenue
Small Scale Wind Turbines	349	Capacity of turbines (kWe)	36%	£1,572,737	£97,783	1.7	£7,489	£466
Solar Water Heating	596	Solar panels (m^2)	14%	£521,708	£62,462	2.8	£2,484	£297
Biomass Heating (communal)	366	Heating capacity (kWth)	36%	£1,513,078	£98,873	1.7	£7,205	£471
Roof Mounted Photovoltaic Panels	2929	PV panels (m^2)	36%	£1,810,936	£132,209	13.9	£8,624	£630

Table 6-11: Options for zero carbon, with APEE

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling		
						Size	Capital cost	Annual FIT/RHI revenue
Small Scale Wind Turbines	246	Capacity of turbines (kWe)	29%	£1,109,085	£68,956	1.2	£5,281	£328
Solar Water Heating	565	Solar panels (m^2)	14%	£494,250	£59,174	2.7	£2,354	£282
Biomass Heating (communal)	258	Heating capacity (kWth)	29%	£1,398,435	£69,725	1.2	£6,659	£332
Roof Mounted Photovoltaic Panels	2065	PV panels (m^2)	29%	£1,277,062	£93,233	9.8	£6,081	£444

6.1.4 Proposed strategy for Lower Milehouse Lane

It can be seen from the above analysis that, if a site-wide community energy scheme can be shown to be financially sustainable, higher targets for renewable energy could be achieved.

Table 6-12 shows the renewable energy selected above for each option. Total energy cost has been calculated by adding together the cost of energy efficiency, renewable energy, and allowable solutions (for zero carbon). For further comparison, the capitalised FIT/RHI/ESCO revenue discussed in section 5.2, has also been taken away and is shown in the final column. Options with and without capitalisation are shown graphically in Figure 6-5.

It is shown that for all three target levels APEE is an expensive solution, with the additional cost not justified by the reduced cost of renewable energy. This is also apparent for BPEE, although the cost difference is not as pronounced.

For the 25% target, the developer is advised to consider BPEE with solar hot water. It is more expensive than the Part L efficiency option with PV, but the energy efficiency costs could be reduced and the benefits of improved insulation will have a longer life. This would work out at around £4,200 per dwelling extra over cost, reducing to £3,000 with capitalised revenue.

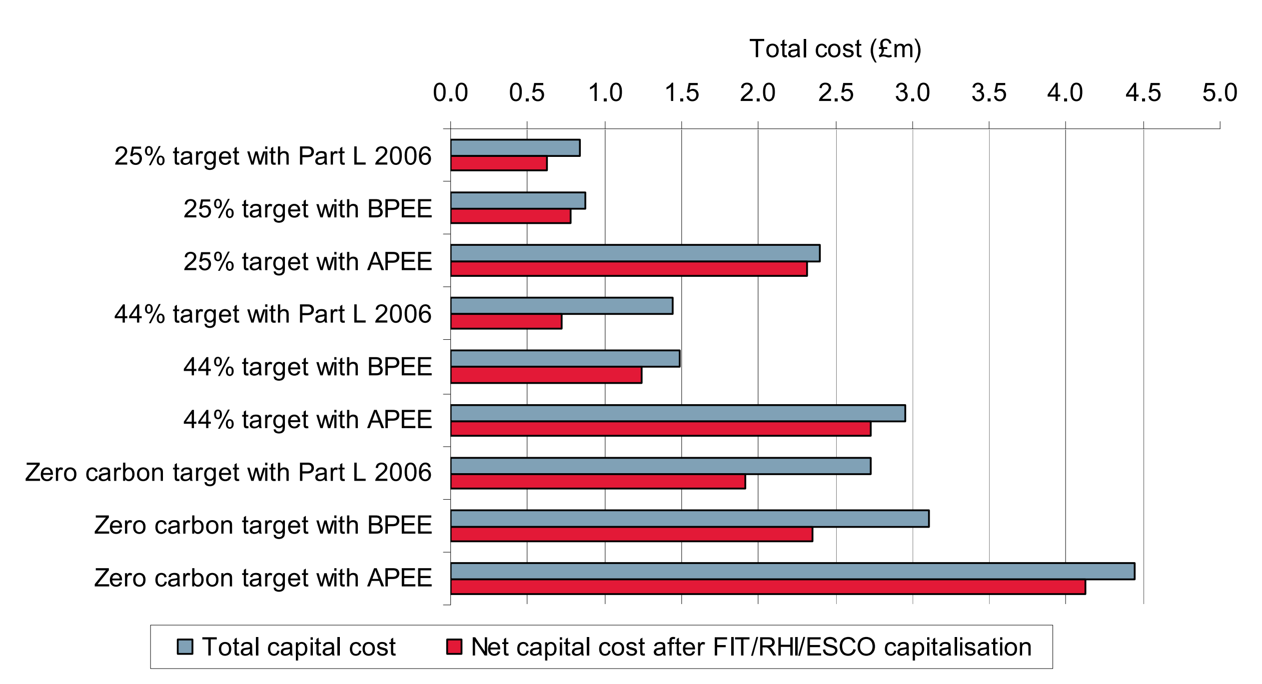
For the 44% target, Part L with biomass and BPEE with PV have similar total capital costs. However if an ESCO can be set up the reduction in capital cost makes Part L with biomass the clear favourite. This would add around £3,433 per dwelling extra over cost.

For zero carbon biomass communal heating from an ESCO would be advisable. This would add around £9,140 per dwelling extra over cost. With this and the 44% target, developers should always be encouraged to improve energy efficiency as much as possible where it can be achieved at low cost.

Table 6-12: Total cost of energy efficiency and renewable energy options

Target	EE standard	EE cost	Most suitable RE	Capital cost	Allowable solutions capital cost	Total capital cost	Net capital cost after FIT/RHI/ESCO capitalisation
25%	Part L 2006	£0	Roof Mounted Photovoltaic Panels	£839,812		£839,812	£629,859
25%	BPEE	£488,326	Solar Water Heating	£384,039		£872,365	£776,356
25%	APEE	£2,061,327	Solar Water Heating	£343,042		£2,404,369	£2,318,608
44%	Part L 2006	£0	Biomass Heating (communal)	£1,441,886		£1,441,886	£720,943
44%	BPEE	£488,326	Roof Mounted Photovoltaic Panels	£1,003,289		£1,491,615	£1,240,793
44%	APEE	£2,061,327	Roof Mounted Photovoltaic Panels	£896,184		£2,957,511	£2,733,465
Zero carbon	Part L 2006	£0	Biomass Heating (communal)	£1,630,586	£1,104,037	£2,734,623	£1,919,330
Zero carbon	BPEE	£488,326	Biomass Heating (communal)	£1,513,078	£1,104,037	£3,105,441	£2,348,902
Zero carbon	APEE	£2,061,327	Roof Mounted Photovoltaic Panels	£1,277,062	£1,104,037	£4,442,426	£4,123,160

Figure 6-5: Total cost of energy efficiency and renewable energy options



6.2 Anker Valley, Tamworth

6.2.1 Schedule of accommodation

As this development is at an early stage, an estimate has been made of what may be built. The accommodation schedule below is based on information received but may not reflect the final development.

Table 6-13: Predicted accommodation schedule for Anker Valley, used in calculations

Unit type	Number of units	Average floor area (m^2)	Total floor area (m^2)
Apartments in 3/4 storey blocks	150	60	9,000
Terraced houses	500	77	38,500
Semi-detached/ and end terraces	300	93	27,900
Detached houses	200	106	21,200
Retail (5 units at 50m^2 each)	5	50	250
Health centre	1	2,000	2,000
Community centre	1	400	400
Primary/Junior school	1	3,000	3,000
Domestic total	**1,150**		**96,600**
Non domestic total	**8**		**5,650**

The above accommodation schedule was used together with Camco's in-house software to get an estimate of the energy demand.

6.2.2 Energy demand and efficiency savings

94% of the development is residential, therefore this will dominate the overall site energy demand, even though dwellings typically have lower energy demand per square metre than commercial buildings. An assumption of the dwelling mix has been made - apartments, semi–detached, detached and terraced houses. As the development is predicted to be mainly houses, most energy efficiency savings will come from reducing heat demand. This can be done through a number of measures, including:

- Improved insulation U-values for walls, floors, roofs, doors and windows
- Higher boiler efficiencies, which should also reduce hot water emissions
- More airtight dwellings, which reduces heat loss through infiltration
- Heat recovery ventilation

In a detached house heating demand could make up 60% of the regulated emissions, hence a 50% reduction would be 30% overall. On the other hand, heating demand for an apartment with only one external wall might be only 20% of the regulated emissions. Hence the maximum efficiency saving from an apartment block might only be 10%, whereas a detached house could achieve 30%.

There is little opportunity to reduce electricity demand within the SAP calculation.

For the non-residential buildings, it should also be possible to get a significant reduction in heat demand compared to the building regulations standard. There is also opportunity for carbon savings from a more energy efficient lighting design and cooling systems. These have been considered here, noting that they are broad assumptions as nothing is known about the design of these non-residential buildings.

It is estimated for this development that BPEE will reduce heat demand by 30% and hot water demand by around 5%, giving an overall carbon saving of 16%.

APEE would require super-insulation, triple glazing, and a level of build quality that is not yet common in UK construction. The low level of airtightness (i.e. below 3 $m^3/m^2/hr$ @50Pa; the building regulations maximum is 10), will require whole house mechanical ventilation, with heat recovery ensuring emissions are reduced. Heat recovery ventilation will actually increase electricity demand as fans run all the time, but overall carbon emissions will reduce from the heat saving.

In order to achieve the 31% carbon saving estimated in Table 5-2**, it is estimated that APEE will have to reduce heat demand by 70% and hot water demand by around 10%.**

Table 6-14 shows the projected carbon saving and estimated capital costs. The costs are calculated for the Anker Valley development based on individual dwellings costs from the CLG Zero Carbon Definition document.

Table 6-14: Predicted carbon saving and capital cost of energy efficiency improvements

Energy efficiency standard	Development regulated emissions estimate ($kgCO_2$)		Capital cost premium	£/tCO_2 saved
Part L 2006	2,248,340			
Best Practice (BPEE)	1,887,291	16%	£3,949,847	£10,940
Advanced Practice (APEE)	1,561,518	31%	£8,812,597	£12,831

Figure 6-6 shows heat demand reduces significantly, hot water demand stays the same, but electricity demand increases due to heat recovery ventilation.

Figure 6-6: Regulated energy demand for Anker Valley broken down for each scenario.

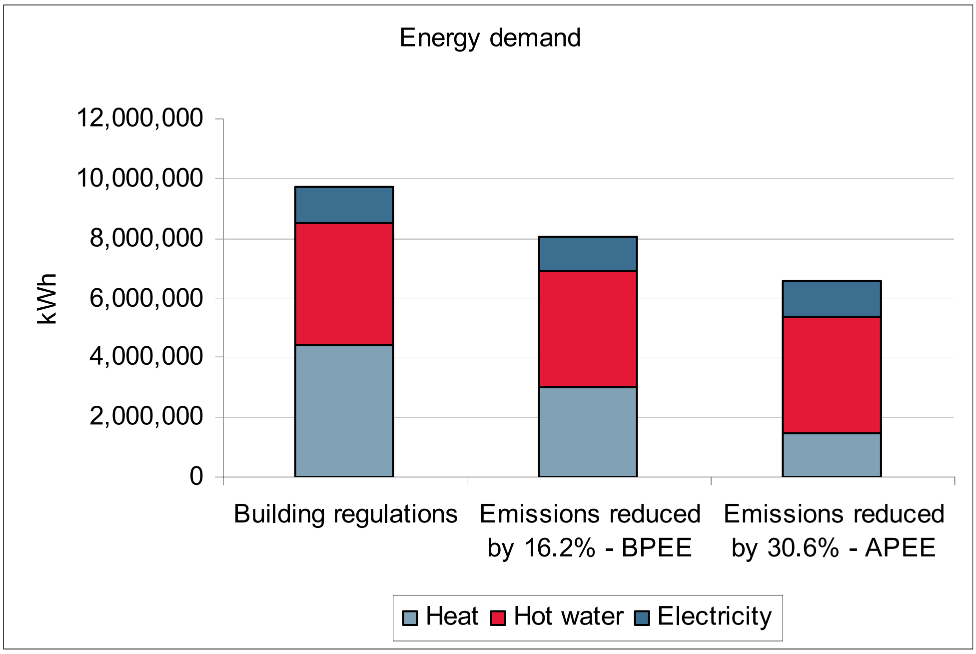
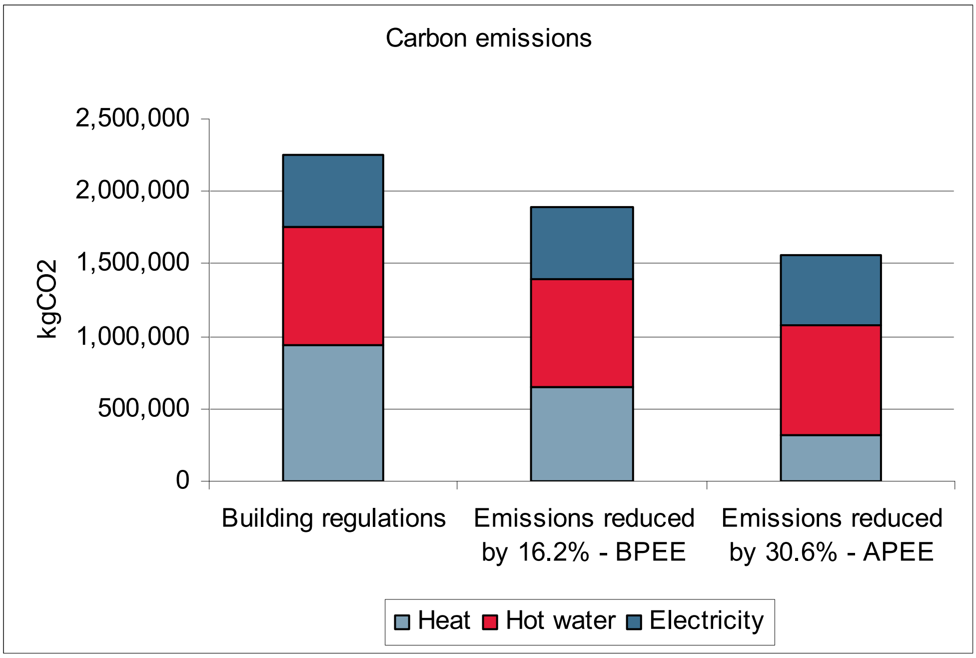


Figure 6-7: Regulated carbon emissions for Anker Valley broken down for each scenario.



This mirrors Figure 6-6 but for carbon, showing electricity has a higher carbon impact per kWh than gas.

Figure 6-8: Estimated energy demand for Anker Valley, including unregulated demand

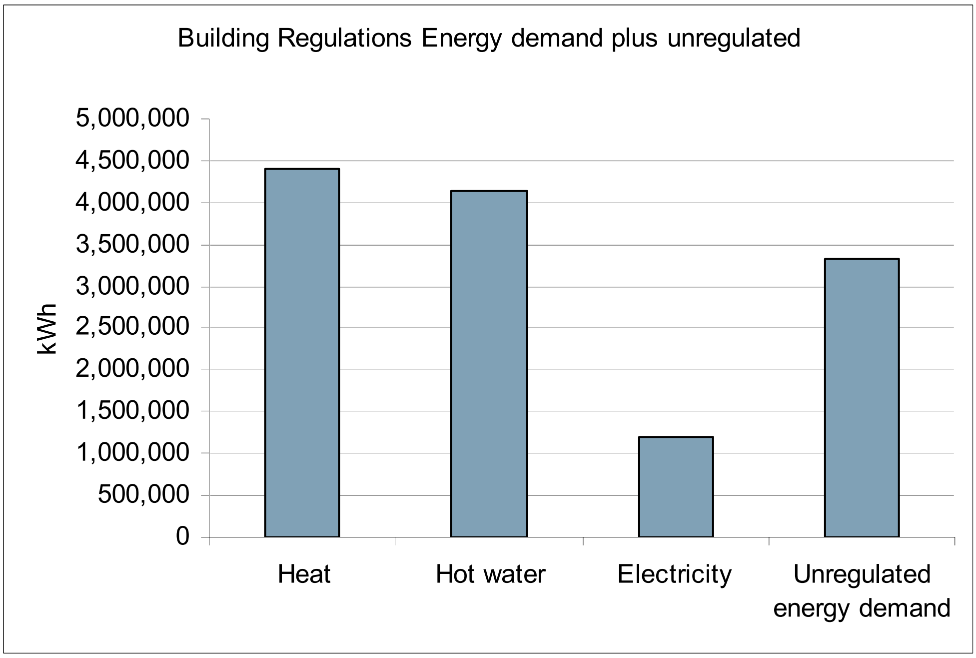
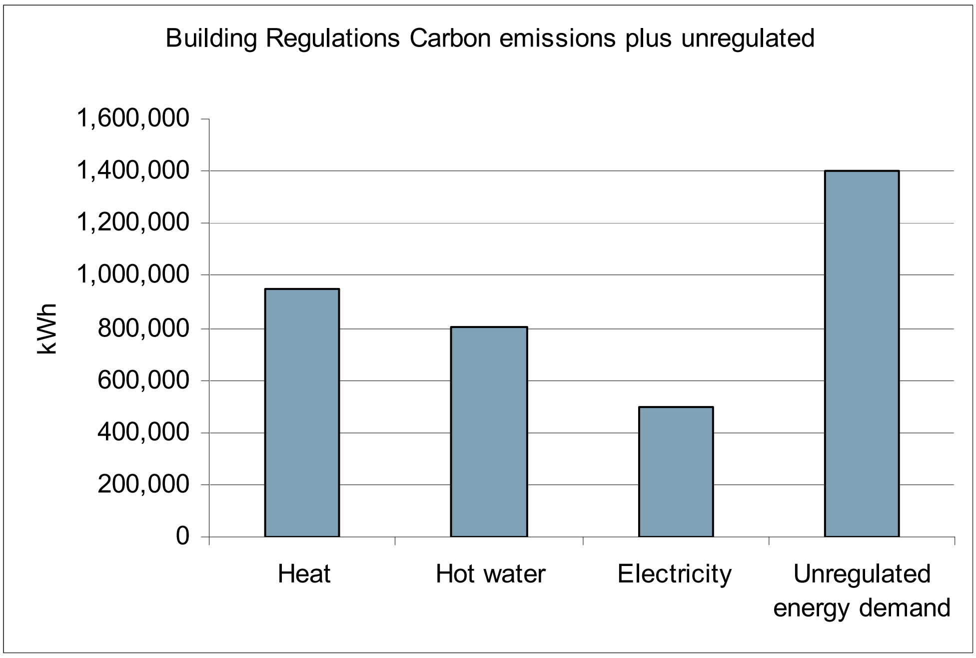


Figure 6-9: Estimated carbon emissions for Anker Valley, including unregulated demand



6.2.3 Renewable energy options

A development of this scale should be a good candidate for a communal energy network, generating heat and electricity centrally. The scale should provide long term efficiencies in comparison to a smaller development. It would also provide higher revenues. This high revenue - low risk model will be of greater interest to organisations looking to manage the system, when compared to smaller sites. The development also contains a small amount of non-residential buildings. They only make up 6% of the overall development area (according to estimates used in this study), but will make a useful contribution to the energy demand. The buildings will have heat demand during the day (when most houses are unoccupied), helping to balance out the overall system baseload. A steady baseload means technologies like CHP and biomass can run more efficiently and provide a greater proportion of the overall energy demand.

However, investment in the network will be high, as the development is expected to be of medium density. Costs in this assessment have been estimated to include for a communal energy network. These are budget costs based on a number of assumptions. It is strongly recommended that a more detailed pre-feasibility study is undertaken into the potential for communal energy.

As with the other housing developments in this study, estimates have been made about capital cost on a per dwelling basis. The “per dwelling” figures under the light blue headings are simply the equivalent dark blue headings divided by the number of dwellings. This is a reasonable approximation to make as 94% of the development is residential.

If a cost per square metre comparison is required, the costs can simply be divided by the total development area of 102,250 m^2.

It is worth noting again that the target framework suggests a reduction against regulated emissions (25% and 44%), but the renewable energy reduction is against all remaining emissions plus unregulated. Better energy efficiency means less renewable energy will be required to achieve the percentage renewable energy target.

For a target of 25% regulated emissions reduction and 10% renewable energy, three options have been assessed:

1. No energy efficiency improvement over Part L 2006 standard, requiring 15.4% renewable energy to reduce emissions by 562,085 $kgCO_2$.
2. BPEE, requiring 10% renewable energy to reduce emissions by 328,725 $kgCO_2$.
3. APEE, requiring 10% renewable energy to reduce emissions by 296,148 $kgCO_2$.

The most cost effective solution for Anker Valley would be large scale wind turbines – namely a single turbine approximately 100m in height. There could be land surrounding the site that is suitable for a large wind turbine, therefore it has been included it. In the SES study only large wind has been considered for Anker Valley. The suitability has not been assessed in detail for the development. It is included as an option for all percentage renewable energy scenarios, with one turbine having the potential to reduce CO_2 emissions by 50%. However, it has not been selected as a recommended technology as it may not be possible to get planning permission. It is recommended that a more detailed study be completed.

Solar water heating on roofs of houses would be most suitable for a 10% renewable energy reduction. But if the energy efficiency standard is only Part L 2006, solar hot water will not be sufficient to provide the 15.4% saving required. Therefore solar photovoltaic panels are recommended if solar hot water cannot provide sufficient savings.

Photovoltaic panels are an expensive option, but can often provide the most pragmatic solution. The cost could be reduced by installing larger systems on fewer dwellings, or on the non-residential properties.

Small scale wind turbines may be appropriate if they can be suitably sited. An option may be to have a number of 15kW turbines on land surrounding the development.

If the development is only looking to achieve the lower target, it is unlikely that a communal energy system would be feasible. Therefore it is not included here, but is considered when looking at higher targets.

Table 6-15: Options for 25% regulated emissions reduction, 10% renewable energy, with Part L energy efficiency

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling Size	Per dwelling Capital cost	Per dwelling Annual FIT/RHI revenue
Small Scale Wind Turbines	947	Capacity of turbines (kWe)	15%	£4,259,496	£264,829	0.8	£3,704	£230
Solar Water Heating	3664	Solar panels (m^2)	13%	£3,206,415	£383,890	3.2	£2,788	£334
Medium/ Large Scale Wind Turbines	703	Capacity of turbines (kWe)	15%	£702,596	£186,472	0.6	£611	£162
Roof Mounted Photovoltaic Panels	7932	PV panels (m^2)	15%	£4,904,619	£358,065	6.9	£4,265	£311
Ground Source Heat Pump (individual)	2675	Heating capacity (kWth)	12%	£3,210,189	£406,529	2.3	£2,791	£354

Table 6-16: Options for 25% regulated emissions reduction, 10% renewable energy, with BPEE

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling Size	Per dwelling Capital cost	Per dwelling Annual FIT/RHI revenue
Small Scale Wind Turbines	558	Capacity of turbines (kWe)	10%	£2,510,561	£156,091	0.5	£2,183	£136
Solar Water Heating	2498	Solar panels (m^2)	10%	£2,185,352	£261,643	2.2	£1,900	£228
Medium/ Large Scale Wind Turbines	414	Capacity of turbines (kWe)	10%	£414,112	£109,907	0.4	£360	£96
Roof Mounted Photovoltaic Panels	4675	PV panels (m^2)	10%	£2,890,799	£211,045	4.1	£2,514	£184
Ground Source Heat Pump (individual)	2205	Heating capacity (kWth)	10%	£2,646,216	£325,067	1.9	£2,301	£283

Table 6-17: Options for 25% regulated emissions reduction, 10% renewable energy, with APEE

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling Size	Per dwelling Capital cost	Per dwelling Annual FIT/RHI revenue
Small Scale Wind Turbines	503	Capacity of turbines (kWe)	10%	£2,264,257	£140,778	0.4	£1,969	£122
Solar Water Heating	2249	Solar panels (m^2)	10%	£1,968,233	£235,648	2.0	£1,712	£205
Medium/ Large Scale Wind Turbines	373	Capacity of turbines (kWe)	10%	£373,485	£99,124	0.3	£325	£86
Roof Mounted Photovoltaic Panels	4217	PV panels (m^2)	10%	£2,607,191	£190,340	3.7	£2,267	£166
Ground Source Heat Pump (individual)	1766	Heating capacity (kWth)	6%	£2,118,813	£244,217	1.5	£1,842	£212

For a target of 44% regulated emissions reduction and 20% renewable energy, three options have been assessed:

1. No energy efficiency improvement over Part L 2006 standard, requiring 27.1% renewable energy to reduce emissions by 989,269 $kgCO_2$.
2. BPEE, requiring 20% renewable energy to reduce emissions by 657,450 $kgCO_2$.
3. APEE, requiring 20% renewable energy to reduce emissions by 592,295 $kgCO_2$.

Without any energy efficiency improvement over Part L 2006, heat demand is sufficient for biomass community heating. The development is also large enough to make biomass CHP cost effective.

Once energy efficiency standards are improved to advanced practice, the biomass CHP is not required to provide as much heat, but still has a high capital cost for the community heating system. At this point simply installing photovoltaic panels on each house becomes the best solution.

Solar hot water panels will no longer generate enough energy for this target, as they are limited by development hot water demand. In a communal system there is opportunity for solar hot water panels to provide heating, but with an alternative low carbon heat source (such as biomass) the benefits are not as great.

Ground source heat pumps have also been discounted, as a maximum emissions reduction of less than 10% is estimated, based on the Anker Valley accommodation schedule. However, it would be possible to combine the heat pumps or solar hot water with another technology, such as photovoltaic panels, to get the overall target reduction.

Table 6-18: Options for 44% regulated emissions reduction, 20% renewable energy, with Part L energy efficiency

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling		
						Size	Capital cost	Annual FIT/RHI revenue
Biomass CHP (communal)	233	CHP size (kWe)	27%	£7,933,335	£320,726	0.2	£6,899	£279
Biomass Heating (communal)	1796	Heating capacity (kWth)	28%	£8,636,478	£485,020	1.6	£7,510	£422
Medium/ Large Scale Wind Turbines	1236	Capacity of turbines (kWe)	27%	£1,236,387	£328,142	1.1	£1,075	£285
Roof Mounted Photovoltaic Panels	13959	PV panels (m^2)	27%	£8,630,855	£630,102	12.1	£7,505	£548

Table 6-19: Options for 44% regulated emissions reduction, 20% renewable energy, with BPEE

						Per dwelling		
Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Size	Capital cost	Annual FIT/RHI revenue
Biomass CHP (communal)	156	CHP size (kWe)	20%	£7,639,760	£214,846	0.1	£6,643	£187
Biomass Heating (communal)	1211	Heating capacity (kWth)	21%	£8,014,677	£326,925	1.1	£6,969	£284
Medium/ Large Scale Wind Turbines	828	Capacity of turbines (kWe)	20%	£828,225	£219,814	0.7	£720	£191
Roof Mounted Photovoltaic Panels	9351	PV panels (m^2)	20%	£5,781,597	£422,090	8.1	£5,027	£367

Table 6-20: Options for 44% regulated emissions reduction, 20% renewable energy, with APEE

						Per dwelling		
Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Size	Capital cost	Annual FIT/RHI revenue
Biomass CHP (communal)	141	CHP size (kWe)	20%	£7,581,317	£193,768	0.1	£6,592	£168
Biomass Heating (communal)	1096	Heating capacity (kWth)	21%	£7,892,874	£295,956	1.0	£6,863	£257
Medium/ Large Scale Wind Turbines	747	Capacity of turbines (kWe)	20%	£746,970	£198,249	0.6	£650	£172
Roof Mounted Photovoltaic Panels	8433	PV panels (m^2)	20%	£5,214,382	£380,680	7.3	£4,534	£331

For a target of zero carbon, three options have been assessed:

1. No energy efficiency improvement over Part L 2006 standard, requiring 43.1% renewable energy to reduce emissions by 1,573,838 kgCO_2.
2. BPEE, requiring 36.9% renewable energy to reduce emissions by 1,212,789 kgCO_2.
3. APEE, requiring 30% renewable energy to reduce emissions by 887,016 kgCO_2.

Each of these options will give a 70% regulated emissions reduction. To achieve zero carbon, the developer will be required to purchase allowable solutions to offset 2,074,461 kgCO_2, costing £6,223,384.

With a zero carbon target, biomass CHP becomes the clear solution for this large development.

FIT/RHI revenues for photovoltaic panels still show it to be a favourable option. However, it is likely that a business case for community heating should be able to provide a long term financially sustainable scheme. Again, this will require a much more detailed analysis.

Table 6-21: Options for zero carbon, with Part L energy efficiency

						Per dwelling		
Technology	**Size**	**Units**	**% Carbon saving**	**Capital cost**	**Annual FIT/RHI revenue**	**Size**	**Capital cost**	**Annual FIT/RHI revenue**
Biomass CHP (communal)	354	CHP size (kWe)	41%	£8,394,561	£487,069	0.3	£7,300	£424
Solar Water Heating	3664	Solar panels (m^2)	13%	£3,206,415	£383,890	3.2	£2,788	£334
Biomass Heating (communal)	2844	Heating capacity (kWth)	44%	£9,749,280	£767,953	2.5	£8,478	£668
Medium/ Large Scale Wind Turbines	1966	Capacity of turbines (kWe)	43%	£1,966,357	£521,878	1.7	£1,710	£454
Roof Mounted Photovoltaic Panels	22200	PV panels (m^2)	43%	£13,726,563	£1,002,118	19.3	£11,936	£871

Table 6-22: Options for zero carbon, with BPEE

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling: Size	Per dwelling: Capital cost	Per dwelling: Annual FIT/RHI revenue
Biomass CHP (communal)	284	CHP size (kWe)	36%	£8,128,275	£391,032	0.2	£7,068	£340
Solar Water Heating	3451	Solar panels (m^2)	14%	£3,019,265	£361,484	3.0	£2,625	£314
Biomass Heating (communal)	2218	Heating capacity (kWth)	38%	£9,083,945	£598,790	1.9	£7,899	£521
Medium/ Large Scale Wind Turbines	1528	Capacity of turbines (kWe)	37%	£1,528,075	£405,557	1.3	£1,329	£353
Roof Mounted Photovoltaic Panels	17252	PV panels (m^2)	37%	£10,667,046	£778,755	15.0	£9,276	£677

Table 6-23: Options for zero carbon, with APEE

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling: Size	Per dwelling: Capital cost	Per dwelling: Annual FIT/RHI revenue
Biomass CHP (communal)	211	CHP size (kWe)	30%	£7,849,585	£290,521	0.2	£6,826	£253
Solar Water Heating	3451	Solar panels (m^2)	15%	£3,019,265	£361,484	3.0	£2,625	£314
Biomass Heating (communal)	1635	Heating capacity (kWth)	31%	£8,464,675	£441,339	1.4	£7,361	£384
Medium/ Large Scale Wind Turbines	1120	Capacity of turbines (kWe)	30%	£1,120,455	£297,373	1.0	£974	£259
Roof Mounted Photovoltaic Panels	12650	PV panels (m^2)	30%	£7,821,573	£571,020	11.0	£6,801	£497

6.2.4 Proposed strategy for Anker Valley

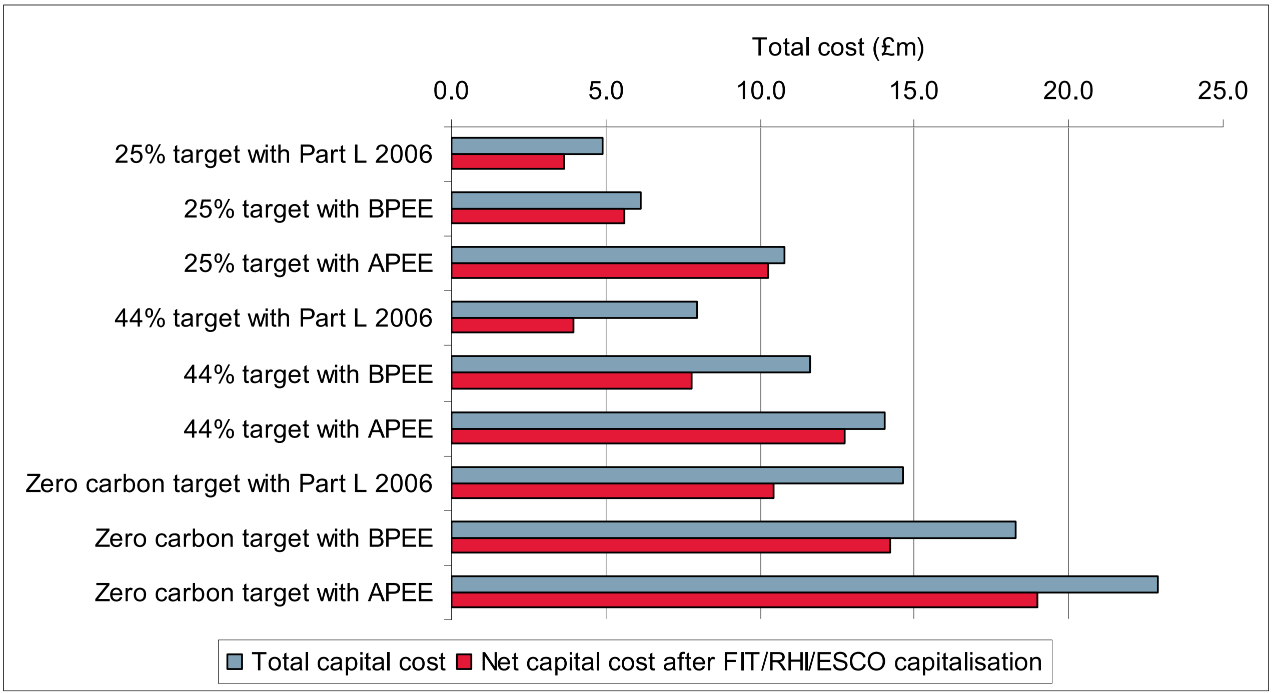
The large development planned for Anker Valley in Tamworth presents a range of opportunities for low and zero carbon technologies. For a development of this scale, it is strongly recommended that these options are explored in detail before a decision is made. Feasibility studies should be commissioned that look at communal heating systems and large scale wind in more detail, including production of business models and analysing investment potential. The correct time to do this is debatable. It should be considered at an early stage, but masterplan drawings for the development may be required to get an estimate of the underground heating network costs. Ideally an experienced consultant should feed into the masterplanning process, to further explore the potential of achieving the best possible carbon standards.

Table 6-24 shows the renewable energy selected above for each option. The capitalised FIT/RHI revenue is taken away from the renewable energy capital cost, then energy efficiency and allowable solutions (for zero carbon) costs added, to provide the total net energy cost. Options are then compared graphically in Figure 6-10.

Table 6-24: Total net energy cost of energy efficiency and renewable energy options

Target	EE standard	EE cost	Most suitable RE	Capital cost	Allowable solutions capital cost	Total capital cost	Total Energy Cost net
25%	Part L 2006	£0	Roof Mounted Photovoltaic Panels	£4,904,619		£4,904,619	£3,678,464
25%	BPEE	£3,949,847	Solar Water Heating	£2,185,352		£6,135,198	£5,588,860
25%	APEE	£8,812,597	Solar Water Heating	£1,968,233		£10,780,829	£10,288,771
44%	Part L 2006	£0	Biomass CHP (communal)	£7,933,335		£7,933,335	£3,966,667
44%	BPEE	£3,949,847	Biomass CHP (communal)	£7,639,760		£11,589,606	£7,769,726
44%	APEE	£8,812,597	Roof Mounted Photovoltaic Panels	£5,214,382		£14,026,979	£12,723,383
Zero carbon	Part L 2006	£0	Biomass CHP (communal)	£8,394,561	£6,223,384	£14,617,945	£10,420,665
Zero carbon	BPEE	£3,949,847	Biomass CHP (communal)	£8,128,275	£6,223,384	£18,301,505	£14,237,368
Zero carbon	APEE	£8,812,597	Biomass CHP (communal)	£7,849,585	£6,223,384	£22,885,566	£18,960,773

Figure 6-10: Total net energy cost of energy efficiency and renewable energy options



6.3 Holt Lane, Kingsley

Table 6-25: Schedule of accommodation

Unit type	Number of units	Average floor area (m^2)	Total floor area (m^2)
2 bed semi detached	8	90	720

The above accommodation schedule and Camoo's in-house software have been used to get an estimate of the energy demand.

6.3.1 Energy demand and efficiency savings

All dwellings are small semi-detached houses. This means they have a large external wall area, resulting in higher heat loss through the building fabric than for an average dwelling. The focus for reducing emissions from these dwellings would most likely be to minimise this heat loss. It is a similar strategy to that for Lower Milehouse Lane; the larger heat loss area for Holt Lane dwellings (on average) should present a greater percentage opportunity for reducing heat loss. The main options for reducing heat loss are repeated from above, as follows:

- Improved insulation U-values for walls, floors, roofs, doors and windows
- Higher boiler efficiencies, which should also reduce hot water emissions
- More airtight dwellings, which reduces heat loss through infiltration
- Heat recovery ventilation

In a semi-detached house heating demand could make up 50% of the regulated emissions, hence a 50% reduction would be 25% overall.

There is little opportunity to reduce electricity demand within the SAP calculation.

It is estimated for this development that BPEE will reduce heat demand by 30% and hot water demand by around 5%, giving an overall carbon saving of 14%.

APEE would require super-insulation, triple glazing, and a level of build quality that is not yet common in UK construction. The low level of airtightness (i.e. below 3 $m^3/m^2/hr$ @50Pa; the building regulations maximum is 10), will require whole house mechanical ventilation, with heat recovery ensuring emissions are reduced. Heat recovery ventilation will actually increase electricity demand as fans run all the time, but overall carbon emissions will reduce from the heat saving.

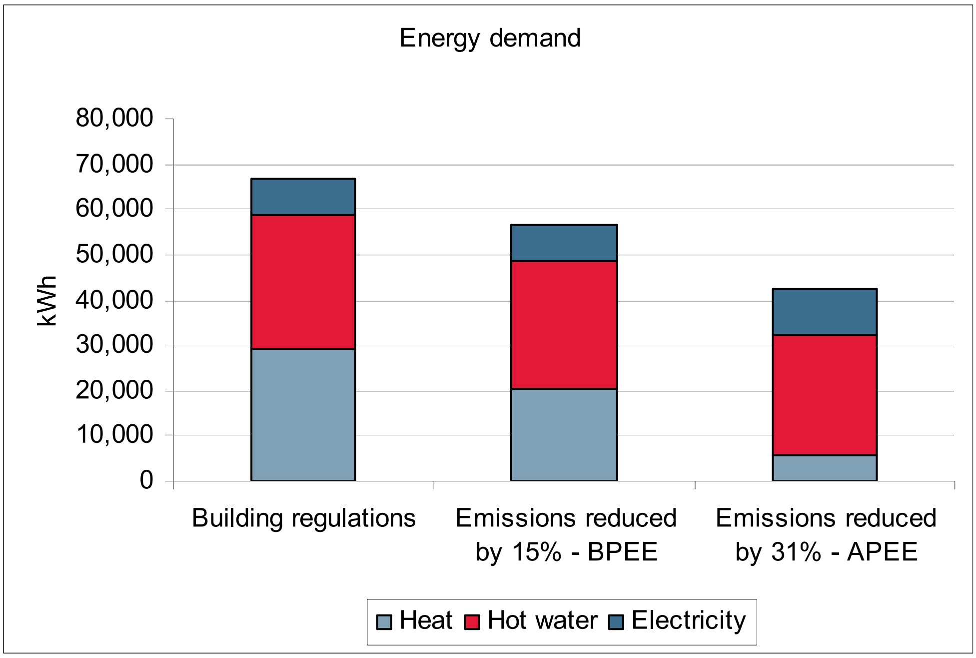
In order to achieve the 31% carbon saving estimated in Table 5-2**, it is estimated APEE will have to reduce heat demand by 80% and hot water demand by around 10%.**

Table 6-26 shows the projected carbon saving and estimated capital costs. The costs are calculated for the Holt Lane development based on individual dwellings costs from the CLG Zero Carbon Definition document.

Table 6-26: Predicted carbon saving and capital cost of energy efficiency improvements

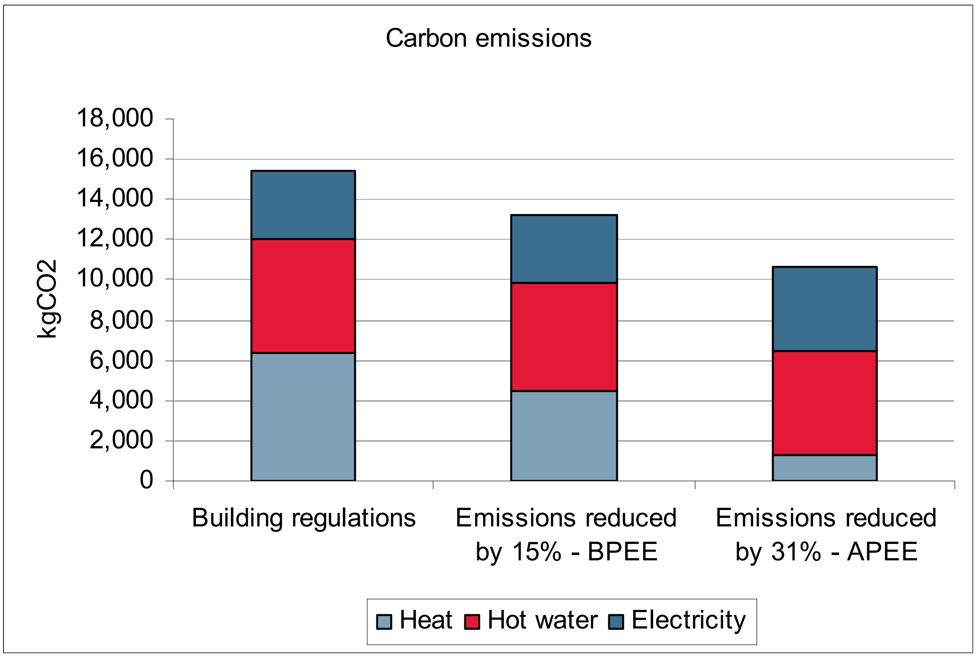
Energy efficiency standard	Development regulated emissions estimate ($kgCO_2$)		Capital cost premium	£/tCO_2 saved
Part L 2006	15,408			
Best Practice (BPEE)	13,218	14%	£16,744	£7,649
Advanced Practice (APEE)	10,672	31%	£45,904	£9,694

Figure 6-11: Regulated energy demand for Holt Lane broken down for each scenario.



The figure shows heat demand reduces significantly, hot water demand stays the same, but electricity demand increases due to heat recovery ventilation.

Figure 6-12: Regulated carbon emissions for Holt Lane broken down for each scenario.



This mirrors the above figure but for carbon, showing electricity has a higher carbon impact per kWh than gas.

Figure 6-13: Estimated energy demand for Holt Lane, including unregulated demand

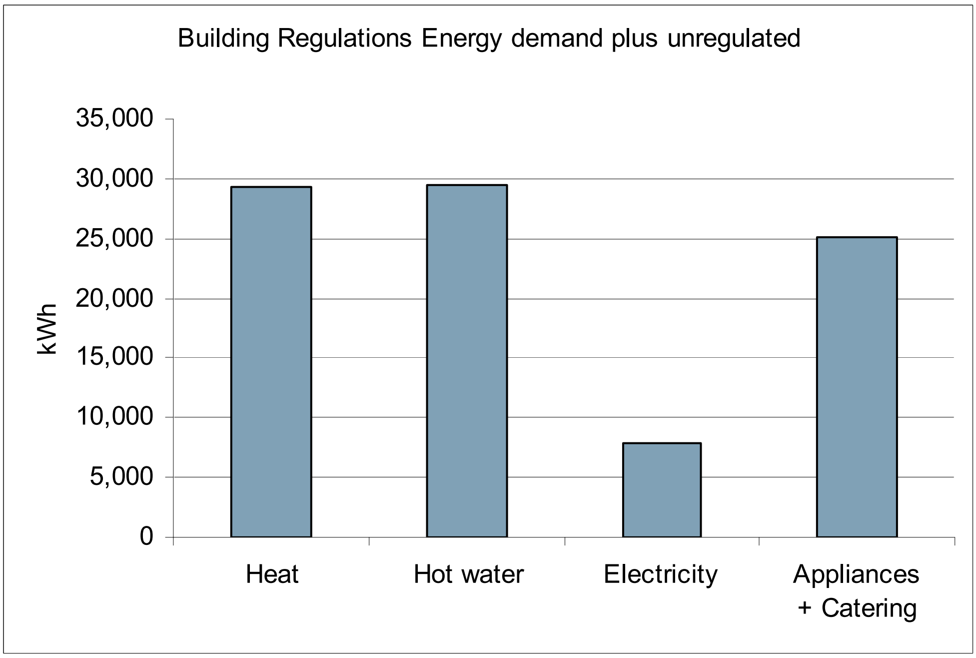
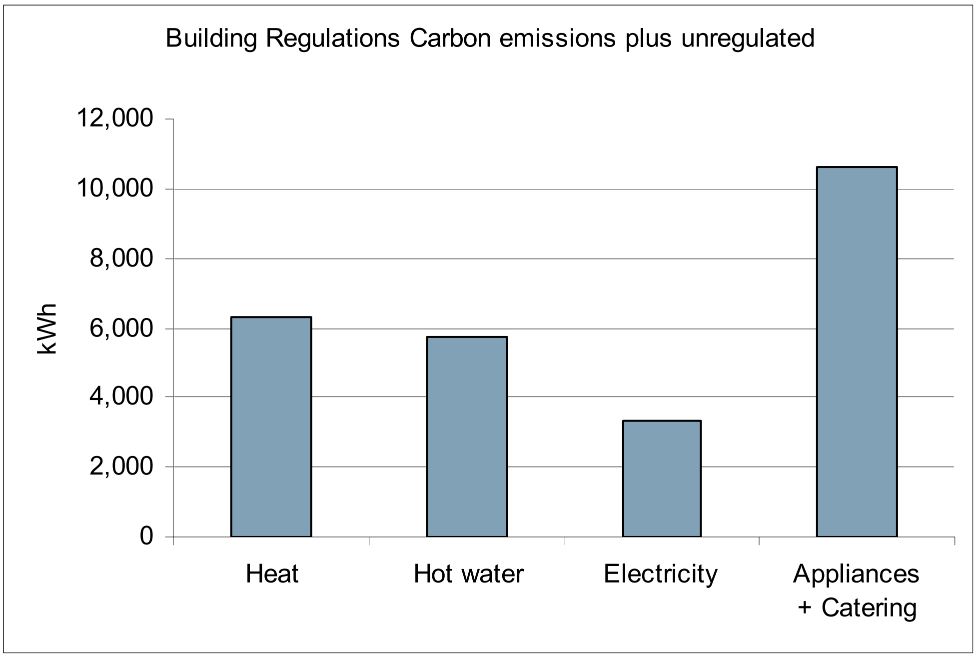


Figure 6-14: Estimated carbon emissions for Holt Lane, including unregulated demand



6.3.2 Renewable energy options

A small development like Holt Lane has limited potential for renewable energy technologies. In most cases, "on-dwelling" technology will be the only option. This includes solar hot water, photovoltaics, small scale wind and ground source heat pumps. It is possible to install a communal heating system for a development of this scale, with a single biomass boiler. A small wind turbine could also be installed to feed into all the houses. However, the end result is an ongoing communal management burden that often deters developers (and homebuyers) from pursuing this option. For this assessment only "on-dwelling" technology has been considered.

It is important to note that, unlike the two developments assessed above, the layout of this site is fixed. At the time of writing the houses are close to completion, with east/west facing roofs. It would have been possible at the design stage to include south facing roofs, but the road layout would mean a contemporary design would be required. It is likely this would have increased the cost, compared to the more traditional design that has been built. A contemporary design could also have encountered problems with planning permission if it was not seen to be in keeping with the local area.

This is of course a side note to the overall aims of this study, but highlights the effects that site constraints can have on renewable energy potential. In this case, it is the output from solar panels that is affected. An east or west facing panel will generally produce 15% less energy than an ideally orientated south facing panel. This is true for both solar hot water systems and photovoltaics. Compensation for this has been made in the assessment by adding 15% to the cost of solar panels. In actual fact the rear of the dwellings face roughly west-south-west, therefore the 15% reduction in output is conservative.

It is worth noting again that the target framework suggests a reduction against regulated emissions (25% and 44%), but the renewable energy reduction is against all remaining emissions plus unregulated. Better energy efficiency means less renewable energy will be required to achieve the percentage renewable energy target.

For a target of 25% regulated emissions reduction and 10% renewable energy, three options have been assessed:

1. No energy efficiency improvement over Part L 2006 standard, requiring 14.8% renewable energy to reduce emissions by 3,852 $kgCO_2$.
2. BPEE, requiring 10% renewable energy to reduce emissions by 2,385 $kgCO_2$.
3. APEE, requiring 10% renewable energy to reduce emissions by 2,131 $kgCO_2$.

The location of Holt Lane means small scale wind turbines might be possible, either mounted on houses or a single turbine mounted on a tower behind the houses. Solar water heating and wind turbines have similar capital costs, with photovoltaics as the most expensive. However the costs could change depending on local conditions and procurement. It is advised that a potential developer looking at this site should investigate all three options further.

The recommendation for this target level is solar hot water, but without energy efficiency improvements will not provide the saving required. For this option, small scale wind turbines are recommended.

Table 6-27: Options for 25% regulated emissions reduction, 10% renewable energy, with Part L energy efficiency

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling Size	Per dwelling Capital cost	Per dwelling Annual FIT/RHI revenue
Small Scale Wind Turbines	6	Capacity of turbines (kWe)	15%	£29,140	£1,812	0.8	£3,643	£226
Solar Water Heating	26	Solar panels (m^2)	13%	£26,313	£2,739	3.3	£3,289	£342
Roof Mounted Photovoltaic Panels	64	PV panels (m^2)	15%	£39,461	£2,450	8.0	£4,933	£306

Table 6-28: Options for 25% regulated emissions reduction, 10% renewable energy, with BPEE

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling Size	Per dwelling Capital cost	Per dwelling Annual FIT/RHI revenue
Small Scale Wind Turbines	4	Capacity of turbines (kWe)	10%	£18,034	£1,121	0.5	£2,254	£140
Solar Water Heating	18	Solar panels (m^2)	10%	£18,282	£1,903	2.3	£2,285	£238
Roof Mounted Photovoltaic Panels	39	PV panels (m^2)	10%	£24,422	£1,516	4.9	£3,053	£190

Table 6-29: Options for 25% regulated emissions reduction, 10% renewable energy, with APEE

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling		
						Size	Capital cost	Annual FIT/RHI revenue
Small Scale Wind Turbines	4	Capacity of turbines (kWe)	10%	£16,109	£1,002	0.4	£2,014	£125
Solar Water Heating	16	Solar panels (m^2)	10%	£16,330	£1,700	2.0	£2,041	£213
Roof Mounted Photovoltaic Panels	35	PV panels (m^2)	10%	£21,815	£1,354	4.4	£2,727	£169

For a target of 44% regulated emissions reduction and 20% renewable energy, three options have been assessed:

1. No energy efficiency improvement over Part L 2006 standard, requiring 26.0% renewable energy to reduce emissions by 6,779 $kgCO_2$.
2. BPEE, requiring 20% renewable energy to reduce emissions by 4,771 $kgCO_2$.
3. APEE, requiring 20% renewable energy to reduce emissions by 4,261 $kgCO_2$.

For this higher target, solar hot water cannot provide sufficient generation under any of the three options. A larger wind turbine might still be appropriate if other conditions were satisfied. The most likely solution is photovoltaic panels, with the roofs capable of incorporating the 8.8m^2 to 14m^2 per dwelling of panels required. With BPEE and APEE, it should still be possible to install sufficient wind turbines on dwellings.

A combination of solar hot water, photovoltaic panels and wind turbines could be used. Experience shows that developers would rather pay a little more to remove the added complication of multiple technologies on a small site.

Table 6-30: Options for 44% regulated emissions reduction, 20% renewable energy, with Part L energy efficiency

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling		
						Size	Capital cost	Annual FIT/RHI revenue
Small Scale Wind Turbines	11	Capacity of turbines (kWe)	26%	£51,192	£3,183	1.4	£6,399	£398
Roof Mounted Photovoltaic Panels	112	PV panels (m^2)	26%	£69,324	£4,303	14.0	£8,666	£538

Table 6-31: Options for 44% regulated emissions reduction, 20% renewable energy, with BPEE

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling Size	Per dwelling Capital cost	Per dwelling Annual FIT/RHI revenue
Small Scale Wind Turbines	8	Capacity of turbines (kWe)	20%	£36,068	£2,243	1.0	£4,509	£280
Roof Mounted Photovoltaic Panels	79	PV panels (m^2)	20%	£48,844	£3,032	9.9	£6,105	£379

Table 6-32: Options for 44% regulated emissions reduction, 20% renewable energy, with APEE

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling Size	Per dwelling Capital cost	Per dwelling Annual FIT/RHI revenue
Small Scale Wind Turbines	7	Capacity of turbines (kWe)	20%	£32,218	£2,003	0.9	£4,027	£250
Roof Mounted Photovoltaic Panels	71	PV panels (m^2)	20%	£43,629	£2,708	8.8	£5,454	£339

For a target of zero carbon, three options have been assessed:

1. No energy efficiency improvement over Part L 2006 standard, requiring 41.4% renewable energy to reduce emissions by 10,785 $kgCO_2$.
2. BPEE, requiring 36.0% renewable energy to reduce emissions by 8,596 $kgCO_2$.
3. APEE, requiring 28.4 % renewable energy to reduce emissions by 6,050 $kgCO_2$.

Each of these options will give a 70% regulated emissions reduction. To achieve zero carbon, the developer will be required to purchase allowable solutions to offset 15,257 $kgCO_2$, costing £45,770.

To achieve zero carbon at Holt Lane, photovoltaic panels might be the only option. Up to 22m^2 may be required, which would probably need a change in the roof design. It is also a costly option. Wind turbines are listed as an alternative, but they would most likely need to be on a 12m pole away from the houses, which may not be possible. Without the potential for a wind turbine away from houses, it may not be possible to achieve zero carbon at Holt Lane with the current designs. But an improved design should be able to achieve the target.

Table 6-33: Options for zero carbon, with Part L energy efficiency

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling Size	Per dwelling Capital cost	Per dwelling Annual FIT/RHI revenue
Small Scale Wind Turbines	18	Capacity of turbines (kWe)	41%	£81,514	£5,068	2.3	£10,189	£634
Roof Mounted Photovoltaic Panels	179	PV panels (m^2)	41%	£110,385	£6,852	22.3	£13,798	£857

Table 6-34: Options for zero carbon, with BPEE

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling Size	Per dwelling Capital cost	Per dwelling Annual FIT/RHI revenue
Small Scale Wind Turbines	14	Capacity of turbines (kWe)	36%	£64,923	£4,037	1.8	£8,115	£505
Roof Mounted Photovoltaic Panels	142	PV panels (m^2)	36%	£87,918	£5,458	17.8	£10,990	£682

Table 6-35: Options for zero carbon, with APEE

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per dwelling Size	Per dwelling Capital cost	Per dwelling Annual FIT/RHI revenue
Small Scale Wind Turbines	10	Capacity of turbines (kWe)	28%	£45,750	£2,844	1.3	£5,719	£356
Roof Mounted Photovoltaic Panels	100	PV panels (m^2)	28%	£61,954	£3,846	12.5	£7,744	£481

6.3.3 Proposed strategy for Holt Lane

Solar hot water panels have become the default renewable energy technology for many developments of this size. For a greater reduction in emissions, photovoltaic panels might be required, which adds to the capital cost. Other options such as ground source heat pumps and wind turbines should also be considered, but in most cases the relative simplicity of solar panels makes them the most attractive option.

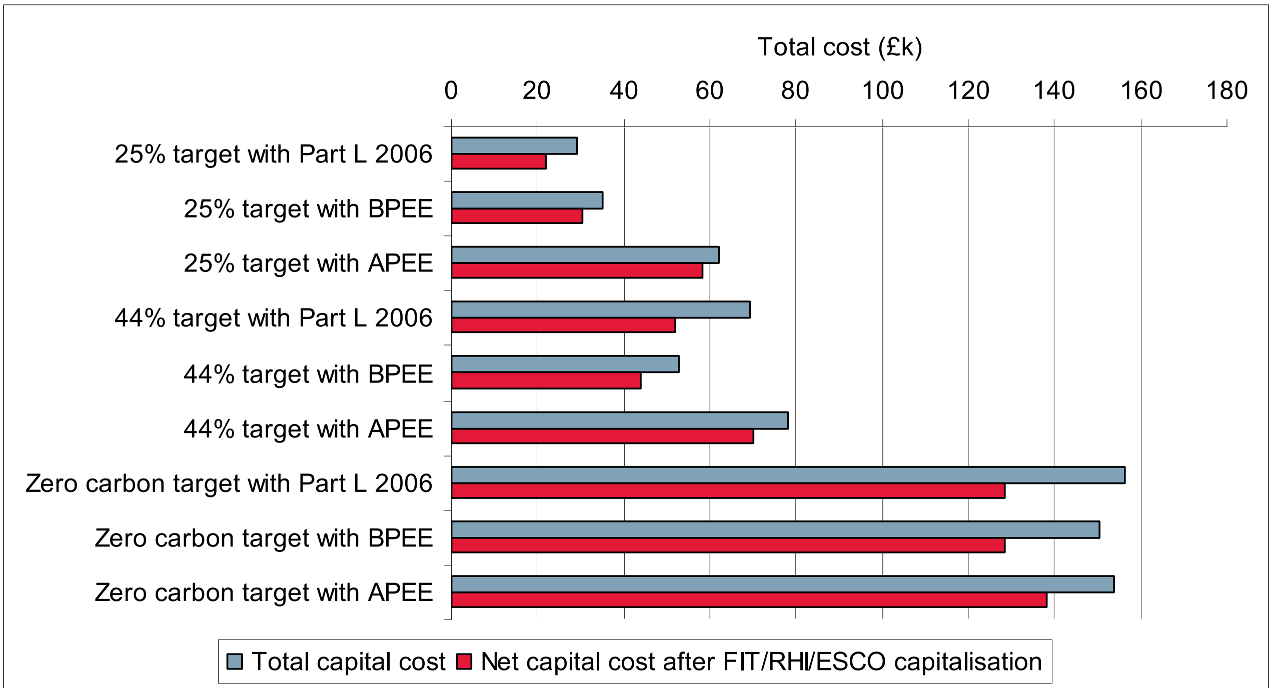
If there is the option of some sort of site management, communal energy systems should also be considered.

Table 6-36 shows the renewable energy selected above for each option. The capitalised FIT/RHI revenue is taken away from the renewable energy capital cost, then energy efficiency and allowable solutions (for zero carbon) costs added, to provide the total net energy cost. Options are then compared graphically in Figure 6-15.

Table 6-36: Total net energy cost of energy efficiency and renewable energy options

Target	EE standard	EE cost	Most suitable RE	Capital cost	Allowable solutions capital cost	Total capital cost	Total Energy Cost net
25%	Part L 2006	£0	Small Scale Wind Turbines	£29,140		£29,140	£21,855
25%	BPEE	£16,744	Solar Water Heating	£18,282		£35,026	£30,455
25%	APEE	£45,904	Solar Water Heating	£16,330		£62,234	£58,152
44%	Part L 2006	£0	Roof Mounted Photovoltaic Panels	£69,324		£69,324	£51,993
44%	BPEE	£16,744	Small Scale Wind Turbines	£36,068		£52,812	£43,795
44%	APEE	£45,904	Small Scale Wind Turbines	£32,218		£78,122	£70,067
Zero carbon	Part L 2006	£0	Roof Mounted Photovoltaic Panels	£110,385	£45,770	£156,155	£128,559
Zero carbon	BPEE	£16,744	Roof Mounted Photovoltaic Panels	£87,918	£45,770	£150,432	£128,453
Zero carbon	APEE	£45,904	Roof Mounted Photovoltaic Panels	£61,954	£45,770	£153,628	£138,139

Figure 6-15: Total net energy cost of energy efficiency and renewable energy options



6.4 Tipping Street, Stafford

Figure 6-16: Image of proposed buildings. Source: www.cabe.org.uk

6.4.1 Schedule of accommodation

The total area of ground floor Class A use is 1,308m^2, with office space totalling 14,543m^2. For benchmark estimates, it has been assumed half the Class A use will be retail and half will be restaurants/cafes. This is in the absence of any further information and in order to get an approximation of the energy demand.

This gives the below predicted accommodation schedule for energy calculations:

Table 6-37: Predicted accommodation schedule for Tipping St, used in calculations

Unit type	Floor area (m^2)
Class A1 (Retail)	654
Class A3 (restaurant and cafes)	654
Class B1 (offices)	14,543
Total	**15,851**

6.4.2 Energy demand and efficiency savings

Without a more detailed understanding of the building design, it is difficult to estimate where savings will be made against regulated emissions. The form, layout, orientation and structure all play a vital part in the energy performance of buildings of this type. The design team most likely looked at these issues and it would be interesting to see their findings. The site's location in the town centre would certainly be expected to largely dictate the buildings architectural design. This could limit the opportunity for a passively designed low carbon building. For example space requirements in the limited area available might mean narrow plan natural ventilation is not possible. This is not to say that options won't exist, but they can be much more expensive on challenging sites.

For the purposes of the exercise, possible methods of reducing the main energy demands from the usage type benchmarks have been considered. In reality it will need considerable thought from an experienced design team to achieve these levels of emission reduction.

The dominant energy demand by area for the building will be the restaurant, which will have high catering demands as well as lighting, heating and hot water. Retail space also has high lighting demands. In offices the majority of the energy demand is for heating and hot water.

A large part of the heat demand for the building will be ventilation. A first step in energy efficiency would be to better control ventilation to recover heat. This should be combined with high levels of insulation, draught lobbies and attention to detail for airtightness to reduce heat loss through building fabric.

An energy efficient design would also target lighting demand, by including lighting control systems and using modern low energy fittings. High frequency lamps and modern LED fittings can produce significant savings.

Designers should also look to reduce hot water demand through low flow fittings and lower water temperatures for handwashing.

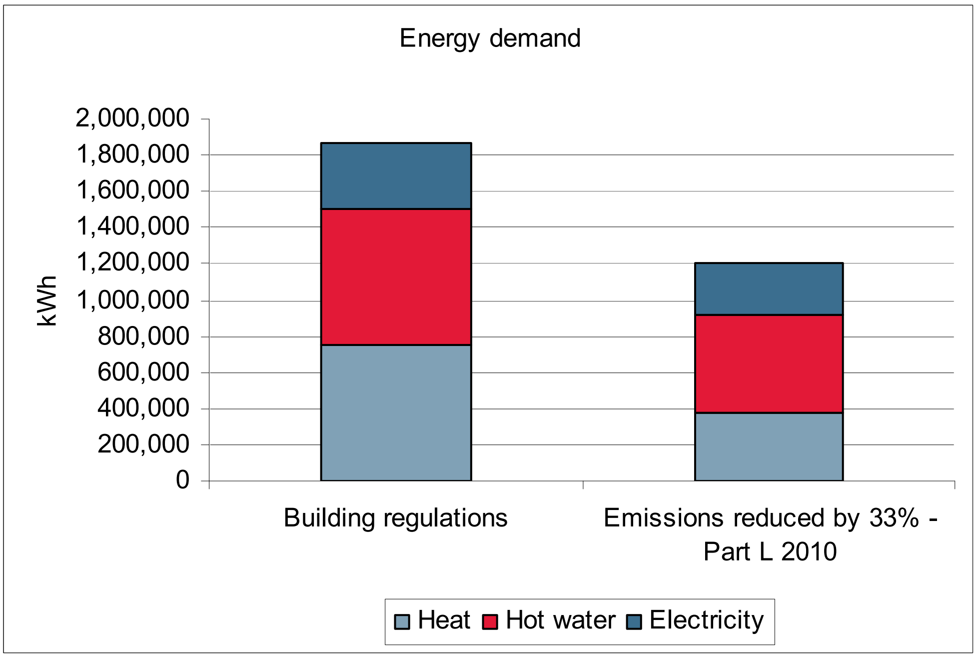
The Part L 2010 consultation[7] estimated a 33% reduction would be possible for a development of this type from energy efficiency. Following the methodology used for dwellings in this report, renewable energy options have been considered at each target level, with energy efficiency improvements and without.

To achieve the 33% carbon saving indicated below, assumed a 50% heating demand reduction has been assumed, 40% from lighting demand and 25% from hot water demand. The capital cost premium is also from the Part L 2010 consultation. This is shown in Table 6-38.

Table 6-38: Possible energy efficiency standard for Tipping St

Energy efficiency standard	Development regulated emissions estimate ($kgCO_2$)		Capital cost premium	£/tCO_2 saved
Part L 2006	460,533			
33% regulated emissions reduction	306,453	33%	£4,527,204	£29,382

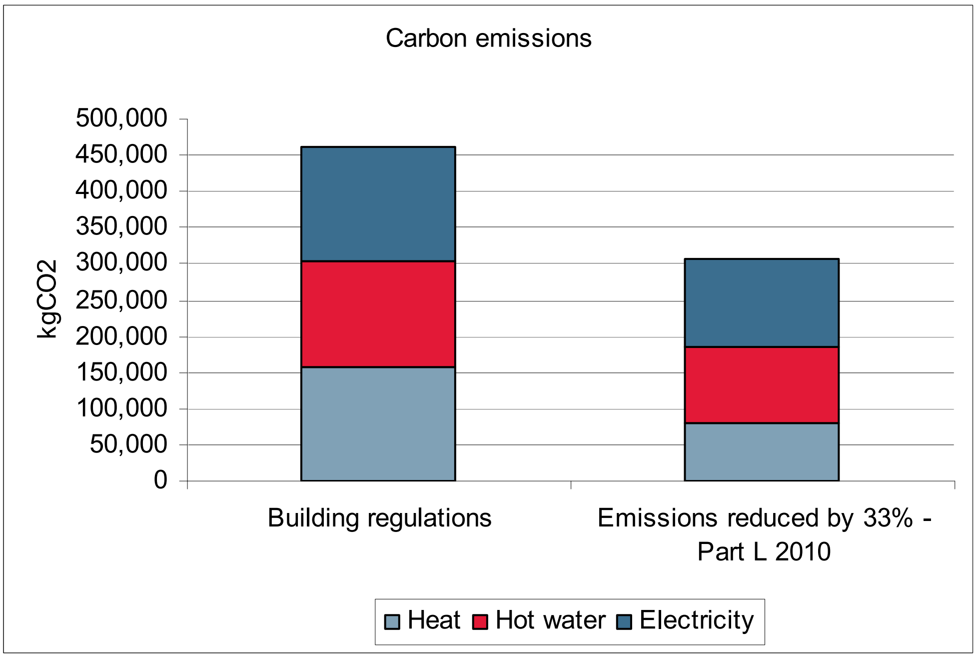
Figure 6-17: Regulated energy demand for Tipping St broken down for each scenario.



[7] http://www.communities.gov.uk/publications/planningandbuilding/partlf2010consultation

The figure shows heat demand reduces significantly, hot water demand stays the same, but electricity demand increases due to heat recovery ventilation.

Figure 6-18: Regulated carbon emissions for Tipping St broken down for each scenario.



This mirrors the above figure but for carbon, showing electricity has a higher carbon impact per kWh than gas.

Figure 6-19: Estimated energy demand for Tipping St, including unregulated demand

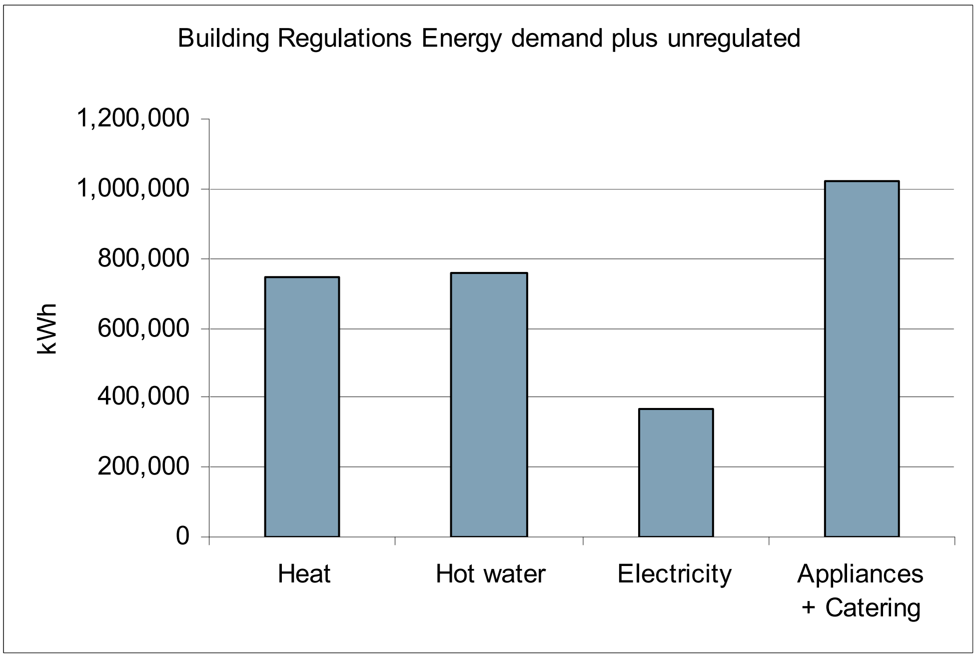
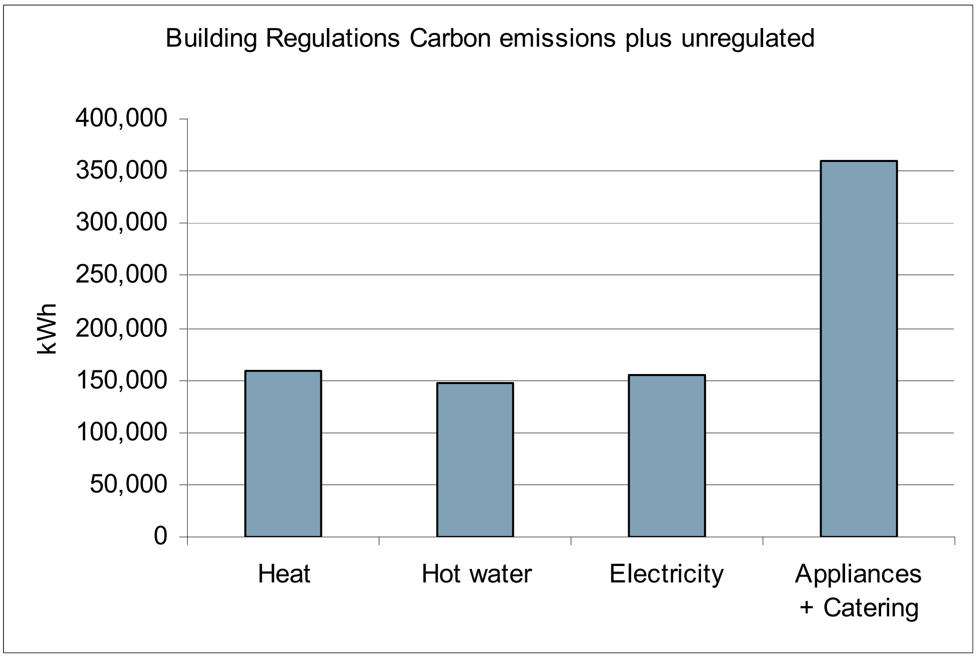


Figure 6-20: Estimated carbon emissions for Tipping St, including unregulated demand



6.4.3 Renewable energy options

It can be seen from the above analysis that Tipping St is a large development with substantial energy demand. It provides a lot of options for renewable energy. A basic analysis of options is completed here, based on the total demand for heat, hot water and electricity. In residential dwellings it can be assumed with a high degree of certainty how the building services will be designed. When dealing with a mixed use building such as this, there are several options for building services design. They will be dependant on the specification for the building, the eventual occupants, detail of the architectural design preference of the design team for certain features, and so on. This design can greatly affect the options for renewable energy generation. For example if the designers decide to use a VRF[8] system for heating and cooling, the amount of heat that can be supplied by a biomass boiler will be limited. In such a situation, a ground source heat pump would be much more favourable. The building design team really need to consider renewable energy as an integrated part of the building services design, and must design the building accordingly.

In this study the luxury of detailed building services design is not available. However, the study objectives can still be achieved by outlining what options might be available and discussing their appropriateness to different building designs.

It is worth noting again that the target framework does not suggest a reduction for non-domestic building regulations beyond building regulations compliance. However, the same methodology has been followed as with the other developments. The results should be of use to Staffordshire when looking at non-domestic targets in future.

For a target of 25% regulated emissions reduction and 10% renewable energy, two options have been assessed:

1. No energy efficiency improvement over Part L 2006 standard, requiring 14% renewable energy to reduce emissions by 115,133 $kgCO_2$.

[8] *VRF is variable refrigerant flow. It is a popular system in commercial buildings, providing heating and cooling. It is similar to standard split systems which link directly to an external condenser, but is more efficient.*

2. 33% energy efficiency improvement, requiring 10% renewable energy to reduce emissions by 66,671kgCO_2.

If the building is primarily heated by gas boilers (serving either radiators or heated ventilation), part of the demand for heat could be provided by biomass. Biomass is much more cost effective for a commercial building than for a housing development, as expensive underground heat networks are not required. However, the cost could increase when the need for fuel delivery and storage is considered.

Electricity generation from small scale wind turbines and photovoltaic panels are shown as expensive options. They could contribute to the overall renewable target, but in reality it would be difficult to install the amount required on the roof. Solar water heating requires less roof space. The hot water demand for offices is very low; hot water demand will mainly come from any restaurants/cafés. This means a roof mounted bank of panels would have to get hot water down to the ground floor. Again in reality such a system would not really be suitable for this type of building.

Ground source heat pumps have been estimated at providing an 11% to 13% carbon saving. This could be higher if the building services are designed to suit. There is limited space around the development for ground loops, but it may be possible to install loops below the building and even integrate into building piles.

Table 6-39: Options for 25% regulated emissions reduction, 10% renewable energy, with Part L energy efficiency

						Per 1,000 m^2		
Technology	**Size**	**Units**	**% Carbon saving**	**Capital cost**	**Annual FIT/RHI revenue**	**Size**	**Capital cost**	**Annual FIT/RHI revenue**
Small Scale Wind Turbines	194	Capacity of turbines (kWe)	14%	£874,393	£54,364	12.3	£55,163	£3,430
Solar Water Heating	670	Solar panels (m^2)	11%	£585,895	£70,147	42.2	£36,963	£4,425
Biomass Heating (communal)	204	Heating capacity (kWth)	14%	£227,404	£54,971	12.8	£14,346	£3,468
Roof Mounted Photovoltaic Panels	1628	PV panels (m^2)	14%	£1,006,824	£73,504	102.7	£63,518	£4,637
Ground Source Heat Pump (individual)	575	Heating capacity (kWth)	13%	£690,278	£90,179	36.3	£43,548	£5,689

Table 6-40: Options for 25% regulated emissions reduction, 10% renewable energy, with 33% energy efficiency

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per 1,000 m^2 Size	Per 1,000 m^2 Capital cost	Per 1,000 m^2 Annual FIT/RHI revenue
Small Scale Wind Turbines	113	Capacity of turbines (kWe)	10%	£508,073	£31,589	7.1	£32,053	£1,993
Solar Water Heating	387	Solar panels (m^2)	8%	£338,742	£40,556	24.4	£21,370	£2,559
Biomass Heating (communal)	118	Heating capacity (kWth)	10%	£136,827	£31,941	7.5	£8,632	£2,015
Roof Mounted Photovoltaic Panels	946	PV panels (m^2)	10%	£585,024	£42,710	59.7	£36,908	£2,694
Ground Source Heat Pump (individual)	394	Heating capacity (kWth)	11%	£473,147	£61,200	24.9	£29,850	£3,861

For a target of 44% regulated emissions reduction and 20% renewable energy, three options have been assessed:

1. No energy efficiency improvement over Part L 2006 standard, requiring 24.7% renewable energy to reduce emissions by 202,635 kgCO_2.
2. 33% energy efficiency improvement, requiring 20% renewable energy to reduce emissions by 133,343 kgCO_2.

For this target level, biomass heating is still the most viable technology, but biomass CHP also becomes an option. Dynamic demand modelling would be required to accurately size the plant required. A larger unit than that estimated in the tables could be installed (in actual fact, the smallest biomass CHP unit currently available has an output of around 90kW_e), which would involve dumping heat in summer. This might be considered acceptable as the overall reduction in carbon emissions would be high from excess electricity generated. If the development is aiming to achieve zero carbon status, the client should see the value in investing in a full feasibility study for biomass, biomass CHP and gas CHP.

Table 6-41: Options for 44% regulated emissions reduction, 20% renewable energy, with Part L energy efficiency

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per 1,000 m^2 Size	Per 1,000 m^2 Capital cost	Per 1,000 m^2 Annual FIT/RHI revenue
Biomass CHP (communal)	48	CHP size (kWe)	25%	£1,332,439	£66,009	3.0	£84,060	£4,164
Biomass Heating (communal)	359	Heating capacity (kWth)	25%	£392,646	£96,984	22.7	£24,771	£6,118
Roof Mounted Photovoltaic Panels	2873	PV panels (m^2)	25%	£1,776,326	£129,682	181.2	£112,064	£8,181

Table 6-42: Options for 44% regulated emissions reduction, 20% renewable energy, with 33% energy efficiency

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per 1,000 m^2 Size	Per 1,000 m^2 Capital cost	Per 1,000 m^2 Annual FIT/RHI revenue
Biomass CHP (communal)	32	CHP size (kWe)	20%	£1,264,710	£43,479	2.0	£79,787	£2,743
Biomass Heating (communal)	237	Heating capacity (kWth)	20%	£262,454	£63,882	14.9	£16,558	£4,030
Roof Mounted Photovoltaic Panels	1892	PV panels (m^2)	20%	£1,170,047	£85,420	119.4	£73,815	£5,389

For a target of zero carbon, three options have been assessed:

1. No energy efficiency improvement over Part L 2006 standard, requiring 39.3% renewable energy to reduce emissions by 322,373 $kgCO_2$.
2. 33% energy efficiency improvement, requiring 25.2% renewable energy to reduce emissions by 168,293 $kgCO_2$.

Each of these options will give a 70% regulated emissions reduction. To achieve zero carbon, the developer will be required to purchase allowable solutions to offset 498,419 $kgCO_2$, costing £1,495,258.

As noted above, biomass CHP may be the best option, but will need a more detailed study to show this. Biomass heating is still recommended.

Table 6-43: Options for zero carbon, with Part L energy efficiency

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per 1,000 m^2 Size	Per 1,000 m^2 Capital cost	Per 1,000 m^2 Annual FIT/RHI revenue
Biomass CHP (communal)	76	CHP size (kWe)	39%	£1,448,020	£104,456	4.8	£91,352	£6,590
Biomass Heating (communal)	571	Heating capacity (kWth)	39%	£617,587	£154,176	36.0	£38,962	£9,727
Roof Mounted Photovoltaic Panels	4571	PV panels (m^2)	39%	£2,826,300	£206,336	288.4	£178,304	£13,017

Table 6-44: Options for zero carbon, with 33% energy efficiency

Technology	Size	Units	% Carbon saving	Capital cost	Annual FIT/RHI revenue	Per 1,000 m^2 Size	Per 1,000 m^2 Capital cost	Per 1,000 m^2 Annual FIT/RHI revenue
Biomass CHP (communal)	40	CHP size (kWe)	25%	£1,298,103	£54,587	2.5	£81,894	£3,444
Biomass Heating (communal)	298	Heating capacity (kWth)	25%	£327,781	£80,492	18.8	£20,679	£5,078
Roof Mounted Photovoltaic Panels	2384	PV panels (m^2)	25%	£1,474,259	£107,629	150.4	£93,007	£6,790

6.4.4 Proposed strategy for Tipping Street

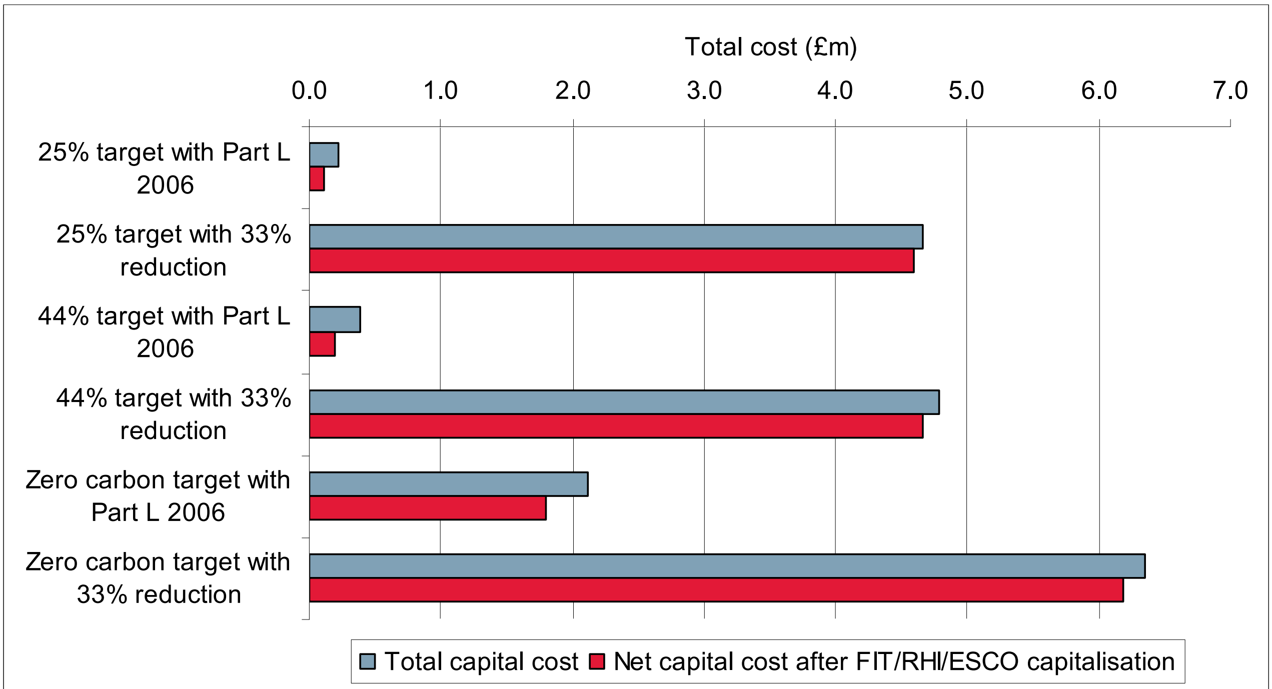
Tipping Street is a relatively big building, providing good opportunities for a substantial amount of energy efficiency and renewable energy generation. In target setting, a development of this type is considered a large development.

Table 6-45 shows the renewable energy selected above for each option. The capitalised FIT/RHI revenue is taken away from the renewable energy capital cost, then energy efficiency and allowable solutions (for zero carbon) costs added, to provide the total net energy cost. Options are then compared graphically in Figure 6-21.

Table 6-45: Total net energy cost of energy efficiency and renewable energy options

Target	EE standard	EE cost	Most suitable RE	Capital cost	Allowable solutions capital cost	Total capital cost	Total Energy Cost net
25%	Part L 2006	£0	Biomass Heating (communal)	£227,404		£227,404	£113,702
25%	33% reduction	£4,527,204	Biomass Heating (communal)	£136,827		£4,664,031	£4,595,618
44%	Part L 2006	£0	Biomass Heating (communal)	£392,646		£392,646	£196,323
44%	33% reduction	£4,527,204	Biomass Heating (communal)	£262,454		£4,789,659	£4,658,431
Zero carbon	Part L 2006	£0	Biomass Heating (communal)	£617,587	£1,495,258	£2,112,845	£1,804,052
Zero carbon	33% reduction	£4,527,204	Biomass Heating (communal)	£327,781	£1,495,258	£6,350,243	£6,186,353

Figure 6-21: Total net energy cost of energy efficiency and renewable energy options



6.4.5 Connection to neighbouring developments

The Tipping Street development is part of a larger ongoing regeneration of Stafford town centre.

Figure 6-22 below shows new and future development around the Tipping St site. The Tipping St office buildings assessed above are the two triangular buildings marked as number 04. Across the road from the building is the proposed civic centre (03) and large Riverside Regeneration area

(06). This will include development of retail, leisure and residential accommodation. Also of note is number 05, which is an existing Stafford Leisure Centre.

Together these buildings will have a substantial energy demand, with a commercial and residential mix that will maintain demand from early morning to late evening. This is an ideal opportunity for a town centre community energy network, similar to those in use in Birmingham, Woking, Sheffield and Southampton.

The Local Planning Authority should work with developers and designers to encourage joined up thinking between these sites, which should elevate the potential for more efficient energy generation.

Figure 6-22: Development in Stafford, from "Stafford Renewed" brochure, courtesy of Stafford Borough Council

7 Summary and conclusions

The sustainable energy strategy study has shown that each scenario in the proposed target framework for Staffordshire can be achieved at varying financial cost. A range of development types have been considered from a handful of dwellings, to a major urban extension.

Larger developments present a greater range of options for renewable energy, as communal energy systems can be incorporated. Providing a large amount of heat demand from a single source can result in significant economies of scale.

For small developments where communal energy is not feasible, options are limited. For higher carbon targets, photovoltaic panels are often the only option, with estimated capital costs of up to £14,000 per dwelling. With the feed in tariff revenue capitalised, the total cost per dwelling has been estimated at possibly reducing from £19,500 to £16,000. Note that this is a worst case scenario where options for reducing emissions are limited.

The Feed in Tariff (FIT) and Renewable Heat Incentive (RHI) can provide long term revenue for renewable energy installations. By capitalising the benefit of this revenue, the net capital cost of the renewable energy can be reduced, for a more realistic comparison against energy efficiency costs. However, this assumes the developer will be able to claim the revenues, which in some cases might be difficult.

The study has shown that, in most cases, energy efficiency improvements cost more than renewable energy. Hence the cheapest option is to not improve energy efficiency over the Part L 2006 standard, and to instead install more renewable energy. The benefit from FIT/RHI helps make renewable energy more attractive. Energy efficiency, such as improved insulation, should always be promoted as it will last for the lifetime of the building.

A level of energy efficiency beyond Part L 2006 should be promoted for new developments, even if it is shown to not be the most cost effective option. Developers should be encouraged to look at alternative construction methods that could bring the cost of energy efficiency improvements down.

For non-domestic developments, options for energy efficiency and renewable energy will vary greatly depending on the design and site constraints. Analysis of Tipping St has shown biomass heating to be the most suitable option. However, this assumes biomass will be available and that the building is designed for a wet heating system.

It is essential for developers to consider energy efficiency and renewable energy targets from the earliest stage of development, to ensure designs can accommodate the most suitable sustainable energy solution.

Appendix I: Glossary of terms

Allowable solutions	Allowable solutions allow developers to purchase emissions reductions from other projects, for example improving insulation in existing homes. They can be purchased by developers when looking to achieve zero carbon standards.
APEE	Advanced Practice Energy Efficiency standard, as proposed by the Energy Saving Trust
BPEE	Best Practice Energy Efficiency standard, as proposed by the Energy Saving Trust
CHP	Combined Heat and Power; also known as cogeneration: Generation of both heat and power from a single heat source by recovering waste heat from electricity generation
ESCO	Energy Service Company: This is a professional business providing a broad range of comprehensive energy solutions including designs and implementation of energy savings projects, energy conservation, energy infrastructure outsourcing, power generation and energy supply, and risk management. The ESCO performs an in-depth analysis of the property, designs an energy efficient solution, installs the required elements, and maintains the system to ensure energy savings during the payback period The savings in energy costs is often used to pay back the capital investment of the project over a five- to twenty-year period, or reinvested into the building to allow for capital upgrades that may otherwise be unfeasible. If the project does not provide returns on the investment, the ESCO is often responsible to pay the difference.
FIT	Feed-in-Tariff: A UK Government cashback scheme outlined in the Energy Act 2008 effective from 1 April 2010 guaranteeing payment to people who generate small scale low carbon electricity.
GSHP	Ground Source Heat Pump: A heat pump installation that uses the earth as a heat sink to store heat or as a source of heat.
GWh	Gigawatt hour – 1,000,000 kWh. A convenient unit of energy for power generation equipment.
kW	Kilowatt – unit of power. Can be expressed as thermal power (kW_{th}) and electrical power (kW_e). The productive capacity of small scale renewable generation is usually measured in kW
kWh	kilowatt hour – unit of energy. Can be expressed as thermal energy (kWh_{th}) and electrical energy (kWh_e). A convenient unit for consumption at the household level.
kWp	kilowatt peak – maximum power output of a photovoltaic cell, occurring with intense sunlight.
LZC	Low and Zero Carbon
MW	Megawatts. The productive capacity of electrical generation plant is often measured in MWe.
MW_e	Megawatts of electrical capacity.
MW_{th}	Megawatts of thermal capacity.
MWh	Megawatt-hour, equal to 1,000 kWh.
MVHR	Mechanical ventilation with Heat Recovery
NCM	National Calculation Methodology, used when assessing carbon emissions under Part L of the Building Regulations

RHI	Renewable Heat Incentive
Part L of the Building Regulations	The section of the building regulations that deals with Energy (Conservation of Fuel and Power). Part L specified the NCM used for SBEM and SAP calculations.
Regulated demand	Energy demands regulated by Part L of the Building Regulations. It includes heating, hot water, lighting and other building services. It does not include appliance energy demand, for example kitchen equipment and computers. This demand is known as 'unregulated'. The NCM calculates an estimation of regulated demand per year.
SAP	Standard Assessment Procedure, used to calculate regulated carbon emissions for domestic buildings.
SBEM	Simplified Building Energy Model, used to calculate regulated carbon emissions for non-domestic buildings.
SHW / STHW	Solar Hot Water; also known as Solar Thermal Hot Water
Small wind	Small scale wind, for this study this is assumed as being below 500 kW in capacity (tip height typically less than 60 m)
Solar PV	Solar Photovoltaic
tCO_2/yr	Tonnes (metric) of CO_2 per year
Unregulated demand	(see regulated demand)

camco

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