ZERO CARBON TASK GROUP
Terms of Reference

ROLE

The role of the group is to review the current definition of ‘zero carbon’ in the Code for Sustainable Homes (CSH) as it relates to the use of ‘off-site’ renewables and propose amendments where required.

While the focus of the group will primarily be domestic dwellings, it would be desirable if the definition arrived at was equally applicable to the non-domestic sector.

If appropriate the group would also recommend changes to the requirement to achieve stamp duty relief with justification as to why such a change is necessary.

METHODOLOGY

The group will bring together existing work and potentially commission new work to deliver a ‘fact base’ that will support any proposed changes.

This work will examine a number of domestic development types and renewable solutions taking account of specific considerations in making its assessments.

DEVELOPMENT TYPES

Development types considered will attempt to accurately represent the sector, and the group will be advised on this by research organisations within the UK-GBC. Likely to include:

- Large mixed use
- High density urban in-fill sites
- ‘Average’ home build site (50-70 units, Brownfield and lower density)
- Small urban in-fill (c. 20 units)

CONSIDERATIONS

- Cost of delivery, including capital cost and ongoing cost/benefits (i.e. heat ‘sales’)
- Deliverability including planning, physical limitations & technology and fuel sourcing
- Reliability/maintainability of solution
- Measurability and magnitude of the carbon emissions reductions achieved
- Potential impacts outside of the construction industry - e.g. cost of ROCs or LECs

Whilst these considerations will inevitably have to be based on current data, account should be taken of expected future changes in the cost and maturity of the technologies available as well as the potential changes to the carbon content of grid-derived electricity.
OTHER AREAS OF WORK

In the event that off-site renewables are seen as part of the solution the group will need to describe a regime that ensures they are ‘additional’ and are available for the life of the development.

The regulatory regime that sits around renewables, connection to the grid and export to the grid need to be clear.

Fuel factors (carbon intensity factors for different fuels).

The group will consider the need for a hierarchy of delivery to be put in place recognising the concerns of being too prescriptive and not prescriptive enough! This may take the form of a decision tree.
UK Green Building Council
Zero Carbon Task Group Report
Appendix 2
Extract from the Code for Sustainable Homes
Technical Guidance: Ene1 Credit
Category 1: Energy and Carbon Dioxide Emissions

<table>
<thead>
<tr>
<th>Issue ID</th>
<th>Description</th>
<th>No. of credits available</th>
<th>Mandatory Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ene 1</td>
<td>Dwelling Emission Rate</td>
<td>15</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Aim

To limit emissions of carbon dioxide (CO₂) to the atmosphere arising from the operation of a dwelling and its services.

Assessment Criteria

Credits are awarded based on the percentage improvement in the Dwelling Emission Rate (DER), (estimated carbon dioxide emissions in kg per m² per annum arising from energy use for heating, hot water and lighting for the actual dwelling), over the Target Emission Rate (TER) (the maximum emission rate permitted by Building Regulations), for the dwelling where DER and TER are as defined in AD L1A 2006 Edition of the Building Regulations. Credits are awarded in accordance with the table below. Note that to reach Level 6 (zero carbon) there are additional requirements.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Credits</th>
<th>Mandatory Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Improvement of DER over TER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;=10%</td>
<td>1</td>
<td>Level 1</td>
</tr>
<tr>
<td>&gt;=14%</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>&gt;=18%</td>
<td>3</td>
<td>Level 2</td>
</tr>
<tr>
<td>&gt;=22%</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>&gt;=25%</td>
<td>5</td>
<td>Level 3</td>
</tr>
<tr>
<td>&gt;=31%</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>&gt;=37%</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>&gt;=44%</td>
<td>8</td>
<td>Level 4</td>
</tr>
<tr>
<td>&gt;=52%</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>&gt;=60%</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>&gt;=69%</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>&gt;=79%</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>&gt;=89%</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>&gt;=100%</td>
<td>14</td>
<td>Level 5</td>
</tr>
<tr>
<td>‘Zero Carbon Home’ as defined below</td>
<td>15</td>
<td>Level 6</td>
</tr>
</tbody>
</table>

Default Cases

None
Information required to demonstrate compliance

**Schedule of Evidence Required**
To be read in conjunction with the *Definitions, Glossary and Calculations Sections.*
The following requirements are all required to demonstrate compliance with any of the mandatory levels, for both assessment stages.

<table>
<thead>
<tr>
<th>Design Stage</th>
<th>Post Construction Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design Stage</strong> – SAP 2005 Worksheet* for each Energy Type and accompanying list of specifications from an accredited energy assessor/Part L ‘Competent person’&lt;br&gt;*Full worksheet, dated with energy assessor name, registration number and address of development, prepared at plans approval stage&lt;br&gt;Copy of plans, elevations and sections as designed and construction details sufficient to check building details&lt;br&gt;Where Design and Build contracts or similar contractual arrangements mean SAP calculations cannot be produced at this stage, the specification can be allowed as evidence of intent.</td>
<td><strong>As Built Stage</strong> – SAP 2005 Worksheet* for each Energy Type and accompanying list of specifications from an accredited energy assessor/Part L ‘Competent person’ if different from design stage&lt;br&gt;*Full amended worksheet, dated with energy assessor name, registration number and dwelling address, prepared at construction completion stage, if different from Design Stage&lt;br&gt;Evidence that the build form is as described in the As Built SAP worksheet. This will cover the final construction materials and accompanying list of specifications (including heating, hot water service and ventilation systems) and be in the form of purchase orders, photographs or specification clauses with letter of conformity.&lt;br&gt;OR&lt;br&gt;Code Assessor Site Inspection Report</td>
</tr>
</tbody>
</table>
A copy of the As Built Part L1A Building Regulations Compliance Checklist showing full compliance for each Energy Type. This evidence must be provided by an accredited energy assessor/Part L ‘Competent person.

*In circumstances where it has been agreed with Building Control that the dwelling will pass AD L1A despite full compliance not being indicated on the As Built Part L1A Building Regulations Compliance Checklist, additional documentary evidence from a Building Control Officer confirming full AD L1A compliance must be provided.

Copy of outputs of any calculator tools used (e.g. Stamp Duty Land Tax relief tools and Code Energy Calculator Tool), showing:

- Where averaging used: the weighted average percentage improvement of the Dwelling Emission Rate below the Target Emission Rate for each Energy Group, based on Design Stage SAP 2005 data

- Where Level 6 is sought: Additional calculation sheets are required to include the appliances and cooking element. Each home must provide an amount of renewable electricity equal to a specified amount of kWh per m² of floor space in addition to that required to meet zero carbon in SAP 2005, in order to offset the CO₂ due to appliances and cooking.

When determining the base case property types for measured improvement DER over TER, copies of utilities location maps (service locations) for mains gas and electricity must be provided clearly showing the location of the site boundaries to demonstrate that the option used is both accurate and reasonable.
### Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accredited Energy Assessor/Part L ‘Competent person’</strong></td>
<td>A person registered by an Accredited SAP service provider licensed by Communities and Local Government in respect of the calculation of CO₂ emission rates of buildings.</td>
</tr>
<tr>
<td><strong>As- Built SAP 2005 Worksheet</strong></td>
<td>An output of SAP 2005 software summarising all relevant As Built construction data and the emissions calculated by SAP 2005 for the dwelling As Built.</td>
</tr>
<tr>
<td><strong>Assessor Site Inspection Report</strong></td>
<td>This is a report prepared by the Code assessor during a Post Construction Stage Assessment and issued as evidence with the assessment.</td>
</tr>
<tr>
<td><strong>Building Regulations Compliance Checklist</strong></td>
<td>Checklist illustrated in AD L1A Appendix A. This is also provided as an output of SAP 2005 software detailing a dwelling’s performance against a set of key criteria. Assessed on a ‘PASS’ or ‘FAIL’ basis, all criteria must be met for the dwelling to meet full AD L1A compliance. This document may be sent to Building Control at design stage to demonstrate L1A compliance and again at completion. The DER that is to be used for Code levels 1 to 5 and the TER that is to be used for all Code Levels should be taken from this Checklist.</td>
</tr>
<tr>
<td><strong>DER</strong></td>
<td>The Dwelling Emission Rate is the estimated carbon dioxide emissions per m² for the building, as designed, for energy in use for heating, hot water and lighting. This is calculated using the SAP method, and is defined in AD L1A of the Building Regulations. The DER is shown on the Building Regulations Compliance Checklist. N.B. The DER is determined by using the assumed amount of dedicated energy efficiency lighting of 30 per cent. This means that the DER should be used for all Code Levels from 1 to 5. However, for Code Level 6, the Design Stage SAP 2005 Worksheet, CO₂ emissions figure, (SAP Line 109), should be used as this accounts for the actual number of dedicated energy efficient lighting that will be installed.</td>
</tr>
<tr>
<td>**Design Stage SAP 2005 Worksheet *</td>
<td>An output of SAP 2005 software summarising all relevant design stage construction data and the emissions calculated by SAP 2005 for the dwelling as designed.</td>
</tr>
</tbody>
</table>
**Energy Averaging/ Energy Groups**

Energy Groups only apply when a building contains multiple flats/apartments within the same building envelope. The DER, TER and HLP results can be averaged across the whole building as defined in AD L1A provided that the same building services strategy is adopted throughout. These dwellings are defined as an Energy Group. Note this averaging rule cannot be applied to terraced housing or maisonettes and is subject to the additional criteria set out below.

Where varying servicing strategies (including the provision of renewable energy systems) are adopted in the building, dwellings should be grouped by strategy. Each group set will be treated as a separate Energy Group for the purposes of assessment and an average DER and TER used to calculate the percentage improvement.

It is the Code Assessor’s choice whether or not the averaging method is used.

The average of SAP results over two similar buildings cannot be used.

All dwellings averaged within Energy Group must be contained within the same envelope.

Note: This is a different requirement to that described in Clause 23 of AD L1A.

**Energy Type**

A set of dwellings on a development site are of the same ‘Energy Type’ if they have the same SAP output for DER, TER and HLP. They will exhibit each of the following:

- The same dwelling size, built form and construction details;
- The same space heating, hot-water system and controls;
- The same orientation and level of over-shading/sheltering; and
- The same assumed/actual air permeability and ventilation system.

**Inverter**

An inverter is an electronic device that produces alternating current (AC) from direct current (DC).

**Onsite Renewable/ Low Carbon Installations**

The installation of Low or Zero Carbon technologies which directly supply the dwelling with heat and/or electricity through a direct connection to the property or through a private wire arrangement.

These installations can be located on/in the dwelling, its curtilage or elsewhere on/off site provided that there is a direct connection to the dwelling.
| **Private Wire Arrangement** | A Private Wire Arrangement when used in the context of the Code for Sustainable Homes for Low or Zero Carbon technology installations is an arrangement where, any electricity generated on or in the vicinity of the site is fed directly to the dwellings being assessed, by dedicated power supplies.

If electricity is generated which is surplus to the instantaneous demand of the dwelling, this electricity may be fed back to the National Grid. The carbon benefit associated with any electricity fed into the grid in this manner can only be allocated against an individual installation or dwelling. In cases where a dwelling is supplied by a communal installation, no carbon benefit can be allocated to dwellings which are not connected to the communal installation. |
| **RIBA Outline plan of work** | The Royal Institute of British Architects publishes an Outline Plan of Work (Royal Institute of British Architects, 1991) which describes the UK traditional approach to the project delivery process in twelve well defined steps, labelled A to M. The RIBA process begins at the project Inception (A), where a general outline of requirements and a plan of action are produced by an architect and the commissioning client, and it ends at Feedback (M) following the completion and hand over of the building to the client. |
| **SAP** | The Government’s Standard Assessment Procedure. This is the approved methodology for rating the energy performance of dwellings. The indicators are used to demonstrate compliance with AD L1A of the Building Regulations and for Energy Performance Certificates for new homes. The current version is SAP 2005.

The SAP computation takes into account energy used for space heating, fixed lighting and hot water provision. Heat and power for this element must be generated either in the home or on the development or through other local community arrangements (including district heat and power).

For an up-to-date list of SAP 2005 approved software visit: www.bre.co.uk/sap2005. |
| **Stamp Duty Land Tax (SDLT) relief** | This is the relief from Stamp Taxes which are payable on land and property for homes which are classified as zero carbon.

Calculation tools to assist in the calculation of zero carbon and the output from LZC technologies are available from the SAP 2005 website.

http://projects.bre.co.uk/sap2005/ |
**TER**

The Target Emission Rate is the maximum allowable carbon dioxide emissions per m² for energy use in heating, hot water and lighting which would meet the Building Regulations. This is calculated using the SAP 2005 method, and is defined in AD L1A of the Building Regulations and is as shown on the Building Regulations Compliance Checklist.

**Utilities Location Maps**

This is a map provided by a utility company which will show the location of locally available services such as mains gas and electricity.

If the development has a choice of services and no clear justification for the choice of fuel is provided, the measured improvement of DER over TER must be reassessed using a base case property with mains gas as the primary fuel.

**Zero Carbon Home**

Where net carbon dioxide emissions resulting from ALL energy used in the dwelling are zero or better. This includes the energy consumed in the operation of the space heating/cooling and hot-water systems, ventilation, all internal lighting cooking and all electrical appliances, these are now dealt with under Section 14 SAP 2005 extension for SDLT. The calculation can take account of contributions from onsite renewable/low carbon installations. Zero Carbon homes with the Code can also take advantage of the allowance with Section 14 to omit the requirement for secondary heating where applicable.

Off-site renewable contributions can only be used where these are directly supplied to the dwellings by private wire arrangement.

Dwellings must meet the minimum mandatory energy requirements for Level 5. This means that emissions as calculated by SAP, including the contribution from any special cases, should be zero or better.

A ‘zero carbon home’ is also required to have a Heat Loss Parameter (covering walls, windows, air tightness and other building design issues) of 0.8 W/ m²K or less, and net zero carbon dioxide emissions from use of appliances and cooking in the homes (i.e. on average over a year). SAP does not contain any provision for energy consumption of appliances but is likely to be updated to do so in due course. Until SAP is updated, the appliances and cooking element of the qualification will be calculated using the formula in the calculation procedures to approximate the average appliance and
cooking energy consumption. This additional power must be renewable power produced either within the area of the building and its grounds, elsewhere in the development, or elsewhere as long as the supply is via a private wire arrangement with robust contractual agreements in place to ensure continued supply over time.

Assessment Methodology

**Design Stage**

- Confirm that the SAP 2005 Worksheets and Building Regulation Compliance Checklist are from an accredited energy assessor/Part L ‘competent person’.
- Documentation provided by a non-authorised SAP 2005 energy assessor/Part L ‘competent person’ must have been verified by Building Control and evidence of this must be supplied before any assessment can take place.
- Confirm that each Energy Type or Group meets full Building Regulations compliance using the relevant Compliance Checklist: Design Stage. Note: All criteria must ‘PASS’.
- Calculate the percentage improvement in DER over TER for each Energy Type, using the methodology detailed in the Calculation Procedures section below.
- When creating the base case TER for calculating percentage improvement the most appropriate fuel use available for the development must be used. To demonstrate that this has been carried out, the choice of services to the development must be supported by drawings indicating the location of utility services, such as mains gas and electricity, in the vicinity of the proposed site.
  
  If there is a choice of services and there is no clear justification for the choice of fuel selected to service the development, or if no justification is provided, the measured improvement of DER over TER must be reassessed using a base case property with mains gas as the primary fuel.
- Where buildings contain multiple flats/apartments, averaging may be carried out in accordance with the criteria in the Definitions section.
- For dwellings with energy systems not currently covered under SAP 2005 such as large scale wind power and / or systems please refer to Special Cases.
- Level 6: Where the dwelling exceeds the percentage improvement of DER over TER of 100 per cent, calculate the total carbon emissions (including that required for appliances and cooking), as for ‘zero carbon home’ below (see Calculation Procedures). Confirm that all renewables comply with the definitions above. Confirm that the heat loss parameter requirements are not exceeded.
Post Construction Stage

- Verify that the evidence provided at the Design Stage is still valid and that no changes have occurred during construction.
- Compare Design stage and As Built SAP 2005 Worksheets (as submitted for Building Control purposes) and confirm that there have been no changes. Where changes have occurred, the assessor should reassess the dwelling as set out above.
- For Design and Build contracts, compare the As Built SAP 2005 Worksheets (as submitted for Building Control purposes), with the specification produced as evidence at Design Stage.
- Verify that each Energy Type or Group meets full building regulations compliance using the relevant Compliance Checklist: As Built. Note: All criteria must ‘PASS’.

Calculation Procedures

All of the SAP line number references stated in the following calculation procedures refer to the actual SAP line numbers as detailed in SAP 2005: The Governments Standard Assessment Procedure for energy rating of dwellings. The SAP 2005 document can be found at http://projects.bre.co.uk/sap2005/

There are a number of spreadsheet tools provided which will assist in the calculation of the emissions from the dwelling and percentage improvement of DER over TER. These will be distributed from Code Service Providers and can also be found at http://projects.bre.co.uk/sap2005/stamp-duty-land-tax.html. However the calculation can be carried out manually as set out in this section, Calculation Procedures.

Use the Code Energy Calculation Tool to enter the floor area, DER, TER and HLP for each Energy Type. Where a building contains multiple dwellings and the averaging option has been selected, state which Energy Types belong to the same Energy Group.

Use Table 1.2 in Checklists and Tables to calculate the total predicted CO₂ emissions for Code Levels 1–5 and use Table 1.3 in Checklists and Tables to calculate the total predicted CO₂ emissions for Code Level 6 dwellings.

Figures used for the calculations of the total predicted CO₂ emissions are based on the output from SAP 2005 worksheets.

\[
\% \text{ reduction} = (1 - \frac{\text{DER}}{\text{TER}}) \times 100
\]

The percentage reduction is truncated (not rounded down) to an integer percentage. Thus 99.8750 per cent becomes 99 per cent. The Level is obtained from the truncated percentage reduction according to Table Cat:1.1.
If the percentage reduction is $\geq 100$ and in addition the criteria for zero carbon homes are met, Level 6 is awarded for Ene 1.

**Note.** A dwelling cannot be described as attaining a particular Level of the Code solely on the basis of the above table; there are numerous other issues that are considered in determining the Level.

### Table : Cat 1.1
Percentage improvement (reduction) of the DER over TER associated to each Code Level

<table>
<thead>
<tr>
<th>% reduction</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\geq 10$</td>
<td>1</td>
</tr>
<tr>
<td>$\geq 18$</td>
<td>2</td>
</tr>
<tr>
<td>$\geq 25$</td>
<td>3</td>
</tr>
<tr>
<td>$\geq 44$</td>
<td>4</td>
</tr>
<tr>
<td>$\geq 100$</td>
<td>5</td>
</tr>
</tbody>
</table>

### Table : Cat 1.2 Total Dwelling CO₂ Emissions for Code Levels 1 – 5

<table>
<thead>
<tr>
<th>Code Levels 1–5</th>
<th>Energy kWh/year (a)</th>
<th>Carbon Emissions Factor (from SAP 2005) (b)</th>
<th>Emissions Kg CO₂/year (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Please use the DER from the Building Regulations Compliance Checklist</td>
<td></td>
<td>[1]</td>
</tr>
<tr>
<td>2</td>
<td>CO₂ emissions from mechanical cooling</td>
<td></td>
<td>[3]</td>
</tr>
<tr>
<td>3</td>
<td>Sub Total CO₂ emissions (1+2) = (A)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>CO₂ reduction from Electricity generated by LZC technologies not considered by SAP 2005. (SDLT calculator Line ZC 6) $\times$ (SAP Line 5)</td>
<td>[5] [6]</td>
<td>[4]</td>
</tr>
<tr>
<td>5</td>
<td>Residual CO₂ emissions offset from biomass CHP (where applicable). $\pm 1 \times$ (SAP Line115*) OR $\pm 1 \times$ (SDLT calculator Line ZC 5) $\times$ (SAP Line 5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Total CO₂ reduction from LZC technologies (in step 4 and 5) (4+5) = (B)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Total predicted CO₂ emissions (A)–(B)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
For Code levels 1–5 (Table : Cat 1.2); The DER will be used as the combined figure for the heating, hot water, lighting, pumps and fans.

[1]. For Code Level 6 (Table: Cat 1.3); Please follow the procedure set out in SAP Section 14 to obtain the dwellings Net CO₂ emissions. This can be found at:

http://projects.bre.co.uk/sap2005/stamp-duty-land-tax.html

The calculation of the additional kg CO₂/year emissions generated by appliances and cooking for zero carbon homes (Code Level 6) follows;

\[ 99.9 \times (TFA \times N)^{0.4714} - (3.267 \times TFA) + (32.23 \times N) + 72.6 \]

Where TFA is the Total Floor Area and N is the Number of Occupants

For TFA < 43m²; N = 1.46

For TFA ≥ 43m²; N = 2.844 \times (1 - \exp(-0.000391 \times TFA^2))

[2]. Mechanical cooling is currently not dealt with under SAP 2005. If mechanical cooling is specified, it will need to be estimated separately. Contact your Code Service Provider for further guidance.

[3]. The CO₂ emissions factor to be used for electricity displaced from the grid is 0.568 kgCO₂/kWh (SAP 2005).

[4]. Where energy and LZC technologies service other users (e.g. mixed use developments), both the thermal and electrical output should be allocated between all users in relation to their proportional net floor area.

[5]. As determined in a separate feasibility study. The common LZC technologies not yet considered in SAP 2005 include:

Wind Turbines over 50kW
Large scale Hydro
Fuel Cells using hydrogen generated from a ‘renewable’ source

If the SAP 2005 SDLT calculator is used then these figures can be found in line ZC 6.

Checklists and Tables

None

Common Cases of Non-Compliance

Green tariffs cannot be used to discount CO₂ emissions as these do not guarantee an increased renewable capacity and are not legally binding on occupiers.

It is not possible to achieve a higher Code levels by offsetting emissions from the dwelling with improved efficiency in non-SAP energy consumption such as appliances.

Only off-site renewables connected to the dwellings by a private wire arrangement can be included within this calculation. Some off-site renewables not connected by private wire can be taken into account under Ene 7 under certain circumstances.

Special Cases

*Photovoltaic (PV) panels in buildings with multiple dwellings*

In the case of a building containing more than one dwelling, eg a block of flats, then:

a) if the PV output goes to particular individual flats, the annual output is credited to the flats concerned

b) otherwise, the total electricity generated is divided amongst all the flats in the block in proportion to their net floor area including cases where the PV arrays serve only communal areas.

In case a) an inverter is needed for each flat with a PV electricity supply.

In case b) there will usually be a single inverter for the total PV array and the electricity generated will be fed to the landlord supply and/or the distribution system for the flats (with provision for the export of electricity generated in excess of instantaneous demand).
**Renewable systems not currently dealt with under SAP 2005:**

Large-scale wind turbines over 50 kW and some other more unusual renewable systems are not currently dealt with under SAP 2005.

For wind power, it is suggested that the calculation method which can be found on the GreenSpec website (http://www.greenspec.co.uk/html/energy/windturbines.html) should be used. However, the wind speed should be replaced by the one calculated using the standard that has been developed for the Microgeneration Certification Scheme. This guidance can be found in document MIS3003 (Appendix B) and can be accessed via the website www.ukmicrogeneration.org.

For some other types of renewables please refer to the SAP Appendix Q website (see http://www.sap-appendixq.org.uk). This provides guidance on how to incorporate the energy performance of new technologies as well as evaluating advanced versions of existing technologies so that they can be included in SAP assessments.

**Background**

CO₂ has a direct environmental impact and is a major greenhouse gas, contributing to climate change. The credit scale relates to the operational energy requirements of the home under standard occupancy assumptions – rather than actual energy use. It should be noted that the actual energy consumption may be markedly different, as a range of user-specific issues will affect it, such as the hours of operation of space heating, type and size of household, use of white goods, etc.

The following Energy Saving Trust standards can give an indication of what is required to meet certain Mandatory Levels for this Issue.

- Level 1: Good Practice Standard – 10 per cent improvement of DER over TER
- Level 3: Best Practice Standard – 25 per cent improvement of DER over TER.

The assessment criteria for the Ene 1 is the percentage improvement of the dwelling emission rate (DER) over the target emission rate (TER). The calculation for TER is based on the methodology used within SAP2005 and Building Regulations AD L1A. The approach allows a weighted fuel factor for carbon emissions from different fuels and does not reflect the absolute carbon emission targets; it therefore enables some technologies based on a particular fuel to achieve a higher TER than others. This increase in the TER allows the technology to secure a large percentage improvement over the DER, but may result in increased emissions from the property compared with a standard gas primary heating system on which the DER is based in SAP2006. The fuel factors used within the SAP calculation methodology are to be redefined subject to a consultation in 2009 on Part L of the Building Regulations to map out new requirements for introduction in 2010 and 2013.
The Code for Sustainable Homes does not intend to reward technologies that work against the objectives of the scheme. Hence, the future revisions to the Code will be aligned with revisions to Part L of the Building Regulations; minimum standards of fabric performance and air tightness are also likely to be introduced.
Dedicated renewables for buildings and developments
A definition paper

Why is this paper needed?
Homes and businesses are increasingly encouraged to source renewable energy. Government measures include the Code for Sustainable Homes, low carbon buildings programme, Carbon Emissions Reduction Target, Zero Carbon Homes and positive planning initiatives such as the ‘Merton Rule’. Many companies are also leading by example and planning for the Carbon Reduction Commitment.

For any site, there may be a number of legitimate ways of achieving this. Which approach is acceptable or desirable will depend on the objectives of the policy concerned. Any regulatory measure is likely to set its own requirements and definitions (e.g. of ‘zero carbon home’).

This paper is intended to describe the various options and assist users in selecting the most suitable and those with the greatest contribution to energy sustainability and the low carbon economy.

What do we mean by dedicated renewables?
Firstly we are addressing renewable energy in this paper. However in many instances its scope can be broadened by replacing ‘renewable’ with ‘low carbon’. This would require low carbon energy sources to be defined (e.g. renewables plus high quality CHP).

We use ‘dedicated’ to define energy systems installed and used specifically to meet all or part of the energy requirements of a particular building, group of buildings, community or development.

By contrast the term ‘merchant’ renewable energy is generated for general distribution. This is another option for buildings and developments and is typically supplied by recognised energy companies. Dedicated renewables can be supplied by the property owner or developer, or an existing or specially constituted energy service company (‘Esco’).

It is probably best to avoid the term ‘microgeneration’ as this refers to systems of a specific size, rather than how it is used. ‘On site’ can also mean different things to different commentators – see below.

What are the options for dedicated renewables?
Let’s define the main options:

- An energy source mounted on the building or within the boundaries of an individual property can be referred to as ‘on-unit’.

- Energy sources may be located within or adjacent to the groups of buildings or developments, which they serve. We’ll call this approach ‘on-campus’. This therefore includes what is often called ‘community renewables’ and may extend to the proposed ‘Eco-Towns’.

- Next, renewables may be located not adjacent the development but close to it (in the same parish or planning area, for example) and with a dedicated private wire or other energy connection. We would call this ‘near-site’.

- Finally the developer, owner or tenant might install or own energy production equipment elsewhere and have long-term agreements in place to ensure that the energy needs of the development can be met by its energy output. We call this ‘off-site’.
Some examples are described below. In all these cases it is assumed that the primary purpose of the energy system is to supply the development, not to sell the output. However, surplus energy may be exported through the grid or to neighbouring users. The user is likely also to import energy from a grid connection at least as backup.

The term ‘on-site’ typically includes on-unit and on-campus systems, though the Treasury only accepts on-unit for stamp duty concessions. The REA Onsite Renewables Group covers on-site and near-site applications.

On-site applications apply to heat as well as electricity. The only energy vector currently suitable for remote sourcing is electricity, though biogas through the gas grid may be a future option.

**What are the other low carbon energy supply options?**

In addition to the dedicated energy options above, building developers, owners and tenants can also source renewable energy from the main merchant energy markets, for example on so-called ‘green tariffs’.

Other indirect abatement strategies include ‘carbon offsetting’.

**On-site and off-site applications for renewables**

The UK is in the process of increasing its targets for renewable energy dramatically. The REA believes that these targets can be met, but only if we use many of the available options – it will no longer be adequate to back just one or two favoured technologies or approaches.

In particular we anticipate that a substantial contribution will come from on-site renewables, which have been historically under-exploited. There is a colossal resource in terms of potential sites, such as roofs of dwellings and commercial buildings, industrial estates and brownfield sites (including water treatment and waste management facilities). Planning permission is likely to be less of a constraint than for many greenfield renewable developments.

The merchant renewables market is more developed in the UK, and this too will need accelerated growth to make its contribution to the extended targets. We anticipate this could constrain the potential for others to source offsite renewables, as there will be increased demand for suitable sites, especially for wind, wave and tidal power.

**Which is the favoured approach, then?**

The best options, clearly, will be those that deliver most in terms of overall sustainability, especially in emissions reductions, at the least additional lifetime cost. Therefore renewables should always be coupled with optimised energy efficiency measures. They should also be ‘additional’, that is increased renewable energy production capacity, not just using a source that is already there.

The table on the following page shows the order in which users might consider the different options, and some questions to assess their suitability. This is not a strict value-based hierarchy like, for example, the Energy Hierarchy proposed by the REA prioritising energy conservation, then renewables, with depletive energy production being the last resort.

We would advocate adopting on-site measures wherever possible, on the grounds of additionality and off-site availability limitations as mentioned above. There will inevitably be some sites where this approach cannot meet all of the
needs, and in these few cases, the remote renewable energy option should be considered.
The examples under each heading are not intended to be exhaustive.

<table>
<thead>
<tr>
<th>On-site dedicated</th>
<th>On-campus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Houses with solar panels, heat pumps, biomass boilers or small wind turbines. Commercial buildings with building integrated PV, biomass heating, wind turbines or heat pumps.</td>
<td>Housing estate with biomass district heating or micro-hydro. Retail units / warehouses with PVs, biomass or wind turbines. Renewables on communal buildings. PV on blocks of flats.</td>
</tr>
<tr>
<td>Are there suitable unshaded roof surfaces? How much wind or ground area is there? Biomass – local supplies, storage space?</td>
<td>How much wind, ground area, local biomass supplies? Adjoining river? Suitable unshaded facades and roof surfaces?</td>
</tr>
</tbody>
</table>

The choice between the two approaches above depends on relative economics and operating efficiency and the use of the buildings. An additional factor is the contractual arrangements for the supply of energy to each user – e.g. Esco, community ownership.

<table>
<thead>
<tr>
<th>Near-site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial / housing estate in a valley, with private wire to a wind turbine on the ridge and/or connected to a heat main serviced by a biomass boiler and ground sourced heat pump array. Food processing factory, with AD facilities nearby.</td>
</tr>
</tbody>
</table>

Technical and resource considerations would define the renewable energy source used. Consider also contractual arrangements (or Esco) for energy distribution and supply. Existing networks may be used for energy transport provided the supply is dedicated.

<table>
<thead>
<tr>
<th>Remote energy supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>In these cases the user needs to ensure long-term energy supply. Generating plant and supply contracts need to last for the anticipated lifetime of the properties they serve.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Off-site dedicated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Here the energy installation would be at a greater distance from the site, but the contractual relationship would still be direct. Large urban development powered by a wind farm elsewhere (even offshore) or a portfolio of projects, from which it is contracted to buy power.</td>
</tr>
</tbody>
</table>

Primary consideration would be contractual arrangements for long-term energy supply. The renewable technology is likely to be selected on availability and preference.

<table>
<thead>
<tr>
<th>Energy from a ‘green tariff’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Here the user would purchase its electricity (and/or gas) from a supplier, under a tariff that stimulates additional renewable energy production.</td>
</tr>
</tbody>
</table>

‘Green’ tariffs are highly variable with no current accreditation process. Those creating new capacity (e.g. through a fund) are preferred – see separate REA info. Some merely allocate pre-existing generation to certain customers, and do not directly stimulate new renewable capacity (criticised by the National Consumer Council as ‘green-wash’).

<table>
<thead>
<tr>
<th>Other offset measures (e.g. carbon offsetting)</th>
</tr>
</thead>
</table>

We are not aware of any existing offset programmes that would specifically qualify as renewable energy production, but some are under development.

Finally, there may be good reasons in some cases to adopt a solution from lower down this table, especially for companies with a dispersed portfolio of premises and opportunities to develop a distinct energy supply network. A supermarket chain, for example could support anaerobic digestion facilities on its suppliers’ farms, and even use them to process its waste. Though less direct than on-site renewables, there could be a great deal of added value in developing such resources that would otherwise not have contributed to sustainable energy production.
UK Green Building Council
Zero Carbon Task Group Report
Appendix 4

Extract from the Code for Sustainable Homes
Technical Guidance: Ene7 Credit
### Aim

To reduce carbon emissions and atmospheric pollution by encouraging local energy generation from renewable sources to supply a significant proportion of the energy demand.

### Assessment Criteria

Credits are awarded based on the percentage reduction in total carbon emissions that result from using Low or Zero Carbon (LZC) Energy Technologies for each dwelling using the calculation method detailed in *Calculation Procedures*, with credits awarded as detailed below:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where energy is supplied from local renewable or low carbon energy sources funded under the Low Carbon Building Programme (or similar), or is designed and installed in a manner endorsed by a feasibility study prepared by an independent energy specialist AND There is a 10 per cent reduction in carbon emissions as a result of this method of supply.</td>
<td>1</td>
</tr>
<tr>
<td>OR There is a 15 per cent reduction in carbon emissions as a result of this method of supply.</td>
<td>2</td>
</tr>
</tbody>
</table>

**Default Cases**

None
Information required to demonstrate compliance

<table>
<thead>
<tr>
<th>Schedule of Evidence Required</th>
<th>To be read in conjunction with the Definitions and Calculations Sections.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design Stage</strong></td>
<td><strong>Post Construction Stage</strong></td>
</tr>
<tr>
<td>Confirmation that a feasibility study has been carried out by an independent energy specialist to establish the most appropriate LZC energy source for the building/development</td>
<td></td>
</tr>
<tr>
<td><strong>AND</strong></td>
<td></td>
</tr>
<tr>
<td>Design Stage – SAP 2005 Worksheet* for each Energy Type and accompanying list of specifications from an accredited energy assessor/Part L ‘Competent person’ showing the carbon emissions arising from energy demand with and without LZC technologies</td>
<td></td>
</tr>
<tr>
<td>*Full worksheet, dated, SAP assessor name, registration number where appropriate and dwelling address, prepared at plans approval stage</td>
<td></td>
</tr>
<tr>
<td><strong>AND</strong></td>
<td></td>
</tr>
<tr>
<td>Drawings showing location of LZC equipment in the dwelling, its curtilage and offsite where appropriate.</td>
<td></td>
</tr>
<tr>
<td><strong>AND</strong></td>
<td></td>
</tr>
<tr>
<td>Text describing (on drawings or in the specification):</td>
<td></td>
</tr>
<tr>
<td>• type and location of LZC equipment in the dwelling</td>
<td></td>
</tr>
<tr>
<td>• type of appliances that use an output from the LZC equipment in the dwelling</td>
<td></td>
</tr>
</tbody>
</table>

**AND**

Drawings showing location of LZC equipment in the dwelling, its curtilage and offsite where appropriate.

**AND**

Text describing (on drawings or in the specification):

• type and location of LZC equipment in the dwelling
• type of appliances that use an output from the LZC equipment in the dwelling

**AND EITHER**

• Assessor Site Inspection Report

**OR**

• Photographic evidence for each dwelling with a different specification accompanied by notes
For LZC technologies and fuels not currently covered by SAP 2005 and Land Duty Stamp Tax relief tools:

- Manufacturer’s technical data and details or calculations stating:
  - the estimated heat or electricity output of the LZC system
  - the carbon dioxide emissions resulting both with and without the LZC technology

Where Design and Build contracts or similar contractual arrangements mean detailed drawings are not available at this stage, the specification can be allowed as evidence of intent.

For LZC technologies and fuels not currently covered by SAP 2005 and *Land Duty Stamp Tax* relief tools:

- As design stage

---

**Definitions**

| **Accredited external renewables** | These are renewable energy schemes located offsite which:
|-----------------------------------|---
|                                   | • Are accredited renewables (as defined by the Energy Act 2004). These will be Renewable Energy Guarantee of Origin (REGO) certified
|                                   | • Create new installed generation capacity, designed to meet the loads of the dwelling (i.e. not just units of carbon)
|                                   | • Are additional to capacity already required under the Renewables Obligation
| **Biomass**                       | Note: Some ESCO’s achieve these requirements.
|                                   | Biomass, also known as biofuels or bioenergy, is obtained from organic matter, either directly from plants or indirectly from industrial, commercial, domestic or agricultural products.
|                                   | Biomass can be converted into heat and electricity in several ways. Depending on the source of the biomass, these processes include;
|                                   | • burning, (the decomposition or transformation of a compound caused by heat)
|                                   | • gasification (the conversion of solid biomass into a gaseous fuel)
• anaerobic digestion (the decomposition of an organic biodegradable material by bacterial action in the absence of air, and in warm, moist conditions) or fermentation.

Energy Group
Refer to Ene 1

Energy Type
Refer to Ene 1

ESCO
An Energy Services Company

Design Stage SAP 2005 Worksheet
Refer to Ene1

As-Built SAP 2005 Worksheet
Refer to Ene1

Feasibility Study
A study carried out by an independent energy specialist to establish the most appropriate LZC energy source for a building or development.

The feasibility study must cover as a minimum:

• Energy generated from LZC energy source per year
• Payback
• Land use
• Local planning requirements
• Noise
• Whole life cost and lifecycle impact of the potential specification in terms of carbon emissions
• Any available grants
• All technologies appropriate to the site and energy demand of the development.
• Reasons for excluding other technologies.

It is recommended that the feasibility study must be carried out at the outline proposal stage, Royal Institute of British Architects (RIBA) stage C. The feasibility study may be carried out at later stages but the options available to benefit from LZC energy sources may be significantly restricted. When undertaking a feasibility study at a later stage than RIBA C, an additional element will need to be included in the report to highlight the LZC energy sources which have been discounted due to the constraints placed on the project by the late consideration, and the reason for their omission.
**Independent energy specialist:** An individual who:

- has acquired substantial expertise or a recognised qualification for undertaking assessments, designs and installations of low or zero carbon solutions, in the residential sector;
- is not professionally connected to a single low or zero carbon technology or manufacturer.

**Inverter** Refer to Ene1

**Life cycle impact** This is the requirement to look at the carbon balance of each technology over its whole life. This encourages people to not just consider the savings or emissions over its operational life but also the savings or emissions over the whole life of the technology (from ‘cradle to grave’), therefore reflecting the fact that different technologies have different life spans.

**Low Carbon Buildings Programme** Department for Business Enterprise and Regulatory Reform (BERR) Low Carbon Buildings Programme provides grants for microgeneration technologies to householders and is managed by the Energy Saving Trust.

**Low or Zero Carbon Technologies** The following Low and Zero Carbon Emission Technologies may be considered:

- Solar:
  - Solar Hot Water
  - Photovoltaics
- Water:
  - Small scale hydro power
- Wind:
  - Wind turbines
- Biomass:
  - Biomass single room heaters/stoves
  - Biomass boilers
  - Biomass community heating schemes where the majority of heating comes from biomass
- Combined Heat and Power (CHP) and micro CHP for use with the following fuels:
  - natural gas
  - biomass
  - sewerage gas and other biogases
- Community heating, including utilising waste heat from processes such as large scale power generation where the majority of heating comes from waste heat
• Heat Pumps:
  Ground source heat pumps (GSHP)
  Geothermal heating systems

• Other:
  Fuel cells using hydrogen generated from any of the above ‘renewable’ sources.

For heat pumps to comply the heat source must be from a renewable source, for example soil, ground water or water courses.

For recently developed LZC technologies or LZC technologies that are not mentioned here, please contact a service provider to ensure compliance.

The Department for Business Enterprise and Regulatory Reform (BERR) have recently launched The Microgeneration Certification Scheme (MCS). This scheme will approve microgeneration equipment and installers.

It is a UKAS (United Kingdom Accreditation Service) accredited certification scheme covering products, installers and manufacturers. It provides consumers with an independent indication of reliability of products, assurance that the installation will be carried out to an appropriate standard, and a route for complaints should something go wrong.

This scheme is currently being managed by the Building Research Establishment (BRE) on behalf of Government.

All microgeneration equipment will need to comply with this scheme in order to satisfy the requirement for credits.

The Low or Zero Carbon (LZC) Energy Technologies can be situated either on site or off site. If the LZC technologies are located off-site the source of the electricity should be an “accredited external renewable”. The electricity from both off-site LZC technologies and accredited external renewable are often delivered via an Energy Services Company (ESCO).

**Microgeneration**
Microgeneration is the production of heat and/or electricity on a small-scale from a low carbon source.

**Payback period**
The period of time needed for the return on an investment to equal the sum of the original investment
**Stamp Duty Land Tax (SDLT) relief**

Refer to Ene1

**‘Standard’ case SAP worksheet**

Please note that the ‘Standard’ case SAP worksheet is to be produced separately to the ‘Actual’ SAP worksheet.

In order to facilitate the production of a ‘Standard’ case SAP worksheet, the ‘Standard’ case worksheet can be submitted as a document with a Draft status from commercially available SAP software.

The ‘Standard’ case includes the minimum space and water heating services as set out in the Domestic Heating Compliance Guide, and are as follows:

- Primary Heating Fuel (space & water) – Mains Gas
- Boiler: SEDBUK 86 per cent, room-sealed, fanned flue
- Secondary space heating: Electric heater assumed
- Cylinder volume: 150 litres
- Maximum permitted cylinder loss: 2.62kWh/day
- Primary Pipework: Insulated
- Space Heating Control: Programmer, roomstat, and TRV’s
- Hot water Control: Boiler interlock, cylinder thermostat, separate water control

All other input values for the Standard case SAP calculation will be the same as for the actual dwelling.

The standard case’s emissions (i.e. the DER) shall equal the Target Emissions Rate (TER) for the actual dwelling.

**Whole life cost**

The whole-life costs of a facility are the costs of acquiring it (including consultancy, design and construction costs, and equipment), the costs of operating it and the costs of maintaining it over its whole life through to its disposal; i.e. the total ownership costs.

These costs include internal resources and departmental overheads, where relevant; they also include risk allowances as required; flexibility (predicted alterations for known change in business requirements, for example), refurbishment costs and the costs relating to sustainability and health and safety aspects.
Assessment Methodology

**Design Stage**

- Calculate the total reduction in carbon emissions resulting from using LZC technologies using Table Cat:1.4.
- Provided that there is a direct supply to the dwelling when there is a demand, any surplus electricity from a local LZC source may be exported to the National Grid. The exported electricity may be included in this calculation as if it were consumed within the dwelling/development.
- Confirm that renewables are accredited.

**Post Construction Stage**

- Verify that the evidence provided at the Design Stage is still valid and that no changes have occurred during construction.
  
  For Design and Build contracts, compare the As Built SAP 2005 Worksheets (as submitted for Building Control purposes), with the specification produced as evidence at Design Stage.

**Calculation Procedures**

Use Table Cat 1.4 in Checklists and Tables to calculate the percentage reduction in CO₂ emissions.

Figures used for the calculations of the percentage of energy provided by LZC technologies are based on the output from SAP 2005 worksheets.

**Checklists and Tables**

Table 1.4 can be used for calculating the contribution of LZC Technologies and the CO₂ savings. Alternatively, the Code Energy Calculation Tool is available for assessors from the Code Service Provider to assist with this calculation.
<table>
<thead>
<tr>
<th>Systems assessed with Section 12a of SAP</th>
<th>Systems assessed with Section 12b of SAP</th>
<th>KWh/year supplied</th>
<th>Carbon emissions factor (from SAP 2005)</th>
<th>Emissions Kg CO2/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>– individual heating systems</td>
<td>– community heating systems with CHP</td>
<td>(A)</td>
<td>(B)</td>
<td>(C)=(A)×(B)</td>
</tr>
<tr>
<td>– community heating without CHP</td>
<td>– heat recovered from power stations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 CO\textsubscript{2} emissions from heating and hot water from Standard case SAP Worksheet [SAP Line 107]</td>
<td>CO\textsubscript{2} emissions from heating and hot water from Standard case SAP Worksheet [SAP Line 108]\textsuperscript{<em>+109</em>+110*+111*+112*+113*]</td>
<td>[1]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 CO\textsubscript{2} emissions for fans and pumps from Standard case SAP Worksheet [SAP Line 108]</td>
<td>CO\textsubscript{2} emissions for fans and pumps from Standard case SAP Worksheet [SAP Line 114*]</td>
<td>[1]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 CO\textsubscript{2} emissions from lighting from Standard case SAP Worksheet [SAP Line 109]</td>
<td>CO\textsubscript{2} emissions from lighting from Standard case SAP Worksheet [SAP Line 116*]</td>
<td>[1]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 CO\textsubscript{2} emissions from air-conditioning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 <strong>Code Level 6 only</strong> – CO\textsubscript{2} emissions from appliances and cooking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Total CO\textsubscript{2} emissions from Standard case SAP System (1+2+3+4+5 [if Code level 6])</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 CO\textsubscript{2} emissions for fans and pumps from As Built SAP Worksheet [SAP Line 108]</td>
<td>CO\textsubscript{2} emissions for fans and pumps from As Built SAP Worksheet [SAP Line 114*]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Reduction in CO\textsubscript{2} emissions for pumps and fans from LZC systems in As Built dwelling (2 – 7)</td>
<td></td>
<td></td>
<td></td>
<td>[4]</td>
</tr>
<tr>
<td>9 CO\textsubscript{2} reduction from Electricity generated by LZC technologies considered in SAP 2005 [SAP Line 110* – SAP line 118*]</td>
<td>CO\textsubscript{2} reduction from Electricity generated by LZC technologies considered in SAP 2005 [SAP Line 117* – SAP line 118*]</td>
<td></td>
<td>[6]</td>
<td>[5]</td>
</tr>
</tbody>
</table>

continued
## Table: L2C Contribution and CO2 Savings

<table>
<thead>
<tr>
<th>Systems assessed with Section 12a of SAP</th>
<th>Emissions Kg CO2/year</th>
<th>CO2 reduction from LZC technologies not considered in SAP 2005.</th>
<th>CO2 reduction from LZC Electricity generation</th>
<th>CO2 reduction from LZC Non-Electrical</th>
<th>Total CO2 reduction from LZC technologies</th>
<th>Calculation of Percentage CO2 saving as a result of using LZC systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>– individual heating systems</td>
<td>(A)</td>
<td>[SDLT calculator Line ZC 6] \times (SAP Line 5)</td>
<td>[SAP Line 50]</td>
<td>[SAP Line 115*]</td>
<td>(8)+(13+14)</td>
<td>[\frac{(15)}{(6)} \times 100%]</td>
</tr>
<tr>
<td>– community heating systems with CHP</td>
<td>(B)</td>
<td>[SDLT calculator Line ZC 6] \times (SAP Line 5)</td>
<td>[SAP Line 50]</td>
<td>[SAP Line 115*]</td>
<td>(8)+(13+14)</td>
<td>[\frac{(15)}{(6)} \times 100%]</td>
</tr>
<tr>
<td>– community heating systems without CHP</td>
<td>(C) \times (A) \times (B)</td>
<td>[SDLT calculator Line ZC 6] \times (SAP Line 5)</td>
<td>[SAP Line 50]</td>
<td>[SAP Line 115*]</td>
<td>(8)+(13+14)</td>
<td>[\frac{(15)}{(6)} \times 100%]</td>
</tr>
</tbody>
</table>

\[KWh/year\] supplied

\[Carbon emissions factor (from SAP 2005)\]

[2] Air-conditioning is currently not dealt with under SAP 2005. If air-conditioning is specified, it will need to be estimated separately. Contact the scheme operator who will provide further information on how to proceed.

[3] Kg CO\textsubscript{2}/year from appliances and cooking. See Ene 1:

\[
99.9 \times (TFA \times N)^{0.4714} - (3.267 \times TFA) + (32.23 \times N) + 72.6
\]

Where TFA is the floor area and N is the number of occupants

For TFA < 43 m\textsuperscript{2}; N = 1.46

TFA \geq 43 m\textsuperscript{2}; N = 2.844 \times (1 - \exp(-0.000391 \times TFA^2))

[4] This value may be negative

[5] Carbon emissions factor (SAP 2005) to be used. The most common are listed below. Please see SAP table 12 for further details.

- Grid electricity = 0.422 Kg CO\textsubscript{2}/kWh
- Electricity displaced = 0.568 Kg CO\textsubscript{2}/kWh
- Gas = 0.194 Kg CO\textsubscript{2}/kWh
- Heating oil = 0.265 Kg CO\textsubscript{2}/kWh

[6] Where renewable sources service other users (e.g. mixed use developments). The outputs should be allocated between all users in proportion to their net floor area.

[7] As determined in a separate feasibility study. The common LZC technologies not yet considered in SAP 2005 include:

- Wind Turbines over 50kW
- Large scale Hydro
- Fuel Cells using hydrogen generated from a ‘renewable’ source

If the SAP 2005 SDLT calculator is used then these figures can be found in line ZC 6.

Common Cases of Non-Compliance

Energy supplied from remote sources through the National Grid will not be eligible for any credits in this Issue. This includes electricity procured through ‘Green Tariffs’. 
The energy generated from any renewable energy must first of all be made available to all of the dwellings. For example, where electricity is generated from LZC technologies the energy requirements of the dwelling, dwellings or communal areas must first be satisfied before any surplus generation can be exported to the national grid.

The excess CO₂ savings generated from the energy supply from an initial or earlier phase of the development cannot be used to contribute towards the emissions of a later phase of the development.

Special Cases

*Photovoltaics in buildings with multiple dwellings*

In the case of a building containing more than one dwelling, eg a block of flats, then:

a) if the PV output goes to particular individual flats, the annual output is credited to the flats concerned

b) otherwise, the total electricity generated is divided amongst all the flats in the block in proportion to their net floor area.

In case a) an inverter is needed for each flat with a PV electricity supply.

In case b) there will usually be a single inverter for the total PV array and the electricity generated will be fed to the landlord supply and/or the distribution system for the flats (with provision for the export of electricity generated in excess of instantaneous demand).

Background

The use of zero and low emission energy sources will not only lead to reduced emissions of greenhouse gases and other pollutants, but will also help to conserve the finite global fossil fuel resources and develop a market for such technologies.

The government has set a target that 20 per cent of energy in the UK should be generated from renewable sources by 2020. The greater the number of individual buildings that obtain 10 per cent or more of their energy from renewable sources, the easier this target will be to achieve.

This credit rewards energy efficient design in addition to the inclusion of renewable energy technology. Supplying energy efficient buildings with 10 per cent of their energy demand from zero or low carbon sources will be easier than for less energy efficient buildings since their total demand is lower.
List of parked issues:

- Economic implications for householders
- Householder acceptance of LZC technologies
- Ensuring that householders maintain, optimize the use of, and replace when necessary, their installed renewable technologies
- Discrepancy between ‘real’ and ‘predicted’ energy consumption
- Legal implications of locking householders into heat supply contracts
- If ESCo’s absorb the upfront capital costs of zero carbon electricity generation and charges this as a component of the electricity price what stops the householder just switching to a lower kWh cost ‘regular’ supplier?
- Carbon intensity of Biomass assumptions within SAP - no incentive for local supply and no factors for other biofuels
- Particulate emissions implications from use of biomass
- Build rates of zero carbon new homes 2016 through to 2020
- Implications of the occupancy cycle
- Creation of standard ESCo contracts
- Development of Biomass supply infrastructure
- Sustainability of biomass supply
- Standardisation of CHP community pipework
- Fuel factors
- Lack of wide-spread, consistent actual building performance data
- The implications of/for wider public policy issues and processes that may be affected by the proposed definition
### Development Scenario 1: Single dwelling

- Assumed grid connected but remote from community heat systems
- ‘On-site’ renewables considered
  - Solar PV
  - Solar Thermal
  - Micro-wind
  - Ground source and extract air source (using heat-pump)
  - Wood pellet

#### Scenario 1a  (Pellet boiler + PV)

<table>
<thead>
<tr>
<th>Wood pellet boiler</th>
<th>Conclusions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serves all heating &amp; DHW</td>
<td>• PV makes this too expensive.</td>
</tr>
<tr>
<td>Current boilers, thermal stores and fuel stores are too big for ZC demands.</td>
<td>• Available pellet boiler products currently too larger for very low energy homes.</td>
</tr>
</tbody>
</table>

| Solar PV | Technology proven but large area needed. |
| To meet CSH6* electrical generation needs. | |

#### Scenario 1b  (Heat-pump + PV)

| GSHP | Conclusions: |
| Serves all heating & DHW | • Heat-pump adds to PV area needed (& its cost) such that for typical home there is insufficient roof mounting area. |
| Adds to renewable electrical demand | • PV makes this too expensive. |
| Watch CoP as mainly at larger $\Delta T$.... | |
| Current units too big for ZC demands | |

| Solar PV | Technology proven but very large area needed. |
| To meet CSH6* electrical generation needs. | |

#### Scenario 1b  (Heat-pump, micro-wind + PV)

| GSHP | Conclusions: |
| For all heating & DHW | • First generation micro-wind not technically good enough and costly approvals procedure. |
| Watch CoP as mainly at larger $\Delta T$.... | • PV makes this too expensive. |
| Increases renewable electrical demand | • Heat-pump compounds this. |

| Micro-wind | |
| ‘On-building’ yield is small v demand | |
| Technically performance & service life doubts | |
| As costly as PV due to installation procedures. | |
| Larger on-site option not normally practical | |

| Solar PV | Technology proven but large area needed. |
| Provides bulk of electricity | |

- Solar thermal can be added to each of above scenarios. However it added further capital costs because it only supplements the above technologies, and does not replace any of them.

- **Scenario conclusions**
  - Generating on-site all the electricity needed for the CSH6* is unrealistic in cost terms.
  - Generating the CSH5* electricity on-site is potentially viable.
  - An ‘off-site’ renewable electricity source for CSH6* (CSH6* less CSH5) is needed
  - Development of smaller capacity heat-producing products is needed.
Development Scenario 2: Cluster housing

- Assumed grid connected but remote from community heat systems
- ‘On-site’ renewables considered:
  - Solar PV
  - Micro-wind (<2.5kW) & Mini-wind (2.5 - 50kW)
  - Ground source and extract air source (using heat-pump)
  - Wood pellet (boiler & micro-CHP)

### Scenario 2a  (Pellet boiler + Wind/PV)

**Wood pellet boiler**
- Single boiler serves all heating & DHW via mini district heating system.
- Need to ensure management in place.

**Wind**
- ‘On-building’ yield is small v demand
- Technically performance & service life doubts
- Larger mini-wind on-site option occasionally practical but is often prevented by planning.

**Solar PV**
- To meet CSH6* electrical generation needs.
- Technology proven but large area needed.

**Conclusions:**
- PV makes this too expensive.
- Cluster management/outsourcing of boiler operation needed.
- Sites where communal mini-wind practical should be encouraged.

### Scenario 2b  (Heat-pump + Wind/PV)

**Heat-pump**
- Single unit serves all heating & DHW via mini district heating system.
- Watch CoP as needs to mainly operate at larger source/sink temperature differences.
- Increases renewable electrical demand
- Need to ensure management is in place.

**Micro-wind**
- ‘On-building’ yield is small v demand
- Larger mini-wind on-site option occasionally practical but is prevented by planning.
- NB beware larger electrical demand for GSHP so likely to only contribute part of demand

**Solar PV**
- To meet CSH6* electrical generation needs.
- Technology proven but large area needed.

**Conclusions:**
- PV makes this too expensive.
- Heat-pump compounds this.
- Cluster management/outsourcing of heat-pump operation needed.
- Sites where communal mini-wind practical should be encouraged.

### Scenario 2c  (Pellet micro-CHP + Wind/PV)

**Wood pellet micro-CHP**
- Emerging new European technology
- Single CHP serves all heating & DHW via mini district heating system.
- Typically ‘heat-led’ with low electricity:heat ratio so deliver perhaps only 20% of electrical demands
- Need to ensure management in place.

**Solar PV**
- Extensive top-up of electrical needs
- Technology proven but large area needed.

**Conclusions:**
- Technology not yet available in the UK.
- PV still makes this too expensive.
- Cluster management/outsourcing of district heating operation needed.

- Solar thermal can be added to each of above scenarios. However it added further costs because it adds to the above technologies, and does not replace them. It also reduces micro-CHP viability.

- **Scenario conclusions**
  - Generating on-site all the electricity needed for the CSH6* is unrealistic in cost terms.
  - Generating the CSH5* electricity on-site is potentially viable.
  - An ‘off-site’ renewable electricity source for CSH6* (CSH6* less CSH5) is needed.
**Development Scenario 3: Average house developments (25-100 units, brownfield & lower density)**

- ‘On-site’ renewables considered
  - Solar PV
  - Mini-wind (2.5 - 75kW?)
  - Ground source and extract air source (using heat-pump)
  - Wood pellet (boiler & mini-CHP)

### Scenario 3a  (Pellet boiler + Wind/PV)

<table>
<thead>
<tr>
<th>Wood pellet boiler</th>
<th>(Pellet boiler + Wind/PV)</th>
<th>Conclusions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood pellet boiler</td>
<td>Single boiler serves all heating &amp; DHW via district heating system.</td>
<td>Sites where communal mini-wind practical should be encouraged</td>
</tr>
<tr>
<td>Wind</td>
<td>Larger mini-wind option occasionally practical if designed into communal landscaping</td>
<td>PV top-up can make this too expensive.</td>
</tr>
<tr>
<td>Solar PV</td>
<td>Resisted by planning.</td>
<td></td>
</tr>
</tbody>
</table>

### Scenario 3b  (Heat-pump + Wind/PV)

<table>
<thead>
<tr>
<th>GSHP</th>
<th>(Heat-pump + Wind/PV)</th>
<th>Conclusions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSHP</td>
<td>Multiple units serves all heating &amp; DHW via mini district heating system. Watch CoP as needs to mainly operate at larger source/sink temperature differences. Increases renewable electrical demand Need to ensure management is in place.</td>
<td>Sites where communal mini-wind practical should be encouraged</td>
</tr>
<tr>
<td>Wind</td>
<td>Larger mini-wind option occasionally practical if designed into communal landscaping Resisted by planning.</td>
<td>PV top-up makes this too expensive.</td>
</tr>
<tr>
<td>Solar PV</td>
<td>Greater top-up to wind compared with 3b</td>
<td>Heat-pump compounds this.</td>
</tr>
</tbody>
</table>

### Scenario 3c  (Pellet micro-CHP + Wind/PV)

<table>
<thead>
<tr>
<th>Wood pellet micro-CHP</th>
<th>(Pellet micro-CHP + Wind/PV)</th>
<th>Conclusions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood pellet micro-CHP</td>
<td>Emerging new European technology Single / multiple CHP serves all heating &amp; DHW via district heating system. Typically ‘heat-led’ with low electricity:heat ratio serves perhaps 40% electrical needs</td>
<td>In mini-wind not available then PV still makes this too expensive.</td>
</tr>
<tr>
<td>Wind</td>
<td>Larger mini-wind occasionally practical if designed into communal landscaping Resisted by planning.</td>
<td></td>
</tr>
<tr>
<td>Solar PV</td>
<td>Top-up to wind</td>
<td></td>
</tr>
</tbody>
</table>

- Solar thermal can be added to each of above scenarios. However it added further costs because it adds to the above technologies, and does not replace them. It also reduces micro-CHP viability.

- **Scenario conclusions**
  - Emerging European wood pellet fuelled mini-CHP technology has potential to reduce extent of site PV / wind needed and reduce so costs. Reconfiguring ‘heat-led’ to ‘electricity-led’ mini-CHP is possible but no experience in UK as yet of doing this.
  - 100% of CSH6° heat could be generated on site
  - Probable realistic to consider 50% of CSH6° electricity could be generated on site.
  - An ‘off-site’ renewable electricity source is needed for remainder.
**Development Scenario 4: High density urban in-fill sites (25 units- 150 units)**

- ‘On-site’ renewables considered
  - Solar PV
  - Mini-wind (2.5 - 75kW)
  - Ground source and extract air source (using heat-pump)
  - Wood pellet (boiler & micro-CHP)

<table>
<thead>
<tr>
<th>Scenario 4a (Pellet boiler + Wind/PV)</th>
<th>Conclusions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood pellet boiler Wind</td>
<td>Single boiler serves all heating &amp; DHW via district heating system. Roof mounted micro/mini-wind option may be practical but likely to meet no more than 10% electrical needs</td>
</tr>
<tr>
<td>Solar PV</td>
<td>Roof mounted to meet say 10% electrical needs</td>
</tr>
</tbody>
</table>

- Unable to generate sufficient on-site renewable electricity

<table>
<thead>
<tr>
<th>Scenario 4b (Heat-pump + Wind/PV)</th>
<th>Conclusions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSHP</td>
<td>Multiple units serves all heating &amp; DHW via mini district heating system. Can serve perhaps up to 4 storey from ground below building footprint. Watch CoP as needs to mainly operate at larger source/sink temperature differences. Increases renewable electrical demand Need to ensure management is in place.</td>
</tr>
<tr>
<td>Wind</td>
<td>Room mounted micro/mini-wind unlikely to meet 10% of larger electrical needs</td>
</tr>
<tr>
<td>Solar PV</td>
<td>Roof mounted to meet up perhaps 10% electrical needs</td>
</tr>
</tbody>
</table>

- Unable to generate on site sufficient renewable electricity

<table>
<thead>
<tr>
<th>Scenario 4c (Pellet micro-CHP + Wind/PV)</th>
<th>Conclusions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood pellet micro-CHP</td>
<td>Emerging new European technology Single / multiple CHP serves all heating &amp; DHW via district heating system. Typically ‘heat-led’ with low electricity:heat ratio serves perhaps 40% electrical needs</td>
</tr>
<tr>
<td>Wind</td>
<td>Larger mini-wind occasionally practical if designed into communal landscaping but resisted by planning.</td>
</tr>
<tr>
<td>Solar PV</td>
<td>Top-up to wind</td>
</tr>
</tbody>
</table>

- If mini-wind not available then PV still makes this too expensive.

- Solar thermal can be added to each of above scenarios. However it added further costs because it adds to the above technologies, and does not replace them. It also reduces micro-CHP viability.

- **Scenario conclusions**
  - Emerging European wood pellet fuelled mini-CHP technology has potential to reduce extent of site PV / wind needed and reduce so costs. Reconfiguring ‘heat-led’ to ‘electricity-led’ mini-CHP is possible but no experience in UK as yet of doing this.
  - 100% of CSH6* heat could be generated on site
  - Probably realistic to consider 40% of CSH6 electricity could be generated on site.
An ‘off-site’ renewable electricity source is needed for remainder.

**Development Scenario 5: Smaller non-domestic building <1000m²**

- Broadly assumed to have double the electrical use of domestic (note there is a wide tolerance)
- ‘On-site’ renewables considered
  - Solar PV
  - Micro-wind (<2.5kW?) & Mini-wind (2.5 - 50kW?)
  - Ground source heat and cooling (GSHP)
  - Wood pellet (boiler & micro-CHP)

### Scenario 5a (Pellet boiler + Wind/PV)
- Wood pellet boiler
- Single boiler serves all heating & DHW
- Wind: Roof mounted micro/mini-wind option may be practical but likely to meet no more than 5% electrical needs
- Solar PV: Roof area limits to 5% electrical demand

**Conclusions:**
- Can generate renewable heat
- Unable to generate sufficient renewable on-site electricity

### Scenario 5b (GSHP + Wind/PV)
- GSHP: Single unit serves all heating, cooling & DHW. Watch CoP as mainly at larger ∆T.... Increases renewable electrical demand
- Micro-wind: ‘On-building’ yield is small v demand. Larger mini-wind on-site option occasionally practical but is prevented by planning. NB beware larger electrical demand for GSHP so likely to only contribute part of demand
- Solar PV: Roof area limits to 3% electrical demand

**Conclusions:**
- Unable to generate sufficient renewable on-site electricity.
- GSHP compounds this.

### Scenario 5c (Pellet micro-CHP + Wind/PV)
- Wood pellet micro-CHP: Emerging new European technology. Single CHP serves all heating & DHW. ‘Heat-led’ with low electricity:heat ratio so delivered perhaps 15% of electrical demands
- Solar PV: Roof area limits to 5% electrical demand

**Conclusions:**
- Micro-CHP electricity:heat ratio not suited to predominate electrical demand
- Unable to generate on site sufficient renewable electricity

- Solar thermal can be added to each of above scenarios. However it added further costs because it adds to the above technologies, and does not replace them. It also reduces micro-CHP viability.

**Scenario conclusions**
- Generating on-site all the electricity needed for ZC is unrealistic in cost terms.
- Generating all heat and say 5% electricity on-site is potentially viable.
- An ‘off-site’ renewable electricity source is needed for remainder.
Development Scenario 6: Medium non-domestic building <10,000m²

- ‘On-site’ renewables considered
  - Solar PV
  - Solar Thermal
  - Mini-wind (2.5 - 75kW?)
  - Ground source heat and cooling (GSHP)
  - Biomass: wood pellet/chip (for boiler / CHP)

<table>
<thead>
<tr>
<th>Scenario 6a</th>
<th>(Biomass boiler + Wind/PV)</th>
<th>Conclusions:</th>
</tr>
</thead>
</table>
| Biomass boiler | Boiler serves all heating & DHW
|               | Could serve cooling via mini-absorption unit |
| Wind         | Roof mounted micro/mini-wind 10% electrical needs. Larger turbine occasionally practical if designed into larger sites. Resisted by planning. |
| Solar PV     | Roof mounted to meet say 20% electrical |

<table>
<thead>
<tr>
<th>Scenario 6b</th>
<th>(GSHP + Wind/PV)</th>
<th>Conclusions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSHP</td>
<td>Multiple units serve heating, cooling &amp; DHW. Can serve perhaps up to 4 storeys from ground below building footprint. Increases renewable electrical demand</td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td>Room mounted micro/mini-wind unlikely to meet 6% of larger electrical needs</td>
<td></td>
</tr>
<tr>
<td>Solar PV</td>
<td>Roof mounted to meet up to 15% electrical</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario 6c</th>
<th>(Biomass-CHP)</th>
<th>Conclusions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass-CHP</td>
<td>Emerging technology. Limited sizes available best suited to larger buildings. Can meet all heat, DHW (&amp; cooling using absorption). Best match to buildings where electrical demands have been reduced.</td>
<td></td>
</tr>
</tbody>
</table>

- Solar thermal can be added to each of above scenarios. However it added further costs because it adds to the above technologies, and does not replace them. It also reduces CHP viability.

- Scenario conclusions
  - 100% of ZC heat and electricity could be generated on site using biomass CHP
  - Ideally should be linked to other buildings with summer heat demand so that surplus heat can be fully used (eg existing housing stock and absorption cooling)
  - Careful definition of this scenario is needed because of limited CHP size availability suitable for smaller non-domestic buildings within this range.
**Development Scenario 7: Large & mixed-use developments**

- ‘On-site’ renewables considered
  - Solar PV
  - Wind
  - Ground source heat & cooling (GSHP)
  - Biomass: wood pellet/chip / (for boiler / CHP)

<table>
<thead>
<tr>
<th>Scenario 7a (Biomass boiler + Wind/PV)</th>
<th>Conclusions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass boiler</td>
<td>Boiler serves all heating &amp; DHW via district heating. Could serve cooling via mini-absorption unit</td>
</tr>
<tr>
<td>Wind</td>
<td>Roof mounted micro/mini-wind 10% electrical needs. Larger occasionally practical if designed into larger sites. Resisted by planning.</td>
</tr>
<tr>
<td>Solar PV</td>
<td>Roof mounted to meet say 20% electrical</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario 7b (GSHP + Wind/PV)</th>
<th>Conclusions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSHP</td>
<td>Multiple units serve heating, cooling &amp; DHW. Can serve perhaps up to 4 storeys from ground below building footprint. Watch CoP as mainly at larger ΔT.... Increases renewable electrical demand</td>
</tr>
<tr>
<td>Wind</td>
<td>Room mounted micro/mini-wind unlikely to meet 6% of larger electrical needs</td>
</tr>
<tr>
<td>Solar PV</td>
<td>Roof mounted to meet up to 15% electrical</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario 7c (Biomass-CHP)</th>
<th>Conclusions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomass-CHP</td>
<td>Community based decentralised system. Can meet all heat, DHW &amp; cooling using absorption. Full mixed uses allow better use of plant. Best match to buildings where electrical demands have been reduced.</td>
</tr>
</tbody>
</table>

- Solar thermal can be added to each of above scenarios. However it added further costs because it adds to the above technologies, and does not replace them. It also reduces CHP viability.

**Scenario conclusions**

- 100% of ZC heat and electricity could be generated on site using biomass CHP. If on community scale could be energy-from-waste etc.
- Ideally should be linked to other buildings with summer heat demand so that any surplus heat can be fully used (eg existing housing stock and absorption cooling).
Element Energy Model: Process Diagram

**INPUTS**
- Characterise new build housing to 2025
  - Dwelling types
  - Development size
  - Urbancy
  - Tenure
- Regulation requirements
  - CO₂ targets
  - Limitations
- Low and zero carbon technologies
  - Performance and cost projections
  - Suitability for different dwelling types

**TECHNOLOGY ASSESSMENT**
- Define energy demands for each dwelling
  - All energy demands
  - 2 efficiency scenarios
- 32 dwelling types energy demands

**CONSUMER CHOICE**
- Developer choice
  - Consumer decisions based on cost and other factors

**RESULTS**
- Technology uptake
- Cost
- Number of homes not meeting legislation
UK Green Building Council
Zero Carbon Task Group Report
Appendix 8
Discussion paper on CO₂ emissions factors
CO₂ Emission Figures for Policy Analysis

Christine Pout
26th July 2005

For policy analysis and applications that relate to end users it is important to use CO₂ emission factors that accurately reflect the net change in CO₂ emissions that would result from specific policy action or other decision. For example, it is important that those used in SAP and SBEM encourage choices that result in lower annual carbon emissions for a particular building, and that their application in Part L of the Building Regulations provide an equitable basis between different fuels. This means using emission factors that relate to delivered energy, which include emissions from processing and distributing emissions, as well as from combustion, as a reduction in energy use at the point of delivery will also reduce these upstream emissions.

The fossil fuel emission figures that are currently proposed for SAP 2005 are based on delivered energy CO₂ emission factors, which had previously been generated for DEFRA’s Global Atmosphere Division for use in carbon abatement studies. To date, the way in which the SAP 2005 figures have been derived has not been set out which has led to the figures currently proposed for SAP 2005 figures being challenged.

This paper sets out to describe how delivered energy emission figures relate to other emission factors in the public domain, and to review the currently proposed SAP 2005 emission factors and describe their provenance. It considers more recent data on emissions arising from LPG that has been provided by the Liquid Petroleum Gas Association (LPGA) and makes recommendations as to how these emission factors should be adjusted, based on more recent information, but using the existing methodology. This work was funded by DEFRA’s Global Atmosphere Division.

Background

The CO₂ emission factors that are presented in DEFRA’s environmental reporting guidelines (and which are used to assess carbon emissions for both Negotiated Agreements and the UK Emissions Trading Scheme) differ from those proposed for SAP, which can lead to confusion. However, the key difference between the SAP figures and the environmental reporting guidelines lies in the scope of emissions considered. Whereas the environmental reporting factors are combustion factors, the SAP figures relate to delivered energy and thus include upstream emissions from fuel production and distribution as well as from combustion.

Whereas emission factors for fossil fuels are not likely to change significantly from year to year1, for electricity, the emission factor will vary significantly depending on the mix of generation plant used in a particular year. For this reason, the emission factor for electricity needs to reflect the expected generation mix over the period which the emission factor is to be used. Hence the electricity emission factor is based on the expected fuel mix over the period in question, which for the purpose of SAP 2005 has been taken as 2005-2010. The emission factor for electricity is further complicated by the issue of marginal emissions, which relate to emissions avoided as a result of reduced or increased demand for electricity. In the past the marginal

1 Whilst there may be year to year variations these are not generally large and significant changes are only likely to be relevant where this is a step change in either the composition of the fuel, or to the production or distribution of the fuel.
emission factor for UK generated electricity has been higher than the system average, although it is clear that the gap has been closing in recent years.

**Delivered Emission Factors for Fossil Fuels**
The fossil fuels emission factors for SAP 2005 put forward in the consultation document are listed below:

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>kgCO₂/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>mains gas</td>
<td>0.194</td>
</tr>
<tr>
<td>bulk LPG</td>
<td>0.249</td>
</tr>
<tr>
<td>bottled LPG</td>
<td>0.249</td>
</tr>
<tr>
<td>heating oil</td>
<td>0.270</td>
</tr>
<tr>
<td>house coal</td>
<td>0.291</td>
</tr>
<tr>
<td>anthracite</td>
<td>0.317</td>
</tr>
<tr>
<td>manufactured smokeless fuel</td>
<td>0.392</td>
</tr>
</tbody>
</table>

These emission factors are based on the combustion emission factor for that fuel, plus a production overhead emission factor. NETCEN values provide the combustion emission factors. For solid and liquid fuels, these are provided in terms of emission per tonne and are converted to emissions per kWh based on the average annual calorific value as published in the Digest of UK Energy Statistics (DUKES). The total CO₂ emissions associated with the production of each fuel is calculated from the amount of fuel used in producing each fuel, which is provided by the aggregated energy balance provided by Table 1.1 of DUKES and the combustion emissions factor for that fuel.

The production overhead emission factor for each fuel is calculated by dividing the total CO₂ emission arising from production by the total UK energy production for that fuel. The production overhead for UK fuel production is then applied to the total UK fuel supply with losses between supply and consumption being accounted for by multiplying the production overhead for fuel supply by supply divided by consumption.

where,

\[
\text{Production} = \text{gross production} \\
\text{Supply} = \text{production} + \text{imports} - \text{exports} - \text{stock changes} - \text{statistical difference} \\
\text{Consumption} = \text{Supply} - \text{Losses}^4
\]

An example calculation is set out below which shows how emissions from fuel production associated with exported fuels are "exported" along with the fuels and imported fuels are assumed to have the same production emissions as UK produced fuel. In contrast emissions associated with losses are included in the production overhead for final consumers.

---

3. Where losses include metering differences and theft as well as leakage assessment.
<table>
<thead>
<tr>
<th></th>
<th>GWh</th>
<th>tonnes CO₂*1,000</th>
<th>kgCO₂/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK fuel production</td>
<td>17,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon emissions from energy use during fuel production</td>
<td>170</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production overhead UK produced fuel</td>
<td></td>
<td></td>
<td>0.010</td>
</tr>
<tr>
<td>Imports and other additions</td>
<td>+5000</td>
<td>50</td>
<td>0.010</td>
</tr>
<tr>
<td>Exports and other removals</td>
<td>-2000</td>
<td>-20</td>
<td>0.010</td>
</tr>
<tr>
<td>UK fuel supply</td>
<td>20,000</td>
<td>200</td>
<td>0.010</td>
</tr>
<tr>
<td>Losses</td>
<td>-2000</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>UK fuel consumption</td>
<td>18,000</td>
<td>200</td>
<td>0.011</td>
</tr>
</tbody>
</table>

The methodology for deriving delivered energy emission factors is summarised in the following schematic:
This methodology:

- Assumes carbon emissions arising from the production of imported fuel are the same as those for UK produced fuel.
- Restricts consideration of greenhouse gas emissions to CO₂. This is appropriate for SAP and SBEM as the Energy Performance of Buildings Directive states, "The energy performance of a building shall be expressed in a transparent measure and may include a CO₂ indicator" and makes no mention of other greenhouse gases.
- Treats all distribution losses (as they appear on Table 1.1 of DUKES) as material loss to the energy supply chain. Thus, methane leakage from natural gas distribution increases the emission figures in proportion to the relative loss, but takes no account is taken of the relative greenhouse impact of methane.
- Where energy industry use is associated with production of one or more fuels the emissions are apportioned between the fuels according to their energy content.
- Does not include emissions from transportation by road or rail, for oil and gas these make up less than 10% of the total production overhead for most fuels.

Smokeless fuel is slightly different in that it is produced by transforming coal. Here, in addition to emissions associated with energy used in the manufacture of smokeless fuel, a mass balance approach is used to determine the additional emissions from the fuel transformation process itself. This relates to the difference between the emission that would result from combustion of the input fuel (coal) and the output fuel (smokeless solid fuel).

These emission factors have been checked against delivered energy emission factors calculated using 2001 energy consumption data and 2001 NETCEN combustions emission factors. There are some small variations which arise from either, revisions to DUKES consumption data, yearly variations in the average annual calorific value and changes to the NETCEN emission factors, and/or to converting figures quoted to two significant figures between units. Nevertheless these changes are not significant; However, for oil, it appears that the mix of heating oil, fuel oil and gas oil used across all building types was assumed for the domestic sector, when in fact nearly 90% of domestic oil consumption is burning oil. For this reason it is recommended that the proposed emission factor for SAP should be changed to that of burning oil, 0.265kgCO₂/kWh. (Coincidently, the emission factor would be the same for the average mix of heating oil used in the domestic sector.). As burning oil is the main heating oil for all buildings it may also be applied to the non-domestic oil

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5 This approach is consistent with the requirement of Part L and the Energy Performance of Buildings Directive which only require consideration of CO₂ emissions.

use as well. The emission factor is also 0.265 to reflect the mix of oil products used in the domestic sector.

The proposed figures only quote an emission factor for house coal, so an additional emission factor is suggested for the non-domestic coal of 0.300kgCO₂/kWh. (c.f. 0.291kgCO₂/kWh for domestic).

As the combustion emission factor for propane has been revised downwards since 1997, a revised emission factor for LPG has been proposed by the LPGA. This is based on 2003 emission factors for propane and production overheads provided in a 1997 report for an EC funded project on transport emission produced by AEA Technology, resulting in a figure of 0.237 kgCO₂/kWh. However, this report is specifically concerned with transport fuels and the production emissions considered are wider in the scope than that for other fuels in that they include transportation as well as other processing and distribution overheads. Hence value of 0.234 kgCO₂/kWh is proposed.

Delivered Energy Emission factors for renewable fuels

The renewable fuels emission factors for SAP 2005 put forward in the consultation document are listed below:

- wood logs 0.025
- wood pellets in bags 0.025
- bulk wood pellets 0.025
- wood chips 0.025
- heat from boilers – biomass or biogas 0.025
- heat from boilers – waste combustion 0.043
- waste heat from power stations 0.018

The emission factors for the first five fuels listed above include estimates of CO₂ emissions from planting, harvesting, sawing up and other processing, and delivery to the point of use. The inclusion of transportation for renewable fuels is justified as they tend to be bulkier than fossil fuels, and because they are less widely used so the distances travelled are likely to be larger.

As around 90% by weight of the combustible materials in municipal solid waste is from renewable sources, the remaining 10% being mainly plastic. On this basis a more reasonable figure here would be 0.057kgCO₂/kWh, which is based on 30% of MSW heat arising from non-renewable sources and assumes similar processing overheads to other renewable sources.

Alternative options would be to use the emissions factor for fuel oil (which is the main heating oil used in the public and commercial sectors) of 0.278kgCO₂/kWh, or an emission factor based on the average mix of heating oils used, which would be 276kgCO₂/kWh.


These estimates are notional and are not based on detailed assessments.

10% by weight translates to 30% by heat content as the calorific value of plastic is three times that of wood/paper.
Delivered Energy Emissions factor for dual fuel appliances

Dual fuel appliances are ones that can burn either mineral solid fuel or wood. The actual choice of fuel is a matter of user preference, and for the purposes of ratings and building regulations a figure was derived on the basis of a market mix of mineral and wood fuels.

A report commissioned from HETAS\textsuperscript{11} made estimates of the total annual burn of wood and mineral fuels for domestic heating purposes. The primary estimate of wood burn was obtained from consideration of wood purchased from merchants, wood purchased from arboricultural arisings (woodland management) and wood usage from own land (principally farmers) giving a total estimated burn (England, Scotland and Wales) of 1,041,000 tonnes. Broadly similar figures were obtained from the 1997 GfK Marketing Services Report for the Solid Fuel Industry, and the 2001 English House Condition Survey. A figure of 1m tonnes was taken as a reasonable estimate of current wood burning for domestic heating.

The total burn of mineral fuel (bituminous coal, anthracite and manufactured smokeless fuel) was estimated at 1.6m tonnes in 2001. It has reduced appreciably since then, particularly for anthracite due to a decline in the number of gravity-feed boilers in use. The total usage of mineral fuel in 2004 was estimated as 1.05m tonnes, of which about two-thirds being used outside smoke control (0.45m tonnes of bituminous coal, 0.135m tonnes of anthracite and 0.11m tonnes of smokeless fuel). This has been estimated on the basis that ~50% of UK properties are covered by smoke control legislation (ref NETCEN) the overwhelming majority of which have gas available: solid fuel usage is increasingly concentrated in rural areas off the gas network. Taking account of the relative calorific values, the weighted average emission factor is 0.187 kgCO\textsubscript{2}/kWh.

Within smoke control areas, all appliances (other than exempted appliances) are taken as burning anthracite or manufactured smokeless fuel.

Delivered Energy Emission factors for Electricity

The expected average annual emission factor for grid electricity of 0.422 kgCO\textsubscript{2}/kWh is based on the expected mix of electricity supply for the average of the Central Growth/Low Price and Central Growth/High Price scenarios between 2005 and 2010 from the DTI energy projections presented in Energy Paper 68\textsuperscript{12} which have been adjusted to take account of expected transmission and distribution losses\textsuperscript{13}. Although there will be variations in the actual emission factors at different times of the day, it is appropriate to use an average value for SAP calculations.

The emission factor of 0.568 kgCO\textsubscript{2}/kWh which is used for avoided electricity consumption is based on a mixture of the average carbon intensity of the marginal plant and the carbon intensity of new plant built or avoided. Here the average carbon intensity of marginal plant has been modelled based on actual electricity generation

\textsuperscript{11} An assessment of annual wood and mineral fuel usage in the domestic solid fuel heating industry, Report 3404 B, HETAS Ltd, April 2005.


\textsuperscript{13} The carbon intensity of electricity: How many kgC per kWhe?, ER Hitchin, CH Pout, 2002.
data for 1998/1999 for England and Wales, and new plant build/avoided is assumed to be combined cycle gas turbines\(^9\). As for the system average emission factor the avoided electricity consumption factors takes account of expected transmission and distribution losses.

The data and data sources used to calculated the delivered fuel emission factors are summarised in Table 1.

**Emission figures for SAP 2005 and Part L**

With the amendments mentioned above, the emission factors given in SAP 2005 and SBEM, and used to derive the fuel factors given in the Approved Documents for Part L, are summarised in the final column of Table 1.
<table>
<thead>
<tr>
<th>Fuel</th>
<th>DUKES Calorific value GJ/tonne</th>
<th>NETCEN emission factor kgC/kWh</th>
<th>NETCEN emission factor gC/GJ</th>
<th>Combustion only kgCO2/kWh</th>
<th>Production overhead kgCO2/kWh</th>
<th>Delivered energy kgCO2/kWh</th>
<th>Proposed SAP 2005 kgCO2/kWh</th>
<th>Revised SAP 2005 kgCO2/kWh</th>
</tr>
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<tbody>
<tr>
<td>mains gas</td>
<td>-</td>
<td>-</td>
<td>14.230</td>
<td>0.188</td>
<td>0.006</td>
<td>0.194</td>
<td>0.194</td>
<td>0.194</td>
</tr>
<tr>
<td>bulk LPG</td>
<td>-</td>
<td>-</td>
<td>16.230</td>
<td>0.214</td>
<td>0.020</td>
<td>0.234</td>
<td>0.249</td>
<td>0.234</td>
</tr>
<tr>
<td>bottled LPG</td>
<td>-</td>
<td>-</td>
<td>16.230</td>
<td>0.214</td>
<td>0.020</td>
<td>0.234</td>
<td>0.249</td>
<td>0.234</td>
</tr>
<tr>
<td>fuel oil</td>
<td>43.5</td>
<td>850.0</td>
<td>-</td>
<td>0.258</td>
<td>0.020</td>
<td>0.278</td>
<td></td>
<td></td>
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<tr>
<td>burning oil</td>
<td>46.2</td>
<td>859.0</td>
<td>-</td>
<td>0.245</td>
<td>0.020</td>
<td>0.265</td>
<td></td>
<td></td>
</tr>
<tr>
<td>gas oil</td>
<td>45.6</td>
<td>857.0</td>
<td>-</td>
<td>0.248</td>
<td>0.020</td>
<td>0.268</td>
<td></td>
<td></td>
</tr>
<tr>
<td>domestic oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.265</td>
<td></td>
</tr>
<tr>
<td>non-domestic oil</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.276</td>
<td></td>
</tr>
<tr>
<td>heating oil</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>0.270</td>
<td></td>
</tr>
<tr>
<td>house coal</td>
<td>30.9</td>
<td>676.8</td>
<td>-</td>
<td>0.289</td>
<td>0.001</td>
<td>0.291</td>
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<tr>
<td>non-domestic coal</td>
<td>29.2</td>
<td>659.6</td>
<td>-</td>
<td>0.298</td>
<td>0.001</td>
<td>0.300</td>
<td>0.300</td>
<td></td>
</tr>
<tr>
<td>anthracite</td>
<td>33.9</td>
<td>813.4</td>
<td>-</td>
<td>0.317</td>
<td>0.001</td>
<td>0.317</td>
<td>0.317</td>
<td></td>
</tr>
<tr>
<td>manufactured smokeless fuel</td>
<td>30.6</td>
<td>774.2</td>
<td>-</td>
<td>0.334</td>
<td>0.058</td>
<td>0.392</td>
<td>0.392</td>
<td>0.392</td>
</tr>
<tr>
<td>wood logs</td>
<td>Production overheads for planting,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wood pellets in bags</td>
<td>harvesting, sawing up and other processing,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bulk wood pellets</td>
<td>and delivery to the point of use.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>wood chips</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.025</td>
<td>0.025</td>
</tr>
<tr>
<td>dual fuel appliance (mineral and wood)</td>
<td>Separate calculation - see text</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.187</td>
<td>0.187</td>
</tr>
<tr>
<td>heat from boilers – biomass or biogas</td>
<td>As for other biofuels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.025</td>
<td>0.025</td>
</tr>
<tr>
<td>heat from boilers – waste combustion</td>
<td>See text</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.043</td>
<td>0.057</td>
</tr>
<tr>
<td>waste heat from power stations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.018</td>
<td>0.018</td>
</tr>
<tr>
<td>electricity from grid</td>
<td>Average emission for grid electricity between 2006-2010 based on DTI EP65 CL/CH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.422</td>
<td>0.422</td>
</tr>
<tr>
<td>electricity displaced from grid</td>
<td>Average of marginal carbon intensity and generation plant built or avoided 2005-2010</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.568</td>
<td>0.568</td>
</tr>
</tbody>
</table>

NB – Production overhead + combustion only emission factor may not equal delivered energy emission factor due to rounding.
Desirable characteristic of a ‘zero carbon’ definition:

- **Predictable** - To provide certainty for house-builders, product manufacturers, landowners and others to plan and invest. This is critical for strategic land purchase/sale decisions, product research and development investment and supply chain capacity building. Uncertainty significantly impacts all types of investment decisions.

- **Low development type distortion** - Different definitions may influence the viability of particular development or building types. This distortion could lead to unintended consequences which have a detrimental effect such as, for example, a reduction in in-fill development and increased pressure on green-field land. Indeed, in the example given, overall CO₂ emissions could even be higher through increased transport emissions. The definition of ‘zero carbon’ itself should, as far as it is practical, have no impact on the types of developments constructed.

- **Not overly complicated** - An over-complicated definition is more likely to produce unintended consequences and increase the potential for errors in implementation.

- **Encourages innovation** - The definition should allow the broadest possible range of potential solutions, and therefore market opportunities. This should be clearly communicated to encourage innovation and investment in research and development, and to provide security for supply-chain capacity building.

- **Financially viable** - Zero carbon buildings represent a significant challenge. The types of solutions available are not the same across all sites which affects the relative viability of different development types. The wider goals of affordability and build-rate must also be achieved, together with ‘zero carbon’, so the definition must ensure that the vast majority, if not all, developments remain financially viable.

- **Optimises use of “on-site” renewable resource** - Most buildings constructed now will still be standing in 2050. The scale of the CO₂ reductions required by this date mean that all practicable energy efficiency measures and renewable technologies will be required to contribute. The most effective time to deploy many of the required measures is when the building is constructed, such as community CHP. The zero carbon definition has a significant role in optimising the uptake of the available renewable resource.

- **Encourages demand reduction** - There will be increasing competition for the limited renewable resources available. Increasing energy efficiency and reducing demand stretches out these limited resources and lowers energy bills.
‘Future proof’ - The definition needs to allow future technologies, service offers and policies to be accommodated as readily as possible without the need for constant changes to the core definition. In addition the definition should be flexible enough to cope with scenarios where the development or mass-scale deployment of technologies is slower than assumed.

Shouldn’t limit number of houses built (technological impediments) - Government has been very clear about its aspirations for an ambitious increase in the number of dwellings built over the next 10 years. This is a significant challenge and one that should not be compounded by technological constraints.

Applicable to non domestic buildings - The different load profiles of domestic and non-domestic buildings provide significant opportunity for more efficient mixed-use developments. A universal definition, capable of being applied to domestic and non-domestic buildings, reduces the potential for unintended consequences, reduces confusion and simplifies calculations for mixed-use developments.
Discussion of potential mechanisms for defining the minimum level of mitigation required on-site.

Planners decide

Allow the planners to decide on what represents a ‘reasonable requirement’ for each site, and assess whether the design team has mitigated sufficient greenhouse gas emissions.

Comments:

- Individual site circumstances can be catered for in order to ensure best use of available resources without disadvantaging restricted sites.
- Provides little/no predictability for developers, particularly in terms of strategic land purchasing decisions and business planning as each site could be expected to meet bespoke requirements.
- Does not provide market certainty for investment in micro-generation or other low carbon building products
- Would need significant changes to skills required by planners
- Potential for inconsistency across the country further complicating the task of developing cost effective solution and increasing the engineering resource requirements
- Could require a high level of design detail to be decided much earlier in the project process increasing cost and risk

Renewable resource estimation tool

Similar to the above, but rather than relying on the planners’ judgement, a computer-based tool is developed as part of a systematic resource mapping exercise in order to enable an estimate of the available renewable energy resources at any particular site. The amount of renewable energy available to the site would determine the required performance standards.

Comments:

- Individual site circumstances can be catered for in order to ensure best use of available resources without disadvantaging restricted sites.
- Similar problems as above in terms of bespoke requirements for each site
- Complicated tool could take time to be developed to a level suitable for roll-out on a national level
- However well-designed a tool is, it is unlikely to deliver robust recommendations for all situations
 Tradable ‘carbon quota’ for developers

Effectively enables developers to be ‘zero carbon’ across all of their developments; smaller developments would potentially be allowed to achieve less than the full ‘zero carbon’ requirement, but excess zero carbon energy would have to be produced at larger sites in order to ‘off-set’ the short-fall. The programme could be extended to allow developers to trade carbon emissions, enabling developers with larger sites to generate excess zero carbon energy and sell it to developers with smaller sites.

Comments:

- Results in ‘zero carbon’ on-site averaged across developments
- May unduly disadvantage smaller developers (who make up a good proportion of the industry), particularly those with only smaller sites
- Developers with larger sites could monopolise the market
- Would be difficult to administer and ensure that sufficient carbon savings were made across a developer’s portfolio in order to be ‘zero carbon’
- There is an issue of timing, as smaller developments could be waiting years for a larger development to be built in order to off-set additional carbon emissions
- Could be very hard to claim the buildings on smaller sites were ‘zero carbon’
- Complicated and costly to administer

Define requirement based on development size or type

Small, high-density in-fill sites find it hardest to meet the target and therefore could be subjected to less stringent requirements. Equally the requirements could vary in terms of type, e.g. domestic/non-domestic or even specific dwelling types, such as ‘apartment’ or ‘maisonette’ could be assigned different requirements.

Comments:

- Simple mechanism for promoting best use of available resources for each category of development
- Predictable future market for companies investing in research and development; particularly renewable generation technologies and building products manufacturers
- Easier to create standardised ESCo models
- Potential to skew the market: If there are less-stringent requirements for smaller developments, then it may incentivise larger developments to be split into several smaller developments
Size and ‘type’ definitions would alter strategic land purchasing decisions and risks adverse outcomes

Defining building ‘types’ is fraught with difficulties, particularly within the non-domestic sector, further risking perverse consequences by incentivising particular development types/mixes in order to meet the zero carbon target, rather than customer demand.

Could be difficult to justify calling some buildings/developments ‘zero carbon’ if the requirements were less stringent than for others.

**Define ‘energy types’ required on-site**

Currently the Building Regulations only deal with certain ‘types’ of energy (such as heating, lighting and ventilation (pumps and fans) for domestic buildings), and other energy types are dealt with via a fixed equation based on the floor area. Furthermore, much of the regulated energy is heat energy, whereas the occupant energy is predominantly electrical energy. It can be difficult to generate renewable electricity without generating heat, and given that modern buildings often have very small heat demands this can sometimes lead to generation of excess heat. The definition could allow all electricity to be mitigated off-site, or individual energy types could be required on-site and others could be mitigated off-site.

**Comments:**

- Relatively simple as could be implemented via existing calculation tools such as SAP and SBEM (simplified Building Energy Model, the non-domestic National Calculation Methodology - SAP’s non-domestic equivalent). Therefore no additional calculations would be required by the design team.

- Indicative dwelling calculations could still be used for strategic land purchases.

- Although this could be designed to circumvent some of the barriers to certain technologies contained within the current definition, it could be creating new barriers to future technologies.

- Despite all of the calculations occurring within SAP or SBEM; explaining the principles behind the definition, and the reasons for requiring, for example, predicted emissions from cooking to be mitigated on-site, but allowing pumps and fans to be mitigated off-site, could cause confusion within the industry.

**Define on-site ‘carbon performance’**

The minimum on-site requirement could be defined in terms of the amount of carbon that must be mitigated on-site, expressed either in terms of the Enery 1 requirements of the CSH e.g. ‘100% of regulated carbon emissions must be mitigated on-site’; or as a percentage of the total predicted carbon emissions from the building e.g. ‘80% of total predicted carbon emissions must be mitigated by on-site’.
It should be noted that in both cases, the application of energy efficiency measures is assumed to happen first as this should always be the first step. The definition should be written so as to require this before any mitigation is calculated.

Comments:

- Provides predictable market
- Could be simply and easily incorporated into existing calculation methodology
- Familiar: Most developers will have prior experience of dealing with either the CSH or percentage requirements for renewables.
- Does not prescribe or prohibit the use of particular technologies

Focuses on main policy objective of reducing carbon
Discussion paper:

Potential model for a Community energy fund

- The community energy fund provides a mechanism for the provision of district heating systems to addresses the fact that currently there is no regulatory framework for its provision.

- The following roles and responsibilities are envisaged:
  - Local government: Commission the outline design of community heating systems. Locate community energy centres (with upgrade space and fuel transport access), and put policies in place to oblige all new developments to connect. Define limits on the new development energy demand profiles for compatibility with community heating systems. Define in policy those areas expected to be eventually connected. Administer CIF established from planning tariffs and zero carbon buy-out funding (predominately for funding of pipework systems). Provide land for energy centre. Oversee process of clustering individual new developments with connecting pipework with temporary energy centres prior to full community networks. Oversee connections of existing building stock to the same district heating network using CERT funding to allow good use of any surplus heat.
  - Energy companies: Enter long term franchise obligation to provide and operate district heating systems. Fund and build energy centre. Comply with obligation to upgrade to zero carbon where initially set up using natural gas fired CHP. Install pipework system drawing on CIF for top-up funding. Operate district heating system to meet quantify service standards. Agree terms for supply of energy to consumers. Implement connections of existing properties using CERT funding.
  - Developers: Obligation for building systems to be compatibility with, and to connect to, district heating (even if not initially installed). In particular there would be obligations to minimise electrical demand. This would include absorption chilling to make use of spare summer heat capacity (& 100% winter free-cooling systems when heat demand is at its highest for the remainder of the network). Meet zero carbon targets set by planning/building regulations and contribute buy-out into CIF where full zero carbon not met on site. Heed that some on-site renewables would not be permitted because they reduce the financial viability of district heating.
  - Central government: Prepare scenarios illustrating formulation and evolution of district heating system to serve new and existing buildings. Set obligations and guidance for local authorities to implement systems. Draw up standard contracts with industry. Relax energy supply monopoly rules where energy companies commit to longer term investment
in local community energy systems. Establish basis for locally administered district heating CIF. Stimulate demonstration projects.

- Community energy systems would also include large scale wind turbines located in local parks, perhaps paid for by public subscription with dividend return - part of community engagement

- One of the advantages of community based CHP is that it offers flexibility of fuel sources without having to retrofit the buildings it serves. Fuel examples include clean wood biomass, waste timber, municipal solid waste, commercial waste, sewage/food waste anaerobic digestion, specialist waste streams like old tyres, etc.

- It is clear that planning policy will need to become far more proscriptive on what are the appropriate local energy systems, their future trajectory to low and zero carbon for the community, how systems are to be implemented, and to describe the default measures needed of development proposals to connect and support these systems. Hence within the framework of national building regulations defining the overall performance to be attained, i.e. zero carbon with various deemed to satisfy means of achieving this, the local planning policy defines which options are compatible with the community energy systems.
Implications and issues for further investigation

The Element Energy model was used to predict some possible outcomes. Although the analysis does not consider all variables, and therefore cannot be considered a full assessment, it begins to paint a picture of what might be expected.

The assumptions used in this run of the model are outlined in table 2 below:

<table>
<thead>
<tr>
<th></th>
<th>Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat energy efficiency</td>
<td>High (HLP 0.8)</td>
</tr>
<tr>
<td>standards</td>
<td></td>
</tr>
<tr>
<td>Technological development</td>
<td>High learning rate</td>
</tr>
<tr>
<td>Biomass CHP availability</td>
<td>Available</td>
</tr>
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<td>CHP Heat dumping</td>
<td>Allowed</td>
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<tr>
<td>Direct electric heating</td>
<td>Yes</td>
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<tr>
<td>allowed</td>
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<td>Off-site renewable energy</td>
<td>Price set above community CHP</td>
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<td>generation</td>
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<td>Grid CO2 emission factors</td>
<td>SAP differential not</td>
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<tr>
<td></td>
<td>allowed</td>
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<td></td>
<td>Intensity high</td>
</tr>
<tr>
<td>Consumer behaviour</td>
<td>Capital expenditure only</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Assumptions used in final modelling run

Technology implications

The model was configured, as before, to assume that developments meet the targets for the minimum upfront capital expenditure, albeit assuming no overall maximum.

The primary influence on technology mix was the method used to generate zero carbon electricity. As such, medium and large-scale developments tended to use biomass CHP configured for meeting all the electrical requirements including exporting a proportion of the electricity to ‘pay for’ the carbon associated with biomass fuel use. As a consequence these developments produced excess heat.

Within the model, sites which had access to ‘large and medium wind’ used this for their electrical needs, and as the upfront capital cost is low they tended to use direct electrical heating. Small and ‘micro’ sites used a combination of on-site renewables and paying into the fund to achieve ‘zero carbon’.

Technologies such as gas CHP and ground source heat pumps tended not to be selected in this model as additional electricity would need to be generated to offset the carbon intensity of the
fuel or run the pumps. However, as the carbon intensity of grid electricity falls (as it is expected to as a result of the RO and EU 2020 targets) these technologies may feature more prominently.

Further modelling work is needed if the implications of the full range of variables are to be properly understood.

**Biomass demand implications**

The model indicated a very high take up of Biomass CHP to provide both the heat and electrical energy. This resulted in a significant demand, of 2.2TWh per annum in 2016 (approximately 1 million tonnes of wood) on a cumulative basis. The Carbon trust report ‘Biomass Sector Review’ identified 41TWhpa of existing biomass with a potential for double.

The group are not qualified to make a comment about the implications for growing the supply chain and the effects on price but recognise that the cumulative annual requirement for new build is considerable and further work on this issue is required. Furthermore, the potential implications for fuel poverty need to be understood.

**Sustainability of biomass supply**

Biomass is only a sustainable fuel source if managed properly and, without proper guidelines on what is and is not acceptable, there is significantly potential for negative impacts from the use of biomass e.g. clear-cutting Malaysian rain-forests to supply biodiesel to countries around the world.

Clearly it was beyond the scope of this study to investigate and propose guidelines for the sustainable sourcing and management of biomass, but the group recognised that this was important if the true spirit of the zero carbon policy was to be upheld. Where biomass or biofuels have been referred to in this report they are assumed to be from sustainably managed sources.

**Excess heat implications**

With the exception of large-scale wind, the lowest cost, readily available source of LZC electricity for large-scale new developments is biomass CHP. If one only considers capital cost, then generating electricity by producing excess heat is a fairly logical solution. However, in terms of efficient use of resources, it represents a significant waste and in urban environments it could have a detrimental impact on the Urban Heat Island (UHI) effect.

Furthermore, dumping waste heat to the atmosphere represents a significant missed opportunity. Older, existing buildings tend to be far less thermally efficient and therefore tend to have much higher heat demands. Being able to supply the existing stock with low or zero carbon ‘waste’ heat could achieve a significant reduction in national greenhouse gas emissions.
The heat could be sold to the existing buildings, potentially at a lower cost than their current heating fuel, and this could be used as an additional income for the new development in order to bolster the business case.

The model suggests that around 1.5TWh of surplus heat will be generated per annum. This equates approximately to the heat load of some 60,000 of the least energy efficient dwellings.

It should be noted that this is only a model projection based on one set of assumptions including unlimited supply of biomass fuel. Other factors, including the cost of fuels and carbon intensity of the grid, may impact these numbers.

**Air quality implications**

Work done for London Councils investigating the impact of increased use of wood-fuelled systems as a result of the Mayor’s policies found that, while individual systems may not significantly reduce air quality, the cumulative effect of a large number of small installations (where emissions control may be less cost-effective) probably would. Further work is required in this area in order to better understand the implications of a national policy that might incentivise widespread use of wood-fuelled systems as well as the impacts of new technological developments. The full report done for London Councils can be found in appendix 13.

**Site build-out implications**

Like other development infrastructure, community heating pipework needs to be installed in the early stages of a development build-out. Furthermore, in many cases, the final CHP plant required is likely to be considerably larger than that required in the early phases of a development. It is likely therefore that mechanisms used to fund early infrastructure construction will need to be extended to help deliver heat networks, and potentially smaller, portable, gas-fired CHP units will be required as a temporary measure until the full-scale permanent plant can be installed and sensibly operated. In such cases achieving full ‘zero carbon’ would be phased in.

**Community energy fund size**

Using the parameters and assumptions listed, the Element Energy model suggests that the fund created would be around £300m per year (assuming a one off payment). If this were used to support the creation and extension of community heating networks serving hard-to-treat dwellings. In order to provide an idea of scale, this could provide around £5,000 per dwelling for 60,000 dwellings (see excess heat implications).
Regulatory and Legislative Issues

This document attempts to outline some of the key regulatory and legal issues relating to the work done for the UK-GBC Zero Carbon Task Group report. It discusses the extent to which changes are likely to be required to the regulatory regime in terms of export to the grid and supplier switching. There may be other implications if grid connections are to be used instead of local private wire. Consumer protection issues will need to be covered in terms of service, price and the right to switch, or not.

The group is grateful for a large amount of valuable input to this element from:

- Martin Crouch and Adhir Ramdarshan of Ofgem, who have provided much of the regulatory content of the section, and
- Colin Hall of Lane & Partners LLP, who has provided much of the contractual assessment

The review to date has looked at the use of energy supply options on-site, near-site and off-site. It has not considered proxies to energy supply, such as offsetting or buying out, so may need extending / made partly redundant by developments in other work elements.

Ofgem considers that existing regulatory provisions in the energy supply market will cover many of the aspects likely to arise from the activities we are considering (though many may also have to be strengthened to cope with the substantial increase in volume that will arise). Rather than cover all the questions posed in the first draft paper, therefore, we list here the main issues which are already the subject of ongoing regulatory development, or which will need further consideration.

**General provisions for distributed generation**

These would be applicable to on-site and near-site systems, and in many cases off-site systems too.

BERR and Ofgem are currently exploring the needs of Distributed Energy schemes under the current consultation process (see [www.ofgem.gov.uk](http://www.ofgem.gov.uk) under Live Consultations) which due to report in early June 2008.

**Dedicated and non-dedicated energy generation systems**

We have considered the contractual arrangements that might apply to energy supply from systems installed by the developer to achieve a zero carbon rating.

If these are installed on-unit or on-campus in such a way that the building is directly connected to them, and its entire (net) energy needs are met, then it is assumed that the requirement is
achieved, provided that if the householder eventually opts to source energy from another source, the energy produced by the system can be effectively used elsewhere.

If these are installed on campus, near-site or off-site but not necessarily directly connected (for example, both the buildings and the energy system are connected to the grid), then again it can be deemed that the requirement is met, provided that:

- The capacity of the energy production system is adequate to meet the (net) energy required by the building (after calculation of any on-site or dedicated supply also incorporated).
- The non-dedicated capacity is not also ascribed to any other development or incremental carbon-reduction measure.

The implications of these approaches, inter alia, are that:

a) There needs to be a robust methodology to establish what the energy requirements of a building are realistically deemed to be;

b) There needs to be a definition of the types of renewable capacity that are considered to provide a service life commensurate with the design life of the building;

c) There is no need for the zero carbon building policy to make provisions for the future contractual arrangements for energy supply to the building occupiers; and

d) A register will need to be established of all non-dedicated energy production systems ascribed to zero carbon developments.

These issues merit further consideration.

**Contractual and regulatory issues that may apply to any system location**

**Consents**

- Planning and building regulations (considered elsewhere in the project)
- Connection. See under the different location options below. Need also to consider:
  - Power or gas quality
  - Safety standards

**Incentives and fiscal measures**

Applicable to any grants, tax concessions or other support measures that might apply to energy efficiency measures or renewable energy generation

- Which ones would be eligible?
• Who qualifies? (Developer, Householder, landlord, tenant etc.)
• What conditions would apply? - and to whom?

**Common law rights and duties**

In addition to the usual, one might need to consider access to the renewable resource (the right to take your neighbour's wind and/or ground heat).

**Commercial contracts**

We probably don’t need to give any special consideration in this project to:

• Procurement Agreements - owner purchasing and operating plant
• Concession Agreement - if Concessionaire will build and/or operate plant

There now follows an assessment of other issues relevant to the alternative options for the location of the renewable supply (using the definitions in appendix 3).

**On-unit systems**

**Connection requirements - electricity**

The Electricity Safety, Quality and Continuity Regulations 2006 contain requirements for the installation and operation of generators in parallel with the distributors’ network. These generally prohibit the connection of a generator without prior consent of the distributor. Refer to: [http://www.opsi.gov.uk/SI/si2006/uksi_20061521_en.pdf](http://www.opsi.gov.uk/SI/si2006/uksi_20061521_en.pdf)

However, an exemption is given for the installation of generation rated up to a total of 16A per phase (e.g. Domestic Scale Microgeneration) provided a number of conditions are met including that the installer notifies the distributor before or at the time of commissioning the microgenerator.

This is supported by a detailed technical connection standard for installers (Engineering Recommendation G83/1). This approach minimises the interaction with distribution network operators, minimising the process burden on those installing microgeneration and provides a plug-and-play solution for consumers. It avoids the need for connection quotations and inspections, and avoids the possibility of connection charges and delays caused by an approval process.

**Connection requirements - gas**

There are certain steps that any party needs to undertake ahead of gaining access to the network: i.e. the party would need a local connection to the gas distribution system so that it
could export (whereby it would be necessary to liaise with the local gas DN for this purpose); the
gas would need to be quality compliant; a gas treatment plant would be necessary to remove
carbon dioxide from biogas and to deliver it at an acceptable pipeline pressure etc.

There may be specific safety questions to be considered with the HSE.

**Metering requirements - electricity**
Both export and import meters would be required.

If claiming ROCs, a generation meter would be required.

**Energy infrastructure on building owned by third parties**
Householders are allowed to enter into commercial arrangements with 3rd parties to provide
solar panels etc subject to prevailing legislation, including consumer protection and European
Directives relating to competition.

**Tenancies**
If energy generation is performed by an occupier who is not the freeholder, the tenancy
agreement would need to include rights and obligations specific to energy supply.

**Shared ownership schemes**
There is the potential need for Consortium Agreement for sharing costs and benefits of energy
generation and reductions in consumption.

Assuming that such a scheme fell within the limits of the current Exemption Order 2001 (see
below), Ofgem would have no jurisdiction over the scheme.

**On-campus (and shared / multi-occupancy on-unit) systems**

**Network issues**
The energy distribution network may be subject to the private wire network issues identified
under near-site systems below. Contractually, the following issues will probably need to be
addressed:

- Wayleaves
- Maintenance
- Responsibility for outages
- Right to sell spare capacity (see below)
- Joint user issues
Regulations

Systems of this type may be subject to many of the other regulatory issues discussed under near-site systems below, including those for ESCos.

It is possible that regulations may be introduced on the standards of measurement of energy distributed.

Export of surplus electrical output

Under current arrangements, should electricity be produced beyond demand requirements, this surplus can be sold to a 3rd party supplier, traded in the wholesale market or supplied to other customers subject to the current licensing regime.

Heat networks

BERR Heat Call for Evidence, which closed on 31st March, explicitly asked the question “Should government consider setting up a regulatory regime for the heat market?” This may lead to a new regulatory infrastructure for heat networks.

User agreements

There would probably need to be agreement involving the occupiers and any ESCo (if not a co-operative scheme), covering:

- Rights and obligations
- Potential for different contributions to renewable fuel (e.g. wind or ground heat)
- Potential for different consumptions and therefore different contributions to any need for supplements from the grid
- Potential for different rights to the value of ROC’s (flexibility to allow for feed-in tariffs)

Access to third party suppliers

There is a case being heard in the European Court of Justice (ECJ) brought by an electricity supply undertaking, Citiworks AG, concerning third party access rights to a system at Leipzig/Halle Airport. The situation with regard to the consumer’s right to change supplier, and even other suppliers’ rights to access consumers will be influenced by the outcome of this case.

Near-site systems

Private wire networks

The term ‘private networks’ usually refers to a distribution network that is licence exempt. The Electricity (Class Exemptions from the Requirement for a Licence) Order 2001 sets out the exemption classes. This removes the customer protections offered by the supply licence (as
retained following the supply licence review in 2007) and the opportunity for unsatisfied customers to switch supplier due to lack of third party access.

This eliminates the risk of lost revenue due to customer switching. It can also lead to duplicate networks of electric cables. The Citiworks AG case (see above) has however put a question mark over the legitimacy of exemptions more generally as they relate to private wires in this context.

Whilst the exemption order provides for an exemption from the requirement to hold a licence for the purpose of distributing electricity, there are a range of other statutory instruments that an electricity distributor (licensed or licence exempt) would need to comply with, for example the Electricity, Safety, Quality and Continuity Regulations 2006.

Requirements for distribution of electricity

In respect of electricity, the regulatory regime is determined by the size of the scheme. If the scheme falls within the terms of the 2001 Exemption Order, the supplier, to operate on the licensed electricity network, requires a contract with a licensed supplier for a range of services (known as Exempt Supplier Services) which include:

- providing top-up and back-up to meet any shortfalls in production relative to customer demand and to cover plant outages due to a failure or maintenance;
- meter registration, data collection and processing;
- settlement of the charges incurred by the licensed supplier on behalf of the Exempt Supplier such as energy, metering, network charges, etc.

In the Distributed Energy Consultation published jointly by BERR and Ofgem in Dec 07, there is a consideration as to whether a case exists for re-impose a previous obligation on suppliers to offer such services in the Supply licence.

Operators of DE schemes who, in their capacity as suppliers, are too large to operate within the terms of the 2001 Class Exemption Order need to apply to become a licensed supplier.

Requirements for distribution of biogas

Ofgem are still looking at this question and we hope for a response shortly.

Regulation of ESCos

Ofgem are currently examining the regulatory arrangements around DE following the publication of the joint BERR/Ofgem Consultation Paper and at present believes that the current consumer protection regime is adequate to cope with a growing number of ESCos. They are however concerned when consumers fall outside the current licensing regime (e.g. private wires) given its implication for switching notwithstanding the current Citiworks case.
Some take the view that more will be needed (e.g. national model agreements) to enable ESCos to be established on a more widespread basis.

**Off-site systems**

We have thus far considered only the use of off-site systems on the basis of contracted capacity to meet the energy needs of a development. This seems to leave many unresolved issues, as it is unclear how the property developer could provide an arrangement which would guarantee the supply of zero carbon energy for the lifetime of any given building.

The more routine regulatory issues are fairly clear in this instance however, as off-site energy supply is an established regulated business.

**Matching intermittent supply with demand**

In terms of the electricity, given the intermittency of many renewable technologies, developers can contract with a licensed supplier to provide top-up and back-up to meet any shortfalls in production relative to customer demand and to cover plant outages due to a failure or maintenance.

**Metering and settlement**

If using the network, then the current system provides arrangements for metering and settlement of demand and generation.

**Network losses and embedded benefits**

Loss Factor is a factor that is entered into settlement as an estimate of the electricity losses in distribution network lines. It is applied to the generator’s output before being entered into settlement.

Realising the full value of the embedded benefits within the settlement process depends on similar demand and generation Line Loss Factors (LLFs) being applied to the site. These LLFs are critical to ensuring that the generation is attributed the benefits of being connected to the distribution as opposed to the transmission network.

The BERR/Ofgem’s distributed energy consultation proposes to encourage licensed networks to develop a methodology for calculating Line Loss Factors for DE that reflects the close location of demand and generation within 12 months.

**Consumer choice issues**

The 28 day notice period formerly required from customers to terminate a domestic supply contract has been removed as a result of the Supply Licence Review. This means that licensed suppliers can enter into long-term contracts with customers that might cover the life of the
project or even just the early years to cover the payback period. However, transferring long
term contracts between owners of a new development when selling-up is not straightforward

CHP based systems there is a low risk that customers will switch their hot water and heating
requirements given the high upfront cost of installing a boiler. The boiler and pipes of a district
heating system represent a significant proportion of the total investment which is then largely
secure given the high switching costs

For customers that do switch to another electricity supplier, the surplus electricity can be
exported wholesale to a third party supplier. The value of the scheme could be further
enhanced by supplying customers on another site that are not served by the heat network. The
flexibility of the existing electricity arrangements mean that the location of the customer is not
the primary factor in determining their viability for commercial supply

Innovative pricing mechanisms or add on services (such as energy management advice) can be
introduced that encourage customer loyalty, and

It is possible to finance the energy scheme on the back of the development and include the cost
of the plant in the sale price of the housing. There after, customers may then get the benefit of
only paying the marginal cost of their energy generation - assuming that an on-site ESCO was
responsible for ongoing supply - further limiting their incentive to switch.

It should be noted that on this first example of long term contracts, it is not only “consumer
protection” law which is important but competition law will also need to be considered. Given
that DE projects often have their own particular characteristics there would likely need to be
assessment on an individual basis.
International Case Study

Hammarby Sjöstad

Hammarby Sjöstad is a good example of energy planning where each of the primary stakeholders in development has well defined and essential roles for delivering an overall carbon reduction strategy. Planning started in the early 1990’s before zero carbon became a priority, however its long term thinking has allowed the principles of zero carbon to be easily adopted for the future. There are many lessons from Hammarby Sjöstad that would be useful for the UK with its own zero carbon new build objectives.

Hammarby Sjöstad is built on former industrial brownfield land located on the south side of Hammarby Lake, to the south of the Stockholm city centre. This new 200 hectare city district will comprise 9,000 apartments, housing a population of 20,000 people, and 200,000 sq m of commercial floor space attracting a further 10,000 people to work in the area. Approximately half of the total area has been developed to date and it is anticipated that the final scheme will be completed by 2015.

For the energy aspects the key stakeholders are the local planning authority, the individual plot developers and the local utility (in the form of joint venture between energy company, water company and waste management authorities). The local planning authority had the lead role because of its ability to oversee all aspects of the process. A well defined set of enhanced building standards was established complete with heat and power demand limits, and the obligation to connect to the community systems. Financial contributions from the developers were used by the local authority to install district heating network, with the utility responsible for providing community scale energy generation and operating the overall system. The use of energy from waste and sewage is an interesting aspect, demonstrating the flexibility of a community based system to include a variety of different renewable energy sources. Discussions with the utility showed how their thinking has adopted the zero carbon objectives for integrating into the system as primary plant comes up for renewal.