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| The Development of a ‘Low Carbon Affordable Housing Development Framework Assessment Tool’ for New Development in Mid Devon |

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| CENTRE FOR ENERGY AND THE ENVIRONMENT  University of Exeter  Hope Hall  Prince of Wales Road  Exeter, EX4 4PL  +44(0)1392 724143/4/5  www.exeter.ac.uk/cee | | |
| *Cover image:*  *RAMM Museum, Exeter* | | |

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Management Summary

This report outlines the development of a ‘Low Carbon Affordable Housing Development Framework Assessment Tool’ for Mid Devon District Council (MDDC). The tool enables the additional costs of various “low carbon” performance standards for new housing developments to be established. This paper describes the underlying methods and assumptions of the tool.

# Introduction

Mid Devon District Council (MDDC) declared a climate emergency on 26 June 2019 and pledged for Mid Devon to be carbon neutral by 2030. As part of its ambition for low carbon new development the Council secured grant funding for the Centre for Energy and the Environment (CEE) at the University of Exeter to progress a ‘Low Carbon Affordable Housing Development Framework Assessment Tool’ (referred to in this report as ‘the tool’). The aim is to gain a greater understanding of low carbon technologies, how to implement them on a challenging site and then replicated on other sites. The project will build knowledge within the Council on the different technologies available, and their cost and carbon impact as well as their effect on deliverability of schemes at scale. This report outlines the scope and methods for the tool.

# Tool Scope

Table 1 describes the scope of the tool.

Table : A high level description of the scope of the tool

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| --- | --- | --- |
| Factor | Scope | Reason/Justification |
| ***General Scope*** |  |  |
| Building type | Residential only | Housebuilding makes up most new development in Mid Devon. Non-domestic buildings are much more diverse and details on generic costs are not available from consistent sources. |
| Climate change impact | Carbon dioxide equivalent | Carbon dioxide equivalent is used where data is available (e.g., benchmarks for embodied emissions - the most significant source of emissions in the tool). However, operational emissions from Part L methods are expressed as carbon dioxide only (the impact of other greenhouse gases from operational emissions is not significant). |
| Modelling software | MS Excel | The tool has been constructed in Excel as it is readily available for MDDC users. The underlying method in the tool is based on pre-processed energy performance of different building types and standards and is not a substitute for full SAP modelling of individual building designs. |
| ***Model Inputs*** |  |  |
| Year of construction | Included | The year of construction is a single year. It is used to apply the most relevant version of Part L of the Building Regulations. The tool assumes that the current version is Part L 2021 and that the Future Home Standard (FHS) becomes the minimum in 2025. A one-year transitional period is built into the model i.e., from 2026 the FHS is the minimum. |
| Development mix | % Split by type | Four dwelling typologies are used: Detached, Attached, 1 bed flat, 2 bed flat. These are defined in a source document. The tool calculates the results for each type based on the desired standard, and then applies development metrics based on the overall number of dwellings and the percentage of each dwelling type. |
| Building design | Excluded | The dwelling typologies are pre-defined in the source document and there is therefore no potential in the tool to refine building form, massing, orientation, or façade design. The tool is not a substitute for full SAP modelling which could show that there is some potential to improve performance by optimising these parameters. |
| Fabric standard | kWh/m2.year | The tool models a range of potential design standards for building fabric. The minimum is 35 kWh/m2.year, reducing in 5 kWh/m2.year to 15 kWh/m2.year (the Passivhaus standard). This captures fabric U-values and air exchange losses. Attaining the lowest levels requires mechanical ventilation with heat recovery (MVHR). |
| Limit gas on site | Included | It is possible to set the tool to omit potential solutions that rely on connection to gas (i.e., boilers). When this is applied, air source heat pumps are used. |
| District heating | Excluded | The tool does not include district heating (DH) solutions. The technical and economic performance of DH schemes are very site specific making it impractical to incorporate in the tool. Also, DH will only be relevant where there is a source of low carbon heat (e.g., waste heat) in the locality of the site which is unlikely for most development in Mid Devon. Separate modelling will be required if there are instances of sites with a local low carbon heat source. |
| Carbon standard | % Reduction on Part L | The minimum performance standard in the tool is meeting the relevant version of Part L. The tool includes provision for setting tighter standards in 10% increments up to a 50% improvement on Part L, and a 100% option (zero carbon regulated emissions – see below). |
| Bespoke fabric specification | Included | The bespoke input table enables a user-defined specification for all fabric and building services elements. If the bespoke fabric specification is chosen it is applied to all dwelling types. |
| On-site renewable energy | Included | The tool looks to meet the target performance in the most cost-effective manner. In practice, this means dynamically sizing roof mounted PV until the standard is met, or until the roof is filled. If the roof is filled the tool states that the specified performance cannot be met. The tool does not include other renewable energy technologies, as PV is the most appropriate in this context. |
| Editable costs | Excluded | The model relies on built-in cost assumptions from the source data. Further iterations could allow these to be edited by the user if required. |
| ***Model Outputs*** |  |  |
| Operational emissions | ‘Regulated’ only | Operational emissions those that are covered by Part L of the Building Regulations i.e., those from any fixed building services. These are known as ‘regulated’ emissions. Unregulated emissions include those from white goods and equipment and are outside the control of developers. |
| Embodied emissions | Lifecycle embodied carbon | Embodied emissions are based on benchmark standards that capture both upfront embodied emissions, and those that occur over a building’s lifecycle at the in-use (additional to operational emissions due to energy use) and end of life stages. The tool assumes a dwelling life of 60-years. |
| Cost impact | Capital cost uplift | The tool establishes the additional capital cost of a dwelling compared to the cheapest option to meet the building regulations of the day. Absolute costs are not calculated. |

# Data Sources

The following data sources underpin the tool:

* Part L documentation: Government consultation and response documents [1], [2], [3], [4], outlining proposed changes to Part L of the Building Regulations in 2021 and the Future Homes Standard (due in 2025), are used to determine minimum performance standards and specifications. These documents are also used to check final estimated costs that are built up using more detailed data in the Currie and Brown report (see below).
* SAP 10.2: The latest version of the Government’s Standard Assessment Procedure (SAP) [5] is used to calculate energy consumption from various end uses where it was not directly available from the Currie and Brown report (see below). It is important to note that the tool is based on pre-processed results for energy consumption and its results are not intended as a replacement for detailed SAP calculations on individual dwellings in practice.
* Currie and Brown Report: The 2019 Currie and Brown (C&B) [6] analyses the costs of different standards for the construction of new dwellings. This report informed the recent changes to Part L and remains the most up to date cost analysis for dwelling construction standards in the public domain. It examines four housing typologies, with detailed descriptions of their geometry and specification as well as modelled heating and hot water energy use, and costs of the different fabric and building services elements. These form a key component of the tool.
* LETI: The London Energy Transformation Initiative (LETI) has produced several documents [7], [8] that are used to define potential embodied energy standards, and break these down further by life stages. The LETI data does not have associated cost data, and so the cost (whether higher or lower) of meeting more aspirational embodied carbon performance is not included in the tool.
* Other Sources: Additional data sources are used when the sources above are insufficient to capture the full requirements for the tool. For example, the Climate Change Committee’s 6th Carbon Budget Report is used to determine the projected carbon intensity of the electricity grid to 2050.

# Modelling Approach

The tool models the carbon and cost impact of different development mixes and standards by implementing the following sequence:

1. The user is prompted to enter inputs to the model which are:
   1. Year of development: A single year input by the user assigns the relevant version of Part L to the development i.e., the minimum operational standard for the development. A one-year transition period is built-in to the model, meaning that any development up to 2025 inclusive is assumed to be constructed to Part L 2021 whereas, from 2026 onwards, the FHS is adopted as the minimum standard. The tool assumes that all development occurs in the input year, meaning that phased developments that extend beyond 2025 need separate assessment. The assignation of electricity grid emission factors, fuel costs, and carbon-offset costs also refers to the input year.
   2. Number of Dwellings: The tool uses the number of dwellings in the development to establish the total greenhouse gas impact and costs for the development.
   3. % split of dwelling type: The number of dwellings is apportioned based on user defined splits (in %) of each of the pre-defined dwelling typologies taken from the C&B report, which are: detached, attached, 1 bed, and 2 bed flats.
   4. Number of stories for buildings containing flats: The number of stories for buildings with flats is needed to assign effective floor, roof, and available PV capacity for individual flats. For example, a very tall block of flats would have less heat loss from the floor/roof compared to one with only two stories.
   5. Fabric standard: The tool includes the potential for the user to specify a minimum acceptable fabric performance standard. These are based on scenarios that are modelled in the C&B report and are expressed in kWh/m2.year ranging from 35 to 15 (Passivhaus) in 5 kWh/m2.year increments. There is also the option to not prescribe a fabric standard, in which case the tool can also specify the baseline model in the C&B report (called “Notional Building C&B” in the tool), or the minimum specifications given in Part L documents for both the 2021 and FHS standards. Finally, there is the option to select a bespoke specification where the user gives individual performance values to specific elements of the building fabric. Where this option is selected, the calculation is only undertaken for that specification.
   6. Gas connection: The user can require that new a development does not connect to the gas network. Where this is the case, all gas boiler scenarios are omitted. The introduction of the FHS in 2025 (2026 in the tool with the transitional period) will ban the use of gas, and the tool automatically omits all those scenarios from the assessment. The tool provides a warning where this occurs.
   7. Carbon standard: The user can require that new development improves on the carbon performance target of the building regulations of the day by pre-set increments of 10%, 20%, 30%, 40%, 50% and 100% (i.e., “zero carbon” for regulated carbon).
   8. Embodied carbon target: The user can select embodied carbon targets on an A++ to G scale (taken from LETI), with E representing current typical practice. The carbon impact is included in the output but the lack of cost data means that the cost of different embodied targets is not. There is also an option to exclude embodied emissions from the analysis.
2. Energy performance and costs are specific to each of the four dwelling typologies, so the tool undertakes specific calculations for Part L operational performance for a representative of each type as follows:
   1. A number of performance scenarios are set up, which are combinations of each of the fabric standards, and heating system (gas boiler or ASHP [air source heat pump]) and ventilation (natural or MVHR [mechanical ventilation with heat recovery]) strategies.
   2. For each scenario, the specification of each fabric and building services element is taken from a source document e.g., Part L or C&B. An assumption is made where this information is not available for a particular scenario.
   3. For many of the scenarios, the C&B report already provides modelled space heating demand values (kWh/m2.year). For those scenarios, these values are plotted against the calculated heat loss parameter (W/K) and a second order polynomial line of best fit is used to establish a relationship between the two. This enables space heating demand to be calculated for any scenario where it is not available i.e., for the Part L 2021 and FHS scenarios, and for some of the fabric standards for flats (the C&B report does not model all of them).
   4. Hot water energy demand is generally already available from C&B, although this is adjusted for the inclusions of wastewater heat recovery (WWHR) in the Part L 2021 baseline scenario using SAP 10.2 Appendix J calculation methods.
   5. Auxiliary energy is calculated based on SAP 10.2 Tables 4f (and 4g and 4h) which cover central heating system circulation pumps, and fan energy for ventilation. Natural ventilation scenarios include mechanical extract ventilation, and MVHR scenarios balanced whole house ventilation.
   6. Lighting energy calculations are as per Sap 10.2 Appendix L using a fixed lighting efficacy of 80 lumens/Watt.
   7. The energy demand values calculated above are converted to gas and electricity demand (kWh/m2.year) using the appropriate fuel and heating system efficiency used by each system.
   8. The capital cost of each scenario is established by multiplying the element cost of each part of the specification by the size of that element (e.g., m2, number of etc.). The costs and sizes of elements are taken from the C&B report and housing typologies.
   9. For each scenario, the model calculates the size of roof mounted PV array needed to meet the selected input performance standard (i.e., Part L target). Where a scenario already meets the standard, then no PV is specified. Where there is a shortfall in performance, PV is added based on the calculation method in SAP 10.2 Appendices M and U. It is assumed that the climate zone is “South West” and the roofs are oriented SE/SW at a 45o inclination with “little to no shading”. The maximum size of available PV on a roof is capped at double the capacity assumed in the Part L 2021 reference building (which assumes 40% roof coverage). For flats, the available roof space is shared between all flats directly beneath that part of the roof.
   10. The cost of the modelled PV system is calculated based on costs of PV (fixed and variable) reported in the Part L Impact Assessment (2019). For each combination of carbon performance sought and scenario the overall cost, and the cost difference relative to the lowest cost option for that desired performance level is calculated.
   11. The lowest overall capital cost option that meets the input criteria is selected and taken forward to the next stage of the analysis.
3. Embodied emissions are calculated as follows:
   1. LETI publishes embodied emission benchmark values (kgCO2e/m2) for each input band (A++ to G with E representing current practice). These are broken down for both “upfront carbon” and “embodied carbon”. Upfront carbon captures emissions from the product (raw material supply, transport, and manufacture) and construction phases (transport and construction/installation process). Embodied carbon includes upfront carbon and emissions from the in-use (use, maintenance, repair, refurbishment, and replacement – but not operational energy (covered with Part L) or water (likely to be very small) and end of life stages (deconstruction and demolition, transport, waste processing, and disposal).
   2. The tool separates the embodied carbon benchmarks into upfront, in-use and end of life stages. The upfront benchmarks are provided by LETI. The balance of embodied emissions was allocated to in-use and end of life based on the case study building from LETI which has in-use impacts in years 15, 25 and 50, and at the end of life (taken to be 60 years). From this, 60% of all embodied emissions were upfront, 19% in-use (17% in year 15, 60% in year 25, and 24% in year 50) and 22% at the end of life.
   3. The benchmarks aer applied to the development based on the number of dwellings and floor area per dwelling type (taken from the C&B typologies).
4. Trajectories are calculated for the lifetime of the development as follows:
   1. The electricity and gas consumed by each dwelling type over a 60-year lifetime is taken from the identified lowest capital cost specification for achieving the target input standard.
   2. Operational emissions for regulated emissions are calculated by multiplying the energy consumption by the emission factor (kgCO2e/kWh) for gas (taken from the UK Government’s Conversion Factors for Company Reporting 2021 [9] and assumed to be fixed over the period) and electricity (taken from the CCC’s 6th Carbon Budget report [10] and extrapolated from 2050). In both cases, well to tank (WTT) emissions are excluded.
   3. Embodied emissions are allocated to each year in the time series i.e., year 0 for upfront, years 15, 25, and 50 for in-use, and 60 for end of life.
   4. Upfront additional costs (over the cheapest way to meet the current version of Part L) are calculated for the development.
   5. The operational energy costs for regulated energy use in the development are calculated based on projected gas and electricity prices from Annex M of the Government’s energy and emissions projections [11]. For years beyond 2035 (where data is not available), the 2035 values are used. These projections are significantly lower than current fuel prices.
   6. It is assumed that 40% of electricity generated by PV is self-consumed (based on typical levels observed in the sector) resulting in an effective offsetting in cost of the equivalent amount of electricity demand. The remaining 60% is assumed to be exported and sold at a rate of 5 p/kWh (based on a scan of current export prices) which inflates at the same rate as projected electricity prices.
   7. The cost of carbon (£/tonne) is also taken from Annex M based on prices to the energy supply sector.
   8. The cost in each year is discounted using discount rates from the Government’s Green Book [12] and summed for the period to establish the net present value (NPV) for both operational energy (over 30 and 60 years), and cost of carbon (over 60 years).

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