JOINT SPATIAL PLAN
STRATEGIC DEVELOPMENT LOCATIONS:
ROUTES TO ZERO CARBON

For Bath and North-East Somerset Council, South Gloucestershire Council and North Somerset council

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Executive Summary

The draft West of England Joint Spatial Plan (WoE JSP November 2017) Policy 5 expects all development to be informed by a set of place-shaping principles, including: *"minimise energy demand and maximise the use of renewable energy, where viable meeting all demands for heat and power without increasing carbon emissions."* The JSP goes on to state *that "through the production of the new Local Plans and supporting SPD, the potential for development to be built to a zero carbon standard, that is net zero emissions from regulated and unregulated heat and power, will be investigated using a consistent methodology across all four Unitary Authorities."* This is necessary to meet the area's climate change target of a 50% reduction in carbon emissions by 2035. This study evaluated the routes to zero carbon for the JSP's proposed Strategic Development Locations (SDLs) within Bath & North East Somerset, North Somerset and South Gloucestershire authority areas.

The results of this study are intended to inform the development of each Authority's Local Plans, to be developed along a similar timeframe in conjunction with the JSP. In particular, the indicative costs provided by this study could inform viability testing of zero carbon options for forthcoming Local Plans. The National Planning Policy Framework (NPPF) sets the requirement that local policies must not render development unviable. Viability varies by area, depending for example on land value and the other costs associated by bringing development forward, so each Authority must demonstrate through viability studies that their policies are viable for developers to deliver in their area.

This study finds that there are routes to zero carbon development that could be applied to each SDL:

1. **Large onsite CO2 reductions possible:** For the domestic element of the SDLs, the regulated carbon emissions of each SDL can be reduced by 71% compared to Part L of the Building Regulations 2013, and total emissions (including unregulated emissions) can be reduced by 47% for around £5,886 per residential unit through on-building measures; namely improving the building fabric to the equivalent of Code for Sustainable Homes Level 4 (a 19% reduction in regulated emissions from a baseline of Part L 2013) and deploying the maximum possible levels of rooftop solar PV. To achieve the zero carbon aim in the draft JSP, the remaining emissions would need to be addressed by offsite measures, allowable solutions or a higher level of fabric performance.

2. **The cost of these onsite CO2 reductions are within currently modelled SDL viability constraints:** The West of England JSP Topic Paper 4 assessed the viability of the SDLs at a high level, before detailed site-specific development costs are known. It assumed a 6% uplift on build costs to represent the cost of low carbon development and found that the SDLs could support this uplift. The 6% uplift is an average of £8683 for the housing mix tested in this study, considerably more than the £5,886 per unit required to meet the onsite reductions noted in Point 1.

3. **Allowable Solutions** (payments into an "offset" fund for low carbon measures elsewhere in the district) could enable zero carbon to be met within the currently modelled viability constraints. The cost of zero carbon development including Allowable Solutions, as assessed in the 2014 report "The Cost of

Zero Carbon" (Zero Carbon Hub), ranges from £2,200 to £7,500 depending on house size and so is also less than the £8683 average 6% uplift tested in the current SDL viability modelling.

4. **Third party options could keep costs off the developer's balance sheet:** For each SDL, there are also options to mitigate the remaining CO2 through heat networks, ground-mounted solar PV or wind turbines. Ground mounted renewables or heat networks could provide investment opportunities for a third party, at no or little additional cost to developers. Further policies would be needed to support these third-party options e.g. renewable energy site allocations or Heat Network priority areas.

5. **Falling costs and new business models** utilising off-site construction, modular systems and performance guarantees may enable net-zero energy homes in the coming years, with drastically lower emissions than current construction methods; for example the Dutch Energiesprong model. Whilst current modelled costs are high for ultra-low carbon fabric standards such as Passivhaus several schemes within the UK have achieved this standard within normal construction budgets. Costs are anticipated to fall as the global construction market and supply chains respond to increasingly stringent energy requirements.

The study considers the technical routes and associated costs of meeting both definitions of zero carbon: zero regulated emissions and "zero total emissions"[i]. The results show that for all SDLs there are several routes to zero carbon that could be facilitated by policies within the Authorities' Local Plans, depending on viability constraints and the policy preference of each Authority. These policy options fall into two categories:

A. Requirements for energy performance of buildings, through on-building measures which a developer would pay for directly as part of the development cost, which could be required through a policy for energy efficiency or renewable energy such as those which already exist in each of the Authority areas. Namely, the study looked at a 19% improvement in fabric efficiency from a baseline of Building Regulations, and roof-mounted solar PV. Developers could also be enabled to make "Allowable Solutions" paying into a fund per tonne of carbon they are not able to mitigate onsite. This could provide a lower cost option compared to delivering carbon reductions onsite. Allowable Solutions funds are used in other areas for in-district carbon reduction activities such as domestic retrofitting or renewables. It is beyond the scope of this work to consider Allowable Solutions in detail other than to note their potential for delivering zero carbon based on experiences elsewhere[ii].

B. Enabling policies for approaches which move the cost of compliance from the developer to a third party private sector provider, namely:

1. Through allocating Heat Network areas where third party Energy Service Companies (ESCos) can deliver low carbon energy through heat networks

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[i] http://www.zerocarbonhub.org/zero-carbon-policy/zero-carbon-policy
[ii] Review of Carbon Offsetting Approaches in London (NEF) https://www.london.gov.uk/sites/default/files/gla_cof_approaches_study_final_report_july_2016.pdf

2. Through allocating space for stand-alone renewable energy installations. These could be sited near to the SDL either to supply it directly - the potential for this is increased with the advent of battery storage meaning that power can be provided when needed - or to retain a visible "link" with the site whilst supplying the grid. The potential for near-site solar and wind energy was explored in this study. However, renewables could also be installed elsewhere in the district in order to "offset" the emissions from the SDLs. By allocating sites for renewables it becomes very likely that renewables will come forward since planning risk is reduced. Therefore, the emissions savings from these installations could be considered "additional" to renewables that would have been delivered had no allocations been made.

Further work needed

In order to set a requirement for the SDLs, a decision will need to be taken on which of the policy instruments above are to be used in each Local Plan. Further evidence could support the setting of policy requirements, including:

- Inclusion of figures to express policy options in the more detailed Local Plan viability studies which will assess site-specific costs of development
- Consideration of the viability of carbon reduction options for other development within the district, since this study only considers the SDLs

The West of England local authorities are now working together on the next stages of evidence development, as per the requirement in the draft JSP.

Introduction

Regen was commissioned in March 2017 to understand the viability of zero or low carbon developments in the Strategic Development Locations (SDLs) proposed in the JSP for the Bath & North East Somerset, South Gloucestershire and North Somerset local authority area. This was achieved by undertaking a high-level assessment of the site carbon emissions and what impact different measures would have in mitigating them.

We appraised a range of building fabric scenarios, different types of heat network provision and on/near site solar PV or wind technologies to establish any routes to achieving zero carbon for each development site through on or off-site measures and the potential cost implications. 'Zero Carbon' was examined in two versions:

- Zero total emissions: Carbon emissions from all unregulated and regulated emissions, also known as 'true emissions' as it includes the emissions generated by heating, lighting and cooking (regulated) and those from the use of other small-power appliances (unregulated)
- Zero carbon emissions from regulated emissions only

National context

The UK Carbon Plan (HM Gov, 2011) states that if we are to achieve the 2050 carbon target “by 2050 the emissions footprint of our buildings will need to be almost zero” (page 30). This is a key component of meeting the legally binding national target in the Climate Change Act, which is to reduce CO2 emissions by 80% by 2050. The English Housing Survey (2008) identified that nearly 80% of the current housing stock was built more than 34 years ago. The reality is that homes we build today will still be in use in 2050 when all our housing stock must be almost zero carbon. The homes we build today must be built to run without emitting greenhouse gas emissions, or they will add to the costly retrofit requirements of our existing building stock over the next 30 years.

If a zero carbon requirement is not introduced, the properties built will need to be retrofitted before 2050. Retrofitting is more expensive and therefore less efficient than building to high standards in the first instance; and the cost of retrofit falls either to the owner or the tax payer where government retrofit programmes are in place.

LPAs are bound by the legal duty in Section 19 of the Planning and Compulsory Purchase Act 2004, as amended by Section 182 of the Planning Act 2008, to ensure that, taken as a whole, plan policy contributes to the mitigation of, and adaptation to, climate change. Section 19 states:

‘Development plan documents must (taken as a whole) include policies designed to secure that the development and use of land in the local planning authority’s area contribute to the mitigation of, and adaptation to, climate change.’

This is a powerful outcome-focused legal duty on LPAs and signals the clear priority to be given to climate change in the plan-making process. In discharging this duty, local authorities should consider Section 10 (paragraphs 93-108) of the NPPF and ensure that policies and decisions are in line with the objectives and provisions of the Climate Change Act 2008 (Section 1).

Paragraph 94 of the National Planning Policy Framework (NPPF) recognises this challenge, stating that *“Planning plays a key role in helping shape places to secure radical reductions in greenhouse gas emissions, minimising vulnerability and providing resilience to the impacts of climate change, and supporting the delivery of and low carbon energy and associated infrastructure. This is central to the economic, social and environmental dimensions of sustainable development.”* Paragraph 94 goes on to state that “*Local planning authorities should adopt proactive strategies to mitigate and adapt to climate change*”.

The Deregulation Act 2015 proposed to change the policy tools available to Local Planning Authorities (LPAs) for achieving this aim, however these changes have yet to be enacted and despite the proposed changes, LPAs will retain the ability to require higher standards for non-residential development and for on site renewable energy generation (Merton rule style policies). Merton-style policies, if strong enough (e.g. relating to 100% of energy use, rather than 10 or 20%), are not only a driver for onsite renewables, but also for maximising energy efficiency; if a development has high energy use due to a lack of energy efficiency measures, a big investment in renewables is required. If energy efficiency measures have been maximised, it will be relatively straightforward (and cost-effective) to meet the small residual demand through onsite renewables.

West of England Context

The local authorities in the West of England (Bath & North East Somerset Council, South Gloucestershire Council, Bristol City Council North Somerset Council) have a combined target of reducing CO2 emissions by 50% by 2035 to be delivered by each authority meeting its own targets.

Since the targets is based on the need to reduce overall global emissions, it is an absolute, not a per-capita target. This means that emissions from any new housing will add to the challenge.

The JSP and Local Plans set the target for more than 100,000 homes to be built over the plan period. If emissions from these homes are not addressed, it will be very challenging to meet the West of England target CO2 emissions target. As a result, addressing climate change is a priority in the emerging West of England Joint Spatial Plan and the draft JSP includes a requirement to assess the potential for zero carbon development.

Assessment methodology overview

Each strategic development location was modelled using basic key data provided by the local authorities. This included:

- Number of residential units and if available, data on the proportion of building type
- Amount of non-domestic land to be developed
- Indications of the non-domestic land use: leisure, employment, schools etc.
- Impact of the *current* available grid capacity

The assessment took the Council data on proposed strategic development locations and modelled how much carbon dioxide (equivalent) would be emitted by both the domestic and non-domestic elements of the development on an annual basis. For the domestic element, there were two tranches of assessment; just the regulated emissions, and regulated plus unregulated emissions. Please see Appendix 2 for more detail and the assumptions for residential development. The non-domestic development was assessed for just regulated emissions, given that the exact nature of how the development will be used is not predictable.

Each site was assessed for how a combination of the following measures could achieve zero carbon:

- fabric improvement,
- rooftop solar,
- heat networks (biomass, gas and heat pump led),
- standalone renewables (wind and solar) that could be brought forward near to the site, either to directly supply the site or as a way of offsetting the emissions that were not possible to mitigate through on-building measures.

For each element, the additional cost per residential unit was calculated, enabling 29 different ‘routes to zero carbon’ to be assessed for each site.

For the scenarios that examined wind turbines as a standalone technology, a wind energy resource assessment was performed. Where there was insufficient resource to support a viable wind farm, this scenario was excluded from further analysis. For scenarios that considered either solar or wind, the size of the standalone project was assumed to be the minimum size required to reduce the *remaining* carbon emissions of the development to zero.

Where non-domestic buildings were considered to have had a fabric upgrade on buildings regulations 2013, this improvement was set at the equivalent of BREEAM Outstanding, or a 55% carbon emissions reduction on a 2010 baseline, taking into account the trend of improvement in building performance between 2010 and 2013. The non-domestic properties had a 55% carbon emissions reduction applied to a 2013 baseline.[iii]. Sources vary in their analysis of typical energy efficiency improvements for non-domestic properties. 55% carbon emission reduction on 2013 levels represents an ambitious but achievable target.[iv]

In addition, the local electricity network conditions were taken into account for each scenario. Where analysis indicated that there would be insufficient capacity on the network to support either a solar PV or wind development, this is noted in the results.

Results: Overall

The results for each SDL are shown in two tables: the first reporting the routes and costs to a zero carbon development for just the domestic part of the development, the second reporting the routes and costs for the non-domestic element of each development.

Note on changes to quantum of development on SDLs: This study has found that housing developments of several hundred homes or more can achieve significant reductions in carbon emissions beyond the requirements of building regulations, because of the flexibility developers have in terms of orientation and massing on a large site. During the planning and development process, the number of dwellings anticipated on each site might change, however, provided the SLD remains as a site with significant levels of housing, the cost profiles used in this study and therefore the results of this study are unaffected.

The same applies to any additional developments at this scale, since these may be added during the planning process. The outputs of the study will also continue to be relevant when considering allowable solutions or accommodating onsite renewable energy (i.e. routes to zero carbon over and above the contribution made by housing fabric improvements and rooftop solar PV) provided the overall ratios of housing to non-domestic development are similar to those modelled.

District heating

District heating is a robust method of reducing the carbon emissions emitted by a development, particularly if that network is fed by renewable heat from biomass or heat pumps. There is increasing focus on, and support for, heat networks to be installed in the UK as retrofit but there still seem to be few schemes being built as part of new developments.

[iii] https://tools.breeam.com/filelibrary/Briefing%20Papers/Assessing-Carbon-Emissions-in-BREEAM--Dec-2015-.pdf
[iv] https://tools.breeam.com/filelibrary/BREEAM%20and%20Value/The_Value_of_BREEAM.pdf

The analysis undertaken in this study generates typical costs of circa £22,000 - £25,000 per residential unit for the delivery of a heat network. Most of these costs are driven by the amount of pipework installed. For the purposes of this study, we used a simple multiplier of 20m of installed pipework per property.[v] These generated costs are similar to those reported by large, new heat network schemes like Cranbrook. However, it is extremely unlikely that housing developers would be investing in the heat network themselves. As heat networks generate revenue from heat sales (and potentially the renewable heat incentive), they offer long-term investment opportunities to third parties. As such, the cost element of heat network installation would not be inputted into a viability test, which just assesses the cost of development that would be borne by the developer[vi].

To reflect this, we have included above the indicative cost of building a heat network for the development for clarity, but not apportioned those costs to the developer. The possible carbon saving from heat networks is shown.

Three different sources of heat were modelled for the heat networks, natural gas, biomass and heat pump-led. In general, the greatest emission savings were seen by biomass led heat networks, but the low carbon benefits associated with biomass driven heat networks must be tempered by their impact on local air quality and high investment costs. Heat pump-led networks have been included in the analysis as there is growing focus on the exploitation of water and ground sources of heat for low temperature networks.[vii]

For developers to realise the cost savings possible through heat networks, further analysis would be needed to determine the potential for heat networks at each SDL and the appetite from third party providers. The form, mix and density of development affect the business case for heat networks so these factors would need to be optimised in the detailed policy for the SDLs.

Rooftop solar

Rooftop solar is an extremely cost-effective route to lowering carbon emissions of a new build development. Because of this, we have included rooftop solar in every scenario that was analysed, using the following inputs (PV costs can be found in Appendix 2):

Maximum solar on typical terraced houses	2.9 kW
Maximum solar on typical semidetached houses	3.8 kW
Maximum solar on typical detached houses	4 kW

[v] By comparison, Cranbrook district heating scheme has around 25m of pipework per unit https://goo.gl/HtmWba
[vi] Heat network operators may charge a connection fee based on the avoided cost to the developer of not having to provide a heating system. Bristol City Council for example charges a £2-4,000 connection charge.
[vii] https://www.gov.uk/guidance/heat-networks-overview

Fabric Improvement: residential

For each development site, two different building fabric conditions were applied, with the resulting impact on cost and carbon emissions assessed. The different building fabric options modelled were:

- Current building regulations, 2013
- The 19% uplift in energy performance from a Part L baseline that is equivalent to meeting Code for Sustainable Homes level 4, achieved by improving the thermal performance of each home[viii]

Four different building types were considered in each case: Flats, Terraces, Semi-detached and detached properties. Using industry benchmarks of typical archetype sizes and energy consumptions, 'typical' values for total annual heat demand and electricity (for regulated uses) in kWh were established. These figures were used in the subsequent analysis. The difference in cost between building homes to Building Regulations 2013 and building to the equivalent of Code Level 4 (19% improvement in energy performance) was modelled at an extra £3374 per home making them on average 3% more expensive.

Please see Appx 2 for more detail on the fabric scenarios. The 19% uplift in energy performance noted above has been selected because the Written Ministerial Statement issued on the 25th March 2015 indicated that this is the maximum level of improvement in energy efficiency performance that Local Authorities should require, following the Housing Standards review[ix] (it should be noted however that the London Plan has since enacted their zero carbon requirement, and are now consulting on a further energy efficiency requirement)[x].

Archetype	Typical size m2	Modelled typical build cost to Building Regulations 2013[xi]
Flat	56.9	£110,955
Terrace	82.6	£95,816
Semi	93.2	£108,112

[viii] The 19% reduction in carbon emissions on the BRegs 2013 standard is nominally expected to apply only to regulated emissions.
[ix] https://publications.parliament.uk/pa/cm201415/cmhansrd/cm150325/wmstext/150325m0001.htm
[x] https://www.london.gov.uk/what-we-do/planning/planning-applications-and-decisions/pre-planning-application-meeting-service-0
[xi] https://www.costmodelling.com/building-costs

Detached	151.7	£211,200

Since the housing mix is unknown for the SDLs at this time, a standard mix was applied to all sites:

Flats	10%
Terraced homes	40%
Semi-detached homes	10%
Detached homes	40%

The models used the following parameters for the average home across the four archetypes; flat, terrace, semi and detached:

	Regulated emissions only	**Average emissions tCO2/yr**	**Total emissions**	**Extra over capital cost (£/dwelling)**
CO2 emissions for a typical home, built to Building Regulations 2013	100%	1.95	100%	£0
CO2 savings from building to equivalent of code level 4 compared to Building Regulations 2013	19%	0.37	13%[xii]	£3374[xiii] (Fabric improvements only)
CO2 savings from an average rooftop solar installation	52%	1.01	34%	£2512
Total potential reduction in CO2 emissions from improving fabric and installing rooftop solar	71%	1.38	47%	£5886
Remaining emissions to mitigate through allowable solutions, DHN or onsite renewables	29%	0.57	53%	

It is worth noting that there are new business models and construction methods emerging that may have a significant impact on future strategic development sites. EnergiesSprong[xiv] is one such model that uses a combination of off-site construction and long-term performance guarantees to drive innovation and lower

[xii] On average across archetypes
[xiii] 'Costs of building to the Code for Sustainable Homes', Element Energy September 2013 and 'Costs of building to the Code for Sustainable Homes', Element Energy August 2011
[xiv] http://www.energiesprong.uk/

costs. Currently, this model is being demonstrated as a way of retrofitting homes to a net-zero standard in projects around the UK, but there are plans to use this model for large-scale new build developments too. Whilst building homes using this model is more expensive than standard build costs, the extra cost is funded through the tenant / homeowner paying an energy plan rather than an energy bill. As the energy use of the home is so low, this generates an income to performance guarantee holder, potentially the house-builder themselves. This would result in the net energy demand of these homes being close to zero.

The study did look at whether a Passivhaus strategy could be adopted to reach zero carbon. There are cases where Passivhaus buildings have been delivered at no cost uplift - for example, social housing in Exeter and schools in Wolverhampton, where the project was designed to achieve the standard from the start and choices were made accordingly. However there is insufficient cost data on Passivhaus in the UK, so costs have not been included in the report. From a carbon saving perspective, a Passivhaus strategy can achieve zero carbon and can go beyond zero carbon to produce “carbon positive” development which generates more renewable energy than it uses.

In summary, our modelling shows that carbon emissions can be reduced by 47% and regulated emissions 71% by investing an additional £5886 per housing unit, improving the fabric and applying rooftop PV.

Fabric Improvement: non-residential

It is not possible to identify at strategic planning stage what the energy use of non-domestic employment land will be annually at the development. For that reason, only the regulated emissions (based on industry benchmarks for different types of building) were included in the analyses. These regulated emissions were based on a ‘common sense’ breakdown of the land allocated, in the following categories:

Primary School (m2)
Commercial Leisure (m2)
Employment (m2)
GP (m2)
Retail (m2)
Office (m2)

Depending on each SDL and any additional details of apportionment of land use, each of the categories above had an amount of land assigned. For commercial and employment land, a factor was used to estimate what proportion of this land would actually be built on. Commercial leisure land was set at 40%, Employment land at 30%.

In addition, we considered it unlikely that the full range of fabric improvements could be applied to non-domestic buildings. For the analyses undertaken here, we set the fabric improvements to achieve 55 percent reduction in annual carbon emissions. This broadly equates to a BREAM ‘Outstanding’ rating. We viewed this target as a realistic appraisal of fabric improvements that could be made to non-domestic buildings.

Industry benchmarks for non-domestic buildings were obtained from 2008 sources, so a nominal 25 percent reduction on energy consumption across the board was applied to account for improvements in energy efficiency in the last 9 years. A further 55% reduction was then applied to this figure as the target carbon emissions reduction.

Studies indicate that achieving BREEAM Outstanding in full has the following uplift costs[xv]. Achieving the energy component of BREEAM Outstanding alone would be less costly. [xvi]

RATING	SCHOOL	INDUSTRIAL	RETAIL	OFFICE	MIXED USE
Very good	0.2%	0.1%	0.2%	0.2%	0.1%
Excellent	0.7%	0.4%	1.8%	0.8%	1.5%
Outstanding	5.8%	4.8%	10.1%	9.8%	4.8%

Standalone Renewables

Part of the specification for this study was to explore whether a solar PV array or windfarm could provide a cost-effective route to achieving a zero carbon development. To assess this, we examined the local wind resource and areas of suitable, unconstrained land where a project could be sited. Zones that could feasibly support a wind turbine/farm and reported greater than 6m/s wind speed at 45m were identified and mapped. The siting of solar projects was assumed to be possible for all developments at any scale.

Both wind and solar projects were assessed against the available electricity network capacity or generation 'headroom'. Where there was insufficient headroom available, the scenario was deemed unviable. Depending on local network upgrade costs, some of these scenarios that require solar/wind may still be viable, but this will require further assessment. As new demand is added to the network due to the new development, this can release capacity to connect additional generation.

Viability

The latest draft of the SDL viability assessment[xvii] "West of England Topic Paper 4: An assessment of viability potential within the SDLs" undertook a high-level, early assessment of the viability performance of the SDLs and showed that at least at this level of modelling, a 6% cost uplift over base build costs to account for

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[xvi] https://bre.ac/product/delivering-sustainable-buildings/
[xvii] https://www.jointplanningwofe.org.uk/gf2.ti/-/845730/31472901.1/PDF/-/Topic_paper_4_An_assessment_of_viability_potential_within_the_SDLs.pdf

the cost of low carbon development is within the viability envelope. This viability test is indicative only; site development costs (including infrastructure) will be modelled in the next round of viability testing for Local Plans. The table below indicates the cost of the 6% uplift by house type:

Archetype	Archetype proportion used in this study	Typical size m2	Modelled typical build cost to Building Regulations 2013[xviii]	6% uplift
Flat	10%	56.9	£110,955	£6657
Terrace	40%	82.6	£95,816	£5749
Semi	10%	93.2	£108,112	£6487
Detached	40%	151.7	£211,200	£12762
			Average 6% uplift over the housing mix assumed for SDLs in this study	£8,683

The 6% uplift is greater than the costs for onsite measures as assessed in this study; a £5886 average uplift across the housing mix to deliver a 71% reduction in regulated emissions or 47% reduction in total emissions, compared to an £8683 average when applying a 6% uplift. The 6% uplift figure is also lower than the cost uplift of delivering the zero carbon standard set out in the Zero Carbon Hub 2014 report "Cost Analysis: Meeting the Zero Carbon Standard"[xix], which includes the use of Allowable Solutions, as below:

- Detached homes: £6,700- £7,500
- Semi-detached and mid-terraced homes: £3,700 - £4,700
- Apartments (low rise): £2,200 - £2,400

Whilst a direct comparison cannot be made between the Zero Carbon Hub work and this work due to potentially different assumptions, the calculations above indicates that a zero carbon solution is within the viability tolerance for the SDLs. Further work could explore this, since Allowable Solutions are beyond the scope of this study.

Results: By Local Authority

Below is a summary of findings for each site, highlighting key routes to zero carbon for each type of analysis (domestic, whole development, regulated emissions only, unregulated and regulated emissions).

The SDL was analysed in two parts, domestic and non-domestic. It was assumed that the fabric improvement and opportunity to maximise rooftop solar was taken as appropriate for each residential unit. The routes to abate the remaining carbon emissions from the domestic and non-domestic elements of the SDL are shown in the sections below.

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xviii https://www.costmodelling.com/building-costs

xix http://www.zerocarbonhub.org/sites/default/files/resources/reports/Cost_Analysis-Meeting_the_Zero_Carbon_Standard.pdf

Bath & North East Somerset SDLs

Keynsham

Assumptions

There are 1399 new homes proposed and 165,000m^2 of non-domestic development. This was modelled along the following building uses:

Flats	10%
Terraced homes	40%
Semi-detached homes	10%
Detached homes	40%

Primary School (m2)	4000
Commercial Leisure (m2)	5000
Employment (m2)	151850
GP (m2)	150
Retail (m2)	1000
Office (m2)	3000

Emissions for the development site were modelled as being:

	Total emissions tCO2/yr	Regulated emissions only tCO2/yr
Domestic development only	4383	2910
Emissions that can be abated by fabric improvement and rooftop solar	2336	2057
Remaining emissions to abate	2047	853

Non-domestic development only	2097	1444

Results

	Domestic Development Only – routes to achieving a zero carbon SDL for all residential development on the site				
	Allowable Solutions	Ways to bring domestic development to zero carbon			
		Offsite renewable allocation	Offsite wind resource	Heat Networks & Offsite PV	
	Carbon emissions to be abated tCO2/yr	Mitigation option 1: Offsite PV	Mitigation option 2: Offsite wind	Mitigation option 3: heat network and offsite PV	
				DHN	Onsite renewables
Regulated emissions	853	2.5 MW £2,000,000 5 Ha	1.0 MW £3,000,000 1 Ha	Heat Pump led £30,400,000	N/A
Total emissions	2047	6.0 MW £4,800,000 12 Ha	2.4 MW £7,300,000 Cost 1 Ha	Biomass led £31,700,000	N/A

Non-domestic development only					
Non-residential floor area m2	**Regulated, non-residential emissions, tonnes CO2 / yr**	**C02 reduction from building to BREEAM Outstanding**	**Remaining C02 to zero regulated emissions**	**MW/HA of PV to offset non-domestic regulated emissions to zero**	**Approximate investment in PV to achieve zero carbon**
165,000	1444	291	1153	3.3 MW and 6.7 Ha	£2,600,000

Whitchurch

There are 2,500 new homes proposed and 51,250m^2 of non-domestic development. This was modelled along the following building uses:

Flats	10%
Terraced homes	40%
Semi-detached homes	10%
Detached homes	40%

Primary School (m2)	7000
Commercial Leisure (m2)	5000
Employment (m2)	35,000
GP (m2)	150
Retail (m2)	5000
Office (m2)	0

Emissions for the development site were modelled as being:

	Total emissions tCO2/yr	Regulated emissions only tCO2/yr
Domestic development only	7835	5200
Emissions that can be abated by fabric improvement and rooftop solar	4177	3676
Remaining emissions to abate	3658	1524
Non-domestic development only	587	397

Results

	Domestic Development Only – routes to achieving a zero carbon SDL				
	Allowable Solutions	**Investment opportunity to bring domestic development to zero carbon**			
		Offsite renewable allocation	Offsite wind resource	Heat Networks & Offsite PV	
	Carbon emissions to be abated tCO2/yr	Mitigation option 1: Offsite PV	Mitigation option 2: Offsite wind	Mitigation option 3: heat network and offsite PV	
				Heat Network	Offsite renewables
Regulated emissions	1524	4.5 MW £3,600,000 9 Ha	1.8 MW £5,500,000 1 Ha	Heat Pump led £54,100,000	N/A:
Total emissions	3658	10.7 MW £8,500,000 21 Ha	4.2 MW £13,100,000 Cost 3 Ha	Biomass led £56,700,000 Cost	89 kW Solar £72,000 Space req'd: 0.2 Ha

Non-domestic development only					
Non-residential floor area m2	**Regulated, non-residential emissions, tonnes CO2 / yr**	**C02 reduction from BREEAM Outstanding**	**Remaining C02 to zero regulated emissions**	**MW/HA of PV to offset non-domestic regulated emissions to zero**	**Approximate investment in PV to achieve zero carbon**
51,250	397	178	219	0.6 MW and 1.3 Ha	£505,000

Offsite renewables and grid capacity

The Keynsham SDL has, at time of writing, just under 8.5MVA of grid capacity available which is sufficient to support the offsite renewables required to meet zero carbon emissions, via either solar PV or wind installations. Whitchurch has less headroom, at just under 4 MVA. Under current conditions, this would mean that the SDL at Whitchurch could not support options 1 or 2 (standalone solar or wind) without incurring significant costs in network upgrades.

Technically, meeting zero carbon through a wind turbine is possible as there is sufficient unconstrained wind resource within a 2km boundary of Keynsham and Whitchurch.

South Gloucestershire SDLs

Yate Option 1

At the time this study was delivered, there were 1,900 new homes proposed and 47,500m^2 of non-domestic development. Since the modelling was undertaken, the number of homes has been increased to 2000, but this has not been reflected in the modelling. The following building uses were modelled:

Flats	10%
Terraced homes	40%
Semi-detached homes	10%
Detached homes	40%

Primary School (m2)	2000
Commercial Leisure (m2)	5000
Employment (m2)	35,350
GP (m2)	150
Retail (m2)	5000
Office (m2)	0

Emissions for the development site were modelled as being:

	Total emissions tCO2/yr	Regulated emissions only tCO2/yr
Domestic development only	5954	3952
Emissions that can be abated by fabric improvement and rooftop solar	3174	2794
Remaining emissions to abate	2780	1158

Non-domestic development only	592	400

Results

	Domestic Development Only – routes to achieving a zero carbon SDL				
	Allowable Solutions	**Investment opportunity to bring domestic development to zero carbon**			
		Offsite renewable allocation	Offsite wind resource	Heat Networks & Offsite PV	
	Carbon emissions to be abated tCO2/yr	Mitigation option 1: Offsite PV	Mitigation option 2: Offsite wind	Mitigation option 3: heat network and offsite PV	
				DHN	Onsite renewables
Regulated emissions	1158	3.4 MW £2,700,000 7 Ha	1.4 MW £4,100,000, 1 Ha	Heat Pump led £43,000,000	N/A
Total emissions	2780	8.1 MW £6,500,000 16 Ha	3.2 MW £10,000,000,2 Ha	Biomass led £43,100,000	68 kW Solar £54,000 Space req'd: 0.1 Ha

Non-domestic development only					
Non-residential floor area m2	**Regulated, non-residential emissions, tonnes CO2 / yr**	**C02 reduction building to BREEAM Outstanding**	**Remaining C02 to zero regulated emissions**	**MW/HA of PV to offset non-domestic regulated emissions to zero**	**Approximate investment in PV to achieve zero carbon**
47,500	340	179	221	0.64 MW and 1.3 Ha	£508,000

Charfield

There are 1,200 new homes proposed and 10,100m^2 of non-domestic development. This was modelled along the following building uses:

Flats	10%
Terraced homes	40%
Semi-detached homes	10%
Detached homes	40%

Primary School (m2)	2000
Commercial Leisure (m2)	1000
Employment (m2)	1950
GP (m2)	150
Retail (m2)	5000
Office (m2)	0

Emissions for the development site were modelled as being:

	Total emissions tCO2/yr	Regulated emissions only tCO2/yr
Domestic development only	3761	2496
Emissions that can be abated by fabric improvement and rooftop solar	2005	1764
Remaining emissions to abate	1756	732
Non-domestic development only	91	57

Results

	Domestic Development Only – routes to achieving a zero carbon SDL				
	Allowable Solutions	**Investment opportunity to bring domestic development to zero carbon**			
		Offsite renewable allocation	Offsite wind resource	Heat Networks & Offsite PV	
	Carbon emissions to be abated tCO2/yr	Mitigation option 1: Offsite PV	Mitigation option 2: Offsite wind	Mitigation option 3: heat network and offsite PV	
				DHN	Onsite renewables
Regulated emissions	732	2.1 MW £7,100,000 4 Ha	0.8 MW £2,600,000, 1 Ha	Biomass led £27,000,000	N/A
Total emissions	1756	5.1 MW £4,100,000 10 Ha	2.0 MW £6,300,000 Cost, 1 Ha	Biomass led £22,700,000	43 kW Solar £34,000 Space req'd: 0.1 Ha

Non-domestic development only					
Non-residential floor area m2	**Regulated, non-residential emissions, tonnes CO2 / yr**	**C02 reduction from BREEAM Outstanding**	**Remaining C02 to zero regulated emissions**	**MW/HA of PV to offset non-domestic regulated emissions to zero**	**Approximate investment in PV to achieve zero carbon**
10,100	57	26	31	0.1 MW and 0.2 Ha	£71,600

Chipping Sodbury (Potential reserve site)

This site is no longer identified in the JSP as a Strategic Development Location, but is being held in reserve. There are 1,000 new homes proposed and 12,000m^2 of non-domestic development. This was modelled along the following building uses:

Flats	10%
Terraced homes	40%
Semi-detached homes	10%
Detached homes	40%

Primary School (m2)	2000
Commercial Leisure (m2)	1000
Employment (m2)	3850
GP (m2)	150
Retail (m2)	5000
Office (m2)	0

Emissions for the development site were modelled as being:

	Total emissions tCO2/yr	Regulated emissions only tCO2/yr
Domestic development only	3134	2080
Emissions that can be abated by fabric improvement and rooftop solar	1671	1470
Remaining emissions to abate	1463	610
Non-domestic development only	116	74

	Domestic Development Only – routes to achieving a zero carbon SDL				
	Allowable Solutions	**Investment opportunity to bring domestic development to zero carbon**			
		Offsite renewable allocation	Offsite wind resource	Heat Networks & Offsite PV	
	Carbon emissions to be abated tCO2/yr	Mitigation option 1: Offsite PV	Mitigation option 2: Offsite wind	Mitigation option 3: heat network and offsite PV	
				DHN	Onsite renewables
Regulated emissions	610	1.8 MW £1,400,000 4 Ha	0.7 MW £2,200,000 0.4 Ha	Biomass led £22,700,000	N/A
Total emissions	1463	4.3 MW £3,400,000 9 Ha	1.7 MW £5,200,000 Cost 1 Ha	Biomass led £22,700,000	N/A

Results

Non-domestic development only					
Non-residential floor area m2	**Regulated, non-residential emissions, tonnes CO2 / yr**	**C02 reduction from BREEAM Outstanding**	**Remaining C02 to zero regulated emissions**	**MW/HA of PV to offset non-domestic regulated emissions to zero**	**Approximate investment in PV to achieve zero carbon**
12,000	74	34	40	0.12 MW and 0.23 Ha	£92,300

Coalpit Heath

There are 1,800 new homes proposed and 21,000m^2 of non-domestic development, but at the time of the study this figure was 1500 homes. This was modelled along the following building uses:

Flats	10%
Terraced homes	40%
Semi-detached homes	10%
Detached homes	40%

Primary School (m2)	2000
Commercial Leisure (m2)	1000
Employment (m2)	12850
GP (m2)	150
Retail (m2)	5000
Office (m2)	0

Emissions for the development site were modelled as being:

	Total emissions tCO2/yr	Regulated emissions only tCO2/yr
Domestic development only	4701	3120
Emissions that can be abated by fabric improvement and rooftop solar	2506	2206
Remaining emissions to abate	2195	914

Non-domestic development only	232	155

	Domestic Development Only – routes to achieving a zero carbon SDL				
	Allowable Solutions	**Investment opportunity to bring domestic development to zero carbon**			
		Offsite renewable allocation	Offsite wind resource	Heat Networks & Offsite PV	
	Carbon emissions to be abated tCO2/yr	Mitigation option 1: Offsite PV	Mitigation option 2: Offsite wind	Mitigation option 3: heat network and offsite PV	
				DHN	Onsite renewables
Regulated emissions	914	2.7 MW £2,100,000 5 Ha	1.1 MW £3,300,000 1 Ha	Biomass led £34,000,000	N/A
Total emissions	2195	6.4 MW £5,200,000 13 Ha	2.5 MW £7,900,000 Cost 2 Ha	Biomass led £34,000,000	54 kW Solar £43,000 Space req'd: 0.1 Ha

Results

Non domestic development					
Non-residential floor area m2	**Regulated, non-residential emissions, tonnes CO2 / yr**	**C02 reduction from BREEAM Outstanding**	**Remaining C02 to zero regulated emissions**	**MW/HA of PV to offset non-domestic regulated emissions to zero**	**Approximate investment in PV to achieve zero carbon**
21,000	**155**	**70**	**85**	**0.2 MW and 0.4 Ha**	**£162,000**

Buckover

There are 3,000 new homes proposed and 44,200m^2 of non-domestic development. This was modelled along the following building uses:

Flats	10%
Terraced homes	40%
Semi-detached homes	10%
Detached homes	40%

Primary School (m2)	2000
Commercial Leisure (m2)	1000
Employment (m2)	36050
GP (m2)	150
Retail (m2)	5000
Office (m2)	0

Emissions for the development site were modelled as being:

	Total emissions tCO2/yr	Regulated emissions only tCO2/yr
Domestic development only	9401	6240
Emissions that can be abated by fabric improvement and rooftop solar	5011	4411
Remaining emissions to abate	4390	1829

Non-domestic development only	532	362

	Domestic Development Only – routes to achieving a zero carbon SDL				
	Allowable Solutions	**Investment opportunity to bring domestic development to zero carbon**			
		Offsite renewable allocation	Offsite wind resource	Heat Networks & Offsite PV	
	Carbon emissions to be abated tCO2/yr	Mitigation option 1: Offsite PV	Mitigation option 2: Offsite wind	Mitigation option 3: heat network and offsite PV	
				DHN	Onsite renewables
Regulated emissions	1829	5.3 MW £4,300,000 11 Ha	2.1 MW £6,500,000 1 Ha	Biomass led £68,000,000	N/A
Total emissions	4390	12.9 MW £10,400,000 26 Ha	5.1 MW £15,900,000 Cost 3 Ha	Biomass led £68,000,000	90 kW Solar £71,600 Space req'd: 0.1 Ha

Non-domestic development					
Non-residential floor area m2	**Regulated, non-residential emissions, tonnes CO2 / yr**	**C02 reduction from BREEAM Outstanding**	**Remaining C02 to zero regulated emissions**	**MW/HA of PV to offset non-domestic regulated emissions to zero**	**Approximate investment in PV to achieve zero carbon**
44,200	362	163	199	0.6 MW and 1.1 Ha	£459,000

Offsite renewables

The Yate SDL has, at time of writing, just over 6.4 MVA of grid capacity available which is sufficient to support the offsite renewables required to meet zero carbon emissions, via either solar PV or wind installations, other than a solar array that was intended to meet the total emissions reduction required. At over 8MW, this option would currently not be viable..

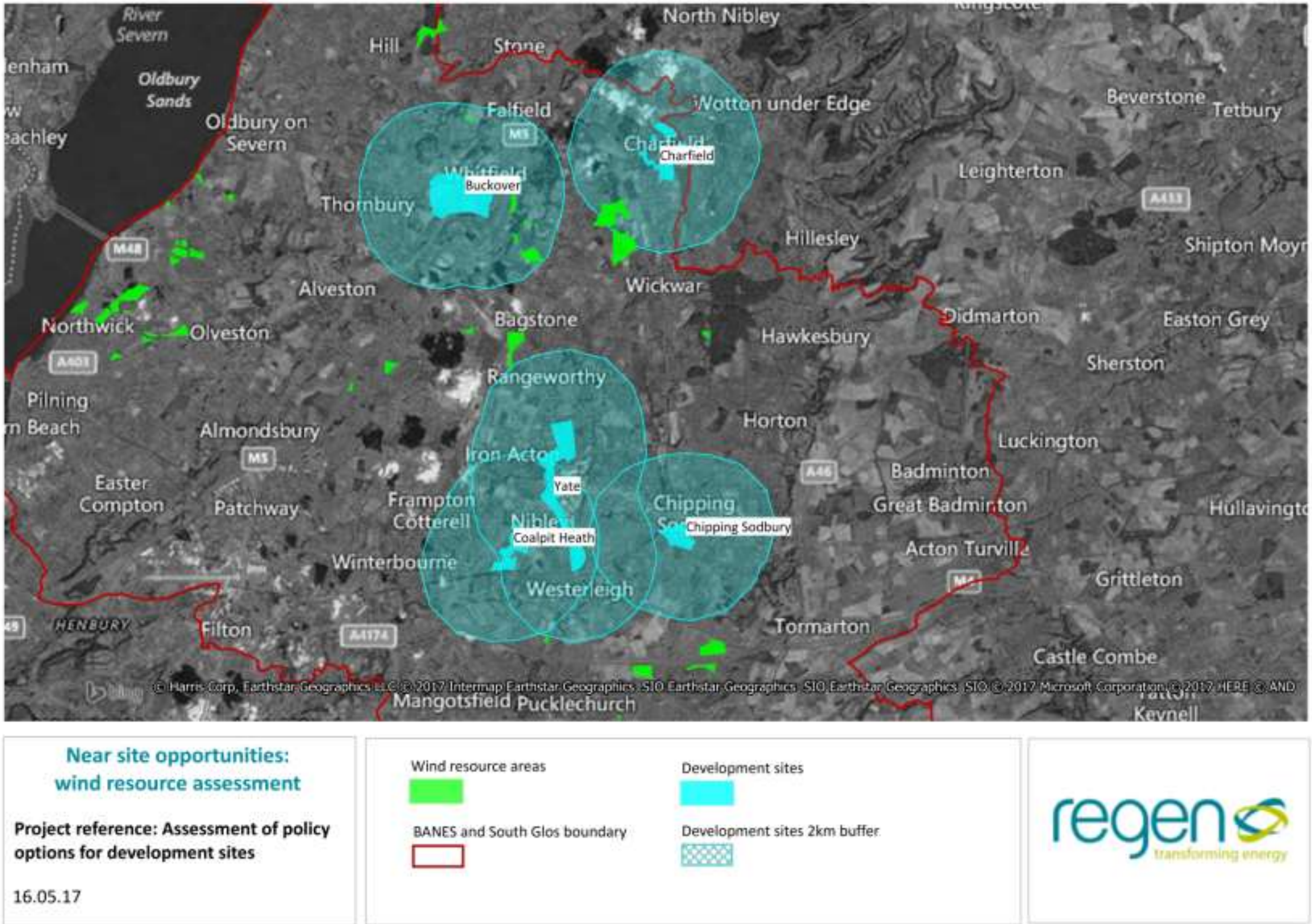
Charfield has more headroom, at just over 10 MVA, enough to cope with all options as they currently stand.

Chipping Sodbury has a grid capacity available of 24 MVA, the largest in the JSP area. This is sufficient to support all options.

Coalpit Heath has 6.4 MVA available, only just enough to support connection of the 6.4 MW solar array required to meet total development emissions (option 1).

Buckover has a headroom of just 3.99 MVA. This is insufficient to support option 1 currently and option 2 for total emissions. Option 3 (district heat) is unaffected by this low headroom.

Out of all the sites in S. Gloucestershire only Buckover and Charfield have sufficient unconstrained wind resource within 2km of the sites to support a wind power solution.


River Severn
Oldbury Sands
Oldbury on Severn
North Nibley
Hill
Stone
Falfield
M5
Wotton under Edge
Charfield
Charfield
Whitfield
Buckover
Thornbury
Beverstone
Tetbury
Leighterton
A433
Hillesley
Shipton Moyne
M48
Alveston
Wickwar
Northwick
Olveston
Bagstone
Didmarton
Hawkesbury
Easton Grey
A403
Sherston
Rangeworthy
Pilning
Almondsbury
Horton
Luckington
M5
Iron Acton
A46
Badminton
Easter Compton
Patchway
Yate
Frampton Cotterell
Chipping Sodbury
Chipping Sodbury
Great Badminton
Coalpit Heath
Acton Turville
Winterbourne
Westerleigh
M4
Grittleton
Henbury
Filton
A4174
Tormarton
Castle Combe
Mangotsfield
Pucklechurch
Near site opportunities:
wind resource assessment
Project reference: Assessment of policy options for development sites
16.05.17
Wind resource areas
Development sites
BANES and South Glos boundary
Development sites 2km buffer
regen
transforming energy

North Somerset SDLs

Nailsea and Backwell

There are 4,000 new homes proposed and 62,200m^2 of non-domestic development. This was modelled along the following building uses:

Flats	10%
Terraced homes	40%
Semi-detached homes	10%
Detached homes	40%

Primary School (m2)	2000
Commercial Leisure (m2)	10000
Employment (m2)	36050
GP (m2)	150
Retail (m2)	5000
Office (m2)	0

Emissions for the development site were modelled as being:

	Total emissions tCO2/yr	Regulated emissions only tCO2/yr
Domestic development only	12535	8320
Emissions that can be abated by fabric improvement and rooftop solar	6681	5881
Remaining emissions to abate	5854	2439
Non-domestic development only	764	524

	Domestic Development Only – routes to achieving a zero carbon SDL				
	Allowable Solutions	**Investment opportunity to bring domestic development to zero carbon**			
		Offsite renewable allocation	Offsite wind resource	Heat Networks & Offsite PV	
	Carbon emissions to be abated tCO2/yr	Mitigation option 1: Offsite PV	Mitigation option 2: Offsite wind	Mitigation option 3: heat network and offsite PV	
				DHN	Onsite renewables
Regulated emissions	2439	7.1 MW £5,700,000 14 Ha	2.8 MW £8,600,000 2 Ha	Biomass led £90,000,000	N/A
Total emissions	5854	17 MW £13,700,000 34 Ha	6.7 MW £21,700,000 Cost 4 Ha	Heat pump led £86,600,000	N/A

Results

Non-domestic development					
Non-residential floor area m2	**Regulated, non-residential emissions, tonnes CO2 / yr**	**C02 reduction from BREEAM Outstanding**	**Remaining C02 to zero regulated emissions**	**MW/HA of PV to offset non-domestic regulated emissions to zero**	**Approximate investment in PV to achieve zero carbon**
62,200	524	244	297	0.9 MW and 1.7 Ha	£686,000

Banwell and Churchill

There are 4,700 new homes proposed and 124,000m^2 of non-domestic development. This was modelled along the following building uses:

Flats	10%
Terraced homes	40%
Semi-detached homes	10%
Detached homes	40%

Primary School (m2)	2000
Commercial Leisure (m2)	1000
Employment (m2)	115850
GP (m2)	150
Retail (m2)	5000
Office (m2)	0

Emissions for the development site were modelled as being:

	Total emissions tCO2/yr	Regulated emissions only tCO2/yr
Domestic development only	14729	9776
Emissions that can be abated by fabric improvement and rooftop solar	7852	6911
Remaining emissions to abate	6877	2865
Non-domestic development only	1563	1078

Results

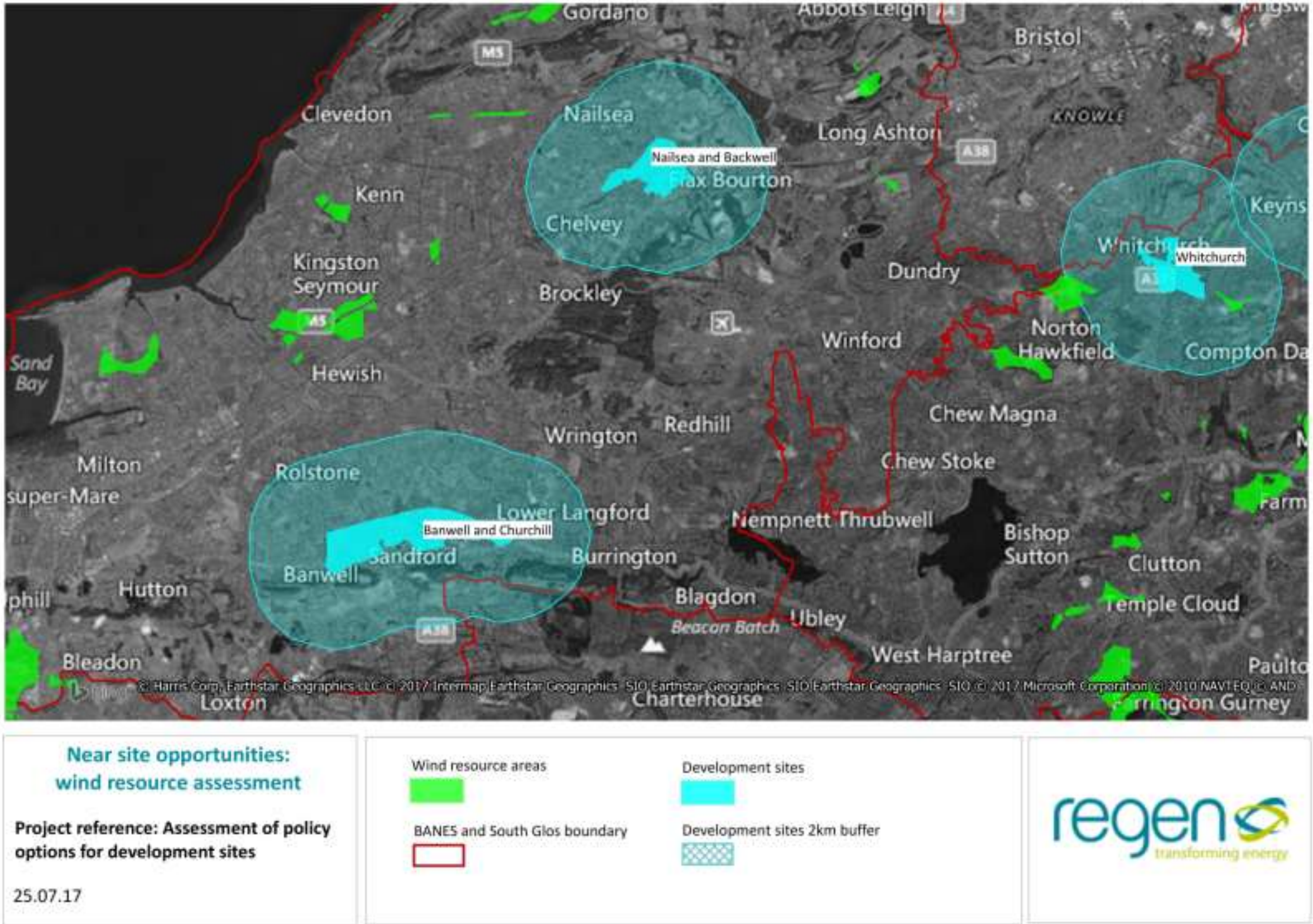
	Domestic Development Only – routes to achieving a zero carbon SDL				
	Allowable Solutions	Investment opportunity to bring domestic development to zero carbon			
		Offsite renewable allocation	Offsite wind resource	Heat Networks & Offsite PV	
	Carbon emissions to be abated tCO2/yr	Mitigation option 1: Offsite PV	Mitigation option 2: Offsite wind	Mitigation option 3: heat network and offsite PV	
				DHN	Onsite renewables
Regulated emissions	2865	8.4 MW £6,700,000 17 Ha	3.3 MW £10,200,000 2 Ha	Biomass led £107,000,000	N/A
Total emissions	6877	20 MW £16,000,000 40 Ha	7.9 MW £24,600,000 Cost 5 Ha	Biomass led £107,000,000	N/A

Non-domestic development					
Non-residential floor area m2	**Regulated, non-residential emissions, tonnes CO2 / yr**	**C02 reduction from BREEAM Outstanding**	**Remaining C02 to zero regulated emissions**	**MW/HA of PV to offset non-domestic regulated emissions to zero**	**Approximate investment in PV to achieve zero carbon**
124,000	1078	484	593	1.71 MW and 3.4 Ha	£1,370,000

Offsite renewables

The Nailsea and Backwell SDL has, at time of writing, just over 15 MVA of grid capacity available which is sufficient to support the offsite renewables required to meet zero carbon regulated emissions, via either solar PV or wind installations, but there is not enough capacity to meet the total emissions reduction required with offsite renewables. At over 17 MW, this option would currently not be viable.

Banwell and Churchill has even less headroom, at just over 5 MVA. At that capacity, option 1 for both regulated and total emissions scenarios are unviable, and option 2 (wind installation) will only be enough to mitigate regulated emissions – however, in any event there is insufficient wind resource within 2km of Banwell and Churchill SDL. Neither SDL in North Somerset has sufficient unconstrained wind resource to support a wind installation solution.


Gordano
Abbots Leigh
Bristol
Clevedon
Nailsea
Long Ashton
Nailsea and Backwell
Flax Bourton
Kenn
Chelvey
Kingston
Seymour
Brockley
Dundry
Whitchurch
Norton
Hawkfield
Winford
Sand
Bay
Hewish
Chew Magna
Wrington
Redhill
Milton
super-Mare
Rolstone
Chew Stoke
Lower Langford
Banwell and Churchill
Sandford
Banwell
Burrington
Nempnett Thrubwell
Bishop
Sutton
Clutton
Hutton
Blagdon
Ubley
Beacon Batch
Temple Cloud
Bleadon
West Harptree
Loxton
Charterhouse
Near site opportunities:
wind resource assessment
Project reference: Assessment of policy options for development sites
25.07.17
Wind resource areas
Development sites
BANES and South Glos boundary
Development sites 2km buffer

Policy implications

Third party delivery options reduce costs to developers

It is possible for the necessary energy infrastructure to be developed, owned and operated by a third party at no or little extra cost to the developer (in fact, there may be a cost saving for the developer – e.g. if a district heat network is delivered, the developer may avoid the cost of putting in individual heating solutions). Potential third party organisations might include:

- A local community energy group who set up a Community Energy Services Company (CESCo) to deliver, own and operate the energy infrastructure
- A national or local Community Interest Company who have a business model that enables them to deliver the energy infrastructure for the benefit of the local community
- A third party infrastructure provider who develops, builds and owns and operates for the long-term infrastructure for the site. Metropolitan (http://www.met-i.co.uk/) is a low carbon infrastructure provider who are able to operate under that business model. They are currently developing the major King's Cross development. There is a gap in the market for other providers to enter this space, following Metropolitan's lead. Local policies of this kind would encourage the development of this market.
- A commercial renewable energy or heat network provider e.g. EoN
- The Council itself

Long term revenues from this approach are generated through the local sale of energy to the occupiers of the new development, ensuring that the business models are robust (given appropriate site conditions) in a subsidy free world. Metropolitan, for example, are able to charge below market rates (currently the lowest price in the UK) for the heat that they provide at their King's Cross development so the occupiers of the new development also benefit from reduced energy bills, which may tackle fuel poverty for some. Or, Swindon Borough Council, who have founded Public Power Solutions, a wholly owned commercial company that is generating revenue for the Council through the ownership of energy assets and by helping other public sector organisations throughout the UK develop energy projects[xx].

This model offers a range of potential benefits for the local community, including cheaper running costs for the occupiers, the creation of locally retained revenue streams, which can include community benefit funds, and local job creation.

[xx] https://www.publicpowersolutions.co.uk/

Where a third-party provider is not able to viably contract with the developer under this type of model, it could be concluded that for that development the policy is not viable. In order to prove that the policy was not viable on a particular site, the developer would need to prove that they have negotiated with appropriate third party and community providers who were not willing to go ahead.

Even rooftop solar could be delivered through a third-party organisation, although this is more unusual; for example, an agreement could be drawn up for a local community energy group or solar installer to invest in solar on new homes through an Energy Services Company arrangement.

Third-party delivery options therefore reduce the financial burden on the developer of a zero carbon requirement. In summary, where utility scale energy infrastructure is proposed as a delivery option, it is likely that only a small proportion of the 'per dwelling' additional cost would be borne by the housing developer.

Offsite or near site generation as a route to zero carbon

The Council needs to consider what type of arrangements would be considered as meeting a zero carbon requirement through stand-alone near-site renewables. In order to claim standalone renewables as part of a zero carbon policy, sites for the renewable would need to be allocated to demonstrate deliverability by removing planning risk. Options might include:

- Solar arrays within the boundary of the development site. West Carclaze in Cornwall is a site with a zero carbon policy requirement. Two solar array sites have been identified within the curtilage of the development site itself, enabling greater control over the development of the arrays.
- A near site development which results in the developer offering a supply tariff to local residents, effectively meaning that residents of the new estate are purchasing the electricity from the near site array/wind turbine.
- A private wire arrangement supplying a single industrial user on the site. This would require there to be a user with sufficient energy use on the site and an interest in this arrangement.
- A private wire arrangement supplying a micro-grid, which can form the basis for a smart local energy solution for the site, including renewable generation, storage, and demand side response. The regulations are complex and there are costs associated with developing a micro-grid. This option is rare. However, this is an option that is being considered for West Carclaze in Cornwall. There are a number of potential benefits to this approach:
    - It allows the development of a private network that can be operated for the benefit of those connected to it. Reduced system charges mean there are economic opportunities, including the potential for reduced electricity bills and/or for any profits generated to be used locally, e.g. for a fuel poverty fund. A local supply company could be set up by the Council or a third party or a partnership approach to capture the economic benefits of local generation and supply for the benefit of the area.
    - It can offer a business case for the development of renewable generation connected to it – currently subsidy free solar is only being developed in the UK where a private wire agreement or corporate PPA has been secured.
    - It can help to overcome constraints on the local electricity network which might otherwise prevent the development of new renewable electricity capacity.

- An “allowable solutions” type arrangement where the housing developer pays an amount towards carbon reduction which is invested in a near site solar farm or wind turbines.
- The housing developer purchasing additional plots of land or partnering with a solar developer to enable near site solar arrays/wind turbines to be built, without the need for a direct electricity connection to the site.

This issue needs further consideration. There are risks to allowing near site solutions:

- How can it be shown that a near site solution is additional, i.e. that it was not going to happen anyway?
- How can a housing developer guarantee that a third-party developer will deliver the required energy generation infrastructure near to the site?
- What if renewable energy project economics change over the course of the development to the point that the proposed array is unviable? This could lead to the situation where the development is already partially delivered before the near site option is deemed unviable, meaning that homes are delivered that emit greater levels of carbon that is not then offset through a near site solution.

However, despite the potential complexity of including near site solutions, it should be noted that these solutions offer the potential not only for the generation of additional renewable energy, but also for additional local economic benefits to be created by enabling local supply models to be developed. These might include private wires, micro-grids or local supply tariffs. These options should be explored in more detail as an energy strategy is developed for the sites.

The Authorities could also consider renewables allocations elsewhere in the district, e.g. in areas where there is strong community support or low visual impact. By allocating sites, it could be argued that delivery of renewables has been facilitated by the Authority and is therefore “additional” to renewables that might have come forward through the usual planning channels.

If the Council decides to pursue a policy that allows near site solutions, a further detailed site search could be undertaken to explore potential solar and wind opportunities. This could include identification of land ownership. The Council could then consider allocating sites identified for solar and wind development as this would help to ensure deliverability of near site solutions. In particular, current national planning policy requires wind turbine planning applications to be in areas allocated by either a Local or Neighbourhood Plan.

Allowable Solutions as a route to zero carbon

It is beyond the scope of this work to discuss in detail the options presented by Allowable Solutions policies, however it is noted that this could provide a valuable mechanism for zero carbon delivery for further exploration. In the Greater London Authority’s London Plan, a zero carbon requirement has been in place for over a year[xxi]. From 1 October 2016 the Mayor has applied a zero carbon standard to new residential development. The Housing SPG defines ‘Zero carbon’ homes as homes forming part of major development applications where the residential element of the application achieves at least a 35 per cent reduction in regulated carbon dioxide emissions (beyond Part L 2013) on-site . The remaining regulated carbon dioxide emissions, to 100 per cent, are to be off-

[xxi] GLA Zero Carbon Requirement: https://www.london.gov.uk/what-we-do/planning/planning-applications-and-decisions/pre-planning-application-meeting-service-0

set through a cash in lieu contribution to the relevant borough to be ring fenced to secure delivery of carbon dioxide savings elsewhere. This approach could be explored for the West of England, using or perhaps updating figures from a 2014 Zero Carbon Hub/Sweett report[xxii], which found the following costs for achieving the Zero Carbon Standard, when Allowable Solutions are included:

- Detached homes = ~£6,700-7,500
- Semi-detached and mid-terraced properties = ~£3,700-4,700
- Apartments (low-rise) = ~£2,200-2,400

Policy wording

It is up to the Council to establish suitable policy wording based on further detailed studies. Cornwall Council's policy relating to West Carclaze includes the following requirements:

- *"Meeting all of the regulated energy requirements of the development from renewable and low carbon sources on or near to the site, nominally within 2km radius but to include significant opportunities that may exist up to 3km radius;"*
- *Provision of low carbon heat via a heat network with consideration given to a range of heat sources (biomass, gas, heat pump)*

Model policy wording developed by Regen SW for a Neighbourhood Planning project in 2016 included:

- *If we are to limit the increase in global temperature rises to a level that will avoid the worst impacts, new housing development must not emit greenhouse gas emissions. Proposals for housing development must therefore demonstrate how all (100%) of the energy requirements of the development will be met from renewable and low carbon energy sources.*
- *Where the energy requirements of the proposed development cannot be met from onsite installations, developers must first demonstrate that all feasible steps have been taken to minimise energy consumption on the site and then identify and secure alternative near site[xxiii] sources of renewable and low carbon energy generation to meet the needs of the development.*
- *In demonstrating that the development will meet this requirement, developers are encouraged to work with community energy organisations to provide the necessary energy generation.*

[xxii] http://www.zerocarbonhub.org/sites/default/files/resources/reports/Cost_Analysis-Meeting_the_Zero_Carbon_Standard.pdf
[xxiii] Near site would need to be defined.

Next steps

This study has shown that zero carbon options are possible for all the strategic sites, with a range of potential solutions and additional costs. The study is based on limited information about the sites: the number of homes proposed, the amount of non-domestic development and limited information about potential uses, and the site boundaries. As a result, a large number of assumptions have been employed, especially regarding the costs of proposed solutions.

As more details of the proposed sites are agreed, the Council should consider commissioning a further detailed study exploring the zero carbon delivery options

All the JSP council's should consider the evidence presented here and in any follow up studies to determine:

- Whether a zero carbon requirement is suitable for its strategic sites and whether the additional costs affect financial viability;
- Whether it wishes to include unregulated domestic emissions in its definition of zero carbon (as this study does);
- How near site solutions could contribute to delivery of the policy.
- How the economic value of a zero carbon energy solution could be captured locally.
- Whether allowable solutions could be used

Appendices

1. Methodology

Input data

Typically, the only information available for each site was **total housing allocation** and a spatial plan outlining employment areas, district centres and schools. For each site, this total housing allocation was split into the four main housing types, using proportions typical in new developments:

Flats (56.9m2 typical)	10%
Terraced (82.6m2 typical)	40%
Semi-detached (93.2m2 typical)	10%
Detached (151.7m2 typical)	40%

For the non-domestic areas, each spatial plan was analysed for indications of land use, and approximate sizes allocated accordingly to employment land, schools, leisure and commercial, GP surgeries and retail.

These spatial assessments were used to establish a baseline of:

	Source
Typical build costs, based on current building regulations	Costs published on www.building.co.uk
Estimated annual electricity demand for the development, based on current industry benchmarks	Extrapolated from typical Target Emissions Rate (TER), and checked against figures published by Ofgem.
Estimated annual heating demand for the development, based on current industry benchmarks	Extrapolated from typical Target Emissions Rate (TER), and checked against figures published by Ofgem
Estimated annual carbon emissions	Typical TER for notional buildings of each archetype, based on carbon emission factors published by DECC, 2017

Fabric improvements and renewable energy routes to zero carbon

For each development site, two different building fabric conditions were applied, with the resulting impact on cost and carbon emissions assessed. The different building fabric options modelled were:

- Current building regulations, 2013
- Code level 4, achieved by improving the thermal performance of each home

- Passivhaus, using gas as the main source of heat
- Passivhaus using electricity as the main source of heat

Each scenario outputs a resultant cost for the development, and an annual carbon emissions total. For scenarios that result in zero (or even less than zero) carbon emissions, the cost is compared to scenario 1, as the baseline. The difference in cost between the zero carbon scenario and the baseline is divided by the number of homes on the development, giving a 'per home' additional cost to achieve zero carbon.

For the wind farm and solar array options, where they resulted in scenarios achieving zero carbon emissions, a proximity search for existing projects was performed within 2km of each development site. If identified, these projects could provide a viable option for achieving zero carbon.

Non-domestic considerations

It is not possible to identify at strategic planning stage what the energy use of non-domestic employment land will be annually at the development. For that reason, only the regulated emissions (based on industry benchmarks for different types of building) were included in the analyses.

In addition, we considered it unlikely that the full range of fabric improvements could be applied to non-domestic buildings. For the analyses undertaken here, we set the fabric improvements to achieve 55 percent reduction in annual carbon emissions. This broadly equates to a BREAM 'Outstanding' rating. We viewed this target as a realistic appraisal of fabric improvements that could be made to non-domestic buildings.

Industry benchmarks for non-domestic buildings were obtained from 2008 sources, so a nominal 25 percent reduction on energy consumption across the board was applied to account for improvements in energy efficiency in the last 9 years. An aspirational target of 55% reduction on this figure was then applied, equating to BREEAM 'Outstanding' status.

Rooftop solar assessments

The rooftop solar assessment was split into domestic and non-domestic components, using the following factors.

Variable factor	**Amount**	**Unit**
Ofgem typical medium household electrical consumption	3,100	kWh
Total consumption emission factor for electricity	0.4120	kg/kWh
Ofgem typical medium per meter gas consumption	12,500	kWh
CO_2 emission factor gas	0.184	kg/kWh
Solar generation per kW south	957	kWh
Solar generation per kW south west/ south east	901	kWh
Typical Watts per m²	0.16	kW/m²

Wind capacity factor	26%	
Maximum solar on typical terraced houses	2.9	kW
Maximum solar on typical semi detached houses	3.8	kW
Maximum solar on typical detached houses	4	kW

Source: Regen, 2016

For each development, each dwelling was assumed to support the maximum level of PV for the archetype. This theoretical maximum was used as it should be possible for each dwelling to support PV. However, a variation in orientation was used to reflect lower generation figures for south west and south east facing roofs.

Additional 'near site' generation

Part of the specification for this study was to explore whether a solar PV array or windfarm could provide a cost-effective route to achieving a zero carbon development. To assess this, we examined the local wind resource and areas of suitable, unconstrained land where a project could be sited. Zones that could feasibly support a wind turbine/farm and reported greater than 6m/s wind speed at 45m were identified and mapped. The siting of solar projects was assumed to be possible for all developments at any scale.

Both wind and solar projects were assessed against the available electricity network capacity or generation 'headroom'. Where there was insufficient headroom available, the scenario was deemed unviable. Depending on local network upgrade costs, some of these scenarios that require solar/wind may still be viable, but this will require further assessment. In particular, as new demand is added to the network due to the new development, this can release capacity to connect additional generation.

2. Modelling assumptions

BRegs 2013 Target Emission Rates (TER) kg $CO_2/m^2/yr$		Typical size m^2	Total tonnes CO_2/unit/yr	Energy demand kWh/unit/yr	TDCV - SH & DHW – gas
Flat	21	56.9	1.19	5857	6912
Terrace	22	82.6	1.82	8908	8856
Semi	23	93.2	2.14	10508	13176
Detached	24	151.7	3.64	17847	15552

Passivhaus specification kWh/m^2 /year	
Primary energy demand	60
Heating demand	15

Source: Passivhaus Trust

CO_2 conversion factors kgCO_2/kWh	
LNG	0.204
Grid electricity	0.382
Biomass	0.0165

Source: BEIS CO2 Conversion factors 2017

Build costs	Bregs 2013 Build costs £/m2	Extra over cost for building to 19% reduction in CO2	Extra over cost for building to passivhaus
Flat	£1,950	+£2660 per unit	+10% on BRegs 2013 build costs
Terrace	£1,160	+£3430 per unit	+10% on BRegs 2013 build costs
Semi	£1,160	+£4140 per unit	+10% on BRegs 2013 build costs
Detached	£1,760	+£3264 per unit	+10% on BRegs 2013 build costs
Sources	Costmodelling.com	'Costs of building to the Code for Sustainable Homes' Element Energy and Davis Langdon, August 2011	Average data extrapolated from 'Passivhaus Capital cost research project' AECOM 2015 'Passivhaus cost comparison in the context of UK Regulation and prospective market incentives' PassivHaus Institut 2012

Typical proportion of archetype in developments		**Unit conventional build cost £**
Flat	10%	£56,558.60
Terrace	40%	£82,104.40
Semi	10%	£92,640.80
Detached	40%	£150,789.80

Efficiency of gas boiler	90%

Breakdown of domestic energy demand	**Current %**	**Passivhaus %**
Space Heating	61	25
Cooking	3	16.5
Lighting/Appliances	18	31
Hot water	18	40
(Proportion of energy demand that is heating)	(78)	
Sources	BEIS	Passivhaus Trust

Heating demand only - proportions	
Proportion of heating that is SH	74%
Cooking	4%
Proportion of heating that is DHW	22%

	Energy costs			
	Heat Sales p/kWh	Biomass fuel costs p/kWh	Electricity costs p/kWh	Gas costs p/kWh
	10	4	12	9
Sources		Forest Fuels	Ofgem	Ofgem

Current consumptions	Regulated[xxiv] Demand	Total annual Electricity (kWh)
Median	496	3100
Between median and low	408	2550
Low	320	2000
Source	Ofgem	

Code level 4: CO_2 reduction on BRegs13 per year (regulated)	19%

PASSIVHAUS: Space heating IS LIMITED TO 15kWh/m_2a, total energy limited to 60kWh/m_2 per year[xxv]						
Typical Passivhaus energy demands						
	floor area (m^2)	SH demand kWh/yr	total energy demand	Hot water demand	Non-heating demand	Heating demand
Flats	56.9	853.5	3414	1365.6	1194.9	2219.1
Terrace	82.6	1239	4956	1982.4	1734.6	3221.4
Semi	93.2	1398	5592	2236.8	1957.2	3634.8
Detached	151.7	2275.5	9102	3640.8	3185.7	5916.3

Non-residential buildings energy demand	Average m^2	Total annual heat requirement (kWh)	CIBSE Benchmark	Total annual elec requirement (kWh)
Retail	50	2475	3	8250
GP surgery	150	22500	19	10500
Primary school	1000	75000	17	40000
Office	100	9000	1	9500

[xxiv] http://www.rtpi.org.uk/media/9600/Topic-3-Energy-Requirements.pdf

[xxv] http://passiv.de/en/02_informations/02_passive-house-requirements/02_passive-house-requirements.htm

Source: CIBSE

Non-residential buildings energy demand	Employment ratio[xxvi]	Elec /kWh/m²/yr	Thermal/kWh/m²/yr
Average 'B' land use	0.3	16.5	46
Commercial Leisure	0.4	45	126

Non-domestic % improvement on 2008 benchmarks	25%

Solar costs		Source
Domestic rooftop £/kWp	£ 1,000.00	Industry practitioners
Non-domestic rooftop £/kWp	£800.00	
Ground mounted solar £/kWp	£800.00	
Wind costs		
£/kW	£3,500.00	Industry practitioners
Connection / Infrastructure costs		
£/kW	150	Industry practitioners

BREEAM costs (Dec 2013)						
Increase in capital costs for different building types and certification levels						
Rating	**School**	**Industrial**	**Retail**	**Office**	**Mixed Use**	**Equivalent CO_2 emissions savings**
Good	0.10%	0.05%	0.10%	0.10%	0.08%	**6%**
Very Good	0.20%	0.10%	0.20%	0.20%	0.15%	15%
Excellent	0.70%	0.40%	1.80%	0.80%	1.50%	35%
Outstanding	5.80%	4.80%	10.10%	9.80%	4.80%	55%

[xxvi] This is the proportion of employment land that will be built on

Heat network costs:

- Assessment of the costs, performance and characteristics of UK heat networks, March 2015, AECOM
- The potential and costs of district heating networks, April 2009, Poyry, AECOM