Chelmsford City Council

Chelmsford Garden Community

Energy Mapping and Renewable, Low Carbon Energy Feasibility Study

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Glossary of terms

Air tightness	Airtightness is the fundamental building property that impacts infiltration and exfiltration (the uncontrolled inward and outward leakage of outdoor air through a building), caused by pressure effects of the wind and/or stack effect.
Embodied carbon	Carbon dioxide and other greenhouse gases associated with the following stages: a) Product: extraction and processing of materials, energy and water consumption used by the factory or in constructing the product or building, and transport of materials and products b) Construction: building the development c) Use: maintenance, replacement and emissions associated with refrigerant leakage d) End of life: demolition, disassembly waste processing and disposal of any parts of product or building and any transportation relating to the above.
Fabric first	A 'fabric-first' approach to building design involves maximising the performance of the components and materials that make up the building fabric itself, which lead to heating energy demand reductions.
Future Homes Standard	The Future Homes Standard is an expected change within the Building Regulations which will ensure that new homes built from 2025 will produce 75-80% less carbon emissions than homes delivered under current regulations (Part L 2013).
Green and blue infrastructure	Green infrastructure refers to trees, lawns, hedgerows, parks, fields, forests, etc. Blue infrastructure refers to water elements, like rivers, canals, ponds, wetlands, floodplains, water treatment facilities and similar.
Heat pumps	Heat pumps extract free heat from the soil, ambient air, or a body of water. This heat is then transferred for domestic use with the help of an electric compressor. This compressor, however, consumes significantly less energy than a boiler. They can be air, water or ground sourced.
IES	Dynamic energy modelling software used for building energy consumption, CO2 emissions, peak demands, energy cost and renewable energy calculations.
M&E	M&E in construction refers to mechanical and electrical systems. Mechanical systems can include elements of infrastructure, plant and machinery, tool and components, heating and ventilation and so on.
MVHR	Mechanical ventilation heat recovery, mechanical ventilation system that extracts heat from indoor air removed and increases the temperature of the incoming air through the system reducing the energy needed to warm up the fresh air in the building.
Net zero / zero carbon	A building which during its operation requires very little energy to run. An amount of this reduced energy demand is covered by on-site renewable energy generation directly. The remainder amount of energy is supplemented by the grid. The building does not rely on fossil fuels, so its carbon emissions during operation are reduced due to the decarbonisation of the electricity grid. All expected operational energy demand is accounted for including both regulated and unregulated energy types.
Net zero / zero carbon ready	The 'ready' element refers to the ability of these buildings to easily be modified to a net / zero carbon status even if currently they are not 100% achieving the standard. Typically, that would include the avoidance of a fossil fuel heating, such as a natural gas boiler
Operational carbon	Carbon dioxide and other greenhouse gases are associated with the in-use operation of the building.
Operational energy use	Energy used during the operation of the building. This includes all energy uses.
Part L	Conservation of fuel and power: Approved Document L of the UK Building Regulations.

Part F	Approved Document F provides guidance on building ventilation, including building air quality, and preventing condensation in a domestic or non-domestic structure.
Photovoltaic panels	A photovoltaic panel (PV panel) refers to an electrochemical type of equipment that is used to facilitate the conversion of light into electricity. It does this by using semiconducting materials that exhibit the photovoltaic effect.
Regulatory changes	Building regulations are expected to be reformed every 3-5 years, which is already indicated by the government's aspiration to introduce the new Part L during 2022 and then subsequently the Future Homes Standard in 2024 (coming in effect from 2025). All new buildings are also expected to halve their overall energy use by 2030 as per the Grand Challenge Missions so it is possible that regulations will be updated again in 2030.
Regulated energy	Regulated energy is building energy consumption resulting from the specification of controlled, fixed building services and fittings, including space heating and cooling, hot water, ventilation, fans, pumps and lighting.
SAP	The Standard Assessment Procedure (SAP) is the UK Government's National Calculation Methodology for assessing the energy performance of dwellings. SAP10.1 and 10.2 released on 08/11/2019 and 20/08/2021 respectively are the new proposed versions that at the time of writing of this report cannot be used for compliance but indicate some potential future changes within the procedure.
SBEM	An SBEM or Simplified Building Energy Model, often know as an SBEM Calculation, is a government led process which calculates the energy performance of new non-domestic buildings.
Thermal bridging	A thermal bridge (sometimes called a cold bridge) is a localised weakness or discontinuity in the thermal envelope of a building. They generally occur when the insulation layer is interrupted by a more conductive material.
Unregulated energy	Unregulated energy results from a process or system that the Building Regulations do not impose a restriction on (lifts, equipment, external lighting, catering, cooking, appliances).
Whole-life carbon	This includes both embodied and operational carbon as defined above.

Executive summary

We are in a climate emergency. New developments are required to drastically reduce their environmental impact. A climate and ecological emergency has been declared in Chelmsford in July 2019 with the council pledging to reduce its own carbon emissions to net zero by 2030.

North East Chelmsford is expected to become a new garden community. A garden community represents the vision of a place where people could work, raise families, travel easily and enjoy green spaces.

Garden communities set clear expectations for the quality of the development and how this can be maintained. They encompass vibrant, mixed-use communities that are holistically planned, self-sustaining and characterful[1].

This study includes several research findings in terms of how to achieve a net zero Chelmsford Garden Community (CGC) and what this means in terms of future energy demand.

There are two set of standards that have been produced within the report. These are:

- Minimum CGC standards
- Zero-carbon

The two standards are applied during three different CGC development periods: current-2025, 2025-2030 and 2030-2036. For reference purposes the expected delivery rates (%) within CGC are shown in Figure 2.

Type	Current - 2025	2025 - 2030	2030 - 2036
Housing	10%	25%	65%
Non-domestic	12%	31%	57%

Figure 1 - Delivery rates - CGC - during the three development phases

We examined three potential roadmaps, based on when each of the two proposed standards can be applied. These roadmaps are shown on Figure 2.

We recommend that the best road map to follow would be introducing the minimum CGC standards until 2025 and thereafter continuing with zero carbon (Roadmap 2).

What is important to remember?

It is very important to note that capital cost is not the driving factor for this recommendation. The main reason for the delaying of the zero-carbon standards is so development can adjust and does not go through a steep learning curve.

The zero-carbon standard includes mandatory minimum amount of energy demand, renewable energy generation per building and energy storage on site. In effect they reflect latest and best industry practice.

To provide early feedback and adjust the development to the post-2025 tightening of standards, we believe it is important that at least 10% of all buildings to be developed currently and by 2025 should be ‘zero-carbon’.

1 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/805688/Garden_Communities_Prospectus.pdf

	**Minimum NCGC standards**: Represent forward thinking minimum standards that align with achieving reasonable level of energy efficiency
	**Zero carbon**: Represent standards required to achieve net zero carbon

Zero Carbon – Roadmap 1

Energy consumption reduction (including PV)

- Housing: 105%
- Non-domestic: 88%

Carbon emissions reduction

- Housing: 101%
- Non-domestic: 93%

Capital construction cost increase – average - compared to Part L 2013 compliant buildings (materials and products only)

- Housing: 11%
- Non-domestic: 6%

Towards Zero Carbon – Roadmap 2

Energy consumption reduction (including PV)

- Housing: 100%
- Non-domestic: 85%

Carbon emissions reduction

- Housing: 98%
- Non-domestic: 90%

Capital construction cost increase – average - compared to Part L 2013 compliant buildings (materials and products only)

- Housing: 10.5%
- Non-domestic: 5.6%

Towards Low Carbon – Roadmap 3

Energy consumption reduction (including PV)

- Housing: 89%
- Non-domestic: 76%

Carbon emissions reduction

- Housing: 89%
- Non-domestic: 79%

Capital construction cost increase – average - compared to Part L 2013 compliant buildings (materials and products only)

- Housing: 9.6%
- Non-domestic: 4.6%

Figure 2 - Three potential roadmaps

Pre-2025 zero-carbon developments will need to be carefully recorded in terms of process and performance outcomes, opportunities, challenges and risks, to inform future development plans.

Our standards are not based on specific technologies, but no fossil-fuel based systems should be used, especially post-2025, for the targets to be realised.

Finally, a net zero CGC champion will need to be introduced by Chelmsford City Council (CCC) to specialise on the planning applications for the location and track the development as it progresses, ensuring that high quality and community satisfaction standards are achieved.

What is the study about?

An Energy Mapping and Renewable and Low Carbon Energy Feasibility Study for Chelmsford Garden Community was conducted to inform the future development of the site and in particular the master planning process in terms of identifying the anticipated energy, heating and cooling demand for all users, opportunities to minimise energy demand and opportunities for renewable and low-carbon energy schemes.

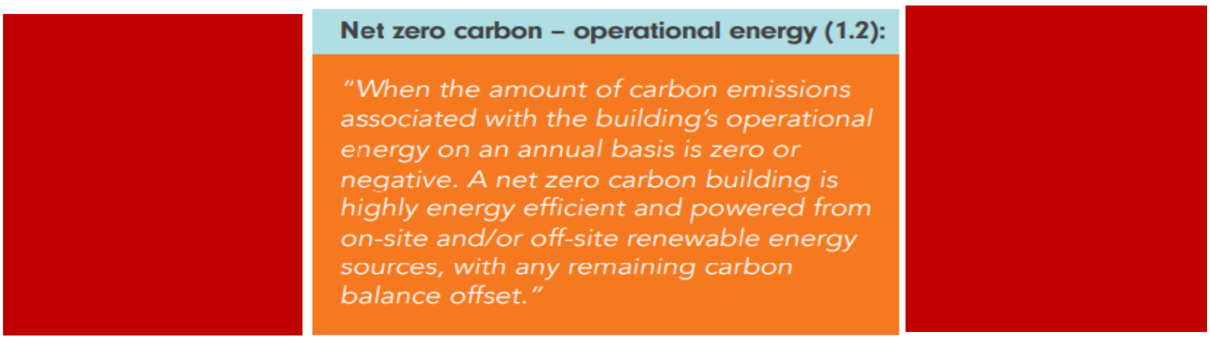
Research included understanding the future CGC development rates, from now to 2036. These were analysed against identified national and local policies and commitments.

Housing and non-domestic building models were used to estimate the future energy and carbon performance of CGC. This was achieved by using them in several potential scenarios achieving different levels of energy and carbon performance. Results were used to produce the different roadmaps the master planning process could take.

Within this study the **definition of net-zero carbon** incorporates reducing the levels of overall expected carbon emissions, the need to minimise total energy consumption for the site and the need to manage peak demand for power from national supply infrastructure.

The working **net-zero carbon definition** used in the study for CGC, in agreement with latest industry guidance, was as follows:

‘A building which during its operation requires very little energy to run. An amount of this reduced energy demand is covered by on-site renewable energy generation directly. The remainder amount of energy is supplemented by the grid. The building does not rely on fossil fuels, so its carbon emissions during operation are reduced due to the decarbonisation of the electricity grid. All expected operational energy demand is accounted for including both regulated and unregulated energy types.’



UK GBC, Net Zero Carbon Buildings, A Framework Definition, April 2019[2]

[2] Net-Zero-Carbon-Buildings-A-framework-definition.pdf (ukgbc.org)

The building blocks of this approach include:

- Minimising energy demand for heating/cooling with appropriate provisions in terms of insulation and ventilation levels. This is established within the report in the sense of specific levels of performance – minimum requirements that need to be demonstrated by the developers.
- Using appropriate mechanical and electrical services, of high efficiency and resilience in all new construction projects.
- Including both regulated and unregulated energy use[3] in energy calculations.
- Maximising renewable energy generation on site. We recommend photovoltaic panels (PV) on the roof of all buildings. To maximise the direct use of renewable energy generation, thermal and electrical storage is recommended (hot water cylinders and batteries).
- Monitoring for at least five years (through detailed sub-metering) the performance of large non-domestic buildings and a representative sample of new houses to ensure that the benefits described are realised.
- Carbon offsetting is not explored within the report but could be used to offset any remaining carbon emissions.

This approach is designed to drastically reduce operational carbon emissions while keeping levels of electricity consumption and peak electrical demand to a minimum. It also protects the ability of the electricity grid to decarbonise while avoiding high energy costs being borne by residents.

Proposed zero carbon roadmaps

There are three roadmaps advised for CCC. These are referred to as:

- Zero-Carbon – Roadmap 1

Higher standards introduced for both housing and non-domestic buildings are set as a minimum requirement as soon as possible. No new building is constructed to lower energy and carbon standards. All buildings contain energy generation and store technologies and use very little energy.

- **Towards Zero-Carbon – Roadmap 2**

Zero-carbon standards are introduced for both housing and non-domestic buildings as minimum requirements on decision making on detailed planning applications from 2025. Up to 2025 the new buildings are constructed to high standards and do not include energy stores. Less energy generation is achieved due to the buildings having less PV installed in the first phase (2020-2025). In addition, the first (pre-2025) new buildings require more energy for heating. 2020-2025 can be used as a trial phase prior to gradually lifting the standards post-2025 providing CCC with the opportunity to receive feedback from early development phases (Phase 1 performance, challenges and progress to be monitored). This is the recommended roadmap.

- Low carbon – Roadmap 3

This roadmap is similar to Roadmap 2 but with the initial ‘Minimum CGC Standards’ applying for longer – from 2020 to 2030.

[3] Noting that the design and specification of the home most directly influences regulated energy, but that unregulated energy use is still part of the scheme’s overall demand and consequent local impact.

All three roadmaps lead to substantial energy and carbon savings that satisfy both current and future Building Regulations requirements as well as the concept of net zero / zero carbon.

The three roadmaps align and exceed currently proposed changes within the Part L of the Building Regulations (Part L 2021). They also exceed the Future Homes Standard expectations of a 75-80% reduction in carbon emissions from new homes from 2025) compared to Part L 2013.

The concept of net zero / zero carbon within the report acknowledges not only the environmental impact of emissions relating to ‘regulated’ energy use (heating, hot water, lighting, and fixed services) but also the impact of unregulated energy consumption (appliances) both in terms of carbon emissions but also energy demand from the electricity grid and time of use (plus peak loads).

As a future proofed, forward thinking, and exceptional development overall, the standards proposed for the NECGC include ‘best practice’, technically robust and cost-effective performance thresholds relating to the overall building energy balance.

What that means is the special provision has been made for energy demand reduction, energy generation and use on site and protection of the user against current and future energy prices.

All roadmaps proposed are expected to satisfy the minimum requirements as expected within the building regulations by 2025 (and in a lot of cases will also achieve halving the buildings overall energy use as per the Grand Challenge Mission requirements, which requires this to be achieved from 2030)

The difference between the roadmaps has to do with when the strictest ‘zero carbon’ requirements are being introduced (current to 2025, 2025-2030 or 2030-2036).

All three roadmaps use the highest standards developed in this report, zero carbon, during 2030-2036 when most of the CGC development takes place.

Cost

- Capital construction cost increases are shown in Figure 2.
- Running cost estimates (energy costs only), have been produced based on the different building models. For houses, the minimum CGC Standards proposed led to annual energy savings of £200-£500 per home.

Key findings and outputs by theme, including recommendations by statement

This section of the executive summary contains the main outputs in numbered paragraphs, and by theme, for ease of accessibility.

Policy direction and development timelines

E1. We reviewed and evaluated both current and future policy landscapes in terms of energy efficiency and carbon emissions requirements for buildings. The Chelmsford Local Plan, May 2020 requirements were in alignment with national regulations.

E2. Three development phases were selected for Chelmsford Garden Community (CGC) based on expected relevant changes to Building Regulations ('regulatory changes') and policy changes for Chelmsford Garden Community (CGC). These are:

- Phase 1: current-2025
- Phase 2: 2025-2030
- Phase 3: 2030-2036

E3. Regulatory and policy research outputs, along with best practice and current state of industry, were used to produce several possible CGC future development scenarios.

E4. The evaluation and review of the site were conducted with absolute respect to the CGC garden community principles which, as per the Town and Country Planning Association (TCPA) guidelines[4], include:

- Land value capture for the benefit of the community.
- Strong vision, **leadership and community engagement**.
- Community ownership of land and **long-term stewardship** of assets.
- Mixed-tenure homes and housing types that are genuinely **affordable**.
- A wide range of local jobs in the garden community within easy commuting distance of homes.
- Beautifully and imaginatively designed homes with gardens, combining the best of town and country to create **healthy communities, including opportunities to grow food**.
- Development that **enhances the natural environment**, providing a comprehensive green infrastructure network and net biodiversity gains, and **that uses zero carbon and energy-positive technology to ensure climate resilience**.
- Strong cultural, recreational and shopping facilities in walkable, vibrant, sociable neighbourhoods.
- Integrated and accessible transport systems.

E5. Main findings from national and local policy evidence reviewed, as expected included a strong drive for energy-efficient and sustainable buildings which could be supported by all electric solutions and renewable energy generation technologies. This is due to the expectation that post-2025 the construction sector should be trying to avoid the use of fossil fuels.

E6. CGC development in the adopted Chelmsford Local Plan spans current - 2036[5]. During that period, different delivery rates in terms of new housing and non-domestic buildings will be achieved each year. At the same time, more changes are expected to be introduced within the Building Regulations in 2025 and 2030. Having a robust plan moving forward and receiving feedback from previous development phases is key to the scheme's success.

[4] https://www.tcpa.org.uk/garden-city-principles

[5] Further development at CGC is expected to be delivered post-2036 following a review of the Local Plan. This report considers the existing Local Plan allocation to 2036.

Maintaining high standards and quality – key points

E7. We highly recommend the introduction of a garden community and net zero (GCNZ) champion focusing on the environmental performance of CGC. Expected responsibilities would include overlooking alignment of planning applications with standards in place, identifying marketing and financing opportunities for new development, co-ordinating the environmental communication strategy and overlooking feedback analysis from monitored data from previous phases.

E8. CGC new building developments need to follow the key performance indicators produced in this report and as shown for the different roadmaps within Table 1 and Table 2.

E9. Data monitoring and evidence of achieving set energy and carbon performance standards are critical to the success of CGC. We recommend an at least five-year monitoring period for large developments and non-domestic buildings. We also recommend the introduction of such monitoring criteria in new housing too, by providing the occupant with the ability to monitor, report and observe the energy and carbon performance of their new homes.

Forecasting future energy demand and capacity requirements – model outputs

E10. To evaluate the impact of new building standards, and therefore the performance of the CGC site under different future scenarios, sets of models were developed. These included four solutions packages for housing and two for non-domestic buildings, used within seven and five future scenarios, respectively.

E11. The models used within the study for the different buildings follow industry standard and common designs and building typologies. Passive solar design and similar design features, assessment of impact of orientation and massing, risk of overheating and other design concerns should be identified and detailed at a planning application stage. The typical building models used in the study were 'design' neutral to represent common practice and how it can achieve higher standards if required.

E12. The analysis undertaken was based on new housing and non-domestic building models. Mechanical and electrical technologies as in the case of heat pumps, PV and mechanical ventilation heat recovery systems (MVHR) were used, in combination with fabric upgrades and improvements.

E13. The measures introduced within the building models (housing and non-domestic), were grouped into packages and applied to the CGC future development phases. Three roadmaps were proposed for CGC in alignment with the aspiration to become a net zero development. It would be for CCC to decide which roadmap would be best suited for meeting their main commitments. Our recommendation is Roadmap 2 as this balances delivery of zero carbon for the vast majority of homes whilst providing time for developers to adapt to the new requirements.

E14. Treating each building at CGC as an independent energy generator using PV, with the option to store heat and electricity and maximise use on site was considered as the least complex way for initiating the net zero-carbon journey. These measures were applied after significant improvements were considered following a 'fabric-first' approach (to reduce the energy demand for heating for each building).

E15. Both housing and non-domestic buildings outputs show that all electric solutions will need to be considered, avoiding the need for the use of fossil fuels on-site. Where gas or hydrogen networks need to be installed in the future, these can only happen by exception (back-up generation). A complete and detailed analysis of their carbon and environmental footprint as well as a list of appropriate mitigation strategies (to be checked by a third party) will need to be presented to and examined by CCC and the net zero CGC champion.

E16. The anticipated demand for energy for power, heating, cooling and mobility for all the proposed land uses in North East Chelmsford will heavily depend on the energy and carbon standards to be adopted during the different development phases, as well as the proposed solutions to meet these standards. We have estimated 22MVa – 27.5MVa of electricity from the grid will be required based on the zero-carbon journeys presented within this study (lowest energy requirement for ‘zero-carbon’ standards).

Table 1 - Key performance indicators (KPIs) - Housing

KPI	Impact		Key: Minimum CGC Standards	Key: Zero Carbon
Space heating demand Through energy modelling kWh/m².year — Minimum CGC Standards: 35; Zero Carbon: 15				
Total energy use (regulated and unregulated) Through energy modelling kWh/m².year — Minimum CGC Standards: 50; Zero Carbon: 35				
Fossil fuel free Fossil fuels such as oil and natural gas shall not be used to provide space heating, hot water or used for cooking.	**Impact**			
Measurement and verification Meter, monitor and report on energy consumption and renewable energy generation post-completion for the first five years.		Energy demand reduction (without/with PV)	43%/59%	60%/105%
Running cost increase Should be less than a scheme compliant with Building Regulations Part L 2013 using a gas boiler.		Increase in peak electricity grid demand	+ 65%	+ 28%
GWP – refrigerants If a system is installed that includes refrigerant, the refrigerant shall have a Global warming potential of no more than 10.		Carbon emissions reduction	28%	101%
Renewables Roof area covered in PV — Minimum CGC Standards: 40%; Zero Carbon: 80%		Construction capital cost increase compared to a Part L 2013-compliant building (materials and M&E additional costs only).	6%	11%
Storage Store needs to be sized so the load is balanced and achieves the following: ▪ A performance target of 60% load variation across the day		Running energy costs per house per year (+ increase, - reduction)	(-) £200 to £500	(-) £275 to £885[6]

Space heating demand

Expected energy demand for heating is currently predicted by using the Standard Assessment Procedure (SAP).

SAP is a steady state simulation method, which uses predictive occupancy levels and does not consider impact of dynamic effects.

The space heating demand noted within the housing KPIs refers to the energy required for heating and excludes the efficiency of the technology providing that heat (gas boiler, heat pump, etc).

It needs to be made clear that the space heating demand addresses the ‘fabric-first’ approach, which requires minimising energy ‘wastage’ which can occur through low airtightness.

The impact of systems such as mechanical ventilation heat recovery (MVHR) is accounted for within the KPIs set.

Carbon emissions reduction compared to Part L 2013

Carbon factors for electricity from the electricity grid are constantly changing as the electricity grid continuous to decarbonise. New factors are expected to be introduced for the assessment period running up to 2025 in the new SAP 10.1 (currently not used for compliance). The scenarios examined lead to the following carbon emissions reduction paths (using current data).

Average CO2e reductions achieved – Housing	%	
Current Building Regulations carbon emission factors	20-30	110-130
SAP 10.1 carbon factors	70-89	130-150

[6] To achieve such high energy cost savings, a minimum 70% of all renewable energy generated through a min 80% roof PV coverage needs to directly be used by the occupier

Table 2 - Key performance indicators (KPIs) – Non-domestic

KPI	Description	Minimum CGC Standards	Zero Carbon
Space heating demand	Through energy modelling		
	kWh/m².year	35	15
Total energy use (regulated and unregulated)	Through energy modelling		
	Office kWh/m².year	75	55
	School kWh/m².year	85	65
	Retail kWh/m².year	130	85
	Leisure kWh/m².year	125	92
	Innovation hub kWh/m².year	90	65
Fossil fuel free	Fossil fuels such as oil and natural gas shall not be used to provide space heating, hot water or used for cooking.		
Measurement and verification	Meter, monitor and report on energy consumption and renewable energy generation post-completion for the first five years.		
Running cost increase	Should be less than a scheme compliant with Building Regulations Part L 2013 using a gas boiler.		
GWP – refrigerants	If a system is installed that includes refrigerant, the refrigerant shall have a Global warming potential of no more than 10.		
Renewables	Roof area covered in PV	15%	30%
Storage	A battery capacity of 3.5kWh per 100m2 installation can be used. Please undertake a detail peak load analysis in order to optimise performance.		

Impact	Minimum CGC Standards	Zero Carbon
Energy demand reduction (without/with PV)	53%/64%	65%/88%
Increase in peak electricity grid demand	-10%	-23%
Construction capital cost increase compared to a Part L 2013-compliant building (materials and M&E additional costs only).	3 %	6 %
Running costs per building per m2 per year (+ increase, - reduction)	Figure 23	Figure 23

How the standards proposed relates to the current version of the Building Regulations (Approved Document L 2013 and the approved current Standard Assessment Procedure).

Space heating demand

Needs to be assessed using dynamic simulation methods, especially in more complex non-domestic buildings.

Carbon emissions reduction compared to Part L 2013

Carbon factors for electricity from the electricity grid are constantly changing as the electricity grid continuous to decarbonise. New factors are expected to be introduced for the assessment period running up to 2025 in the new SAP 10.1 (currently not used for compliance). The scenarios examined lead to the following carbon emissions reduction paths (using current data).

Average CO2e reductions achieved – Non-domestic	%	
Current Building Regulations carbon emission factors	20-35	30-50
SAP 10.1 carbon factors	50-65	60-75

The minimum energy and carbon performance requirements

E17. Within the report, the concept of net zero and therefore the definition used includes both regulated and unregulated energy use and associated carbon emissions during operation. Both need to be included in CGC planning applications and both need to be used to prove that any new plans comply with the thresholds proposed within the report (peak load, overall energy consumption, etc).

E18. The research outputs introduce energy and carbon performance thresholds and appropriate key performance indicators (KPIs) that the buildings need to meet but do not dictate specific technological solutions. It is well established that there is not one strategy that can lead to meeting the targets (energy and carbon) included within this study.

E19. Minimum energy and carbon requirements were established for CGC. These are detailed as in 'Minimum NCGC standards' and 'zero carbon' standards. Additional information on the specifications that were used within the models can be found in Appendix B – Housing and non-domestic buildings model specifications.

E20. Space heating energy demand thresholds introduced refer to the performance of the building's fabric (inclusive of the effect of a mechanical ventilation heat recovery system [MVHR]). It is not the energy demand required from the grid for heating but how much energy needs to be delivered to the building itself to maintain comfort. Therefore, it does not include, and should not include, the impact of the efficiency of the space heating providing equipment (eg a heat pump)[7].

E21. The current research sets requirements in terms of minimum renewable energy generation. If communal solutions are sought, equivalent units need to be used. When renewable energy generation contributions are accounted for within a building's predicted carbon emissions (eg PV generation is removed from overall annual energy demand prediction) it needs to be made clear if the monetary benefits of this generation are attributed to the user, and how this will affect their expected energy bills. This is to ensure that the user/occupier will not face high energy bills.

[7] What this means is that for heating, the amount of energy required for the building to maintain indoor comfortable conditions needs to be reported separately and as calculated within the standard assessment procedure from the energy required from the grid in order to deliver the required energy. In effect the different heating systems efficiencies are excluded so the impact of the insulation, airtightness and MVHR can be separated in a 'fabric-first' approach.

Capital and running cost

E22. Capital cost changes were estimated for housing and non-domestic buildings based on the different road maps. These were:

Roadmap	Housing construction cost increase	Non-domestic capital cost increase
Roadmap 1	11%	6%
Roadmap 2	10.5%	5.6%
Roadmap 3	9.6%	4.6%

These additional capital cost estimates are based on a Part L 2013-compliant building baseline. They refer to additional materials, mechanical and electrical equipment but do not include design, consultant, preliminaries[8] and other fees that could reflect a lack of knowledge, skills or changes required to produce a product of high quality.

E23. Running costs, as in energy bills to the user, will heavily depend on the amount of PV generated energy and direct use on site (allocated to the occupant), overall energy demand of the building and the future cost of energy. Savings estimated for housing in this study were in the range of £200-£885 per year (highest savings in alignment with the strictest energy generation and energy efficiency standards). For non-domestic these were estimated as being £5-£25 per m^2 of the gross internal floor area (GIFA).

Technologies

E24. CGC is at a very early concept level. The report does not exclude or consider as 'inappropriate' any low-carbon and renewable energy technologies. As detailed within the report, the scale of the solutions suggested, along with their operational requirements, might present challenges especially in the case of heat distribution networks. Reasons for those include consumer lock-in, distribution losses and complex design of primary networks to accommodate future development plans.

E25. The CGC development period spans current-2036, with a lot of the stock delivered at a later stage. New technologies and methods will be developed during that period, while current innovation might move to standard practice. New methods of construction, contract structures and supply chains are expected to be supported by new innovative financing, funding and government initiatives. These and their applicability to CGC need to be reviewed and reported annually.

E26. All CGC buildings need to be able to store an amount of energy needed in the form of heat either through hot water stores or other heat battery systems. These systems will ensure that preferential energy tariffs or surplus renewable energy generation on site can be stored to cover part of the heating/hot water demand when required.

E27. The current research, for individual battery systems installed within houses specified a minimum of 2kWh per house. For housing, a performance target is also set of 60% load variation across the day (needs to be met). For non-domestic buildings, a 3.5kWh per 100m2 is specified (or equivalent).

[8] Preliminaries are the cost of the site-specific overheads of any given project.

E28. Due to the current and future cost of electricity, (export price very low, almost 1/3 of the price to purchase electricity from the grid), whatever electricity energy store system is chosen (per building, for block of buildings or more centralised systems) will need to be able to at least store and return 50% of renewable energy generated per building across the year to that building. This is to ensure that running energy costs are kept low and affordability is respected.

E29. Early phases of the development must be used to bring the whole greater thinking together. The report focuses on models that use standalone solutions to achieve energy and carbon performance targets. If more complex solutions are to be sought, community or district based, then careful consideration should be given during master as to their benefits, risk and long-term effect on future development plans.

E30. The overall direction of all electric solutions entails the use of renewables, heat pumps and improved construction standards. Each development phase will need to be reviewed at the time of the planning application on the proposed strategy's merits. Risks can be mitigated by requesting for additional transparency within the decision-making processes, developers to undertake whole-life (where appropriate) and lifecycle (most used currently) energy, carbon and costs assessments and report on the findings.

Adjacent sites (Beaulieu and Channels)

E31. Adjacent and neighbouring sites Beaulieu and Channels were evaluated as part of this study. The review was confined to the energy and carbon performance standards used within the new development. Both developments complied with clauses requiring them to meet a 10% improvement (CO2e) compared to buildings constructed in accordance with Part L 2010 of the Building Regulations[9].

E32. Beaulieu and Channels followed a fabric-first approach. There is a small number of photovoltaic panels on site. (Channels only) All properties are supported by gas boilers. CGC will be seeking to achieve some strict energy and performance targets. We expect that most of the systems installed within CGC will not be able to support the decarbonisation of Beaulieu and Channels. The only exception would be for very specific demand/supply decentralised electricity distribution systems to connect and supply Beaulieu and Channels with renewable energy.

E33. Beaulieu and Channels fossil fuels-based systems will not be able to decarbonise using renewable energy generation as an offset due to the decarbonisation of the electricity grid (cannot claim enough carbon savings). Such developments will transition to zero carbon either through replacement of gas boiler with all electric systems or by converting those to use green hydrogen when it becomes available.

E34. Current models performance, as used within CGC, indicate that they can be constructed to sufficient standards to conform to the stringent CGC performance requirements, but they would not be able to assist adjacent sites such as Beaulieu and Channels. This is unless decentralised supply demand/electricity generation and store networks are expanded. That could be a complex upgrade both technically and commercially given the good performance of the current homes which mean that the savings form any infrastructure would be relatively small but the costs of connections and internal works to enable these would be high. Please note that future changes within the building regulations are also expected to require high standards to be achieved (2.1.3).

E35. A more cost effective and technically straightforward approach is likely to be the transition of the existing homes from gas to electric (heat pump)-based heating and hot water on an individual basis. It is advised that future Beaulieu and Channel development tries to adhere to the standards shown within this report for CGC buildings.

[9] This is the previous version of the current Building Regulations, Part L 2013

Net zero carbon – carbon offsetting and lifecycle/whole-life carbon assessments

E36. Carbon offsetting is not explored as part of this study, and a detailed analysis is not included within the report. It is advised that upon selection of the preferred roadmap to net zero, further research is undertaken in terms of amounts of remaining carbon[10] and possible solutions for those.

E37. Embodied carbon and whole-life energy and carbon assessments were not conducted as part of this research. The research focused on establishing minimum energy demand and carbon emission thresholds during operation. Embodied carbon and whole-life energy and carbon assessments should be undertaken for large developments, upon confirmation of the detailed design approach.

E38. All new buildings and installed systems, plus infrastructure required for centralised systems, will need to be reviewed on an individual basis in terms of lifecycle costs. These costs will derive from predictive and reactive requirements for installed systems as well as their replacement when they reach end of life. Current research did not include such assessment, with a more detailed analysis required at the time of detailed design stage of the different buildings.

E39. Lifecycle and whole lifecycle assessments submitted by the developers/consultants at a planning permission stage are advised. Another research study will need to be commissioned by CCC to better understand what thresholds need to be introduced.

Financing and other considerations

E40. CGC local decentralised, community and occupant-based financing and initiatives (shares in renewables, etc) need to be carefully examined against regulators and financial instrument requirements. The current report includes solutions that focus on a building level, as these were considered as the most appropriate as they deliver the necessary energy performance without requiring significant use of other land on the development site. This thereby enables the maximum potential for green space and other beneficial uses. If these mechanisms are to be introduced for more centralised solutions, caution is advised in terms of protecting the local communities and occupants first from the risk of potentially higher energy bills and reduced flexibility in supplier selection.

E41. For the successful future deployment of measures, and to inform future investors, occupants and purchasers, performance monitoring of a minimum of five years is strongly recommended. This should especially be the case of large non-domestic buildings and estates. Housing designs should include ‘visibility’ and monitoring features, smart meters, dashboard monitors and ways of reviewing the property’s performance (always considering digital security, accessibility, etc). Information needs to be captured and reviewed by the net zero champion or CCC, identifying how closely aligned design targets to ‘actual’ in use performance were.

E42. Certifications such as the Home Quality Mark (HQM), Passivhaus, BREEAM, LEED, WELL and other such products can be used to add an additional layer of ‘accreditation’ to the different delivered buildings. Nevertheless, expected energy use broken down by heating demand due to fabric performance, overall energy demand (regulated and unregulated), renewable energy generation, expected renewable energy use on-site, minimum energy stores (heat, electricity) and others as detailed within this report should always be reported and reviewed separately.

E43. The buildings need to be very easy to use and operate. They need to contain building and user manuals and simple guides. This should be provided both in hard copies and digital forms.

[10] Remaining carbon: operational carbon emissions that cannot be completely offset. The definition can be expanded to include all carbon emissions that cannot be offset during the whole life of the asset from materials, works on site, maintenance/ replacement and repairs to demolition and waste management.

1. Introduction

1.1 General information

Chelmsford, England's newest city, is one of the fastest growing locations in the south-east of England. It has a strong track record for housing and employment delivery and is already delivering around 1,000 new homes and 800 jobs every year. The Chelmsford Local Plan 2013-2036, adopted in May 2020, includes site allocations for almost 10,000 new homes and 55,000sqm of business floorspace alongside a wide range of necessary supporting infrastructure.

North East Chelmsford is a major area of growth for the city. It has been partly allocated through the previous Local Development Framework and is currently under construction (at Beaulieu and Channels). Further development of the area is promoted in the new Chelmsford Local Plan, known as North East Chelmsford (Strategic Growth Site 6). This will expand on the success of Beaulieu and Channels and provide for a high-quality comprehensively planned new sustainable development based on the Town and Country Planning Association (TCPA) garden community principles. The garden community principles are an indivisible and interlocking framework for the delivery of new garden communities, which include:

- "Beautifully and imaginatively designed homes with gardens, combining the best of town and country to create healthy communities.
- Development that enhances the natural environment, providing a comprehensive green infrastructure network and net biodiversity gains, and that uses zero-carbon and energy-positive technology to ensure climate resilience.
- Strong cultural, recreational and shopping facilities in walkable, vibrant, sociable neighbourhoods and
- Integrated and accessible transport systems, with walking, cycling and public transport designed to be the most attractive forms of local transport."

North East Chelmsford has provision for around 3,000 new homes and 45,000sqm of new office/business park floor space within the plan period to 2036. Development is expected to start on site in 2022/2023 and has capacity for a further 2,500 new homes post-2036. The site will provide significant areas of new green and blue infrastructure, neighbourhood centres, three schools and early years childcare nurseries, new bus-based rapid transit and a rail station.

Chelmsford City Council (CCC) has been selected to join the government's Garden Communities Programme in 2019 and again in 2021 were allocated capacity funding to support the delivery of the combined developments (Beaulieu and Channel and North East Chelmsford).
Funding has also been secured via the Housing Infrastructure Fund (HIF) to deliver a new rail station and the Chelmsford North East Bypass. As part of the funding agreement, both the new rail station and Chelmsford North East Bypass must be completed by 2025/26. Beaulieu and Channel and North East Chelmsford will develop around these key pieces of transport infrastructure.

In order to effectively deliver North East Chelmsford, a series of strategies and studies are being developed by CCC, Essex County Council and the Consortium comprising of the site landowners, promoters and developers of Channels, Columbia Threadneedle Investments, Countryside, L&Q, Ptarmigan and Hanson. This study was commissioned by CCC but will be shared and used by the Consortium. The Consortium is currently preparing a masterplan for North East Chelmsford in collaboration with the CCC.

All sections[11] start with a short introduction, note in terms of the questions they respond to or link with, followed by a summary of findings and main content, unless specified otherwise.

[11] Except Sections 1, 11 and 12 that include the introduction of the report and summaries of outputs.

1.2 Research objectives

The key deliverables of the project are set out in Table 3.

Table 3 - Key project deliverables

An Energy Mapping and Renewable and Low Carbon Energy Feasibility Study for North East Chelmsford that will inform the future development of the site and in particular the master planning process in terms of identifying the anticipated energy, heating, cooling and mobility demand for all users, opportunities to minimise energy demand and opportunities for renewable and low-carbon energy schemes.
Model buildings were developed and used in conjunction with expected development rates to produce development scenarios.
Options which outline the different approaches for renewable and low-carbon energy schemes and appraise them in terms of practical usability, cost and benefits.
Choose by advantage assessments were used during workshop sessions with the CCC planners. The report provides additional information of expected capital costs of package solutions used within the different building models. Comments in terms of the specific solutions chosen are made where appropriate.
Respond to several questions around best practice, similar examples, best technologies to use on the village and further information as within the tender specifications issued.
Examples are offered throughout the report, where appropriate. New technologies as well as other exemplar sites are discussed and showcased.

1.3 Research questions

Several questions were asked within the project's tender documents. These are shown within Table 4 to Table 6 including the sections of the report where responses can be found.

Table 4 - Research questions (Part 1)

Research questions
Q1. What is the legislation and policy context for renewable, low carbon and decentralised energy schemes? How is this anticipated to change over the coming years given the international, national and local drive and pledges towards renewable energy generation and carbon emission reductions, including CCC's climate and ecological change declaration?
A1. This is covered within Sections 2 and 3.
Q2. What is the anticipated demand for energy for power, heating, cooling and mobility for all the proposed lands' uses in North East Chelmsford and how is the demand expected to change from the early phases of the development and over the plan period to 2036 and beyond in view of the above?
A2. This is covered within Sections 5 and 6.
Q3. How can the predicted energy demand be minimised by energy-efficient layout and design of the new homes, schools, community uses and businesses? How feasible would it be to make all buildings net zero carbon and how far if any would this require off-setting/capture?
A3. This is covered within Sections 5 and 6.
Q4. What are the links to existing development and infrastructure in adjacent settlements and existing developed areas of Beaulieu and Channels? Are there e.g. any nearby existing or proposed buildings with high energy demand that could benefit and be decarbonised? Or vice versa, could low or zero-carbon energy be supplied from schemes in the vicinity?
A4. This is covered within Section 4.

Table 5 – Research questions (Part 2)

Research questions
Q5. What are the current power and network constraints within the locality that may affect the nature of the design and phasing of development to meet our zero carbon and climate resilient objectives?
A5. This is covered within Section 7.
Q6. What future energy scenarios and carbon reduction pathways to zero carbon should we be designing to and what are the most relevant data and evidence bases on which we should be relying?
A6. This is covered within Sections 7 and 8.
Q7. What renewable and low-carbon energy technologies are available as alternatives to conventional technologies for the residential, employment, retail and other land-uses listed above? How is this expected to change over the plan period to 2036 and beyond?
A7. This is covered within Section 7.
Q8. What are the energy storage opportunities associated with the available energy generating technologies?
A8. This is covered within Section 7.
Q9. What are the benefits, potentials, drawbacks and constraints, eg financial, environmental, cultural, etc, of the renewable, low-carbon and energy storage technologies identified in questions 7 and 8? How can any risks be mitigated?
A9. This is covered within Section 7.
Q10.What are the maintenance and operational needs and life expectancies of the identified technologies?
A10. This is covered within Section 7.
Q11.What are the opportunities for renewable and low-carbon energy schemes, alone or in combination with each other or with conventional technologies for North East Chelmsford? What will be the benefits for North East Chelmsford? What would need to be considered and when, for example: a. Size, location, minimum and optimum land use and density requirements for renewable, low-carbon and decentralised energy schemes and other supporting facilities b. Key design issues of renewable, low-carbon and decentralised energy schemes (eg screening, enclosures, buffers, security, access) c. Site constraints (eg typography, utility cables and services, compatibility with other land uses) d. Costs of providing new renewable, low-carbon and decentralised energy schemes, their capacities and efficiencies e. Fuel sources if applicable for the schemes identified including their availability, reliability, cost, carbon impacts, etc f. Engagement with key stakeholders (eg commercial companies, local communities, etc)
A11. This is covered within Section 7.

Table 6 – Research questions (Part 3)

Research Questions
Q12.What are the costs and financing models for the identified renewable and low-carbon energy schemes? How would they impact on the timing and profitability of development on site?
A12. This is covered within Section 9.
Q13.What renewable and/or low-carbon energy schemes may not be considered appropriate for new North East Chelmsford development?
A13. This is covered within Section 10.
Q14.Are there any good practice examples of renewable and low-carbon energy schemes, especially for strategic scale developments and garden community/village developments that could be relevant for North East Chelmsford?
A14. This is covered within Section 10.
Q15.What options are there for assessing and communicating information on the overall environmental performance of the land uses benefiting from the renewable and low-carbon energy schemes? For example, ways to certify the performance of new homes and to provide buyers with information on the environmental impact of their new home and its potential running costs.
A15. This is covered within Section 10.
Q16.What are the most appropriate strategies for promoting greater acceptance among developers, investors and potential future occupants of the need for energy generated from local renewable and low carbon energy schemes? This should include a consideration of the opportunities for community stewardship/ownership of the renewable and low-carbon energy technologies identified as potentially suitable. The study should examine different methodologies of initiating, financing and maintaining local renewable energy generation groups including co-operative ownership and if there could be a mechanism in place allowing house buyers to purchase shares.
A16. This is covered within Section 10.
Q17.What opportunities are there for promoting renewable energy/low-carbon local enterprise initiatives, employment and training schemes, eg at the proposed employment area/s – in line with one of the actions in the Green Infrastructure Action Plan (see Table 6.4, Economy theme) - and at Anglia Ruskin University and Writtle University College?
A17. This is covered within Section 10.

2. Legislation and policy context

Short introduction:

This section explores main UK policy and regulatory direction in relation to sustainability, climate change and energy efficiency in buildings.

It also describes the idea of garden communities and their founding principles.

Publicly accessible information, as reviewed during the development of this report (until July 2021), is used to establish current recommendations and inform CCC of possible future changes.

Information can be used to further strengthen the CCC position with CGC and, where appropriate, justify development decisions made.

It also ensures that CGC objectives and targets do not conflict with the overall direction of travel.

2.1 Summary of findings – Section 2

Section 2 - Responds to Q1
Q1. What is the legislation and policy context for renewable, low-carbon and decentralised energy schemes? How is this anticipated to change over the coming years given the international, national and local drive and pledges towards renewable energy generation and carbon emission reductions, including CCC's climate and ecological change declaration?

Section 2 - Evidence and summary response

Current policy direction and regulatory frameworks fully support a transition to net zero by 2050. The anticipation is that the National Planning Policy Framework, Building Regulations, local plans and energy policy will align in support of the common goal (Climate Change Act and interim targets). The principles underlying the concept of Garden Communities support sustainable developments using zero carbon and energy-positive technologies.

The National Planning Policy Framework (NPPF, 2019) and consultation (2021) amendments further reiterate the need for sustainable development[12]. NPPF requests ensuring that policies and decisions are in line with the objectives and provisions of the Climate Change Act 2008, demonstrating the need to give priority to climate change in planning. Section 19 of the 2004 Planning and Compulsory Purchase Act, as amended by the 2008 Planning Act, ensures that, taken as whole, planning policy contributes to the mitigation of, and adaptation to, climate change.

Local authorities are still allowed to impose higher energy efficiency and renewable energy generation requirements[13].

The current revision of Part L of the Building Regulations (Part L 2021[14]) for domestic buildings will require a 31% improvement over Part L 2013 CO2e emissions. Strong focus is noted on evidence of as-built performance.

The Future Homes Standard (2025) is expected to set a target for new homes to achieve an at least 75-80% carbon emissions reduction compared to Part L 2013. The homes will be zero-carbon ready, which means that they will not be built with fossil fuel heating, such as a natural gas boiler.

Grand Challenge (2018) sets an aspiration for all new buildings to use half of the energy they require today by 2030.

Amended during 2019, the **Climate Change Act 2008** (2050 Target Amendment) Order 2019, introduced a new 100% net UK emissions target reduction by 2050.

Renewable energy systems installation, net zero-carbon technologies and innovation are strongly supported by a number of government policies, white papers and regulations, along with information on the transition of buildings to net zero. Some examples can be found in the following documents:

- Energy White Paper (2020)
- Planning for the future (2020)
- Spring Statement (2019)

[12] The National Planning Policy Framework was revised on 20 July 2021. It replaced the previous National Planning Policy Framework published in March 2012, revised in July 2018 and updated in February 2019. (https://www.gov.uk/government/publications/national-planning-policy-framework--2)

[13] Planning and Energy Act 2008 (legislation.gov.uk)

[14] Approved Document L volume 1 - consultation version - January 2021 (publishing.service.gov.uk)

2.1.1 Garden Cities - contextualising Chelmsford Garden Community

Founder of the garden city movement, Ebenezer Howard's vision of a garden community was a place where people could work, raise families, travel easily and enjoy green spaces.

Garden communities set clear expectations for the quality of the development and how this can be maintained. They encompass vibrant, mixed-use communities that are holistically planned, self-sustaining and characterful[15].

Strong local leadership is crucial to developing and delivering a long-term vision for these new communities.

According to the Town and Country Planning Association, the garden community principles (2020) include[16]:

- Land value capture for the benefit of the community.
- Strong vision, **leadership and community engagement**.
- Community ownership of land and **long-term stewardship** of assets.
- Mixed-tenure homes and housing types that are genuinely **affordable**.
- A wide range of local jobs in the garden community within easy commuting distance of homes.
- Beautifully and imaginatively designed homes with gardens, combining the best of town and country to **create healthy communities, and including opportunities to grow food**.
- Development that **enhances the natural environment**, providing a comprehensive green infrastructure network and net biodiversity gains, and **that uses zero carbon and energy-positive technology to ensure climate resilience**.
- Strong cultural, recreational and shopping facilities in walkable, vibrant, sociable neighbourhoods.
- Integrated and accessible transport systems.

The Chelmsford Local Plan (adopted 27 May 2020)[17] states that the Chelmsford Garden Community (CGC) will provide a high-quality comprehensive garden community development underpinned by a series of interrelated principles which are based on the Town and Country Planning Association (TCPA) garden community principles.

Of particular interest to the current study are principles and qualities referring to sustainable development, resilience, the application of renewable energy generation technologies and the overall minimisation of the expected development's environmental impact.

As set out in the Chelmsford Local Plan, CCC will encourage the appropriate development of renewable, low-carbon and decentralised energies and schemes on the site, especially where there is a strong degree of community benefit.

The current study is intended to inform the future development of CGC and the master planning process.

It will also support CCC's other strategic considerations and ambitions to promote highly sustainable and high-quality developments.

15 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/805688/Garden_Communities_Prospectus.pdf
16 https://www.tcpa.org.uk/Handlers/Download.ashx?IDMF=f3272413-6d74-44c3-870f-fd333161f3a1
17 Adopted Local Plan - Chelmsford City Council

2.1.2 National Planning Policy Framework (NPPF, February 2019)[18], including proposed 2021 consultation amendments[19].

Local planning authorities are bound by the legal duty set out in Section 19 of the 2004 Planning and Compulsory Purchase Act, as amended by the 2008 Planning Act, to ensure that, taken as whole, planning policy contributes to the mitigation of, and adaptation to, climate change. This powerful outcome-focused duty on local planning clearly signals the priority to be given to climate change in plan-making. In discharging this duty, local authorities should consider guidance provided within the National Planning Policy Framework (NPPF) and understand the economic, social and environmental aspects of their current and future local plan targets.

During 30 January 2021 - 27 March 2021 the government opened a consultation seeking views on draft revisions to the National Planning Policy Framework, 2019. The text has been revised to implement policy changes in response to the Building Better, Building Beautiful Commission's *Living with Beauty* report. **Please note that the NPPF 2021 consultation updated wording and paragraph numbers that are used within the following sections.**

The consultation is also seeking views on the draft National Model Design Code, which provides detailed guidance on the production of design codes, guides and policies to promote successful design. The preferred government approach and final wording are not confirmed at the time of this report writing. Within NPPF, specific reference is made in terms of the supply of a large number of new homes (§ 73), which according to point (C) needs to "*set clear expectations for the quality of the places to be created and how this can be maintained (such as by following Garden Community principles); and ensure that appropriate tools such as masterplans and design codes are used to secure a variety of well-designed and beautiful homes to meet the needs of different groups in the community*".

National Planning Policy Framework (2021 consultation) - Paragraphs 7 and 8 summary
§7. *The purpose of the planning system is to contribute to the achievement of sustainable development. At a very high level, the objective of sustainable development can be summarised as meeting the needs of the present without compromising the ability of future generations to meet their own needs. At a similarly high level, members of the United Nations – including the United Kingdom – have agreed to pursue 17 Global Goals for Sustainable Development in the period to 2030. These address social progress, economic well-being and environmental protection.*
§8. *Achieving sustainable development means that the planning system has three overarching objectives, which are interdependent and need to be pursued in mutually supportive ways (so that opportunities can be taken to secure net gains across each of the different objectives):*
a) an economic objective – to help build a strong, responsive and competitive economy, by ensuring that sufficient land of the right types is available in the right places and at the right time to support growth, innovation and improved productivity; and by identifying and coordinating the provision of infrastructure.
b) a social objective – to support strong, vibrant and healthy communities, by ensuring that a sufficient number and range of homes can be provided to meet the needs of present and future generations; and by fostering a well-designed, beautiful and safe places built environment, with accessible services and open spaces that reflect current and future needs and support communities' health, social and cultural well-being; and
c) an environmental objective – to contribute to protecting and enhancing our natural, built and historic environment, including making effective use of land, helping to improving biodiversity, using natural resources prudently, minimising waste and pollution, and mitigating and adapting to climate change, including moving to a low carbon economy

Figure 2 - NPPF - Paragraphs 7 and 8 extract

18 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/810197/NPPF_Feb_2019_revised.pdf

19 National Planning Policy Framework and National Model Design Code: consultation proposals - GOV.UK (www.gov.uk)

2.1.3 The Future Homes Standard: changes to Approved Document Part L and Part F of the Building Regulations for new dwellings, 2021 amendments

The government is in the process (during the writing of this report, 2021) of reviewing the national Building Regulations (Part L)[20]. These changes will likely include revisions within the Approved Document L (Part L 2020), Approved Document F of the Building Regulations and the introduction of a Future Homes Standard in 2025. The government response to the Future Homes Standard: 2019 Consultation on changes to Part L (conservation of fuel and power) and Part F (ventilation) of the Building Regulations for new dwellings states:

‘’We have said that from 2025, the Future Homes Standard will deliver homes that are zero-carbon ready: We intend to set the performance standard of the Future Homes Standard at a level which means that new homes will not be built with fossil fuel heating, such as a natural gas boiler. These homes will be future proofed with low carbon heating and high levels of energy efficiency. No further energy efficiency retrofit work will be necessary to enable them to become zero-carbon as the electricity grid continues to decarbonise. Our work on a full technical specification for the Future Homes Standard has been accelerated and we will consult on this in 2023. We also intend to introduce the necessary legislation in 2024, ahead of implementation in 2025.” - January 2021[21]

This review may result in changes to the national energy efficiency minimum standard within Part L[22], compliance metrics and assessment method (for example the adoption of the Standard Assessment Procedure [SAP] 10.1 or a successor[23]). The current study (2020-2021) was conducted based on the predicted energy demand and carbon performance requirements for new buildings constructed to Part L 2013 as the baseline, which is currently the Part L version used for compliance.

The new Part L 2021 - key notes from 2021 consultation results and draft documents

- Energy-efficient, low-carbon homes will become the norm. The new Part L is expected to be released by the end of the year (2021). It will potentially come in force during spring 2022. It will target a 31% improvement over Part L 2013 in terms of new housing expected CO2e emissions.
- The planning of the Future Homes Standard is expected to commence in 2023, and necessary legislation will be introduced in 2024.
- Transitional arrangements will now apply to individual homes rather than an entire development and the transitional period will be one year. This means that new developments (larger size) will need to adjust swiftly to the 2025 Future Homes standard.
- As fabric specifications become tighter (less heat loss through the building’s fabric[24]), the government response indicates the transition to all-electric mechanical and electrical (M&E) solutions (no fossil fuels if possible post-2025 – eg no gas boilers) and installed services. A rise in heat pump installations is expected.
- Four performance metrics will be introduced for new houses. These will include: i) primary energy target ii) CO2 emission target iii) fabric energy efficiency target iv) minimum standards for fabric and fixed building service.

[20] https://www.gov.uk/government/consultations/the-future-homes-standard-changes-to-part-l-and-part-f-of-the-building-regulations-for-new-dwellings

[21] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/956094/Government_response_to_Future_Homes_Standard_consultation.pdf

[22] https://www.planningportal.co.uk/info/200135/approved_documents/74/part_l_-_conservation_of_fuel_and_power/7

[23] Latest version in consultation, to be used for future building regulations compliance. Updated to the latest carbon emission factors for gas and electricity.

[24] See ‘fabric first’ within the glossary

- Changes in the Standard Assessment Procedure are expected, along with special provisions for the acknowledgement of airtightness contributions to energy savings, and criteria around natural ventilation thresholds.
- Local authorities for now[25] will retain their ability to request additional to the minimum requirements (energy and carbon) standards.

A drive to quality and as-built performance

The minimum requirements for buildings constitute the worst performance allowed for compliance with Building Regulations. New technologies, new construction methods, new materials and processes mean that good careful design is always a priority. A just 'add new technologies' solution will not suffice. As mentioned in the government's response to Part L and the Future Homes Standard a **photographic evidence section has also been added**, making it clear the criteria that is expected for obtaining sufficient photographic evidence, for building control officers. Handover requirements are also expected to be reviewed as to the information that the new house owner is expected to receive, ensuring the quality of the new house.

The Future Homes Standard (2025) is expected to set a target for new homes to achieve an at least 75-80% carbon emissions reduction compared to Part L 2013. The homes will be zero-carbon ready, which means that they will not be built with fossil fuel heating, such as a natural gas boiler.

2.1.4 Energy White Paper: Powering our net zero future, December 2020[26]

The Energy White Paper establishes the government's goal of a decisive shift from fossil fuels to clean energy, in power, buildings and industry, while creating jobs and growing the economy and keeping energy bills affordable. It addresses how and why our energy system needs to evolve to deliver this goal. And it provides a foundation for the detailed actions government will take in this Parliament (2020) to realise their vision.

Key extracts:

- This white paper puts net zero and the effort to fight climate change at its core, following the Prime Minister's Ten Point Plan for a Green Industrial Revolution. The Ten Point Plan sets out how government investment will leverage billions of pounds more of private investment and support up to 250,000 jobs by 2030.
- Delivering UK's net zero target means largely eliminating carbon emissions from domestic and commercial buildings by 2050.
- While retiring energy capacity from fossil fuels and nuclear, it will need to be replaced to keep pace with existing levels of demand. Government modelling suggests that overall energy demand could double out to 2050.
- The Future Homes Standard will ensure that all new-build homes are zero-carbon ready.
- The benefits of well-insulated homes, on health and wellbeing and on bills, should not be the preserve of households which can afford to pay for energy efficiency measures.
- Offices, retail space, hospitality and industrial buildings account for around 80 per cent of private sector buildings energy demand. Government intends to tighten minimum standards for this sector to reach EPC Band B by 2030.
- To achieve net zero emissions, buildings will have to transition completely away from traditional natural gas boilers for heating homes on the gas grid.

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25 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/852605/Future_Homes_Standard_2019_Consultation.pdf . '2.27. As we move to the higher energy standards required by Part L 2020 and the Future Homes Standard, there may be no need for local authorities to seek higher standards and the power in the Planning and Energy Act 2008 may become redundant'

26 Energy White Paper (publishing.service.gov.uk)

2.1.5 Planning White Paper: Planning for the future, August 2020[27]

At the timing of this report writing (June 2021), no government response has been issued to this consultation.

This consultation paper and the reforms that might follow are, according to the government, an attempt to rediscover the original mission and purpose of those who sought to improve the country's homes and streets in late Victorian and early 20th-century Britain. According to the government, the original vision has been buried under layers of legislation and case law.

Key extracts (proposals):

- Local councils should radically and profoundly reinvent the ambition, depth and breadth with which they engage with communities as they consult on local plans.
- Ensure the planning system supports the efforts to combat climate change and maximises environmental benefits, by ensuring the National Planning Policy Framework targets those areas where a reformed planning system can most effectively address climate change mitigation and adaptation and facilitate environmental improvements.
- Facilitate ambitious improvements in the energy efficiency standards for buildings to help deliver our world-leading commitment to net-zero by 2050.
- Ask for beauty and be far more ambitious for the places created, expecting new development to be beautiful, and to create a 'net gain' for biodiversity not just 'no net harm', with a greater focus on 'placemaking' and 'the creation of beautiful places' within the National Planning Policy Framework.
- Set clear expectations on what is required on land that is identified for development, so that plans give confidence in the future growth of areas and facilitate the delivery of beautiful and sustainable places.

Please note that some proposals, if brought forward, will require new planning policy and legislation.

[27] Planning for the future (publishing.service.gov.uk)

2.1.6 Committee on Climate Change, March 2019

The Committee on Climate Change, now known as the Climate Change Committee, is the UK's independent advisor on tackling climate change.

The Climate Change Committee is an independent, statutory body established under the Climate Change Act 2008.

Its purpose is to advise the UK and devolved governments on emissions targets and to report to Parliament on progress made in reducing greenhouse gas emissions and preparing for and adapting to the impacts of climate change.

The Climate Change Committee's *UK housing: Fit for the future?* 2019 report assessed whether the UK's housing stock is adequately prepared for the challenges of climate change, both in terms of reducing emissions from UK homes and ensuring homes are adequately prepared for the impacts of climate change.

A relevant extract can be found in Table 7.

Table 7 – Climate Change Committee - report extract

Committee on Climate Change – *UK Housing: Fit for the future?* February 2019[28]
Immediate government action is needed to ensure the new homes planned across the UK are fit for purpose, integrating the highest possible levels of emissions reduction with a package of design improvements to adapt to the changing climate. This will require an ambitious trajectory of standards, regulations and targets for new homes throughout the UK: ▪ By 2025 at the latest, no new homes should connect to the gas grid. Instead they should have low-carbon heating systems such as heat pumps and low-carbon heat networks. ▪ Make all new homes suitable for low-carbon heating at the earliest opportunity, through use of appropriately sized radiators and low-temperature compatible thermal stores. This can save £1,500 - £5,500 per home compared to later having to retrofit low-carbon heat from scratch. ▪ New homes should deliver ultra-high levels of energy efficiency as soon as possible and by 2025 at the latest, be consistent with a space heat demand of 15-20 kWh/m2/yr. Designing in these features from the start is around one-fifth of the cost of retrofitting to the same quality and standard. When installed alongside heat pumps in a typical home, ultra-high levels of fabric efficiency can deliver average bill savings of around £85 per household per year, contribute to reducing annual and peak electricity demand alongside other measures, provide comfort and health benefits for occupants, and create an industrial opportunity for the UK to export innovation and expertise. ▪ Statutory requirements should be in place to reduce overheating risk in new-build homes. Evidence suggests that all new-build homes are at risk of overheating. Passive cooling measures should be adopted to reduce overheating risks before considering active measures such as air conditioning. ▪ Improve focus on reducing the whole-life carbon impact of new homes, including embodied [29] and sequestered carbon[30]. Using wood in construction to displace high-carbon materials such as cement and steel is one of the most effective ways to use limited biomass resources to mitigate climate change.

[28] https://www.theccc.org.uk/wp-content/uploads/2019/02/UK-housing-Fit-for-the-future-CCC-2019.pdf
[29] Embodied carbon is the carbon dioxide (CO_2) or greenhouse gas (GHG) emissions associated with the manufacture and use of a product or service. For construction products, this means the CO_2 or GHG emission associated with extraction, manufacturing, transporting, installing, maintaining and disposing of construction materials and products.
[30] Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide.

2.1.7 Spring Statement 2019

The Chancellor of the Exchequer, Philip Hammond presented his Spring Statement to Parliament on Wednesday 13 March 2019.

A relevant extract can be found in Table 8.

Table 8 - UK Spring Statement 2019

UK Government - Spring Statement March 2019[31]
From HM Treasury and The Rt Hon Philip Hammond MP, the Spring Statement builds on the Industrial Strategy, Clean Growth Strategy, and 25 Year Environment Plan as set out in the Budget 2018. In terms of buildings, energy and carbon, the following are noted: ▪ To help meet climate targets, the government will advance the decarbonisation of gas supplies by increasing the proportion of green gas in the grid, helping to reduce dependence on burning natural gas in homes and businesses. ▪ To help ensure consumer energy bills are low and homes are better for the environment, the government will introduce a Future Homes Standard by 2025, so that new-build homes are future-proofed **with low-carbon heating and world-leading levels of energy efficiency.**

2.1.8 Climate Change Act, 2019 amendment

An act to set a target for the year 2050 for the reduction of targeted greenhouse gas emissions; to provide for a system of carbon budgeting; to establish a committee on climate change; to confer powers to establish trading schemes for the purpose of limiting greenhouse gas emissions or encouraging activities that reduce such emissions or remove greenhouse gas from the atmosphere; to make provision about adaptation to climate change; to confer powers to make schemes for providing financial incentives to produce less domestic waste and to recycle more of what is produced; to make provision about the collection of household waste; to confer powers to make provision about charging for single-use carrier bags; to amend the provisions of the Energy Act 2004 about renewable transport fuel obligations; to make provision about carbon emissions reduction targets; to make other provisions about climate change; and for connected purposes.

Amended during 2019, the Climate Change Act 2008 (2050 Target Amendment) Order 2019, introduced a new net UK emissions target for 2050 as shown in Table *9*.

Table 9 - The Climate Change Act 2008 (2050 Target Amendment) Order 2019 (S.I. 2019/1056), arts. 1, 2

The target for 2050

1 The target for 2050

(1) It is the duty of the Secretary of State to ensure that the net UK carbon account for the year 2050 is at least [F1 100%] lower than the 1990 baseline.

(2) "The 1990 baseline" means the aggregate amount of—

(a) net UK emissions of carbon dioxide for that year, and

(b) net UK emissions of each of the other targeted greenhouse gases for the year that is the base year for that gas.

[31] https://www.gov.uk/government/news/spring-statement-2019-what-you-need-to-know

2.1.9 Other UK government targets that include energy-efficient and zero-carbon building targets

Other examples include:

Grand Challenge, 2018[32]:

Industrial Strategy: building a Britain fit for the future[33]. This white paper sets out a long-term plan to boost the productivity and earning power of people throughout the UK.

Through the Clean Growth Grand Challenge, the government has set out its determination to maximise the advantages for UK industry from this global shift, including the mission to halve the energy use of new buildings by 2030.

- Mission: At least halve the energy use of new buildings by 2030[34]

Heating and powering buildings accounts for 40% of our total energy usage in the UK. By making our buildings more energy efficient and embracing smart technologies, we can cut household energy bills, reduce demand for energy and boost economic growth while meeting our targets for carbon reduction.

For homes this will mean halving the total use of energy compared to today's standards for new build. This will include a building's use of energy for heating and cooling and appliances, but not transport.

- Mission: Establish the world's first net zero-carbon industrial cluster by 2040 and at least 1 low-carbon cluster by 2030

It will further establish the UK's position at the forefront of the global shift to Clean Growth by developing world-leading expertise in green manufacturing products, and the technologies and services required to produce them. The mission aims to attract inward investment, new business and employment opportunities.

A Green Future: Our 25 Year Plan to Improve the Environment, 2018[35]

This 25 Year Environment Plan sets out government action to help the natural world regain and retain good health. It aims to deliver cleaner air and water in our cities and rural landscapes, protect threatened species and provide richer wildlife habitats. It calls for an approach to agriculture, forestry, land use and fishing that puts the environment first.

The plan includes targets for clean air, clean and plentiful water, thriving plants and wildlife, reducing the risks of harm from environmental hazards, using resources from nature more sustainably, enhancing beauty, heritage and engagement with the natural environment, mitigating and adapting to climate change, minimising waste and enhancing biosecurity.

It is this government's ambition to leave the environment in a better state than it was found.

[32] https://www.gov.uk/government/publications/industrial-strategy-the-grand-challenges/missions
[33] https://www.gov.uk/government/publications/industrial-strategy-building-a-britain-fit-for-the-future
[34] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/731871/construction-sector-deal-print-single.pdf#:~:text=has%20announced%20a%20mission%20to%20at%20least%20halve,to%20make%20them%20more%20efficient%20and%20more%20sustainable
[35] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/693158/25-year-environment-plan.pdf

3. The Chelmsford Local Plan and the North East Chelmsford site allocation

Short introduction:

The Chelmsford Local Plan adopted May 2020 sets out several policies, aspirations and preferred direction of travel for the area. The researchers reviewed its content ant extracted key findings relevant to the CGC, which are included in this section.

This section should be read in conjunction with the local plan and referenced documents, as its purpose is not to provide all information present within the detailed local plan. Statistics, volume of building forecasts, sustainability policies and supplementary planning documents are all used to clarify the CGC vision. In addition, this information was used in conjunction with information extracted from Building Regulations and national policy requirements in order to inform the scenarios developed by the researchers for the CGC development.

Key extracts used in the study included:

- Information on future population size and type of household
- Distribution of potential housing types required, including one, two, three and four and more bedroom houses and flats
- Allocated spaces for the development of non-domestic buildings and infrastructure

This information was used to build the assumptions around the baseline building models and potential delivery rates, as presented within the following report sections.

In addition, the purpose of this section is to provide a summary of current requirements in place and to highlight relevant references for developers.

3.1 Summary of findings - Section 3

Section 3 - Responds to Q1 - Chelmsford Local Plan
Q1.What is the legislation and policy context for renewable, low-carbon and decentralised energy schemes? How is this anticipated to change over the coming years given the international, national and local drive and pledges towards renewable energy generation and carbon emission reductions, including CCC's climate and ecological change declaration? **CGC local context focused.**
Section 3 - Evidence and summary response
As identified through Section 2, policy direction (local and international) shows strong support for energy-efficient, low-carbon and renewable energy generation solutions. The CCC Climate and Ecological Emergency Action Plan supports several environmental protection actions including those relevant to renewable energy generation, low carbon and energy demand reduction. Local population projections predict increases in the population at virtually all ages, with very large increases projected for those aged in their late 60s and above. As noted within the local plan, this creates the need for diversity in terms of housing types and employment spaces, something that needs to be reflected also within the CGC development. This creates additional needs to introduce the appropriate zero-carbon/sustainability performance thresholds to CGC as soon as possible, and future-proof the development. The local plan policies reflect the aspiration of flourishing, sustainable communities. Some minimum expectations are set out in terms of specific renewable energy generation and low-carbon design benchmarks, eg (extracts): ✓ Policy DM23: all new buildings and developments needs to be of high quality and inclusive design. ✓ Policy DM25: The council will expect all new dwellings and non-residential buildings to incorporate sustainable design features to reduce carbon dioxide and nitrogen dioxide emissions, and the use of natural resources, where relevant. '*Residential development should provide Electric Vehicle (EV) charging point infrastructure at the rate of 1 charging point per unit (for a dwelling with dedicated off-road parking) and/or 1 charging point per 10 spaces (where off-road parking is unallocated).* '*Non-residential development should provide charging points equivalent to 10% of the total parking provision'. All new non-residential buildings with a floor area in excess of 500sqm shall achieve a minimum BREEAM rating (or its successor) of 'Very Good*'. *All new dwellings shall meet the Building Regulations optional requirement for water efficiency of 110 litres/person/day.* Overall, the policies allow for the introduction of renewable energy, low-carbon and energy efficiency performance thresholds for CGC. They also allow for some 'freedom' in terms of application and exact solutions to be used, which was considered as beneficial considering the nature of these policies and the forthcoming changes expected withing Building Regulations. BREEAM rating 'Very Good' covers a number of 'sustainability categories' and it is becoming the industry norm. It was considered that for achieving the net zero aspiration, additional energy criteria need to be introduced. The OAHN report published in November 2016 indicated that the most common household in Chelmsford in 2013 was couples living alone (29.3%) – i.e. with no other adults or dependent children. This trend is set to continue into 2037, where couples living alone will represent 29.1% of households.[36]

[36] Please see Chelmsford Local Plan, adopted 27 May 2021, Policy DM1 as informed by the latest Strategic Housing Market Assessment

3.2 CCC – Climate Emergency (2019-2020)

A climate and ecology emergency has been declared in Chelmsford. This was voted through at a CCC meeting on Tuesday 16 July 2019.

A plan of action to address the climate and ecological emergency was adopted at a CCC Cabinet meeting on Tuesday 28 January 2020[37].

An internal Climate and Ecological Emergency Task Group has been established and charged with effectively co-ordinating the response to the climate and ecological emergency (main areas of focus as noted within Table 10). It is anticipated that a wider 'Chelmsford Climate Change Partnership' will be established as the action planning gains impetus.

It is noted:

'*This partnership will also be responsible for developing a strategy to* ***achieve a net zero carbon position for the wider area and helping to prioritise specific carbon reduction measures****. In accordance with the Declaration, this partnership should include young people so that that they have a clear voice in shaping the future'*.

Table 10 - Climate and Ecological Emergency Action Plan - focus areas

	Initial Climate and Ecological Emergency Action Plan focuses on the following areas of work
1	Establishing a 'carbon baseline' position
2	Updating planning guidance on how on-site renewable energy measures can be integrated into new developments and for all new dwellings to incorporate sustainable design features to reduce CO2 and NO2 emissions and the use of natural resources [including putting in place a low-carbon infrastructure in strategic growth areas]
3	Working with Essex County Council to improve movement around the city, including improvements to the cycling and walking infrastructure, to reduce traffic congestion and journey times and encourage more sustainable travel choices
4	Implementing further measures to reduce the amount of waste generated and ensure that as much as possible of any waste that is generated is reused, recycled or composted
5	Implementing measures to lower energy consumption, ensure the most efficient use of water resources, reduce pollution and improve air quality
6	Undertaking a greening programme to significantly increase the amount of woodland and the proportion of tree cover in Chelmsford
7	Implementing measures to improve the 'green infrastructure' of Chelmsford, protecting and expanding natural habitats and increasing biodiversity
8	Improving the environmental quality, attractiveness and recreational potential of public spaces, rivers and waterways and associated green corridors in the city centre and surrounding areas
9	Upgrading the council's vehicle fleet to embrace the latest low emission technology, including ultra-low emission electric-powered vehicles as they become operationally and commercially viable
10	Supporting the Environment Agency to implement the Margaretting flood alleviation scheme and other flood mitigation measures to reduce the risk of flooding to residential and commercial properties in the city
11	Establishing a 'green investment fund' to support the council's environment plan
12	Reviewing the council's procurement policies and practices in light of the climate and ecological emergency declaration
13	Creating opportunities for people, local organisations and businesses to get involved, to influence and to inspire innovation and co-operation in response to the key challenges identified in the climate and ecological emergency

[37] https://www.chelmsford.gov.uk/_resources/assets/inline/full/0/3649750.pdf

3.3 Chelmsford Local Plan, adopted 27 May 2020[38]

In May 2020 during a council meeting the recommendation to adopt the Chelmsford Local Plan 2013-2036 was made by the cabinet member for sustainable development.

3.3.1 Population growth

Chelmsford's population is continuing to grow and is predicted to increase by 26,989 – from 171,633 in 2014 to 198,622 by 2037 (ONS 2014 Sub National Population Projections).

Over the same period, the number of households is expected to increase by 15,739 – from 70,964 in 2014 to 86,703 by 2037 (CLG 2014 Projections).

Projections show increases in the population at virtually all ages, with very large increases projected for those aged in their late 60s and above.

3.3.2 Homes and employment

The most common household in 2013 was couples living alone (29.3%) – i.e. with no other adults or dependent children.

This trend is set to continue into 2037, where couples living alone will represent 29.1% of households. Demographic changes will shape the type and size of accommodation necessary over the Local Plan period (Figure 3).

There is significant demand for affordable housing or starter homes for first-time buyers or those on lower incomes.

There is also demand for supported housing and independent living accommodation for older people (55+) and adults with disabilities.

3.3.3 Chelmsford Garden Community (CGC)

The council's previously adopted plan or Local Development Framework allocated a minimum of 3,200 new homes and 64,000sqm of commercial floorspace at North East Chelmsford known as Beaulieu and Channels.

Development at CGC (Location 6) will expand on Beaulieu and Channels by providing a new sustainable neighbourhood of 3,000 new homes, 45,000m^2 of employment floorspace and nine plots for travelling show people, to be delivered in the Local Plan period (2013-2036) alongside a wide range of supporting infrastructure including schools, early years and childcare nurseries, recreation, sport and play facilities and neighbourhood centres.

[38] https://www.chelmsford.gov.uk/_resources/assets/inline/full/0/4671682.pdf

3.3.4 Sustainability and design policies

The adopted Chelmsford Local Plan includes a range of policies to promote high-quality design for all new developments including the CGC.

The following parts of key policies relevant to the current research were extracted from the Local Plan. Please refer to the local plan[39] for exact wording and context for each policy noted below:

- **Strategic Policy S1** – Protect biodiversity, utilise infrastructure effectively and ensure development is deliverable
- **Strategic Policy S2** – Addressing climate change and flood risk: Includes a direct reference to the reduction of expected greenhouse gas emissions, energy systems and sustainable growth.
- **Strategic Policy S4** – Conserving and enhancing the natural environment: Includes a direct reference to green infrastructure and biodiversity. It links with space utilisation and overall garden community principles.
- **Strategic Policy S9** – Infrastructure necessary to support new development must provide or contribute towards ensuring a range of green and natural infrastructure, net gain in biodiversity and public realm improvements.
- **Strategic Policy S10** – Securing infrastructure and impact mitigation: Includes a direct reference to 'cumulative impact of development' which needs to be mitigated in line with adopted policies and published guidance.
- **Policy DM1 – size and type of housing** – includes provisions based on number of new dwellings within a development in terms of accessible or adaptable buildings, affordable homes and self-build allowances (Figure 3).

Table 1 Size of new market housing

Size of new owner-occupied and private rented accommodation required in Chelmsford up to 2037	
Dwellings Size	**Indicative Mix**
One Bedroom	6.2%
Two Bedroom	28.0%
Three Bedroom	46.3%
Four or more bedrooms	19.5%
Total	100%

Figure 3 - Expected housing sizes and distribution required in Chelmsford up to 2037, private sector

- **Policy DM2 – affordable housing and rural exception sites** – 35% of the total number of residential units to be provided and maintained as affordable housing within all new residential development (sites more than 11 units).
- **Policy DM16 – ecology and biodiversity** – includes guidance on habitats and biodiversity and impact of new development. Relevant notes link to the preservation and improvements of green spaces and habitats – indirectly in support of space use optimisation and green community principles. Links with policy DM17 on trees, woodland and landscape features.

[39] https://www.chelmsford.gov.uk/_resources/assets/inline/full/0/4671682.pdf

- **Policy DM18** – All major development will be required to incorporate water management measures to reduce surface water run-off and ensure that it does not increase flood risk elsewhere. The principal method to do so should be the use of sustainable drainage systems (SuDS).
- **Policy DM19 – renewable and low-carbon energy** – includes limitations on renewable and low-carbon energy developments. Direct reference to the avoidance of adverse effects or harm of the natural environment.
- **Policy DM23 – High-quality and inclusive design** – specifies that all new buildings and extensions need to be of a high-quality design. Notes that they need to create a safe, accessible and inclusive environment.
- **Policy DM24 - Design and place shaping principles in major developments** – explicit reference is made in terms of site and individual building designs that minimise energy consumption and that provide climate change resilience.
- **Policy DM25 - Sustainable buildings** – the Council will expect all new dwellings and non-residential buildings to incorporate sustainable design features to reduce carbon dioxide and nitrogen dioxide emissions, and the use of natural resources, as follows where relevant. The policy requires new buildings to provide electric vehicle (EV) charging point infrastructure. The Council expects all new development to apply the energy hierarchy by reducing the need for energy, use energy efficiently, supply energy efficiently and use low and zero-carbon technologies. All new non-residential buildings with a floor area in excess of 500sqm shall achieve a minimum BREEAM rating (or its successor) of ‘Very Good’. All new dwellings shall meet the Building Regulations optional requirement for water efficiency of 110 litres/person/day.
- **Policy DM26** – provides information on the design specification for dwellings, which includes a requirement for all new dwellings to comply with the nationally described space standards. As this applies to all new dwellings, evidence of compliance with this requirement will need to be provided prior to the validation of a planning application.

3.4 Supplementary Planning Documents (SPDs), as assessed April 2021[40]

Making Places - Supplementary Planning Document, January 2021

This SPD seeks to promote and secure high-quality sustainable new development. Section 9 Sustainable Design and Construction has four objectives of particular relevance to CGC.

Part 2 - Section 9 notes four objectives:

- Secure high-quality well-designed sustainable development
- Future-proof new developments to allow for fast-changing technology and building standards
- Reduce the use of non-renewable resources
- Reduce carbon emissions from new buildings

CCC Planning Obligations SPD, January 2021

This document sets out how the Council will seek planning obligations when considering planning applications. At developments of over 100 homes, the Council will seek to negotiate Section 106 agreements which secure show homes that incorporate optional sustainable design features to showcase the benefits of including such features in a new build and how to move towards a zero carbon home.

[40] Supplementary Planning Documents - Chelmsford City Council

3.5 Other relevant information extracted from the Chelmsford Local Plan

- To meet identified need, a total of 9 permanent pitches for gypsies and travellers as defined by national planning policy for the period 2016-2036 will be provided.
- To meet identified need, a total of 24 permanent plots will be provided for travelling show people as defined by national planning policy in the period 2016-2036 (SP S6).
- The council (together with Braintree, Colchester and Tendring councils) commissioned an objectively assessed housing need study (OAHN). Detailed analysis in the report affirms that a housing market assessment comprising Braintree, Colchester, Chelmsford and Tendring council areas forms a sound basis for assessing housing need.
- The OAHN report published in November 2016 uses the 2014-based national population and household projections together with an update to the strategic housing market assessment (SHMA) undertaken in December 2015.
- Projections show increases in the population at virtually all ages, with very large increases projected for those aged in their late 60s and above. The most common household in 2013 was couples living alone (29.3%) – i.e. with no other adults or dependent children. This trend is set to continue into 2037, where couples living alone will represent 29.1% of households. Demographic changes will shape the type and size of accommodation necessary over the local plan period.

4. Chelmsford Garden Community background and links to existing development

Short introduction:

Adjacent to the proposed Chelmsford Garden Community (CGC) are the developments of Beaulieu and Channels. With some of their phases now complete, the research team looked into historic energy efficiency and renewable energy standards used on the completed phases.

Beaulieu and Channels complied with the planning clause of achieving a 10% CO2e reduction over Part L 2010 following a fabric-first approach. All buildings produced followed the 'be lean, be clean, be green' hierarchy. Some PV installations were also noted within Channels. The properties within both locations featured natural ventilation and gas boiler systems.

One of the questions posed to the research team in the current project was how and if CGC can benefit the decarbonisation of adjacent developments.

The direct answer would be that this can be quite challenging. The standards and roadmaps to net zero proposed within this report for CGC are design and technology agnostic but they are based on all-electric building services solutions capable of leading CGC to a close to zero-carbon status.

This is since grid electricity is expected to decarbonise as more renewable energy generation technologies connect to the grid. Therefore, the main strategy proposed for CGC includes maximum energy demand reduction, all-electric solutions and maximum benefit of direct use of electricity produced from on-site renewables. Even with the strategy suggested for CGC it would still rely on the main electricity grid for balancing demand and for additional electricity energy when need.

CGC can link to Beaulieu and Channels buildings that might be high-energy (electricity) consumers through a smart renewable energy distribution grid, for some of the electricity produced at peak to be directly used by these buildings and therefore reduce their reliance on the electricity grid.

Nevertheless, carbon emissions generated for heating and hot water from gas boilers within Beaulieu and Channels would not be able to be offset through the CGC site as the carbon intensity of these fuels would far exceed the amount of carbon emission savings allocated to renewable energy generation technologies from CGC (the carbon factors will be the same as the future electricity grid which is ever decreasing).

Furthermore, carbon emissions associated with 'energy wastage' due for example to lower levels of insulation – increased need for energy for heating demand – would be better offset through appropriate, technically robust, and cost-effective retrofit of these buildings.

Finally, for future Beaulieu and Channels phases it is advised that the CGC standards are proposed and if possible implemented.

4.1 Summary of findings – Section 4

Section 4 - Responds to Q4 - Links to existing development
Q4. What are the links to existing development and infrastructure in adjacent settlements and existing developed areas of Beaulieu and Channels? Are there e.g., any nearby existing or proposed buildings with high energy demand that could benefit and be decarbonised? Or vice versa, could low or zero-carbon energy be supplied from schemes in the vicinity?
Section 4 - Evidence and summary response
CGC is set to play a significant role in Chelmsford's future growth. It will be an exemplar site following the garden community principles. Adjacent to CGC there are the developments of Beaulieu and Channels. The two developments were requested to comply, in terms of energy and carbon, with historic planning clauses, as follows: Beaulieu – Condition 35 of the outline planning permission 09/01314/EIA and Channels – Condition 34 of the outline planning permission 10/019766/OUT. In terms of carbon emissions, the planning requirements at the time for both sites were to achieve a 10% reduction of predicted carbon emissions compared to Part L 2010 (now out of date) requirements. Beaulieu and Channels' standards follow the '**Be lean, be clean, be green**' principles in the sense that they follow a fabric-first approach. On all occasions the developments complied with the requirements. Current changes within the Part L (2013 current and 2020 currently pending government confirmation for applications) have led to substantial upgrades on carbon emission requirements superseding and exceeding Part L 2010 and 10% CO2e reduction requirements. The vision of CGC includes properties moving toward a net zero status, based on a phased development delivery plan to 2036. To achieve this goal, a fabric-first approach needs to be followed by a substantial decrease in overall energy demand, with most remaining energy demand needing to be 'covered to a great extent' using on-site renewable energy generation and store technologies and systems. As explored later in the report (Sections 6,7,8) in more detail, achieving such goals will heavily rely on the standards imposed to the new CGC development and the supportive infrastructure. The evaluation of the Beaulieu and Channels' standards show that the developments followed standards practice, in the sense of a) fabric first, contributing to overall energy demand reduction; b) limited amount of renewable energy generation (PV) to offset some of the carbon impact. Due to the potential stringent energy and carbon targets to be imposed to CGC, and pending decisions as to how best to import and set the required thresholds, it is not advised to extend the scope of CGC to connect to existing developments. CGC standards developed would be beneficial if they were to be applied to new Beaulieu and Channels developments. A main opportunity for benefiting existing development using CGC infrastructure and development plans would be to facilitate decentralised energy distribution in case of battery and decentralised energy system infrastructures, taking advantage of the renewable energy generation from CGC. This should be the scope of another study, if required by CCC. No such solutions were considered or modelled within this study.

4.2 The site - Chelmsford Garden Community

CGC is set to play a significant role in Chelmsford's future growth (Figure 4).

Awarded garden community status on 27 June 2019, it has already delivered 1,000 new homes at Beaulieu and Channels, a neighbourhood centre, Essex's first all-through school for 5-18 year olds and bus priority measures for rapid transit into the city centre.

Expanding on the success of Beaulieu and Channels, the new garden community is expected to provide for a high-quality comprehensively planned new sustainable development based on the Town and Country Planning Association (TCPA) garden community principles.

North East Chelmsford has provision for around 3,000 new homes and 45,000sqm of new office/business park floorspace within the plan period to 2036 supported by several other facilities and non-domestic buildings as detailed within Section 5.

Development is expected to start on site in 2022/2023 and the wider allocation may have the capacity for a further 2,500 new homes to be developed post-2036.

The site will provide significant areas of new green and blue infrastructure, neighbourhood centres, three schools and early-years childcare nurseries, new bus-based rapid transit and a rail station.

CCC has been selected to join the government's Garden Cities Programme and in 2019 and 2021 were allocated capacity funding to support the delivery of the combined developments (Beaulieu and Channel and North East Chelmsford).

Funding has also been secured via the Housing Infrastructure Fund (HIF) to deliver a new rail station and the Chelmsford North East Bypass. Beaulieu and Channel and North East Chelmsford will develop around these key pieces of transport infrastructure.

To effectively deliver CGC, a series of strategies and studies are being developed by CCC, Essex County Council and the Consortium comprising of the site landowners, promoters and developers of Channels, Columbia Threadneedle Investments, Countryside, L&Q, Ptarmigan and Hanson.

The current study was commissioned by CCC but will be shared and used by the Consortium. The Consortium is currently preparing a masterplan for CGC in collaboration with CCC.

The current energy mapping and renewable and low carbon energy feasibility study provides independent advice on the predicted energy demand as well as the most appropriate on site renewable and low carbon energy schemes for the strategic scale development at CGC.

In line with the garden community principles, the study also explores how the energy demand of the development can be minimised and how feasible it would be to make the buildings on site net zero carbon.

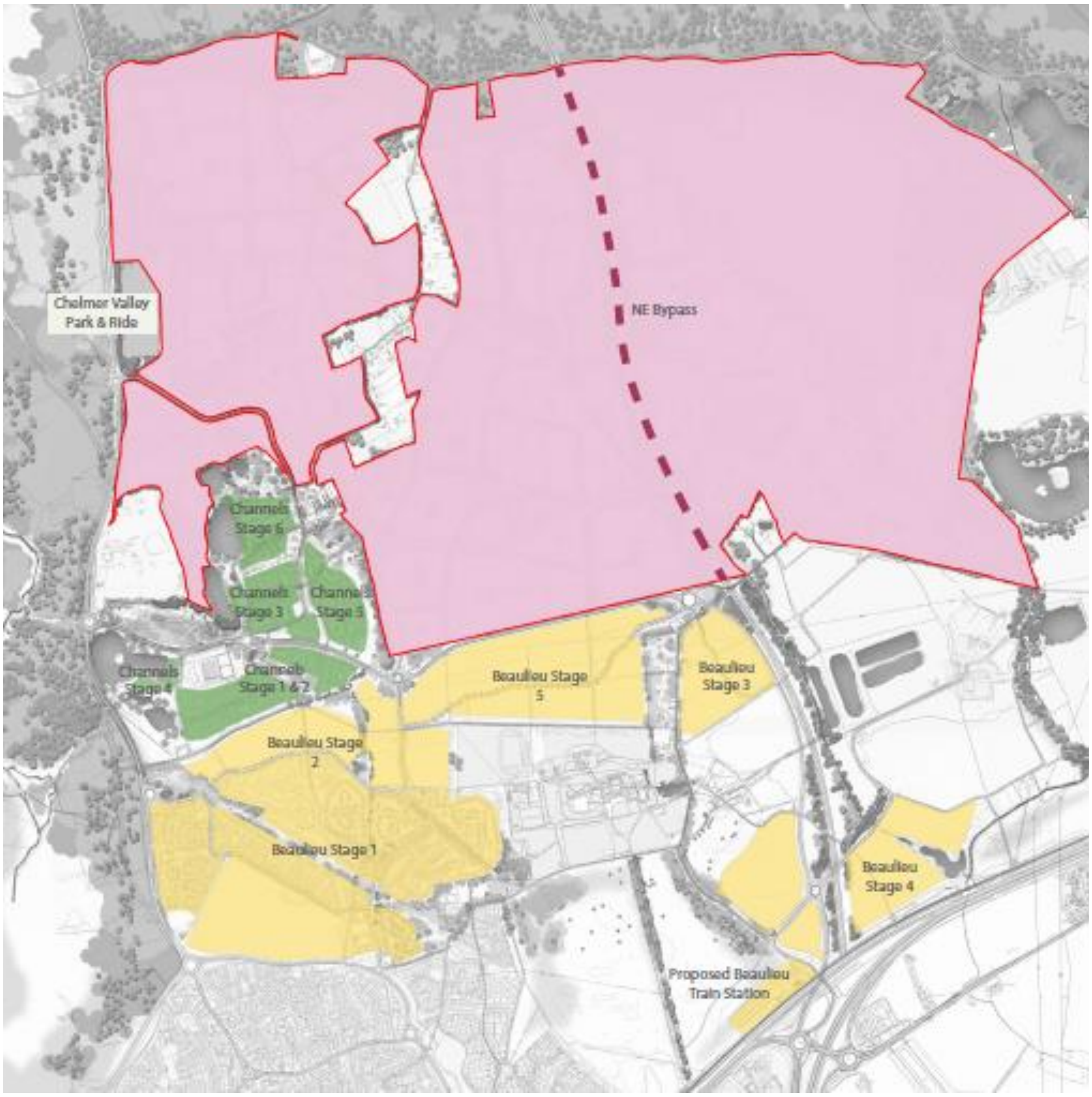

Figure 4 - Location and area of North East Chelmsford Garden Village

The additional land allocated in North East Chelmsford will include:

- Around 3,000 homes of a mixed size and type including affordable housing to 2036, together with the capacity for an additional 2,500 new homes post-2036. Policy DM1 of the Chelmsford Local Plan includes an indicative size guide for the housing types and sizes that will be required to meet local needs.
- 45,000sqm of floorspace in a new office/business park with a range of unit types and sizes (type and location of the new employment floorspace is yet to be determined).
- Travelling show people site for nine serviced plots.
- Neighbourhood centres with food retail, community and healthcare provision.
- A secondary school.
- Two primary schools with early years and childcare nurseries.
- Two additional stand-alone early years and childcare nurseries.
- New community facilities including allotments and formal sports pitches/courts.

4.3 Adjacent development Beaulieu and Channels

4.3.1 Beaulieu and Channels short description

CCC's previously adopted Local Development Framework allocated a minimum of 3,200 new homes and 64,000sqm of commercial floorspace at North East Chelmsford known as Beaulieu and Channels. Outline planning permission has been granted for 4,350 new homes, 40,000sqm floorspace business park and a new rail station.

Construction work commenced on the scheme in 2014. The phased delivery of this allocation will continue into the late 2020s and future detailed planning applications will be considered in accordance with the approved masterplan and Landscape and Design Management Plan which were informed by the relevant sections of the North Chelmsford Area Action Plan (NCAAP)[41].

The residential areas are supported by first-class amenities that will allow the new neighbourhoods to grow and flourish.

A wide range of facilities are being provided including two new primary schools and a secondary school, community, health[42], sport and retail facilities together with an extensive network of parkland and green open spaces.

As part of this research work, it was expected that the adjacent developments of Beaulieu and Channels would be reviewed in terms of energy and carbon emissions, as well as housing development size and housing types. This data was used for:

- Energy and carbon emissions, to identify opportunities deriving from the CGC development that could support the carbon offsetting of remaining carbon from the Beaulieu and Channels developments.
- Housing development size and housing typologies, to inform the CGC housing development models selected.

The housing distributions of the two sites are provided within Table 11 and Table 12.

Table 11 - Beaulieu housing mix

Beaulieu housing mix - all phases (1-3)									
	Flats			Terrace			Houses		
Total houses	1 bed	2 bed	3 bed	1-bed house	2-bed house	3-bed maisonette	3-bed house	4-bed house	5-bed house
2092	343	395	0	8	244	40	509	466	87

Table 12 - Channels housing mix

Channel's housing mix - all phases (1-6)									
	Flats			Terrace			Houses		
Total houses	1 bed	2 bed	3 bed	1-bed house	2-bed house	3-bed maisonette	3-bed house	4-bed house	5-bed house
745	48	81	2	0	145	0	230	155	84

[41] Growth Area 2, Chelmsford Local Plan, 27 May 2020
[42] The health centre has detailed reserved matters approval and it is hoped that it will be delivered within the short to medium term.

Main compliance strategies used in Beaulieu and Cannels can be found in Table 14 and Table 15 and are explained bellow. A list of the reports provided by the CCC for review can be found in Table 13.

Explanation of Table 14 and Table 15 and notes

Currently (2021) the main government policy direction in terms of the future of energy and carbon standards in buildings indicates:

- A move to additional overall energy demand reductions (fabric first and energy stores)
- The introduction of all-electric solutions (very low-carbon content due to the contributions of the renewable energy generation technologies to the main electricity grid) and
- The use of new and energy-efficient technologies such a heat pumps and renewable energy generation and store measures to achieve the different goals.

For Beaulieu and Channels we noted the following:

- All follow the ‘be lean, be clean, be green’ hierarchy.
- Considering the 10% CO2e over Part L 2010 target, all to meet the target following a fabric-first approach. This means that they all target reducing energy that is needed for heating first.
- There are references to the Code for Sustainable Homes (CSH), a now-retired standard that predated the discussion about net zero carbon. The CSH standard was not only targeting energy and carbon but other areas of interest in terms of general sustainability. The Level 3 can be indirectly translated as compliance in terms of energy and carbon with the current in power Part L 2013 of the Building Regulations (soon to be superseded by the new Part L 2020).
- In terms of a ventilation system selection, most buildings are naturally ventilated. The ones that were mechanically ventilated did not include any energy recovery functionality. Currently to achieve net zero, it is common to see the installation of mechanical ventilation with heat recovery (MVHR) systems instead.
- The buildings were evaluated against what is commonly known as regulated energy use, which means that all the measures applied are not targeting the overall impact of the building in terms of running energy but are limited to heating, hot water, installed services and exclude plug loads[43] and other appliances (as per the requirement in the Building Regulations).
- The main heating systems used are gas boilers. Current thinking requires the move away from burning fossil fuels.
- Thermal bridging - this is a parameter that affects how much heating is lost between joints and other areas of the fabric of the building. Good joints and insulation details were used to achieve a reduction in the heating demand (along with the insulation levels of the fabric).
- Accredited Construction Details - when used they are expected to contribute to meeting good thermal bridging performance.
- Airtightness is a parameter that defines how much unintentional air leakage is happening between the house and the external environment through the fabric’s infiltration. Usually anything below $3m^3/m^2h$ would indicate the requirement for a mechanical ventilation system to assist with fresh air. The developments achieved close to $5\ m^3/m^2h$, where natural ventilation can also be used. Very energy-efficient buildings are usually very airtight with airtightness levels targeting less than $1\ m^3/m^2h$.

[43] Plug loads refer to ‘unregulated energy use’ and include the energy required for appliances, white goods and other user provisions that are not relating to fixed heating, ventilation, hot water and energy generation services.

- Some renewable energy generation technologies, photovoltaics, were used to allow meeting the 10% CO2e reduction targets.

In general, it would be challenging to decarbonise Beaulieu and Channels through CGC. This is because ‘key decarbonisation solutions include the removal of gas boilers (fossil fuels) and additional renewable energy generation technologies to be installed to supplement the buildings’ grid electricity demand, which would require substantial retrofit measures to be undertaken to existing buildings.

In the case of new buildings, these would need to be all electric, and connecting and improving them as CGC progresses would require the installation of decentralised smart networks.

As the electricity grid decarbonises, renewable energy generation, which is mainly electricity generation, will not be able to compensate for carbon emissions produced from the combustion of fossil fuels as in the case of gas. This is because the carbon factor assigned to the electricity displaced from the grid will be minimum and ever decreasing while emission from gas and fossil fuels will remain almost constant (kg/kWh).

Beaulieu and Channels future phases could benefit from the introduction of similar if not the same higher performance standards, as the ones established within this report for CGC.

Table 13 - Beaulieu and Channels energy statements

Report title	Date issued
Beaulieu Zone G - Energy Report	2017
Beaulieu Zones K & L - Energy Report	2019
Channels Phase 1 - Energy Statement	2014
Channels Phase 2 - Energy Statement	2014
Channels Phases 3a & 3b - Energy Report	2016
Channels Phases 3c 3d & 5 - Energy Report	2017

Table 14 - Beaulieu and Channels energy statements key findings

Report title	Key findings
Channels Phases 3a & 3b - Energy Report	▪ Cumulative savings ~10% over PartL1A 2010 ▪ Target Fabric Energy Efficiency (TFEE) achieved over development[44]. ▪ Gas boilers ▪ Shower heat recovery units ▪ Solar passive design ▪ 0.5kWp PV panel per dwelling for three types ▪ 0.25kWp PV panel per dwelling for two types ▪ Five house types ▪ 7.86% improvement from fabric first ▪ 2.34% improvement from renewables
Channels Phases 3c 3d & 5 - Energy Report	▪ Be lean, be clean, be green. ▪ Cumulative savings ~10% over Part L1A 2010 ▪ 198 houses and 42 apartments ▪ Gas boilers (89+% seasonal efficiency) ▪ Fireplace in some types ▪ Storage tank cylinder ▪ Centralised mechanical extract ventilation (MEV) ▪ PV considered at 0.93kWp per plot

[44] Fabric Energy Efficiency (FEE), a Part L requirement, in SAP is known as DFEE/TFEE (Dwelling Fabric Energy Efficiency / Target Fabric Energy Efficiency). DFEE and TFEE are the energy demand in kilowatt-hours per m² per year (kWh/yr).

Fabric energy efficiency, as the name implies, is a measure of the efficiency of the building fabric (u-values, air tightness and thermal bridging).

Table 15 - Beaulieu and Channels energy statements key findings

Report title	Key findings
Beaulieu Zone G - Energy Report	▪ Be lean, be clean, be green. ▪ Cumulative savings ~10% over Part L1A 2010 ▪ 68 new homes, 48 houses and 20 apartments ▪ Level 3 Code for Sustainable Homes ▪ Non-domestic, BREEAM 'Very Good' ▪ Gas boilers ▪ ≤125l/person per day water ▪ Decentralised MEV and centralised MEV ▪ Accredited Construction Details ▪ No low and zero-carbon technologies
Beaulieu Zones K & L - Energy Report	▪ Be lean, be clean, be green. ▪ Cumulative savings ~10% over Part L1A 2010 ▪ 300 new homes, 92 x 1-bed, 141 x 2-bed, 67 x 3-bed ▪ Natural ventilation ▪ Gas boilers ▪ Care about thermal bridging ▪ ≤5.01 m3/m2h@50Pa[45] airtightness ▪ No low and zero-carbon technologies
Channels Phase 1 - Energy Statement	▪ Be lean, be clean, be green. ▪ Cumulative savings ~10% over Part L1A 2010 ▪ ≤5.01 m3/m2h@50Pa airtightness ▪ Gas boilers ▪ Hot water cylinder in large dwellings ▪ 84kWp PV panel across the site (588m2) ▪ 5.91% improvement from fabric first ▪ SAP summer overheating Appendix P 'medium' threshold
Channels Phase 2 - Energy Statement	▪ Cumulative savings ~10% over Part L1A 2010 ▪ 9.61% improvement from fabric first ▪ 10.28% improvement from renewables ▪ Gas boilers ▪ Hot water cylinder in large dwellings ▪ 52kWp PV panel across the site ▪ Generated electricity going to mains supply ▪ ≤5.01 m3/m2h@50Pa airtightness ▪ SAP summer overheating Appendix P 'medium' threshold

[45] Pa: reference pressure in Pascal

5. Analysis of new proposals for CGC

Short introduction:

To calculate the anticipated energy demand of the CGC buildings, the research team reviewed the emerging masterplan for CGC.

Section 5 includes the information reviewed and used in later model development. Information was extracted from the site-specific delivery rates included within the Chelmsford Local Plan, early CGC design documents and was also supported by the planners' knowledge and understanding of the site.

Two key pieces of information were confirmed (in the sense of rough estimates):

- The number of non-domestic and domestic buildings expected to be delivered in three phases (2020-2025, 2025-2030, 2030-2036). This is provided in terms of number of units or m2 of gross internal floor area
- The type of non-domestic and domestic buildings expected to be developed and their contribution to the buildings mix (% of total in the case of housing or number of buildings in the case of non-domestic)

While it is understood that this information may not be final, in the sense that elements of the masterplan might change, it was important to evaluate the impact of suggested standards (as produced within this report) on overall site energy demand, how this can develop through the development programme and its impact on the grid. Furthermore, the different types of buildings were used to assess energy use trends and peak load demand to derive to the standards proposed at later sections.

5.1 Summary of findings – Section 5

Section 5 - Responds to Q2, Q3, Q5
Q2. What is the anticipated demand for energy for power, heating, cooling and mobility for all the proposed lands uses in North East Chelmsford and how is the demand expected to change from the early phases of the development and over the plan period to 2036 and beyond in view of the above? Q3. How can the predicted energy demand be minimised by energy-efficient layout and design of the new homes, schools, community uses and businesses? How feasible would it be to make all buildings net zero carbon and how far if any would this require off-setting/capture?

Section 5 - Evidence and summary response

We reviewed future standards and policy direction along with the CGC expected delivery rates. A timeline split into three phases is introduced, in terms of the journey to net zero. This includes current-2025 (Phase 1), 2025-2030 (Phase 2) and 2030-2036(Phase 3).

In this section we reviewed and confirmed with CCC the development rates, types of buildings and sizes expected within the CGC.

- The housing and non-domestic allocation has been distributed across Phases 1-3, following the Chelmsford Local Plan and for housing also as informed by distributions found within Beaulieu and Channels (as advised by CCC planners)
- The potential housing types have been identified. Non-domestic buildings have been characterised in terms main types of use - and enriched in terms of all the different typologies expected (as advised by CCC planners)
- Most of the housing units will be delivered post-2025 (almost two-thirds)
- With the exception of part of the Innovation Hubs, all other non-domestic buildings are also expected to be delivered post-2025

The exact location of the new development sites is not known at this stage. The architectural designs and design information is also not available. Instead of reviewing passive design elements that might not be applicable to the different locations within the sites, the different building types (housing and non-domestic) were reviewed in terms of sizes and potential time of development during the development period.

Having this information in place was important, as they informed the different ‘zero-carbon journeys’ proposed within the report and assisted in understanding the impact of the different development phases on overall energy demand.

The anticipated energy demand will depend on the number of buildings delivered within CGC, the type of buildings and the standards that the building will be delivered to. It will also depend on standards used in the new buildings, addressing all different types of anticipated energy demand. Information in this section also informs the modelling undertaken in response to Q2-Q4.

Figures in this section have been informed by policy and experience but are indicative. They provide a robust basis for this study although do not represent the final housing mix which will be influenced by several factors as per the CCC future decisions direction.

5.2 Timeline and CGC development rates

The predicted plan period for CGC spans around 14 years. The pace of development during that period is variable. The duration of the development programme means that changes within building regulations and policy direction are expected to occur during its lifetime. Current available information in terms of these potential changes were analysed and are visualised within Figure 5.

At the time of writing the report, the two relevant statutory documents in power which provide guidance in terms of energy and carbon requirements for new buildings at CGC are:

- The Chelmsford Local Plan and planning policy requirements[46]
- Part L2013 of the Building Regulations[47]

Local planning authorities are required to review their local plans every five years. CCC has started preparations for the review of their local plan which will start in 2022. Local councillors have indicated a strong desire to amend planning policies such as DM25 - Sustainable buildings, to require new development to be net-zero carbon.

The Part L 2020 of the Building Regulations is expected to come into effect at some point in 2022.

While the government have released a response in terms of the Part L1A (new domestic properties), currently the proposed changes for non-domestic buildings are under consultation[48].

Key confirmed and additional milestones noted:

- **2022**: Minimum requirement for new homes to achieve a 31% CO2e reduction against Part L 2020 (expected from 2022)
- **2025:** Expected requirement through the Future Homes Standard[49] and the Energy White Paper: Powering our net zero future [50], new homes from 2025 to achieve 75-80% CO2e reductions compared to Part L1A 2013 (zero-carbon ready)
- **2030**: a) All new buildings to at least halve their expected energy use[51] and
  b) CCC to reduce its own carbon emissions to net zero[52]

The CGC domestic and non-domestic development rates in this report are allocated across the three defined ‘regulatory change’ phases (i.e. representing changes to the Building Regulations Part L)

- Phase 1: current to 2025
- Phase 2: 2025 to 2030
- Phase 3: 2030 to 2036

Figures in this section have been informed by policy and the CCC planners’ experience but are indicative.

[46] Chelmsford Local Plan, 27 May 2020 (chelmsford.gov.uk)
[47] Approved Documents | Planning Portal
[48] The Future Buildings Standard - GOV.UK (www.gov.uk)
[49] The Future Homes Standard: 2019 - Summary of responses received and government response (publishing.service.gov.uk)
[50] Energy White Paper (publishing.service.gov.uk)
[51] The Grand Challenge missions - GOV.UK (www.gov.uk)
[52] Climate and ecological emergency action plan (chelmsford.gov.uk)

They provide a robust basis for this study although do not represent the final housing mix which will be influenced by several factors as per the CCC future decisions direction.

While progressing with future development plans, it is strongly advised that any estimates used from this report are compared against updated targets.

Detailed relevant analysis (energy, carbon, cost) will need to be undertaken for each planning application and mapped against overall local energy and carbon objectives and overall trajectory, as informed by the updated delivery rate predictions.

Phase 1	Phase 2	Phase 3	
2020	**2025**	**2030**	**2036**
Part L 2020: 31% CO2e reduction in new housing. No target for non-domestic yet.	**Future Homes Standard consultation:** From 2025, it is expected that new homes will produce 75-80 per cent lower CO2e emissions compared to current levels. These homes will be ‘zero-carbon ready’, with the ability to become fully zero-carbon homes over time as the electricity grid decarbonises, without the need for further costly retrofitting work. By 2025 at the latest, no new homes should connect to the gas grid. Instead, they should have low-carbon heating systems such as heat pumps and low-carbon heat networks.	**Grand Challenge, 2018**: At least halve the energy use of new buildings by 2030. **CCC – Climate Emergency (2019-2020):** CCC have pledged to reduce its own carbon emissions to net zero by 2030.	

Figure 5 - Future policy impact on timeline during the CGC development

5.3 Housing and non-domestic delivery plans - CGC

5.3.1 Housing development

Local plan delivery rates were used to forecast housing delivery and house type mix (Table 16). The housing mix is based on the requirement as set out in Policy DM1 in the adopted Chelmsford Local Plan (indicative and as informed by CCC planners).

Table 16 - Housing types - CGC

Number of new houses	2022-2025	2025-2030	2030-2036	Total	CGC Local Plan
One-bedroom properties	18	47	122	187	6.2%
Two-bedroom properties	78	213	549	840	28 %
Three-bedroom properties	128	352	907	1,387	46.3 %
Four or more-bedroom properties	56	148	382	586	19.5%
Total per period	280	760	1,960	3,000	

Beaulieu and Channels housing type distribution data was also analysed for reference purposes (Table 17).

Table 17 - Housing types - CGC, Beaulieu and Channels, and local plan policy DM1

Housing types percentage (%) distribution	Beaulieu	Channels	NE Chelmsford (C&B)	CCC Local Plan
One-bedroom properties	16.8%	6.4%	6.2%	6.2 %
Two-bedroom properties	30.5%	30.3%	28 %	28 %
Three-bedroom properties	26.2%	30.9%	46.3 %	46.3 %
Four or more-bedroom properties	26.4%	32.1%	19.5%	19.5 %

As noted by CCC planners, Beaulieu and Channels' local planning requirements shaped the distribution to the selected representations of the different typologies.
It is therefore possible that, similarly, CGC housing sizes may differ from overall Chelmsford Local Plan reported distributions.

Nevertheless, for the purpose of this research it was decided that for CGC the local plan distribution was appropriate.

The following house types were selected as representative for the area and used in the model analysis.

- Flats
- Semi-detached and terraced properties
- Detached houses

Expected housing delivery rates were analysed against housing types identified and size of homes, with results presented within Table 18 for reference.

Table 18 – Indicative Housing typologies and size distribution - CGC - per year

Type of house	Size	2022 - 2023	2023 - 2024	2024 - 2025	2025 - 2026	2026 - 2027	2027 - 2028	2028 - 2029	2029 - 2030	2030 - 2031	2031 - 2032	2032 - 2033	2033 - 2034	2034 - 2035	2035 - 2036
Flats	1B	6	6	6	9	9	9	10	10	19	20	19	20	19	25
	2B	17	15	15	25	26	25	26	26	52	52	52	52	52	68
Terrace / semi-detached	2B	11	10	10	17	17	17	17	17	35	35	35	35	35	46
	3B	37	33	33	57	57	56	56	56	115	115	115	115	115	151
Detached	3B	9	8	8	14	14	14	14	14	28	28	29	29	29	38
	4B+	20	18	18	30	30	30	29	29	61	60	60	60	61	80
Sum		**100**	**90**	**90**	**152**	**153**	**151**	**152**	**152**	**310**	**310**	**310**	**311**	**311**	**408**
2B Flats (%) over total 2B		61%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%
3B Terrace / semi-detached (%) over Detached		80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Align. check		**100**	**90**	**90**	**760**					**1552**					**408**

Please note that nine plots are allocated during Phase 3 to travelling show people. These comprise a space for parking the caravans and one adjacent supportive residential building for each caravan spot.

These nine plots are approximated as nine 4-bed detached houses in the modelling work.

To assist with ease of read of future housing delivery rates and mixture of housing types, as considered for the purpose of this research, data used is visualised in Figure 6 and Figure 7.

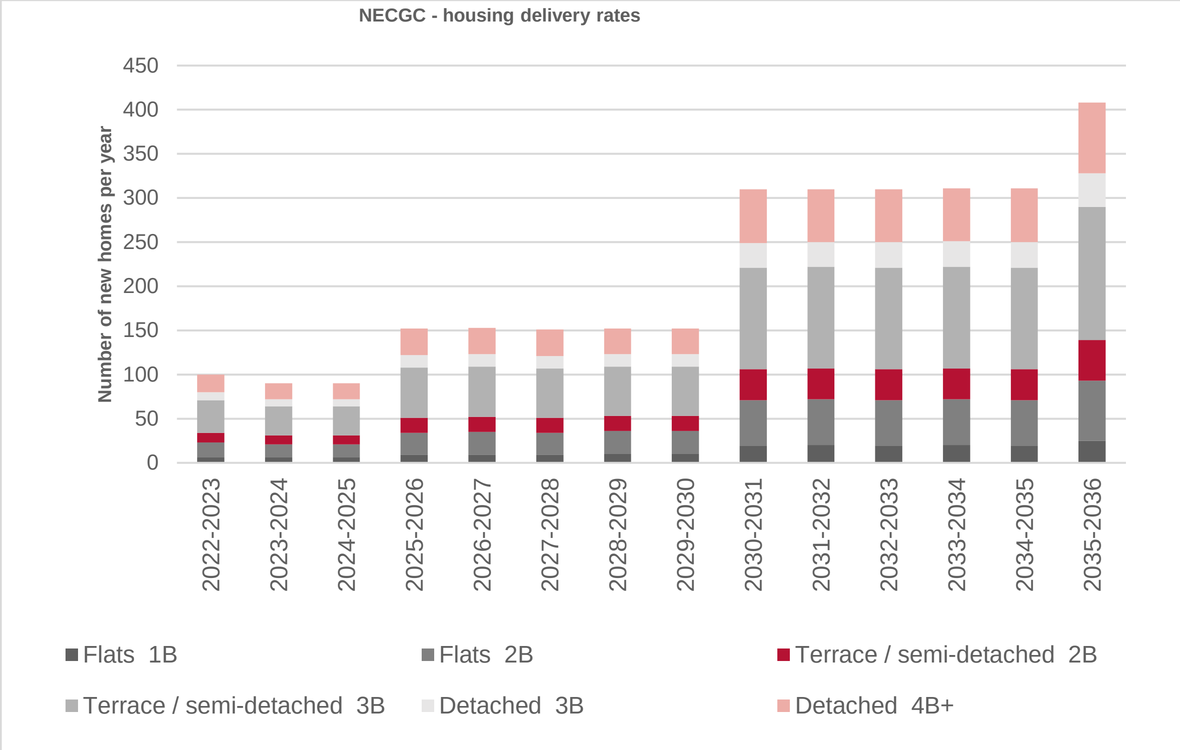

Figure 6 - CGC - new housing delivery - per year and per type

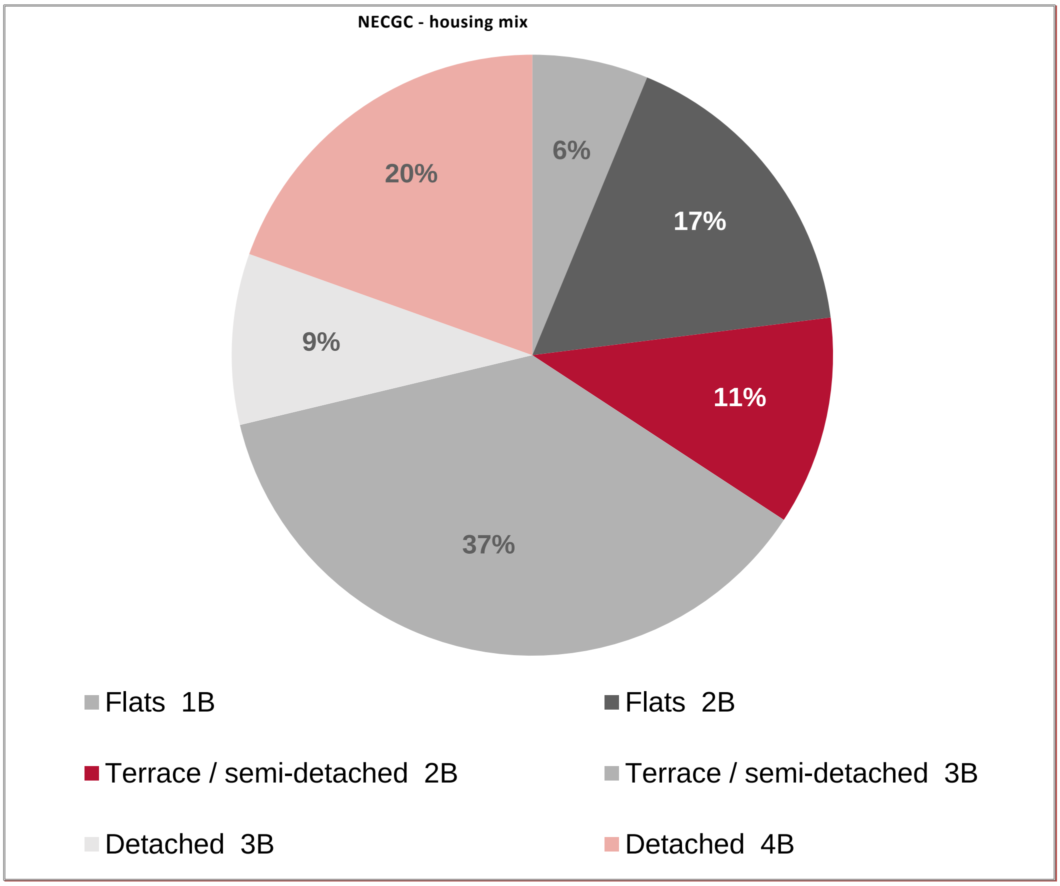

Figure 7 - CGC - new housing delivery - total housing mix

5.3.2 Non-domestic buildings

The CGC is expected to include a wide range of non-domestic buildings in line with the Local Plan site allocation (SGS6). The local plan allocates 45,000sqm for employment/innovation, with the size of other uses to be determined as part of the master planning process and subsequent planning applications.

Information for this section was extracted from the ‘Chelmsford Garden Community Employment Study’. Lichfields, CCC, July 2020.

The locations, timings and make-up of the non-domestic buildings is not fixed at this stage and will be determined as part of the master planning process and subsequent planning applications.

We have used the Lichfield’s study evidence base and CCC officer’s knowledge to develop informed proposals to test in this study.

5.3.2.1 Innovation hubs/employment centres

It is expected that 45,000sqm (Table 19) of employment floorspace will be split equally over two large employment centres. Some employment floorspace will also be allocated to the three neighbourhood centres (on average 375m^2 in each).

The two large employment centres will be a North West Hub by the Chelmer Valley Park and Ride and a Link hub near the proposed North East bypass (Figure 8).

Table 19 - Innovation hubs, development plan (m^2)

Evaluated period	Phase 1	Phase 2	Phase 3
Innovation Hubs	8100 m^2	15150 m^2	20625 m^2

North West hub

The is the first centre to be built near the Chelmer Valley Park & Ride site and Essex Regiment Way. It will be a high-density IT/Media/Professional hub.

North East Bypass/Link road hub

The second centre to be built adjacent to the new North East Bypass. It will be the research and development hub with low density units.

Figure 8 - Innovation hubs location on overall site

According to CCC planners, the approximate space use allocation to different use types is shown in Table 20.

It should be made clear that these figures are very much estimates based on the proposed focus and density of each hub. The demand will inevitably change over time and will depend on the landowner.

Table 20 - Type of space use - Innovation hubs- CGC

Type of use for non-domestic buildings	Approximate total allocation (both hubs)
Offices	51%
Research	20%
Light industry	12%
Heavy industry	7%
Logistics	10%

5.3.2.2 Neighbourhood centres

- It is understood that three neighbourhood centres are proposed at CGC. An element of employment floorspace will be provided within each one of them. It is anticipated that this would principally comprise office or small-scale workspace hubs. Precise offer to be confirmed.
- It is anticipated that each neighbourhood centre will contain approximately 1,500m^2 floorspace which would comprise a range of retail, leisure and commercial floorspace. Of this total, between 250m^2 and 500m^2 employment space should be provided within each neighbourhood centre. On average 375m^2 per neighbourhood centre. This figure is to be subtracted from the total 45.000m^2.
- The mixed-use allocation (1,125m^2 each neighbourhood centre) is expected to be used by retailers, cafes and small businesses. The exact distribution and density of the different business types is at the time of this report writing unknown.

The delivery rate in terms of the development plan is shown in Table 21.

Table 21- Neighbourhood centres, development plan (m^2)

Evaluated period	Phase 1	Phase 2	Phase 3
N. centres mixed use		2250	1125
N. centres offices		750	375

5.3.2.3 Education and travelling show people

The delivery rate in terms of the development plan and type of education facilities planned, are shown in Table 22, Table 23. One communal building will also be provided for travelling show people (Table 24).

Table 22 - Primary schools and nurseries, development plan (m^2)

Evaluated period	Phase 1	Phase 2	Phase 3
Primary schools (2FE)		2235	2235
Co-located nurseries (childcare and early-years care)		416	416

Table 23 - Secondary schools and nurseries, development plan (m^2)

Evaluated period	Phase 1	Phase 2	Phase 3
Secondary school (10FE)			13000
2 x standalone nurseries (childcare and early-years care)			832

Table 24 - Travelling show people, communal building (m^2)

Evaluated period	Phase 1	Phase 2	Phase 3
Travelling show people- Communal building			50

5.3.2.4 Leisure hub and private leisure facility

Information on the type and size of the expected new leisure centres were provided by the CCC planners (Table 25). Exact details on those facilities are not known at the time of the report writing. Proposals are based on local knowledge and evidence where available. An additional leisure facility is being tested although it is not a requirement of the local plan site policy.

Table 25 - leisure facilities, development plan (m^2)

Evaluated period	Phase 1	Phase 2	Phase 3
Leisure facility		5600 (private - 2 stories)	1000 (single story - adjacent to secondary school)
Sport pavilion		100	

6. Energy and carbon modelling approach

Short introduction:

Section 6 details the approach taken to produce the housing and non-domestic building models used within the energy scenarios appraisals and with the roadmaps produced.

The development phases – current-2025, 2025-2030 and 2030-2036 – align with expected changes within the Building Regulations referring to energy and carbon standards in buildings (Part L 2021, Future Homes Standard 2025 and further expected changes every five years on average in 2030 and 2035/36). This alignment of phases to the Building Regulations is intended to assist with future risk and cost assessments.

There are three roadmaps proposed for CGC based on the CCC level of ambition:

- Zero Carbon – Roadmap 1
- Toward Zero Carbon – Roadmap 2
- Towards Low Carbon – Roadmap 3

Standards proposed are (Table 30,Table 37 and Table 38):

- Roadmap 1 proposes zero-carbon standards to be used for the whole CGC development plan from the start
- Roadmap 2 introduces some lower than zero-carbon requirements until 2025, and then all future development post-2025 to meet the proposed zero-carbon standards (this is the proposed roadmap)
- Roadmap 3 uses the same propose lower than zero-carbon requirements as with Roadmap 2 until 2030, and then all future development post-2030 to meet the proposed zero-carbon standards

Section 6 links to questions Q2, 3 and 5 in the sense that these questions cannot be answered without understanding the calculation and thinking process described within this section.

All models and proposed package solutions are based on construction methods and technologies that are currently available. Considering early stage of masterplan development and associated uncertainty in potential housing and non-domestic future designs, and acknowledging they need design flexibility, the proposed measures are not confined by a specific design approach.

It needs to be noted that good architectural and design practices include looking into passive solar design elements, and optimising design layout and the user experience along with improving energy efficiency and overall performance.

Such details can only be introduced upon deciding on the exact building types, location and year of development, supply chains available, materials, local skills and project complexity. The standards produced within this report, and as used for the different roadmaps, are not affected by such factors and are construction method, technology and design neutral.

6.1 Summary of findings – Section 6

Section 6 - Links to Q2, Q3, Q5
Q2. What is the anticipated demand for energy for power, heating, cooling and mobility for all the proposed lands uses in North East Chelmsford and how is the demand expected to change from the early phases of the development and over the plan period to 2036 and beyond in view of the above? Q3. How can the predicted energy demand be minimised by energy-efficient layout and design of the new homes, schools, community uses and businesses? How feasible would it be to make all buildings net zero carbon and how far if any would this require off-setting/capture? Q5. What are the current power and network constraints within the locality that may affect the nature of the design and phasing of development to meet our zero carbon and climate resilient objectives?
Section 6 - Evidence and summary response
This section of the report includes information on the different solution packages confirmed for use within the models, which are more explained within Section 7 in more detail. This is because the answers to Q2-Q5 will heavily rely on minimum standards agreed for CGC future development phases and how these standards may vary at different points in time (current-2025, 2025-2030, 2030-2036). The measures described within section 6 refer to currently available technologies, established construction methods as well as approved products for use within buildings. All packages include standalone, building-specific measures covering all building typologies. The selection of these proxy measures was achieved through a ‘choose by advantage’ assessment method undertaken during workshops with the CCC officers. The packages and solutions used as a proxy within this section are not the only way to achieve higher energy efficiency and carbon performances. They are packages and measures that are becoming more common within the construction sector and are considered as appropriate, and potential measures, for the CGC masterplan. ▪ The technological solutions suggested were as per the consultants’ (Currie & Brown, Elementa) recommendations and they were based on best practise guides as well as on in-house project experience. ▪ The solutions selected follow a lean, clean and green approach - always prioritising a reduction on space heating demand (for buildings that have such a requirement) through improved insulation levels, improved airtightness levels and where buildings are highly airtight (<3 m/m2year @ 50Pa) with the provision of a mechanical ventilation heat recovery system. ▪ All-electric solutions were assigned to each model for the generation of heat and hot water, in alignment with main policy direction. ▪ Both hot water stores and electrical batteries were assigned to the different building packages. This was in order to fully benefit from both types of energy surplus generation and to secure the benefits of additional heat or electricity energy need at peak times (smoothing peak load demand). ▪ Renewable energy generation was provided through the assignment of photovoltaic panels on the roof of each building - maximising use of available space and minimising development footprint.

None of the packages include a community/district-based system. While there may be opportunities for such systems application within CGC, usually they are subject to detailed master planning and design reviews. At this stage of CGC such information was not available and the introduction of such systems would introduce additional unnecessary complexity in the modelling work.

The packages and scenarios developed were used to inform the scenario appraisals undertaken in response to Q2-Q5.

The concept of three roadmaps is introduced (Table 30), which involves highlighting those scenarios leading to net zero and low-carbon development results. The three roadmaps reflect in effect:

- Roadmap 1: an early (at start) adoption of zero-carbon[53] standards
- Roadmap 2: relatively high standards adoption in first phase (current-2025) and tightening to net zero for the remainder of the development
- Roadmap 3: relatively high standards from current to 2030 and tightening to net zero from 2030 and onwards

[53] As defined within this report – see Table 37 and Table 38

6.2 Methodology

A baseline model was produced for each housing typology. All baseline models complied with current energy and carbon performance requirements (Part L 2013). This section contains information on these models and how they were used in future CGC development scenarios. Full model specifications can be found in Appendix B – Housing and non-domestic buildings model specifications.

It needs to be noted that good architectural and design practices include looking into passive solar design elements, and optimising design layout and the user experience along with improving energy efficiency and overall performance. These factors are not explored in detail within this report as they are affected by architectural decisions. To increase the robustness of the current method, the building typologies used within the report are generic and common within the industry.

Passive design and layout details can only be introduced upon deciding on the exact building types, location and year of development, supply chains available, materials, local skills and project complexity. The standards produced within this report, and as used for the different roadmaps, are not affected by such factors and are construction method, technology and design neutral.

Please note that packages and improvements proposed would require using skilled contractors to ensure best practice for the building fabric is really achieved, eg avoid thermal bridges, high levels of air tightness, and as mentioned in other sections as well, the monitoring of a sample of buildings during each phase of development.

6.2.1 Housing models

Each housing model, for all housing types produced, was assigned a package solution (Table 26). The package solutions, four in total including a baseline, in effect represented a group of measures assigned to the different housing types to optimise their predicted energy and carbon performance.

The packages reflected a progressive improvement of energy and carbon performance over the baseline. Package 1 is the easy route developers would take to indicate some small improvement over minimum regulatory requirements, Package 2 is a zero-carbon ready house, in effect an energy and carbon-efficient house, Package 3 is a further improvement over Package 2 and is also able to store energy on site and Package 4, which is described as zero carbon plus, has the ability to almost reach a net zero carbon target (best practice/high end, most energy required is generated from the house itself).

The packages comprise of:

- A fabric specification which achieves a certain heating energy demand requirement (energy demand reduction measure). There are three levels of performance set at 50, 35 and 15 kWh/m2/year. The less energy is required for heating the more energy efficient the building’s fabric is.
- All packages except for the baseline package were assigned higher levels of airtightness and a mechanical ventilation heat recovery unit (MVHR) to support fabric improvements and assist in meeting the heating demand thresholds set.
- Three types of heating systems were used in the different packages ranging from a gas boiler in the baseline model (not appropriate for net zero), to an efficient air source heat pump (ASHP) and an even better performing ground source heat pump (GSHP).
- A thermal store, which is a hot water cylinder, was assigned to all models. There are two types of hot water cylinders that were used, a standard and an enlarged cylinder.

Enlarged cylinders can store more hot water at times of lower energy cost or additional renewable energy generation.

- Two battery systems were assigned to the more energy-efficient packages 3 and 4. The two battery systems characterised as small (A) and large (B) indicate two different systems capacities, with the larger battery being able to store more energy at times of low energy cost or additional renewable energy generation.
- Two % of PV roof coverage options were used, characterised as small and large. Small PV coverage was selected for Packages 1 and 2 where no battery store was present, while large PV coverage was chosen for the properties with battery store.

The following table summarises the technologies considered for the four packages produced for the housing models (each package applies to each house type/size), Table 26.

Table 26 - Housing models - fabric standards and energy systems - Packages

	Purpose of Package	Heating system	Fabric		Storage - thermal	Storage - Batteries	PV generation
			Name	Space heating demand kwh/m2/yr.			
Baseline		Gas boiler	Baseline	50	Standard dwelling cylinders	none	none
Package 1	easy route developer often takes	Direct electric (& MVHR)	Improved	35	Enlarged dwelling cylinders	none	Small
Package 2	Zero- carbon ready	ASHP (& MVHR)	Improved	35	Enlarged dwelling cylinders	none	Small
Package 3	Net zero [54]carbon	ASHP (& MVHR)	Best practice	15	Enlarged dwelling cylinders	Battery A (small)	Large
Package 4	Net zero carbon plus	GSHP (& MVHR)	Best practice	15	Enlarged dwelling cylinders	Battery B (large)	Large

Standard dwelling cylinders	This refers to typical for the number of bedrooms sizes
Enlarged dwelling cylinders	Small/Large: 1B Flat 130/170L, 2B Flat 130/170L, 3B 170/270L, 4B 170/270L.
Battery A (small)	2kWh
Battery B (large)	5kWh
PV small	~40% of roof area
PV large	~80% of roof area

[54] Net zero carbon - operational energy only - regulated and unregulated energy use

The packages were used for the creation of future scenarios, for appraisal. The technologies assigned to each package were considered as currently the most appropriate by the research team and were confirmed with the CCC planners (Table 27).

Table 27 - Housing development - scenarios - current to 2036

	Phase 1	Phase 2	Phase 3
Year	Current - 2025	2025-2030	2030-2036
Scenario A (Baseline)	**Baseline**	**Baseline**	**Baseline**
Scenario B	**Package 1**	**Package 1**	**Package 1**
Scenario C	**Package 2**	**Package 2**	**Package 2**
Scenario D	**Package 3**	**Package 3**	**Package 3**
Scenario E	**Package 4**	**Package 4**	**Package 4**
Scenario F	**Package 2**	**Package 2**	**Package 3**
Scenario G	**Package 2**	**Package 3**	**Package 3**

6.2.2 Non-domestic models

A set of non-domestic buildings was produced to assess their impact on energy demand and capacity requirements for CGC. These were as per the non-domestic building development set out within 5.3.2 .

For each building typology, based on modelled and in-house data, an energy demand profile was produced. This energy demand profiled reflected the type of use and size of the different suggested new buildings.

As with housing models, each model was assigned an improvement package (Table 28). Two main packages were assumed for the non-domestic buildings. Package 1 improved compared to building regulations indicating a route the developers often take and Package 2, net zero carbon based on high energy efficiency, storage and generation standards.

The packages reflected a progressive improvement of energy and carbon performance over the baseline. They comprise of:

- A fabric specification which achieves heating energy demand reductions where possible and as based on the heating profile of the different typologies (targets were set in terms of kW/m2 as explained in Appendix B – Housing and non-domestic buildings model specifications).
- Three types of heating systems were used in the different packages ranging from a gas boiler in the baseline model (not appropriate for net zero), to an efficient air source heat pump (ASHP) and an even better performing ground source heat pump (GSHP).
- A battery energy system (3.5kWh/100m2) was assigned to the models in Package 2.
- Two percentages of PV roof coverage options were used, characterised as small and large. Small PV coverage was selected for Package 1 where there is no energy store and large PV for Package 2.

The following table summarises the technologies considered for the two packages produced for the non-domestic models (each package applies to each non-domestic type), Table 28.

Table 28 - non-domestic models - fabric standards and energy systems - Packages

	Purpose of package	Heating system	Fabric	Storage - batteries	PV generation
Baseline		Gas boiler	Business as usual	none	none
Package 1	Easy route developer often takes	ASHP (and MVHR)	Improved	none	Small
Package 2	Net zero carbon	GSHP (and MVHR)	Best practice	Battery C	Large
Battery C	3.5kWh per 100m2				
PV Small	~15% of roof area				
PV Large	~30% of roof area				

Non-domestic buildings' energy and carbon performance depends mainly on type of use. Fabric improvements lead to energy saving for heating. While offices, schools and other spaces that accommodate people will have a heating requirement, buildings such as research facilities, manufacturing, leisure centres with pools, hospital and others have specific energy requirements that might relate to processes, specific use, or frequency of operation.

Such energy demand might relate more to energy required for hot water generation, cooling, ventilation and other uses that are not affected by the fabric performance/levels of insulation and airtightness. The packages were used for the creation of future scenarios, for appraisal. The technologies assigned to each package were considered as currently the most appropriate by the research team and were confirmed with the CCC planners (Table 29).

Table 29 - non-domestic developments - scenarios - current to 2036

	Phase 1	**Phase 2**	**Phase 3**
Year	**Current - 2025**	**2025-2030**	**2030-2036**
Scenario A (Baseline)	**Baseline**	**Baseline**	**Baseline**
Scenario B	**Package 1**	**Package 1**	**Package 1**
Scenario C	**Package 2**	**Package 2**	**Package 2**
Scenario D	**Package 1**	**Package 1**	**Package 2**
Scenario E	**Package 1**	**Package 2**	**Package 2**

Please note that the rate of development was as per the delivery rates noted earlier in the report.

6.3 The three roadmaps

The CGC development spans 2022-2036 and beyond. During that period, different delivery rates in terms of new housing and non-domestic buildings will be achieved each year. At the same time, more changes are expected to be introduced within the Building Regulations in 2025 and 2030[55].

These include the new Part L 2021 (not issued yet), the government's commitment to the 2025 Future Home Standard, and a further upgrade of the building regulations in 2030.

Having a robust plan moving forward and receiving feedback from previous development phases is key to the scheme's success. Based on the packages and scenarios modelled, three roadmaps were examined for CGC (Table 30).

All three roadmaps lead to the strictest criteria and thresholds being present during 2030-2036. For reference, the expected delivery rates as percentages (%)[56] are shown in Figure 9.

Building type	Current - 2025	2025-2030	2030-2036
Housing	10%	25%	65%
Non-domestic	12%	31%	57%

Figure 9 - Delivery rates - CGC - during the three development phases as aligned with expected changes within the relevant (energy and carbon, Part L) building regulations

Please note that the roadmaps are based on expected energy demand and generation levels of the development. Increased insulation levels and MVHR units have been used within the building models to reduce heating energy demand.

Additional design solutions, including passive solar design measures, optimisation of form and layout, the use of thermal mass and other such solutions following best practice, should always be considered. Please follow latest industry and regulatory guidance for their assessment and evaluation.

[55] Building regulations deliver an update around every five years. It is therefore expected that post-2025 and the Future Homes Standard another update will be introduced in 2030.
[56] As estimated from Section 5: Analysis of new proposals for predictions, based on delivery rated proposed

Table 30 - Roadmaps for the different scenarios.

	**Minimum NCGC standards**: Represent forward thinking minimum standards that algin with achieving reasonable level of energy efficiency (see Table 37 and Table 38)
	**Zero carbon**: Represent standards required to achieve net zero carbon (see Table 37 and Table 38)

Zero Carbon – Roadmap 1

This roadmap follows some of the latest thinking and best practice in construction of net zero carbon buildings. In effect, this roadmap applies the higher end standards from the start of the CGC development. Alignment with scenarios:

- Housing, Scenario D
- Non-domestic buildings, Scenario C

Higher standards for housing as in the case of Package 4 represent the highest end of standards. Considering they include GSHP and large battery stores, it is an option for achieving higher performances. A minimum Package 3 housing level of performance was considered appropriate.

Towards Zero Carbon – Roadmap 2

This roadmap follows some of the latest thinking and best practice in construction of net zero carbon buildings at later phases of the development (2025-2030, 2030-2036).

In effect, this roadmap allows for trialling some lower standards first (current to 2025), obtain feedback and gradually build to the higher standards. Alignment with scenarios:

- Housing, Scenario G
- Non-domestic buildings, Scenario E

Towards Low Carbon – Roadmap 3

This roadmap follows some of the latest thinking and best practice in construction of net zero carbon buildings at the latest phase of the development (2030-2036).

In effect, this roadmap allows for trialling some lower standards first (current to 2030), obtain feedback and gradually build to the higher standards. Alignment with scenarios:

- Housing, Scenario F
- Non-domestic buildings, Scenario D

7. Modelling and research outputs

Short introduction:

Section 7 provides responses to several questions (Q5-Q11) covering considerations around local network constraints, the different road maps that CGC can follow as well as technology options available.

The energy and low-carbon standards introduced within this report allow for design flexibility and a variety of installed services. The models used for the evaluation included heat pumps (air and ground), MVHR, PV and energy battery systems. These are all discussed within this section, along with some other potential technologies that were not included in the models.

The current power constraints will be defined by the peak load expected from the CGC development. As more and more buildings will be delivered within the development period, the standards used in these buildings will play a key role as to overall energy demand and network response. In general the less energy demand is required from the development (Roadmap 1), the less is required from the electricity gird (22MVA).

In terms of new technologies, these need to align with the principles of energy efficiency and low carbon. No fossil fuel-based technology should be used within the development as this will lead to hard to offset carbon emissions. All electric solutions such as heat pumps (all types) can be used to deliver heating and hot water with reduced energy inputs.

Other technologies, such as mechanical ventilation heat recovery systems and waste water heat recovery systems, should be used to recover energy that might otherwise be dissipated to the external environment. This will lead to further reductions of energy demand from the grid.

Energy generation was explored in the sense of roof-mounted PV, while energy batteries and hot water stores were used in the different models produced for some renewable energy direct use.

In terms of benefits, drawbacks and constraints of the different new and emerging technologies, it is strongly advised that their merits are reviewed during the planning application process. The duration the development spans, the preferred government direction (sustainable and net zero), along with recent advancements in construction methods and technologies all mean that the industry will experience a continuous development and upgrade.

It would be limiting and pre-empting to create bias towards certain solutions. The solutions proposed will need as minimum to be warranted and reviewed carefully in terms of their overall impact on carbon emissions, energy demand reduction, running and lifecycle costs and carbon, cost to the user, other challenges as in the case of ease of access, skills and knowledge, maintenance requirements, and environmental and cultural impacts.

Indicative lives of the technologies included within the different building models is provided. Not all systems, materials and combination of technologies can be covered in terms of lifecycle requirements within this research, individual assessments will need to be conducted at each phase of the development depending on the solutions put forward.

As discussed in more detail, individual building solutions, interacting on energy generation and use levels through a decentralised grid, are suggested for CGC. This would maximise the use of the different building’s footprint, will allow for certain level of performance monitoring and the trial of solutions with early feedback provided for future development phases. Solutions proposed in the models with the study are therefore a good way forward.

Q11 refers to a lot of items that are heavily dependent on master planning and detailed design decisions. General good practice information has been provided.

7.1 Summary of findings – Section 7

Section 7 - Links to Q5, Q6, Q7, Q8, Q9, Q10, Q11
Q5. What are the current power and network constraints within the locality that may affect the nature of the design and phasing of development to meet our zero carbon and climate resilient objectives? Q6. What future energy scenarios and carbon reduction pathways to zero carbon should we be designing to and what are the most relevant data and evidence bases on which we should be relying? Q7. What renewable and low-carbon energy technologies are available as alternatives to conventional technologies for the residential, employment, retail and other land-uses listed above? How is this expected to change over the plan period to 2036 and beyond? Q8. What are the energy storage opportunities associated with the available energy generating technologies? Q9. What are the benefits, potentials, drawbacks and constraints e.g. financial, environmental, cultural etc of the renewable, low carbon and energy storage technologies identified in question 7 and 8? How can any risks be mitigated? Q10. What are the maintenance and operational needs and life expectancies of the identified technologies? Q11. What are the opportunities for renewable and low-carbon energy schemes, alone or in combination with each other or with conventional technologies for North East Chelmsford? What will be the benefits for North East Chelmsford? What would need to be considered and when, for example: a. Size, location, minimum and optimum land use and density requirements for renewable, low-carbon and decentralised energy schemes and other supporting facilities b. Key design issues of renewable, low-carbon and decentralised energy schemes (e.g. screening, enclosures, buffers, security, access) c. Site constraints (eg typography, utility cables and services, compatibility with other land uses) d. Costs of providing new renewable, low-carbon and decentralised energy schemes, their capacities and efficiencies e. Fuel sources if applicable for the schemes identified including their availability, reliability, cost, carbon impacts etc. f. Engagement with key stakeholders (eg commercial companies, local communities, etc.)

Section 7 - Evidence and summary response

The current power and network capabilities were reviewed against the phased development energy demand predictions as derived for the three roadmaps (all electric). The main challenge identified is the security over supply during the whole development programme. Unless capacity is purchased and committed upfront, the amount available will depend on electricity grid (UK Power Networks) station availability at the time required.

A detailed review of future energy scenarios is undertaken within Section 8 of this report. Main design principles include minimise energy demand using a fabric-first approach (heating load); minimise energy demand using energy-efficient systems and appliances (regulated and unregulated energy total per year); maximise (cost-effectively and technologically robust) on-site renewable energy generation and store.

Currently, renewable and low-carbon technologies most appropriate for the site include photovoltaic panels, passive and active heat recovery systems, heat pumps and energy stores. Recent trends indicate that these tested technologies will remain key for delivering net zero carbon. Changes are expected in the sense of efficiencies achieved, advanced interfacing and supply-demand controls.

Hydrogen systems are not reviewed as part of this study. Nevertheless, green hydrogen production and therefore associated hydrogen ready and hydrogen boilers could also scale up. Energy storage includes electricity storage (batteries), heat stores (hot water tanks, phase changing materials) and other new and emerging technologies (pressurised gas systems and other). What is common between all these technologies is that they need to be ‘charged’ either through the electricity from the electricity grid and/or from renewable energy generation.

It is well established that there is not one strategy that can lead to meeting the targets (energy and carbon) included within this study. The overall direction of all electric solutions entails the use of renewables, heat pumps and improved construction standards. Each development phase will need to be reviewed at the time of the planning application on the proposed strategy’s merits. Risks can be mitigated by requesting for additional transparency within decision making processes, developers to undertake whole life (where appropriate) and lifecycle (most used currently) assessments and report on findings.

Within this research, technologies used as possible solutions to achieve high energy and carbon efficiency performance targets included heat pumps, mechanical ventilation heat recovery systems, electrical batteries, photovoltaic panels and larger hot water stores. Expected lives of these technologies are reported in more detail within the current section.

Please note, whole lifecycle and lifecycle cost, carbon and energy assessments were not undertaken and reviewed within this report as there is a huge number of solutions and combinations that can be used to achieve the same targets. It is strongly recommended that a requirement for whole life and lifecycle assessments is introduced for CGC, at least from 2025 and onwards if not earlier.

Current research outputs indicate that maintaining the targets and measures on a ‘per individual building’ level is simpler and ‘easier’ to deliver. Decentralised networks, local smart grids with external storage, power centres and so on would require detailed assessment for each proposal and a detailed business case enabling stakeholders to identify best value, impact, risk and interfacing within existing infrastructure. What is key is to introduce quality assurance requirements, accompanied by energy performance monitoring (random sample or whole development plan), of new technologies, relevant infrastructure and buildings early in the process to establish appropriate feedback loops.

7.2 Overview of the responding approach and detailed responses

Question 5 refers to current power and network constraints within the locality. To respond to this question, several future scenarios in terms of standards and technologies that can be used both in new housing and non-domestic buildings were assessed.

As agreed with the CCC planners, two peak loads – in scenarios involving all electric solutions – were produced. These were issued to UK Power Networks (UK PN) to advise on current network capacity availability and are included inAppendix C – UK PN Quotes.

Based on the 'Zero Carbon' (Roadmap 1) and 'Towards Zero Carbon' (Roadmap 2) (see Table 30), the overall site electricity requirements would be:

- 22MVA – One single point of connection (PoC)[57] preferred. This will likely be at 33kV[58] or higher and warrant the construction of a new Primary Substation but may reduce offsite works by only having one PoC to connect to (Roadmap 1).
- 27.5MVA – Multiple smaller PoCs preferred. This should reduce the likelihood of a Primary Substation being required but may prove inefficient if the POCs are very spaced out or there are too many to be practical (Roadmap 2).

The cost for both loads was estimated at £5,300,000.00 (exclusive of VAT) if the POC is at UK PN's BR Springfield Grid Substation.

It needs to be noted that UK PN assessments are valid for three months post-release and that the evaluated capacity was not secured at this stage. This means that post-three months of the study the network status and availability will probably be different.

Unless the total capacity required for the whole development – up to 2036 – is secured in advance, and respected in terms of building requirements, each phase of the development will have to evaluate power and network constraints at the time of the development of that phase.

Question 6 refers to the future energy scenarios and carbon reduction pathways to zero carbon, as well as to provide a reliable evidence base. As noted within Section 5 of this report, government policy announcements, white papers and industry reports all reiterate the importance of reducing energy demand and carbon emissions from buildings. It is expected that by 2025 buildings will move away from using gas and fossil fuels and transition to less carbon intense and all-electric systems supplied to a large extent with renewable energy.

Question 7 refers to renewable and low-carbon energy technologies as alternatives to fossil fuel-based systems. It also poses the question as to which new technologies might emerge post-2036.

Current report models produced for buildings within CGC included technologies such as heat pumps (air and ground), MVHR units, photovoltaic panels, battery energy stores and hot water cylinders. The selection was based on our experience with the current state of the market, existing supply chains, skills and knowledge availability in terms of these technologies as well as latest technology trends. For modelling purposes only, we have assumed that each individual building will be supported by such technologies independently (no communal system considered).

Current report models accounted both for regulated energy use (energy needed for heating, hot water, installed services and lighting), as well as unregulated energy (energy needed for computers, small appliances, specialist equipment and other, typically relating with the type and expected use of the building and occupier).

[57] PoC: connecting to the main electricity grid
[58] In the UK, 33kV is the standard primary distribution voltage

It needs to be noted that there are several possible technologies leading to interconnectivity of buildings with cars/and or blocks of buildings and other such approaches, all of which can be used if the energy hierarchy is respected within CGC. For example, connecting battery stores in buildings with electrical vehicle (EV) charging points and using the EV as an extended battery to the house at time of need. As new technologies emerge, future CGC development should not be limited to consider the construction approaches assumed for the different building models used within this report but should allow for innovation. New solutions should meet the energy demand and generation thresholds proposed within this report and respect the energy hierarchy.

Following the energy hierarchy includes reducing overall energy demand, starting with a fabric-first approach (impact on heating energy demand), using highly rated energy-efficient services (heating, ventilation, lighting and hot water) and appliances, using mostly electricity, maximising renewable energy generation, store and use on-site.

Existing technologies can deliver the required net zero energy and carbon savings. These include the use of heating systems such as heat pumps, in combination with a very efficient building fabric, passive technologies like waste water heat recovery and mechanical ventilation with heat recovery systems and on-site renewable energy generation.

Outlook

Innovation is expected to derive mainly from optimising current systems performance and controls, while scaling up new technologies offered today. It is also expected that the way that the different installed systems interface with each other will be of significant importance.

Moving forward, considering recent industry trends and commitments, monitoring and measuring the performance of the delivered buildings during operation will become critical to identify how targets imposed during design were translated and how effective they were.

Next steps for government and the construction sector are likely to include moving to whole-life energy, carbon and cost assessments of the proposed technologies to ensure that the solutions occupied to deliver operational net zero carbon do not defeat the purpose by having an intense negative carbon and environmental footprint themselves.

While specific technology approaches are not explicitly recommended by changes within the Building Regulations, two changes to Part L are expected if the five-year Building Regulation update cycle is respected to 2036. It is envisaged that new buildings will consume less than half of the energy they require today by 2030, while carbon emissions will be reduced by a minimum of 80% during 2025-2030. That leads to an indirect push for all-electric solutions.

All-electric solutions are expected to have an impact on operational, running, energy costs if substantial energy demand reduction is not achieved (electricity prices currently are 4-5 times higher than gas). To avoid such an impact on the occupants' living experience, energy demand reductions should become a priority for CGC, while compensated by substantial amounts of renewable energy on site.

Renewable energy generation on site should be able to connect with energy stores, which maximise direct use on site at times of peak demand. They should also enable taking advantage of low-cost tariffs, so stored energy can be used during the times of high expected energy consumption and prices.

It needs to be iterated that these new technological approaches might suffer from supply chain unavailability and limitations in local skills and knowledge (install, repair, management, replacement and adjustments).

To keep a good record of solutions used and the performance achieved during the different CGC development phases, the introduction of a strong quality assurance framework/toolkit is recommended. As mentioned in other areas of the report, monitoring performance and establishing a good understanding of the delivered standards and actual performance of buildings is strongly recommended.

The effects of the different standards on the energy use of the buildings can be reviewed through building type sample monitoring and sub-metering or the use of smart controls with feedback outputs. Smart meters will also play a part in establishing the right feedback loops[59]. The monitoring duration should be kept in alignment with house warrantees with a two year minimum.

It is generally advised that developers use building information modelling, offer building manuals, and produce accurate detailed records of what has been installed within the property as part of the building handover process.

Question 8 refers to energy storage opportunities associated with the available energy generating technologies. During this research, several improvement scenarios were developed for the different expected new buildings (types and sizes) within CGC.

Energy stores were assigned to each building for the purpose of detailed energy modelling in this study, with impact analysis on running costs and peak energy demand undertaken too. Both heat and electricity energy stores were used in the different scenarios.

Energy stores can be used to:

- Store energy generated (heat, electricity) at times when renewable energy on site generation peaks and cannot directly be used at the time of the generation.
- Store cheaper energy during different electricity tariffs for later use. Also assist in smoothing peak load energy demand from the electricity grid.
- Support interconnectivity between electric vehicles and buildings (electricity storing batteries only).

What is not explored within the study is the potential for centralised systems, outside the boundaries of the different buildings reviewed. Energy store systems were assigned individually to each building.

Centralised options are not currently common and would raise the complexity of assessed models and financial complications on operational, management, controls and scale elements.

If this is an option recommended by either CCC or developers moving forward, detailed analysis will need to be conducted to produce technical details and the business case for such an investment. This also applies for connections between buildings and vehicles (electric) and more complex decentralised energy models.

Centralised energy store systems are more easily accessible for repairs, replacement and maintenance and can alleviate some of the health and safety risks[60] associated with some of the technologies installed within buildings.

Energy storage options can also be specific to the building or block of buildings within a development phase or a particular development area. As with centralised systems the user/owner, occupier or managing agent will be responsible for such systems.

While there is a plethora or options and managing strategies, the most appropriate for CGC will need to derive from the evaluation of viability assessments, technical reports and system

[59] By tracking design, construction development and in-use performance of a number of new CGC buildings, collating and reviewing the information against the initial objectives in order to extract messages to be used in future phases
[60] Domestic battery energy storage systems - GOV.UK (www.gov.uk)

information provided at the different development phases and the development of appropriate business cases supported by lifecycle assessments.

It needs to be noted that electricity store solutions (batteries) can have a limited life, or their performance can be compromised after a certain number of charging cycles.

These additional costs, along with the costs of the appropriate demand supply and store control systems, system interfaces[61], data stores, space for the battery units and variations between the different system setups can all contribute to different installation, management and operational approaches.

New and emerging technologies, as in the use of compressed atmospheric air for energy stores, production of hydrogen and other[62], are still emerging and are not advised to be currently implemented unless there is an appropriate insurance and liability framework established.

In summary, all energy store systems, and opportunities, will need to be assessed on their merits at the time of the suggested implementation, considering the totality of the development and the impact onto energy demand, peak load, running cost and environmental impact.

Question 9 refers to the benefits, potentials, drawbacks and constraints, eg financial, environmental, cultural, etc, of the renewable, low-carbon and energy storage technologies identified in questions 7 and 8, as well as to how any risks can be mitigated.

Power purchase agreements (PPAs) can provide significant benefits for financing renewables and low-carbon energy schemes, offering greater budget certainty, price discounts and greater transparency. PPAs can drive project profitability by reducing cashflow uncertainty and increasing the security of returns on investment.

A PPA is a long-term contract to buy electricity generated by a renewable energy installation. The contracts are arranged between the buyer, an electricity supply company or third party, and the seller – the owner or developer of the installation.

There are several different PPA options in the UK market. The Contracts for Difference (CfD) scheme is the government's main mechanism for supporting low-carbon electricity generation. The CfD incentivises investment in renewable energy by providing developers of projects with high upfront costs and long lifetimes with direct protection from volatile wholesale prices.

The utility company Engie offers short-term PPAs for solar, wind, combined heat and power (CHP), anaerobic digestion and other technology energy generation. If regular, predictable volumes are exported to the grid, fixed price or flexible contracts to access market-reflective prices are available. Further guidance on PPAs has been issued by the Crown Commercial Service in July 2020 and is available here: https://assets.crowncommercial.gov.uk/wp-content/uploads/Power-Purchase-Agreements-PPA-An-Introduction-to-PPAs.pdf.

We have already included all-electric solutions in the housing model that can be occupied to achieve the higher energy and carbon performance targets suggested. These include a combination of MVHR, heat pumps (air and ground), PV and electrical batteries.

Based on the location of the site and its nature (urban environment), individual building solutions were selected over larger installations. Large installations, as in the case of wind turbines, can increase noise levels within the area and increase the complexity of the electrical decentralised distribution network. Also, outputs would need to follow the needs and requirements of the phased CGC development.

[61] System interfaces: the way battery systems connect with other technologies installed within the house
[62] Fuel cells, new types of untested batteries, new cabling types and anything without a warranty

Each building within CGC must be able to maximise its energy demand reduction and maximise its positive contribution to its own energy balance, as also to the overall energy peak demand from the development.

For those reasons we used heat pump technology in our models, an all-electric solution that follows the grid decarbonisation. At the same time heat pumps can deliver a multiple of the energy input as heat output (heating and hot water) due to their high coefficient of performance (COP). Combined with MVHR units and high insulation levels, they ensure that energy demand is minimised, and outputs are maximised. Any heat pumps used within the CGC development must follow the latest guidance on refrigerants and allowed leakage. Having individual systems installed in each building means that the responsibility of the quality of the installation goes back to the developer. The owner/occupier also has full control and responsibility over the systems operation/maintenance and checks. The footprint of the install is also kept to the minimum, especially with the PV roof coverage which maximises the opportunity for energy generation without requiring additional space.

Finally, the risk of major system failures that would affect several buildings is minimised since each building has their own systems installed within. Additional decentralised controls looking into group of buildings surplus renewable energy generation providing to vehicle charging points, or adjacent buildings with high energy demands (e.g. pools) can be assessed on their benefits and be installed on site.

CGC development follows at least a 14-year schedule, during which time new technologies, guidance and construction methods might be developed and used. Future solutions will need to be reviewed against the benefit they offer to the environment (low/no carbon), to the user (running cost), to the community (cost and overall environmental benefits) and to the overall energy system (electricity grid).

Question 10 refers to the maintenance and operational needs and life expectancies of identified technologies (on the journey to net zero).

This is interpreted as an inquiry for additional information in terms of lifecycle assessments and common technologies used. Undertaking a lifecycle assessment (cost or carbon) reveals invaluable information in terms of outlook of material and system construction selections.

Lifecycle assessments include the evaluation of materials and systems in terms of expected life, interim repairs, replacement and maintenance requirements. Latest information is included within relevant guidance (eg CIBSE Guide M[63]) and is frequently updated.

Mechanical systems and components proposed by developers and consultants for CGC will need to be evaluated on their merits as part of planning applications.

The expected life of mechanical and electrical (M&E) technologies that have been used within this study are provided within Table 31.

[63] Guide M: Maintenance engineering and management (2014), CIBSE - Building Services Knowledge

Table 31 - Lifespan of renewable energy and low-carbon M&E solutions used within the research models

Technology	Reference service life (RSL) (years)	Source
Photovoltaic devices	25	CIBSE Guide M
Ancillary cables, wiring, conduits	15-20	CIBSE Guide M
PV string inverters	5-10 warranty	Literature review
PV micro inverters	15-25	Literature review
Air supply and extract systems	20	CIBSE Guide M
Grilles, fans, filters and other ancillary components	10	CIBSE Guide M
Heat pumps	15-20	CIBSE Guide M
Solar and home batteries	10-15	Literature review

Minor and major repair and replacement cycles, predictive and reactive maintenance as well as potential local skills, supply chains and knowledge all need to be evaluated when undertaking a new development proposal within CGC, especially when the systems proposed are not common within the region or hugely differentiate from adjacent development.

This is of particular importance during the stages of detailed designs, especially if individual building systems are expected or proposed to interface with community infrastructure measures.

Not all systems, materials and combination of technologies can be covered in terms of lifecycle requirements within this research, individual assessments will need to be conducted at each phase of the development depending on the solutions put forward.

Main points to consider when examining recommended solutions:

- Have appropriate lifecycle cost and carbon assessments been undertaken?
- Have sensitivities[64] been identified as in the case of replacement of systems (value engineering) during construction? (Impact on lifecycle, cost and carbon.)
- When reviewing lifecycle – it is not only lifespan that one needs to look at but also replacement, repairs and overall maintenance impact. Have these been evaluated and assigned to the responsible person?
- Lifecycle assessments refer commonly to the ‘operational’ stage of a building’s life. Whole-life energy, cost and carbon assessments might be required at future development stages - following latest industry thinking and potential policy direction.

[64] The impact of change on certain objectives, eg using a product of similar specifications but not the one specified originally. Would that affect, how and by how much the energy reduction targets set?

Q11 refers to the opportunities for renewable and low-carbon energy schemes, alone or in combination with each other or with conventional technologies for North East Chelmsford. What will be the benefits for North East Chelmsford? What would need to be considered and when, for example:

a. Size, location, minimum and optimum land use and density requirements for renewable, low-carbon and decentralised energy schemes and other supporting facilities
b. Key design issues of renewable, low-carbon and decentralised energy schemes (eg screening, enclosures, buffers, security, access)
c. Site constraints (eg topography, utility cables and services, compatibility with other land uses)
d. Costs of providing new renewable, low-carbon and decentralised energy schemes, their capacities and efficiencies.
e. Fuel sources if applicable for the schemes identified including their availability, reliability, cost, carbon impacts, etc
f. Engagement with key stakeholders (eg commercial companies, local communities, etc)

a. Current research utilised several building models, adapted to reflect latest thinking and best practice in terms of net zero energy and low-carbon technical approaches. As noted earlier within this report, and as explained in more detail within the next section, these include energy demand reduction, renewable energy generation and energy store measures.

Local CGC renewable energy generation will mainly include the use of photovoltaic panels. This is common in mixed-used developments as panels can easily be mounted/integrated to roofs. The space requirements therefore fall within the footprint of the building, maximising available land.

As photovoltaic panels would need to maximise their annual yield, it is important that both highly efficient panels are used as well as optimum orientation is achieved (south facing). If optimum orientation is not possible through architectural design, other orientations and higher roof coverage rates should be considered to achieve sufficient levels of on-site renewable energy generation as per the guidance provided within this report.

Battery and hot water store systems used within the building models were assigned within the buildings' footprints. This was due to maintenance, responsibility and individual performance monitoring reasons.

b. Getting to net zero energy/carbon required several systems and solutions to be used together or in parallel to achieve the targets set. Key design challenges for renewable, low-carbon and decentralised energy schemes should not be viewed in isolation and from a 'theoretical' point of view.

It should be the responsibility of the developer to provide to CGC enough information on design choices, benefits and risks prior to commencing any detailed work on site. The number of building typologies expected on-site (housing and non-domestic) means that systems selected will vary in terms of technologies' uses, size and operations.

It would not be possible to list or explore design challenges at this stage of the CGC project. These should be documented and reviewed on an individual application basis.

Cross-cutting considerations should include:

- Avoidance of use of fossil fuel-based systems
- Longevity of solutions (whole life/lifecycle)
- Impact on peak load demand and energy cost
- Ability to monitor systems performance
- Owner, operator and manager responsibilities
- Complexity of operation and key audience

c. As with design concerns, site constraints will vary between the different options selected. Nevertheless, the systems selected for modelling within this report are not affected directly by the site topography and other unique characteristics.

Achieving net zero does not rely on one technology, construction method or system. It needs to be made clear that for each development phase an options appraisal needs to be undertaken in terms of design and M&E systems suggested for that phase.

d. Capital and operational (running energy) costs are covered within Section 9 of this report for all technologies and building types reviewed during the research. These outputs are specific to the design and service strategies used within the different building models.

As application of technologies like heat pumps scale up, and new technologies come to the market, costs will keep decreasing for most low-carbon system solutions. What is of extreme importance is the protection of the user/consumer towards high running costs both in terms of energy bills as well as maintenance/repairs and replacement costs.

An assessment of such an impact, compared to a baseline/building regulations-compliant building (in terms of running cost) should always take place during options appraisal stage.

Such costs also apply to owner/operators of decentralised community-based system proposals (where the owner is a commercial partner, public/private partnership and/or CCC). In the case of large-scale commercial use technologies, the development of detailed business cases is highly recommended.

e. To achieve a net zero carbon status, except from minimising energy demand, it is also critical that the energy source used does not have a large carbon footprint. What this means is that combustion/gas and other fossil fuels are not a viable option if net zero carbon is to be achieved. This is since the remaining carbon footprint will have to be offset either on site or in another location, with the offset checked in terms of viability, robustness, additionality, and several additional complexities that derive from using carbon offsets[65].

It is expected that the simplest, most effective and robust way of meeting a net zero carbon status would be for CGC developments to utilise all-electric solutions, except for potential growth of green hydrogen networks and back-up generators and power plants that might be required within certain building types.

f. Key stakeholders will need to be engaged early on, with the exact plans for CGC explained to them (net zero). They also need to be informed about the potential move to all-electric solutions and additional research and monitoring requirements that will need to be addressed during detailed design.

The current report provides a lot of information on expected levels of energy demand from the development, standards to be used to achieve those, as well as information on what will need to be considered (lifecycle cost and carbon, peak load and other).

In the case of centralised systems and networks, these need to be examined and detailed within this exact scope.

The impact on local communities and prospective building occupiers should always be examined. This needs to include the expected running costs, maintenance costs and usability of systems installed.

[65] https://www.ukgbc.org/ukgbc-work/renewable-energy-procurement-carbon-offsetting-guidance-for-net-zero-carbon-buildings/

The development's 'green' 'sustainable' and 'net zero' credentials should be presented and supported by strong data, while architectural designs should follow the garden Community principles.

Additional benefits expected to be realised for communities by using all-electric solutions (and cars where possible) include reduced air pollution, noise and options around smart energy networks.

More detailed studies will be required to ensure that maximum benefits are realised, and important elements are not overlooked. These studies and assessments would be best placed when more information on designs and solutions suggested for the different development phases becomes available.

8. Energy and carbon future performance – predictions

Short introduction:

Section 8 includes all energy and carbon results from the housing and non-domestic models. Several scenarios and options have been analysed, as described within Section 6.

The number of scenarios developed were:

- Housing: A baseline (Scenario A – compliant with current Part L 2013 of the Building Regulations) and six additional scenarios were developed for housing. From the six additional scenarios, scenarios B-E provide a gradual, between the scenarios, performance improvement using the same standards across the whole development period (Scenario E highest standards used today). Scenarios F and G included a stepped approach to achieving higher performances (please refer to Table 32).
- Non-domestic: A baseline (Scenario A – compliant with current Part L 2013 of the Building Regulations) and four additional scenarios were developed for housing. From the six additional scenarios, scenarios B and C provide a gradual, between the scenarios, improvement using the same standards across the whole development period (Scenario C highest standards used today). Scenarios D and E included a stepped approach to achieving higher performances (please refer to Table 34).

The different results as tabulated within Table 32 and Table 34 were reviewed against a number of parameters and are provided in detail. Parameters used total energy consumption per year for development, impact on peal load demand, total carbon emissions calculated following both the regulatory compliance and a ‘stepped’ carbon factor approach. Results are provided with and without the impact of PV, so the benefits of onsite renewable energy generation and higher standards used during construction are separated and considered on their individual bases and the significance of renewable energy generation on site is demonstrated clearly.

Please note that mobility, part of question 2, is not explored within the report. It is advised that a separate study is conducted based on renewable energy generation and overall layout master planning decisions to allow for such a review to be conducted (electric vehicles, walkable distances, charging points, etc).

8.1 Summary of findings – Section 8

Section 8 - Responds to Q2, Q6
Q2. What is the anticipated demand for energy for power, heating, cooling and mobility for all the proposed lands uses in North East Chelmsford and how is the demand expected to change from the early phases of the development and over the plan period to 2036 and beyond in view of the above? Q6. What future energy scenarios and carbon reduction pathways to zero carbon should we be designing to and what are the most relevant data and evidence bases on which we should be relying?

Section 8 - Evidence and summary response

Six scenarios were developed for future housing energy and carbon performance predictions, and four for non-domestic. Baseline scenarios were developed for both too (compliant with Part L 2013 of the Building Regulations requirements, current legal minimum requirements).

The scenarios were based on four proxy measure packages for housing and two for non-domestic development. These were noted and detailed within 0

The technologies primarily used within the study included heat pumps, photovoltaic panels, hot water stores and electricity energy stores. The use of these systems was complementary, and results achieved could not have been realised within the combination of these systems.

A net zero carbon (operation only) scenario can be achieved in all-electric solutions only if the energy consumption per year equals the annual generation of installed renewable energy systems as in the case of PV or if the ‘net’ element is used to offset carbon emissions off site.

When operational net zero carbon is sought, unregulated energy should be considered, as shown within the sections results.

Total energy demand thresholds and predictions for each building type and development phase will need to be provided. For net zero carbon these need to be in alignment with Table 37 and Table 38.

If other performance targets are sought these need to be explained in detail, with impact on overall expected CGC performance calculated and stated.

There is a requirement for energy generation on-site if net zero carbon is to be achieved. Current results indicate that a large portion of the roof area of new houses will need to have PV installed (Table 33). Similar findings are also noted for non-domestic (Table 35).

Depending on the building standards used at each phase of the CGC the renewable and electricity grid requirements will vary.

It is strongly advised that new development performances are monitored (representative sample of buildings or all buildings) to inform the design and standards of future phases for at least five years.

8.2 Energy and carbon emissions - during operation

This section includes energy and carbon emission predictions for CGC as per the scenarios evaluated. In general, energy demand during operation should be considered in the sense of:

- Energy demand at peak[66] (peak load) - which defines the capacity required from a larger network (national gas/electricity grid)
- Total energy demand per year - which defines the cumulative amount of energy that will be demanded from the site per year (net balance, consumption and generation)
- Type of energy consumed/produced - energy source/type affects the carbon footprint of the development (current research included operational energy use only - does not include lifecycle and embodied carbon impact)

Total energy demand per year needs to include all energy use types, which includes both regulated and unregulated use.

Regulated energy use is the expected energy use during the operation of the building, which includes heating, cooling, hot water demand, lighting and fixed services energy use. This is described as regulated as it is reported for compliance purposes within the Building Regulations.

Unregulated energy use is how much energy the user of the building is expected to use for running appliances and plug loads, elements relating to lifestyle choices and includes for example electronics, white appliances, etc.

8.2.1 Housing development

8.2.1.1 All scenarios – performance overview

Modelling results in terms of the housing development contributions to the future energy and carbon performance of the CGC are provided within Table 32.Information on packages used can be found within Section 6: ‘Energy and carbon modelling approach’, Table *26* and Table *27*.

[66] Highest average demand

Table 32 - Housing - energy and carbon scenarios outputs
A traffic light system is introduced with dark green achieving best under the different categories and red achieving worst. The evaluation is conducted based on a net zero carbon target.

	Energy consumption without PV (MWh)	Energy consumption with PV (MWh)	Peak electricity demand increase (kW)	Carbon emissions (TCO2[67] over 60 years)- stepped	Carbon emissions (TCO2 over 60 years) - flat	Carbon emissions (TCO2 over 60 years)- NO PV stepped[68]	Carbon emissions (TCO2 over 60 years) NO PV - flat
Scenario A (Baseline)	23,954	23,954	n/a	242,566	242,566	242,566	242,566
Scenario B (Package 1)	18,903	15,076	5,980	168,370	45,701	180,770	58,101
Scenario C (Package 2)	13,711	9,884	5,980	84,365	32,023	96,765	44,423
Scenario D (Package 3)	9,523	-1,104	2,550	-3,578	-3,578	30,855	30,855
Scenario E (Package 4)	7,789	-2,838	1,940	-9,196	-9,196	25,237	25,237
Scenario F (2, 2 ,3)	10,969	2,690	3,340	26,791	8,716	53,616	35,541
Scenario G (2,3,3)	9,912	-83	2,610	4,596	-270	36,982	32,116

The peak electrical demand for each residential scenario has been calculated taking into consideration the systems' performance of the associated packages, as well as the diversity attributed to a development of this size.

The simple addition of the peak load of each dwelling would lead to a hugely oversized capacity, this is due to the fact every dwelling is used slightly differently, and as such the peak load in each dwelling is not coincidental. A large part of the diversity is in relation to domestic hot water production, where on a development of this scale, the coincidental peak is predicted to be less than 5% of the overall summated peaks. This means that different types of buildings will require hot water at different times of the day. Less than 5% of the overall peak demand calculated was attributed to coinciding hot water demand.

Therefore, based on well-established diversity calculations, for heating, hot water and electrical loads, we have estimated the above peak electrical loads for the development. In scenario B and C there is large increase due to the switch to electric for heating, and both scenarios have the same fabric performance[69].

8.2.1.2 Annual energy use

The total annual energy consumption per year upon CGC completion (post-2036) is provided within Figure *10*.

This is when all housing units have been completed, as per the assumptions and volumes assumed within this report. The graph does not show peak loads, but total electricity needed per year. Results include annual electricity generation forecasts from assumed PV. All scenarios have been analysed.

[67] TCO2: tonnes of carbon emissions, total over 60 years
[68] See 8.2.1.3
[69] Peak is calculated when the external temperature is -4°C, at which point to generate domestic hot water at 65°C we have conservatively estimated the efficiency to drop to 100% on the heat pump units (ASHP COP ~2, GSHP COP~3)

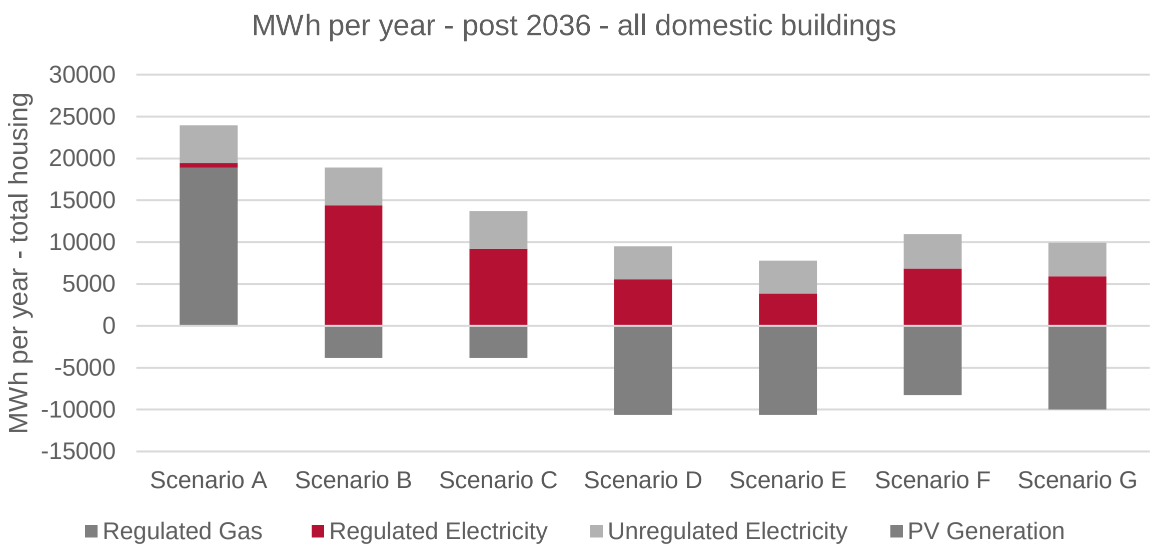

Figure 10 - Energy consumption per year, post 2036 completion - housing

Please note that the contributions of the PV generation are substantial in the case of larger PV installations and in general a large contributor to net annual total energy demand reductions. The amount of PV allocated to the different models is shown in Table 33.

The amount of PV used in the models can be used as an indicator, but please note that different housing types and sizes might have different requirements. Generally, a small PV installation can be understood as roughly 40% of roof area coverage and large PV as roughly 80% coverage of total roof areas.

This is so that the energy generation per year can compensate for a part of the total electricity demand of the house. In the case of blocks of flats, where the roof area is limited, other on-site/off-site renewable energy generation solutions would be required to be introduced. Large PV installations are most appropriate for the net zero scenarios (E,D and G).

Table 33 - Housing models - amount of PV installed.

Housing size	Small PV (m^2)[70]	Large PV (m^2)
	Total m^2	
1 bedroom	3.5	7
2 bedroom	6	12
3 bedroom	10	30
4+ bedroom	10	30

8.2.1.3 Accumulated carbon emissions – post-2036

Carbon emissions associated with the energy demand of the site have been calculated for the different scenarios. It needs to be noted that carbon emissions directly link to the energy type used and the carbon intensity of that type.

[70] The small/large PV terms are used within the context of the scenarios developed. This in effect includes small/typical, large/more than typical PV panels on the roof. Please note that 'Large PV' in the case of small houses can account for around80% of all roof space.

A carbon factor is a value that is assigned to each kWh of energy that is used by the building.[71]

A 'flat rate' carbon factor

This is a carbon emission factor that accounts for projected carbon emission reductions of the electricity grid. Over the 60 years lifespan of the carbon assessment the electricity grid carbon factor is on average 0.054 kg CO2/kWh. This aligns with a decarbonised grid with electricity generated from renewables. No matter how much electricity is used by the buildings, the same carbon factor is applied. This is a standard approach used in industry.

A 'stepped' carbon factor

This is a more detailed approach that has a variable carbon factor that depends on how much energy is used. We think this approach is more robust and should be used for decision-making processes.

There is a finite supply of renewable energy in the UK. Research by LETI[72] shows that all homes must have a maximum energy consumption of 35kWh/m2/year, for all energy consumption to be met by renewables for all homes. Thus, homes looking to achieve net zero must use no more than 35kWh/m2/year.

In this approach for residential, electricity use below the 35 kWh/m2 budget is assigned a decarbonised grid carbon factor. Any electricity above the 35 kWh/m2 budget is assigned a much higher carbon factor associated with generating electricity using a gas turbine.

It is important to note that both approaches are different from the approach used in Building Regulations that uses SAP carbon factors based on three-year average carbon factors, rather than lifetime long-term factors.

Quick review of the housing scenarios outputs

The average annual energy consumption per m^2 of the whole housing development is provided within Figure 11 for the different scenarios. The results shown were produced by estimating the total amount of energy required for each scenario per year, divided by the total gross internal floor area (GIFA) of all housing expected to be delivered by 2036. As the different scenarios introduce different packages at different points in time, these performances are not 'per type' of building or to be used as 'standards'. These are to be used for reference comparison purposes only.

Figure 12 and Figure 13 show the expected overall carbon emissions reduction predicted, post-delivery of all housing units within the CGC (post-2036), when compared to houses that comply with the current version of the Building Regulations (Part L 2013). Figure 12 shows the results using a flat carbon factor approach while Figure 13 shows the results using a 'stepped' carbon factor approach.

The flat carbon factor approach appears to 'benefit' scenarios B and C more. These scenarios do not go very far in terms of energy efficiency standards achieved but benefit from the flat carbon factor accounting method and can claim high savings. This is not the case when the same scenarios are reviewed under a 'stepped' carbon factor approach lens. In both cases, maximum carbon benefits are achieved in both scenarios E and D, which involve the net zero standards.

[71] Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal - GOV.UK (www.gov.uk)
[72] https://www.leti.london/cedg

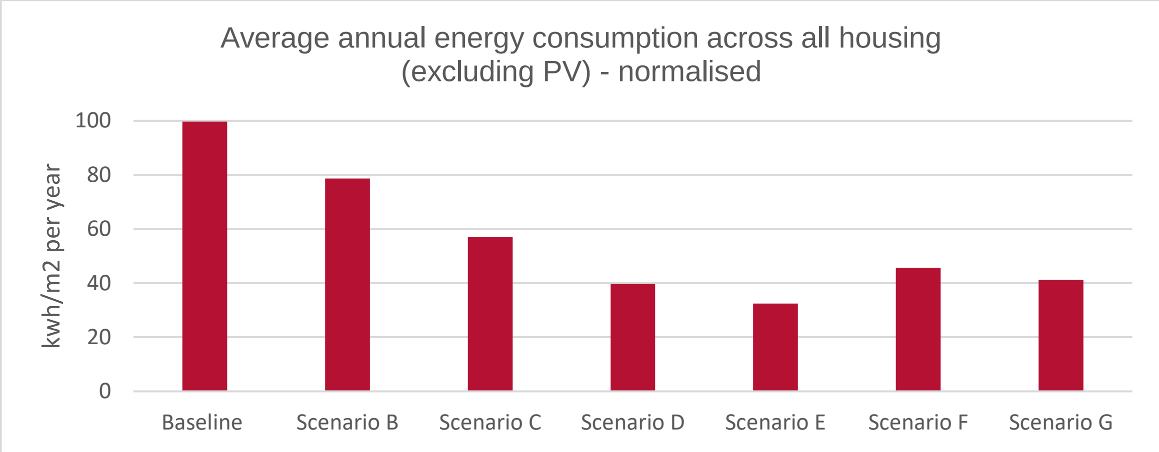

Figure 11 – Average annual energy consumption per m2 (GIFA) across all new housing.

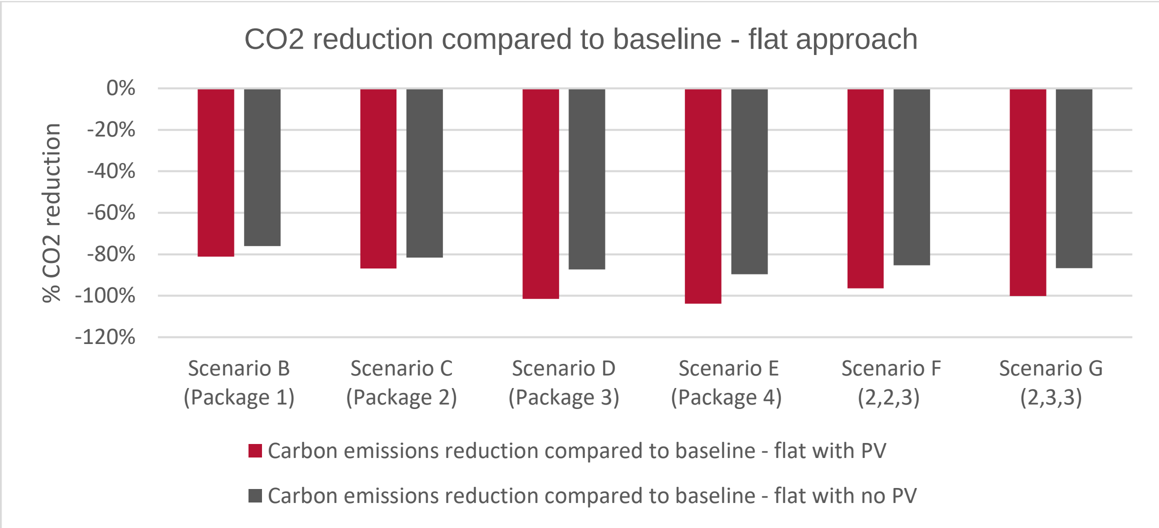

Figure 12 – Carbon emission reductions (housing) compared to a Part L 2013 baseline - flat carbon factor approach. Includes unregulated energy use.

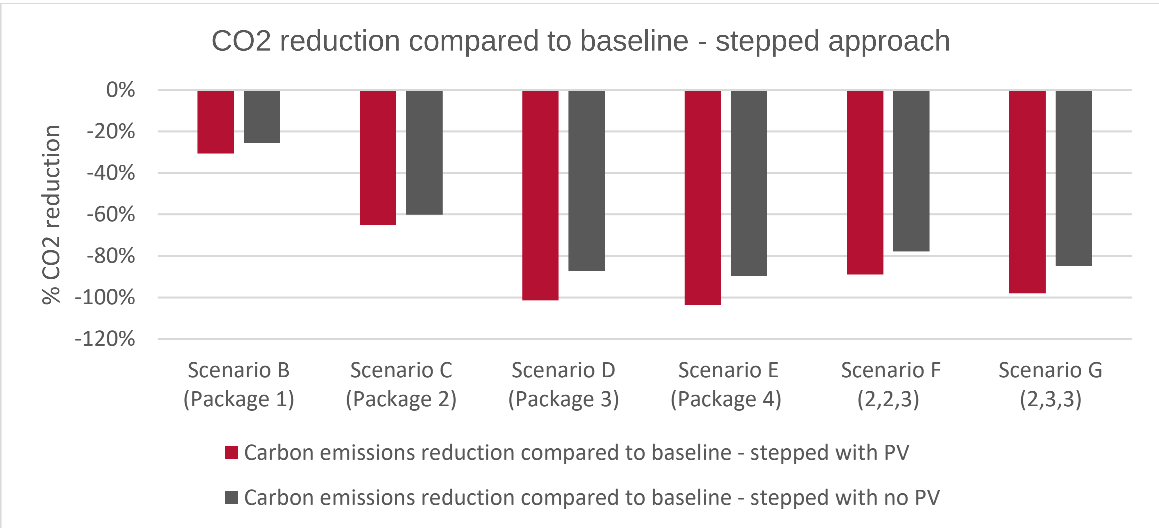

Figure 13 – Carbon emission reductions (housing) compared to a Part L 2013 baseline - stepped carbon factor approach. Includes unregulated energy use

8.2.2 Non-domestic development

8.2.2.1 All scenarios – performance overview

Modelling results in terms of the non-domestic development contributions to the future energy and carbon performance of the CGC are provided within Table 34.

Information on packages used can be found within Section 6: 'Energy and carbon modelling approach', Table *28* and Table *29*.

Table 34 – non-domestic - energy and carbon scenario outputs

A traffic light system is introduced with dark green achieving best under the different categories and red achieving worst. The evaluation is conducted based on a net zero carbon target.

	Energy consumption without PV (MWh)	Energy consumption with PV (MWh)	Peak electricity demand increase (kW)	Carbon emissions (TCO2 over 60 years)-stepped	Carbon emissions (TCO2 over 60 years) - flat	Carbon emissions (TCO2 over 60 years) - NO PV-stepped	Carbon emissions (TCO2 over 60 years) - No PV flat
Scenario A (Baseline)	14,610	14,610	0	79,805	79,805	79,805	79,805
Scenario B (Package 1)	6,907	5,238	-1,410	28,110	16,970	33,520	19,181
Scenario C (Package 2)	5,103	1,763	-3,130	5,712	5,712	16,532	10,135
Scenario D (1, 1 ,2)	6,004	3,444	-2,310	16,416	11,157	24,713	14,752
Scenario E (1,2,2)	5,292	2,135	-3,130	7,939	6,917	18,168	11,339

The non-domestic peak electrical demand for each scenario has been calculated taking into consideration the system performance of the associated packages, as well as the diversity attributed to these types of buildings. In the case of non-residential, the baseline scenario considers values that are commensurate with current common practice, which when reviewed against future net zero carbon performance is poor.

There are significant improvements made to the scenarios B-E which have a notable reduction in electrical energy usage which in turn reduces the electrical peak capacity. In the residential outputs the loads were increased due to the fact heating is delivered through electricity rather than gas.

With non-residential typologies, the heating load is a smaller percentage of total load, thus this switch to electric heating (with the use of heat pumps) has much less of an impact.

These factors combine to result in a net decrease in electrical demand when you move from the baseline package to scenario C, even with the switch from gas to electric heating considered.

8.2.2.2 Annual energy use

The total annual energy consumption per year upon CGC completion (post-2036) is provided within Figure 14.

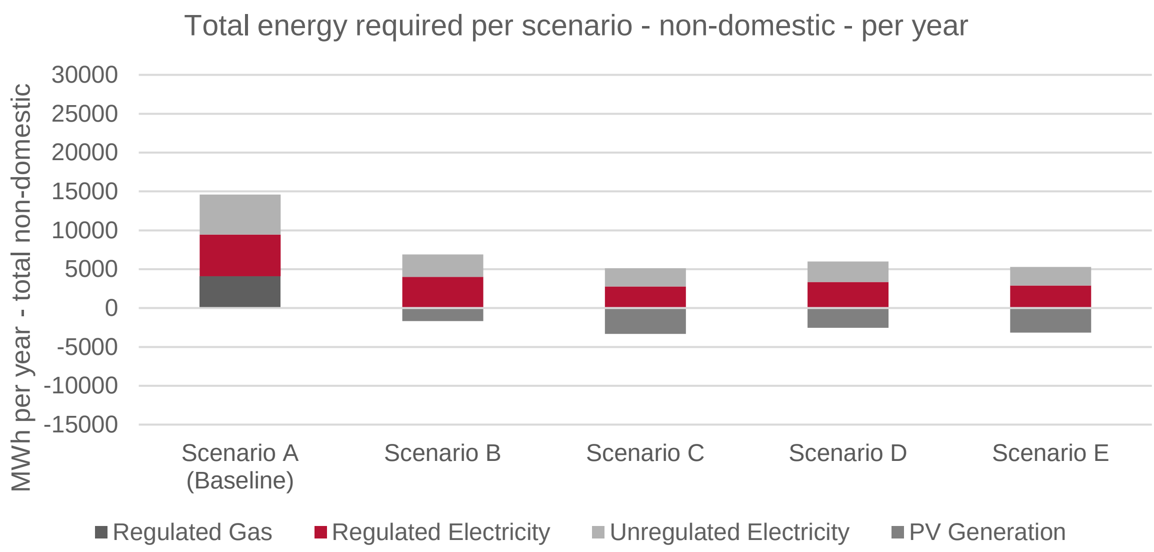

Figure 14 - Energy consumption per year, post-2036 completion – housing non-domestic

Please note that the contributions of the PV generation are substantial in the case of larger PV installations and in general a large contributor to net annual total energy demand reductions. The amount of PV allocated to the different models is shown in Table 35.

Table 35 - non-domestic models - amount of PV installed

	Small PV	Large PV	Small PV	Large PV
	Total m2		% of gross internal floor area	
Innovation hub	6581	13163	15%	30%
Neighbourhood centre	675	1350	15%	30%
Schools and nurseries	2870	5740	15%	30%
Leisure hubs and sports pavilion	1005	2010	15%	30%
Travelling show people	8	15	15%	30%

8.2.2.3 Accumulated carbon emissions – post-2036

Carbon emissions associated with the energy demand of the site have been calculated for the different scenarios. It needs to be noted that carbon emissions directly link to the energy type used and the carbon intensity of that type.

A carbon factor is a value that is assigned to each kWh of energy that used by the building (please see 0).

Quick review of the non-domestic scenarios' outputs

The average annual energy consumption per m^2 of the whole non-domestic development is provided within Figure 15 for the different scenarios. The results shown were produced by estimating the total amount of energy required for each scenario per year and divided by the total GIFA of all non-domestic building typologies expected to be delivered by 2036. As the different scenarios introduce different packages at different points in time – these performances are not 'per type' of building or to be used as 'standards'. These are to be used for reference comparison purposes only.

Figure 16 and Figure 17 show the expected overall carbon emissions reduction predicted, post-delivery of all non-domestic building typologies within the CGC (post-2036), when compared to non-domestic buildings that comply with the current version of the building regulations (Part L 2013). Figure 16 shows the results using a flat carbon factor approach while Figure 17 shows the results using a 'stepped' carbon factors approached.

The flat carbon approach appears to 'benefit' scenarios B and C more. These scenarios do not go very far in terms of energy efficiency standards achieved but benefit from the flat carbon factor accounting method and can claim high savings. This is not the case when the same scenarios are reviewed under a 'stepped' carbon factor approach lens.

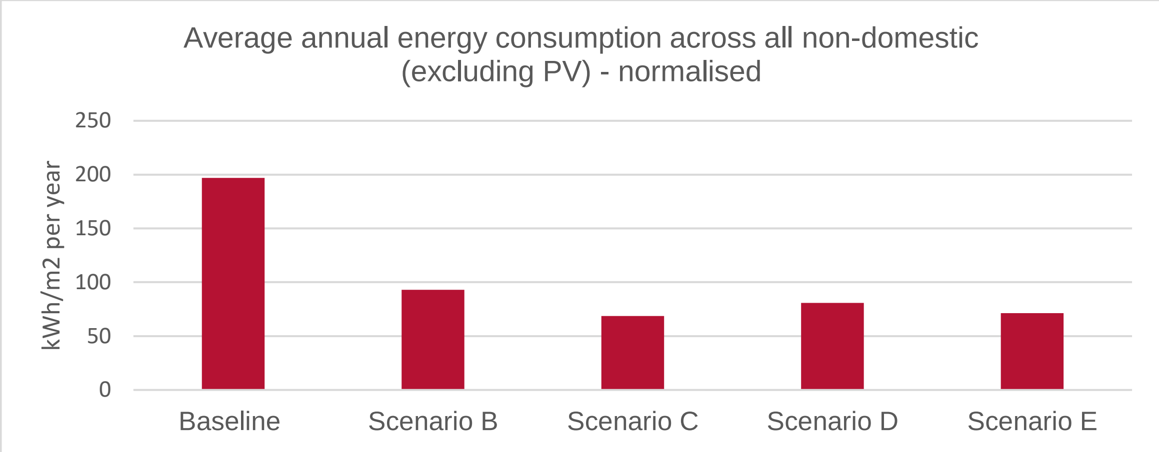

Figure 15 – Average annual energy consumption per m2 (GIFA) -across all new non-domestic

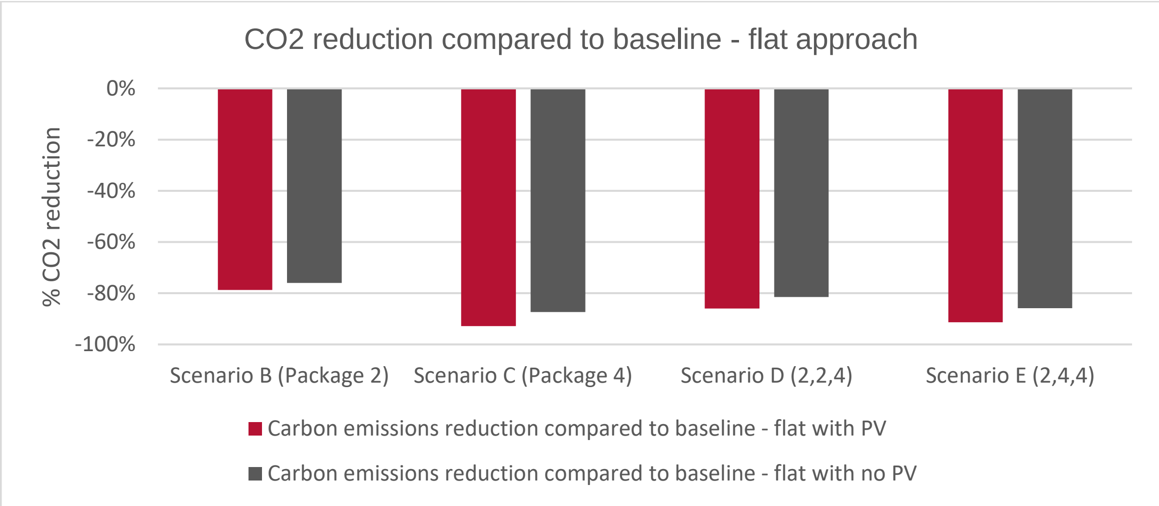

Figure 16 - Carbon emission reductions (non-domestic) compared to a Part L 2013 baseline - flat carbon factor approach. Includes unregulated energy use

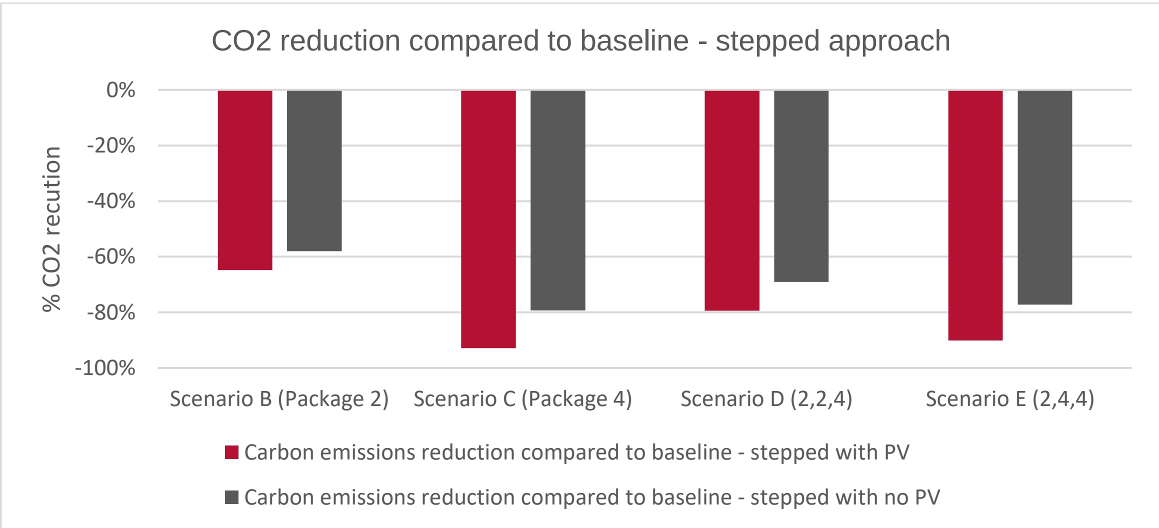

Figure 17 - Carbon emission reductions (housing) compared to a Part L 2013 baseline - stepped carbon factor approach. Includes unregulated energy use

9. Capital cost and running cost (estimates)

Short introduction:

Section 9 provides cost estimates in terms of expected cost changes in capital construction costs for the different housing and non-domestic building typologies expected to be developed within the CGC. These cost changes are assessed against a Part L 2013 of the Building Regulations baseline.

All scenarios and model packages are assessed and then grouped to reflect three potential development roadmaps and their associated capital cost increase on average for housing and non-domestic buildings (Part L 2013 baseline).

Based on energy demand and generation modelling, energy use costs have also been produced for all models using different packages as solutions.

It needs to be noted that costs are sensitive to change and can be affected by a number of factors. As the CGC plan period spans many years, cost plans for the different development phases need to be kept up to date, reflecting future market conditions.

The baseline used for the capital cost change calculations was Part L 2013. The introduction of the new Part L 2021, the Future Homes Standard (2025) and other changes within the Building Regulations striving to achieve higher energy-efficient and low-carbon standards, happening throughout the development, mean that cost change percentages will need to be re-established compared to current minimum requirements at each one of these future times.

Expected running costs, especially in the case of housing, should always be presented to the planners to assess the impact of different construction choices onto the user experience. This becomes even more significant when the review concerns vulnerable groups (eg fuel poverty).

9.1 Summary of findings – Section 9

Section 9 – Indirectly responds to Q12, also responds to overall development and running costs considerations
Q12.What are the costs and financing models for the identified renewable and low-carbon energy schemes? How would they impact on the timing and profitability of development on site? This section provides information on expected additional capital costs for the different building models developed and agreed with CCC (housing and non-domestic buildings). These capital costs refer to increase in costs of material and solutions selections. These additional capital costs do not include design and consultants' fees, accreditation fees, additional labour time on site or lack of skills and knowledge that can lead to additional costs. No district heating or community-based systems were used within the models. This was due to the limitations observed in terms of densities, operations, maintenance, ownership, phasing and other complexities identified which at this early assessment phase of the project would introduce unnecessary complexity. Instead, it was considered important that some capital cost estimates were produced which would support a better understanding of the viability of common solutions likely to be suggested by developers for the site. Timing and profitability are also not explored in detail, with reasons being lack of clarity over critical path, exact timelines and pace of development as well as solutions that will be occupied by the different developers at the end. Profitability can be indirectly assessed by reviewing the capital cost estimates developed within the session for housing units and comparing those to local viability assessments. As capital costs and land prices constantly change, similar assessments will need to be undertaken in more detail at each phase of the development. It is advised that cost estimates, and predictions are examined by a third party upon submission for validation purposes. Similarly, cost-benefit analysis for non-domestic buildings can consider both additional capital cost as well as energy bill savings, in terms of evaluating viability and investment levels.

Section 9 - Evidence and summary response

The proposed renewable and low-carbon technologies are based on individual building level systems. This is because more complicated supply/demand block of level and district level systems would require advanced infrastructure and a holistic approach to be followed across the whole development. To model such bespoke solutions would create unnecessary complexity for this report. During the development of the different phases, it is expected that new methods, technical solutions and systems will be developed.

Energy generation on roofs (PV) combined with energy stores directly contribute to energy bill savings. The preferred strategy would be for independent energy stores and energy generation installations at an individual building level. The models produced and reviewed within this report assume an increased upfront capital expenditure covered by the developer as part of the CGC planning permission agreements.

Detailed studies will need to be undertaken if more complex, commercial, community or block of buildings solutions are sought. It is not within the scope of this study to detail all available combination of potential solutions for CGC for the next 15 years.

As established within this report, it is important that design flexibility is retained while energy and carbon performance thresholds are introduced for each building type to enable alignment with the net zero aspirations. Standards established to be used within CGC can be found in Table 37 and Table 38.

Housing

Capital costs in the case of housing are provided in terms of packages. Packages 3 (Net zero carbon) and 4 (Net zero carbon plus) are the two packages in alignment with the net zero aspiration. Additional capital costs for those two packages were estimated as being £7,500-£12,500 for flats and £15,000-£20,000 for houses (see Table *26* and Appendix B – Housing and non-domestic buildings model specifications).

The higher additional capital costs predicted include large hot water stores, large PV arrays and large battery store systems along with improved fabric and M&E efficiencies. As mentioned in previous sections, all packages consider both regulated and unregulated energy use as well as minimising running (energy bill) costs for the occupant.

Package 3 (Net zero carbon) can lead to annual energy bill savings ranging from £200-£650 pounds (based on the different models/types). This is only achievable if battery energy store systems are installed at each unit so a 50% of direct energy use from PV can be achieved. Higher annual energy cost savings are predicted for package 4 in housing which involved 70% of the PV energy generation to be stored and used directly by the house.

Costs related in terms of maintenance (predictive/reactive) and replacement (end of life) of the technologies assigned to the models (lifecycle cost) is not captured within the report.

Non-domestic buildings

As with housing, for modelled non-domestic building mixes and types used within this report Package 2 (Net zero carbon) of measures led to substantial energy and carbon savings (see Table *28* and Appendix B – Housing and non-domestic buildings model specifications). .

Package 2 implementation (Scenarios C and E) led to a capital construction cost increase of 6-8%. The level of battery store centralisation and individual units per building will need to be assessed from a strategic point of view for each typology.

In non-domestic buildings, as space heating demand decreased through fabric interventions, the amount of energy required for hot water generation, plug loads or processes remains unaffected. This means that energy generation and storage solutions become significantly important.

9.2 Capital cost (indicative)

Indicative costs were produced for the different building models based on the different modelled upgrades (packages). Costs are based on Currie & Brown's professional experience of project costs and are developed from detailed specifications of the full range of cost implications for each element.

Cost uplifts were reviewed against current Part L 2013-compliant buildings. It is important to remember that the costs of developing new homes can vary widely for a range of factors, not least: location, ground conditions, site constraints, access, topography, quality of finishes, design complexity, supply chain and management.

Construction costs can also be subject to sudden and significant change because of market or economic factors, for example varying exchange rates, skills or materials shortages and interest rates (eg Brexit). The overall cost uplift as a function (%) of overall construction costs: the overall construction cost of a building can vary significantly especially in the case of non-domestic bespoke designs.

These extensive factors mean that a benchmark cost analysis is only indicative of overall cost implications of different energy and carbon performance improvement options and representative of their relative significance.

Analysis of the potential for reduced costs associated with achieving higher standards of energy efficiency suggest that the cost premium associated with the most energy-efficient standards may fall by around 20-30% between 2020 and 2030. This is as project teams become more familiar with achieving high levels of air tightness and the markets for new technologies become more established. In addition, it is likely that there will be further reductions in the costs of PV with costs likely to be falling by a further 35% on 2020 levels by 2030.

These cost trajectories mean that it is likely to become less expensive to build to lower carbon and high-energy efficiency standards over time. However, the scale and speed of changes in costs associated with different technologies is relatively small and slow in comparison to other factors such as the changes to the modelling method and carbon factors that might affect the predicted carbon performance of the new buildings.

Infrastructure costs related to gas and electricity networks

It needs to be noted that a very large capital cost saving is expected to be due to the lack of, or reduced requirement for, gas infrastructure as all the scenarios evaluated consider all-electric solutions.

It is not possible to know the capacity of the electricity grid in the area and how this will be shaped during the different CGC development phases unless the capacity is secured at the beginning of the project (this does not usually happen). Any UK Power Networks capacity statement is only valid for three months unless the capacity is secured. A cost assessment will need to be undertaken at each phase of the development to assess costs related to gas[73] and electricity infrastructure. Such cost savings or cost uplifts are not included within this report.

[73] If required for back-up generation or certain types of use. Use of fossil fuels for heating and hot water in new buildings is not advised if a 'net zero' status is to be achieved.

9.2.1 Capital cost estimates (additional costs to construction only)

Lifecycle costs are not included.

9.2.1.1 Housing models - additional capital costs

The capital cost estimates provided in Figure 2 are based on the different solutions used to upgrade the different housing models (packages). Cost only refers to cost of new products and services used. Costs associated with design changes, skill and knowledge required are not included.

Figure 19 shows the estimated capital cost change as a percentage of the different packages when compared to average new capital construction costs associated with Part L 2013 compliance.

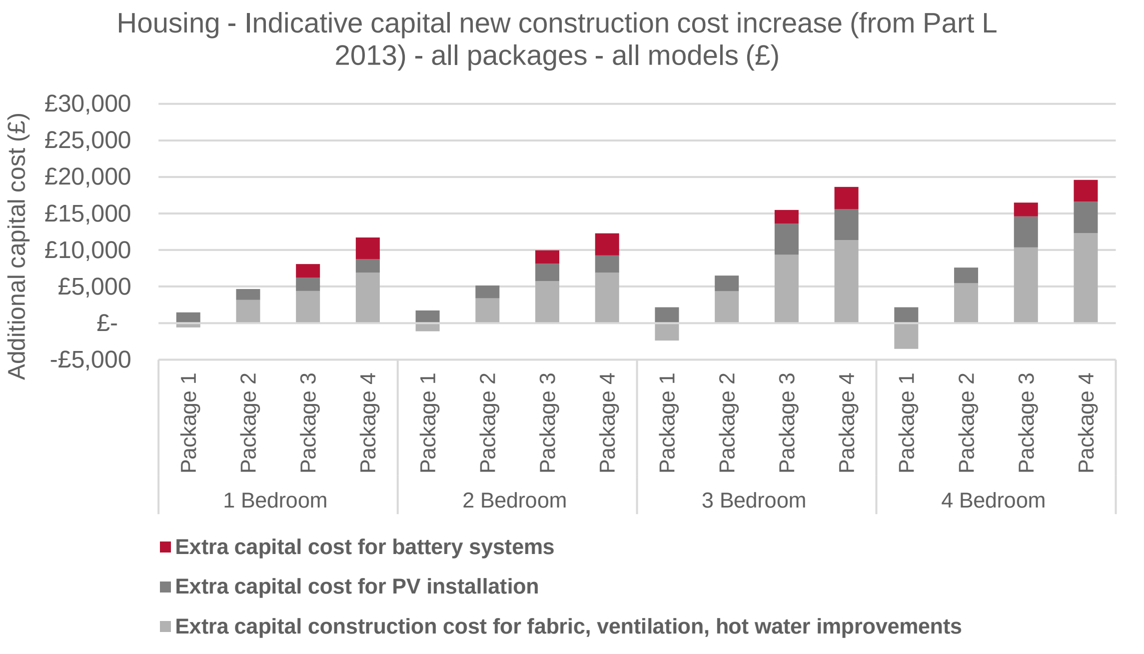

Figure 18 – Capital cost increase estimates per housing type – package based – construction cost only

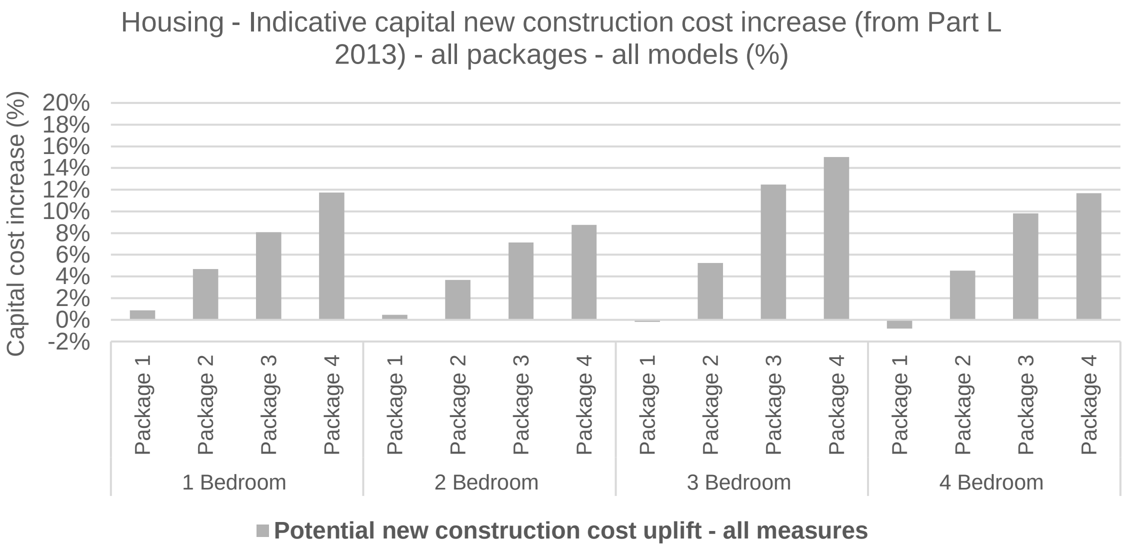

Figure 19 – Percentage of capital cost increase per housing type – package based – construction cost only[74]

9.2.1.2 Non-domestic models - additional capital costs

The following capital cost estimates in Figure 2 are based on the different solutions used to upgrade the different non-domestic models. Cost only refers to cost of new products and services used. Costs associated with design changes, skill and knowledge required are not included.

Figure *21* shows the estimated capital cost change as a percentage of the different packages when compared to average new capital construction costs associated with Part L 2013 compliance.

For non-domestic buildings, the cost is presented as £ uplift per m^2, and % cost uplift per m^2.

Non-domestic buildings are designed around many different types of expected use. All four building types evaluated are expected to have a heating requirement, which needs to be minimised. Hot water efficiency also becomes critical in facilities where heavy hot water use is expected (showers in gyms, schools, laboratories and other). The largest expenditure expected to be incurred for non-domestic buildings is associated with fabric, ventilation and hot water improvements.

[74] Package 1 includes a direct electric system, therefore costs associated with a wet distribution network and central heating units are removed compensating for minor fabric improvement costs.

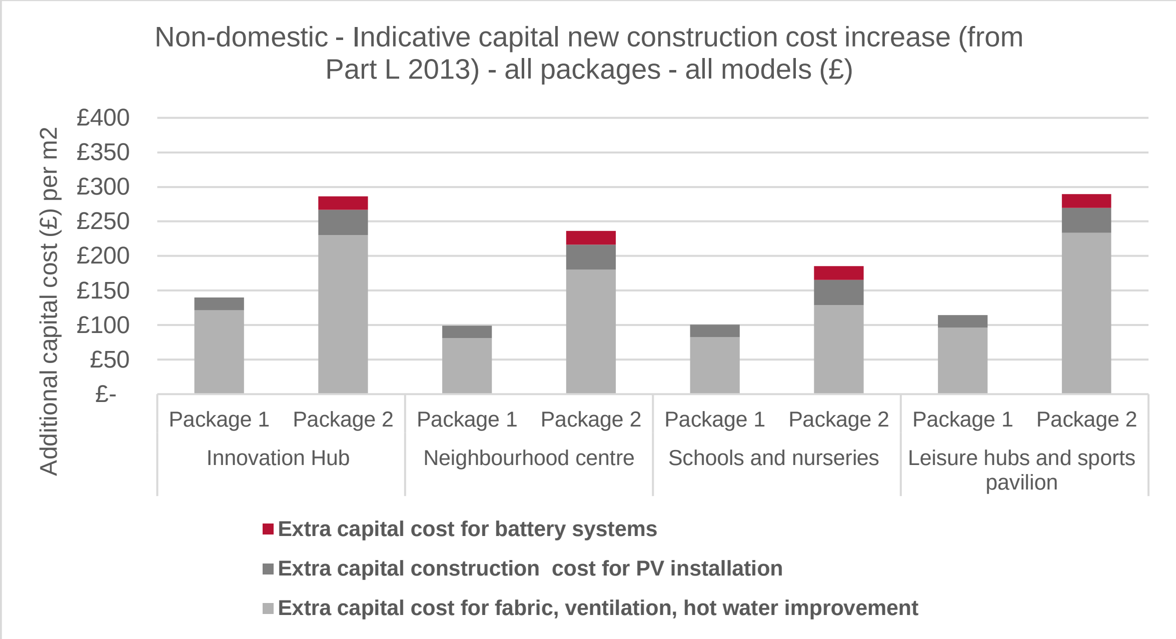

Figure 20 - Capital cost increase estimates per non-domestic building type – package based – construction cost only

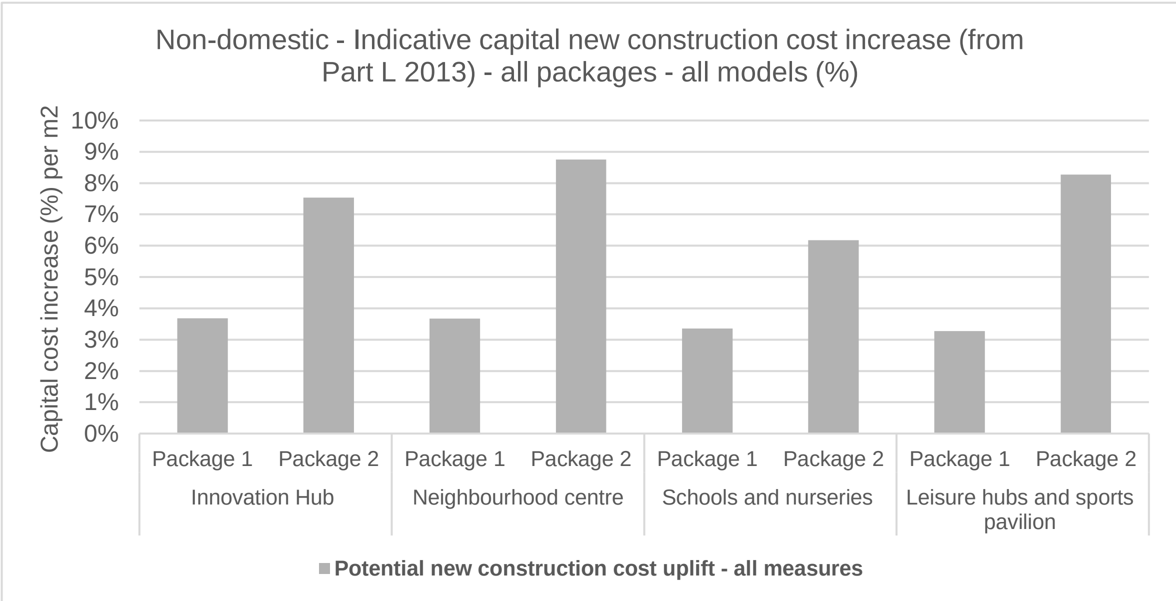

Figure 21 - Percentage of capital cost increase per non-domestic building type – package based – construction cost only

9.3 Capital cost review against roadmaps

Current cost changes predicted within the models only refer to a Part L 2013 baseline. It is expected that as new minimum requirements are introduced through changes within the Building Regulations, the baseline (reference) models will change. This means that it is likely that part of the additional cost will become a by-default additional cost to meet the higher standards being introduced. The change in capital cost was estimated using the housing and non-domestic typologies modelled under the different scenarios as a proxy. While this means that it is reflective of the methods and technologies assigned, as mentioned earlier in the report, costs can quickly and suddenly change to reflect changes within the market.

Costs presented within this report are indicative and have been informed by the Currie & Brown in-house cost database and past project experience.

The following graphs provide additional capital construction costs associated with changes within material quantities and equipment used within the models.

A stepped approach to introducing the standards proposed would introduce different levels of additional capital cost at different development phases.

It is expected that detailed cost appraisals will be undertaken by developers prior to considering new developments within the area. Based on specific options selected, these costs may vary from cost estimates presented within this report.

That being considered, the following costs have been produced with a high degree of confidence, based on current construction prices (Table 36).

Three roadmaps are proposed for CGC in alignment with the aspiration to become a net zero development (details on the three different roadmaps can be found in Table 37 and Table 38). It would be for CCC to decide which roadmap would be best suited for meeting their main commitments. Our recommendation is Roadmap 2 as a minimum/risk averted option.

Table 36 - Capital cost - housing and non-domestic - alignment with the three roadmaps

Housing capital cost uplift		Current-2025	2025-2030	2030-2036
Roadmap 1				
1B		10%	10%	10%
2B		10%	10%	10%
3B		13%	13%	13%
4B+		12%	12%	12%
Average		11%	11%	11%
Weighted average	11.08%			
Roadmap 2				
1B		6%	10%	10%
2B		5%	10%	10%
3B		6%	13%	13%
4B+		6%	12%	12%
Average		6%	11%	11%
Weighted average	10.5%			
Roadmap 3				
1B		6%	6%	10%
2B		5%	5%	10%
3B		6%	6%	13%
4B+		6%	6%	12%
Average		6%	6%	11%
Weighted average	9.19%			
Non-domestic capital cost uplift				
Roadmap 1				
Innovation Hub		6%	6%	6%
Neighbourhood centre		7%	7%	7%
Schools and nurseries		4%	4%	4%
Leisure hubs and sports pavilion		7%	7%	7%
Average		6%	6%	6%
Weighted average	5.93%			
Roadmap 2				
Innovation Hub		3%	6%	6%
Neighbourhood centre		3%	7%	7%
Schools and nurseries		3%	4%	4%
Leisure hubs and sports pavilion		3%	7%	7%
Average		3%	6%	6%
Weighted average	5.57%			
Roadmap 3				
Innovation Hub		3%	3%	6%
Neighbourhood centre		3%	3%	7%
Schools and nurseries		3%	3%	4%
Leisure hubs and sports pavilion		3%	3%	7%
Average		3%	3%	6%
Weighted average	4.64%			

9.4 Running costs (estimates)

New energy-efficient and sustainable buildings offer the opportunity for improving the living experience of the user/occupant. Based on proxy packages developed for this research, this section provides estimated changes in energy bill costs for all building models examined. These average annual running cost differences were calculated using the following assumptions:

- The total annual energy consumption predicted for each house was extracted from the energy and carbon emissions predictions of the models used (PHPP[75]/SAP).
- The HMRC Green Book future energy prices index[76] was used to calculate annual running cost during the life of each model.
- The SAP 2012 standing charges for gas and electricity were used and are included in the annual running cost estimates.
- The contributions of PV to annual energy bills were calculated using a standard export rate per kWh (SAP 10.1[77] - £ 0.053 / kWh) for exported energy. When assumed to be used directly on site the HMRC Green Book future energy prices index was used.
- While the enlarged hot water stores will play a critical role in the case of optimised utilisation of energy tariffs and store of excess energy generation, their impact is assessed only through provisions for less energy demand for hot water generation from the housing models. It is not within the scope of this study to provide information to that level of detail, and it is advised that this type of work is conducted by each developer with assumptions presented to the planning officers for evaluation at each planning application.
- Waste water heat recovery systems are strongly advised for domestic hot water energy demand reduction of new homes. The models used did not include this technology in this study, but we have noticed substantial savings achieved on other projects.
- The PV contributions to energy savings, when connected with a battery system, were set to:
  - 70% of energy generated per year exported to the grid when no battery is present.
  - 50% of energy generated per year exported to the grid when the small battery is present.
  - 30% of energy generated per year exported to the grid when the large battery is present.
  - For each one of the above three scenarios the remaining energy per year generated (100% - % exported) was allocated to on-site use.

The additional capital costs produced did consider the potential impact of ground loop systems that may be required for the installation of ground source heat pumps as percentage (%) cost uplift for M&E. Soil conditions can lead to higher costs, which will be on top of the capital costs shown and will vary based on the size of the network, the location and infrastructure requirements. Key considerations are:

- Economies of scale can be applied to battery systems and PV that are installed on a block of flats level rather than individual flats and therefore such costs might be lower.
- The percentage of new-build cost uplift was calculated based on Currie & Brown average new-build rates of the typologies and can vary based on each developer's strategy. The construction costs presented do not include changes in the construction process, and any

[75] Passive House Planning Package (PHPP) , https://passipedia.org/planning/calculating_energy_efficiency/phpp_-_the_passive_house_planning_package
[76] Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal - GOV.UK (www.gov.uk)
77 SAP-10.1-08-11-2019_1.pdf (bregroup.com)

other costs that might be incurred during the process. These can include additional design, training, consultancy, change of supply chain and other associated costs.

9.4.1 Housing models

The estimated change in the annual energy bill cost for all housing models is provided in Figure 22.

The graph shows the expected annual energy cost change of the different housing models when compared to a Part L 2013-compliant house of the same size/shape and type. The cost breakdown includes expected cost changes (grey) without the contributions of the PV, maximum savings due to PV export (dark grey) and the net cost change if all PV savings are allocated to the payer of the energy bills (red).

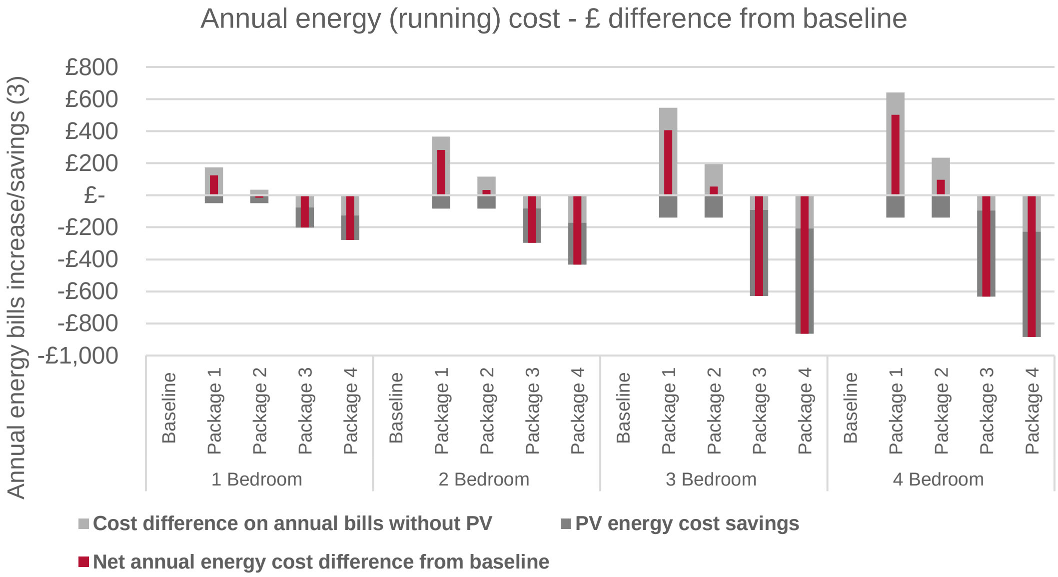

Figure 22 - Annual energy bills - cost difference - housing - compared to Part L 2013 baseline

9.4.2 Non-domestic building models

The estimated change in the annual energy bill cost for all non-domestic models is provided in Figure *23*4.

The graph shows the expected annual energy cost change of the different housing models when compared to a Part L 2013 compliant house of the same size/shape and type. The cost breakdown includes expected cost changes (grey) without the contributions of the PV, maximum savings due to PV export (dark grey) and the net cost change if all PV savings are allocated to the payer of the energy bills (red).

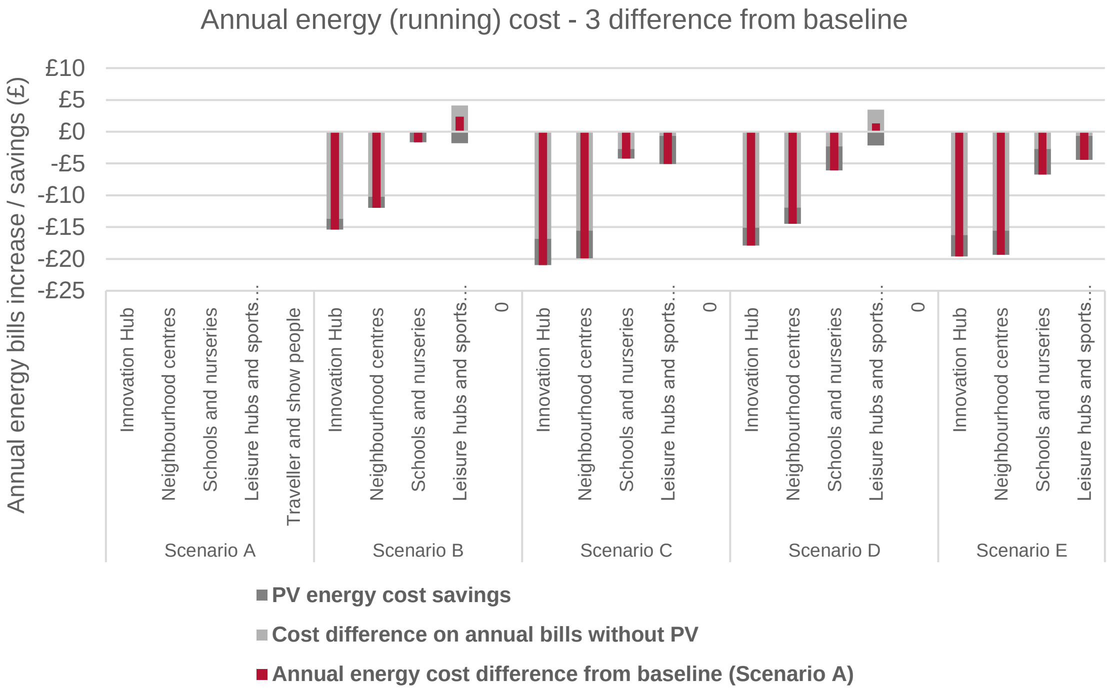

Figure 23 - Annual energy bills - cost difference – non-domestic buildings - compared to Part L 2013 baseline

9.4.3 Key points of this section

The cost analysis in terms of CGC current plan and models used produced the following observations:

Housing

- The additional capital construction cost for Package 3 and 4, which are in alignment with the net zero carbon target, was estimated at 8-16% construction cost on top depending on the different typologies. These costs included large PV installations, large hot water stores and an assigned battery system (Figure 19, Table 36)
- Package 3 (Net zero carbon) led to annual energy bill savings ranging from £200-£650 (based on the different models/types) - only achievable if battery energy store systems are installed at each unit so a 50% of direct energy use from PV can be achieved (Figure *22*).
- Package 4 (Net zero carbon plus) led to annual energy bill savings ranging from £300-£885 (based on the different housing model/types) - only achievable if battery energy store systems are installed at each unit so a 70% of direct energy use from PV can be achieved (Figure *22*).
- Costs related in terms of maintenance (predictive/reactive) and replacement (end of life) of the technologies assigned to the models (lifecycle cost) is not captured within the report.

Non-domestic buildings

- Space heating demand and overall energy consumption proxies were used for the non-domestic potential typologies within the CGC. Energy models produced accounted for both regulated and potential unregulated energy use (Appendix B – Housing and non-domestic buildings model specifications).
- The energy performance of non-domestic building models is harder to predict, as the mix and quantity of energy used, the exact size and mix of typologies and the year of their completion all play a role as ‘differentiating factors’. Current typical and improved performance standards were used for the approximation.
- As with housing, for modelled non-domestic building mixes and types used within this report Package 2 (for non-domestic) of measures led to substantial energy and carbon savings.
- Package 2 implementation led to a capital construction cost increase of 6-9%.The level of battery store centralisation will need to be assessed from a strategic point of view for each building typology (Figure 21,Table 36).

In general

- It is possible that larger PV installations exceeding 30% of the total gross internal floor area will be required from non-domestic buildings - even when constructed to high energy efficiency standards.
- In non-domestic buildings, as space heating demand decreases through fabric interventions, the amount of energy required for hot water generation, plug loads or processes remains unaffected. This means that energy generation and storage solutions become significantly important.

9.5 Proposed energy thresholds and KPIs - Housing and non-domestic buildings

This section contains energy thresholds, supportive renewable energy generation and energy store technologies considered as appropriate for the CGC to achieve a net zero (operational energy only) status.

What needs to be noted though is the energy store (battery and hot water) is very important in not only meeting carbon emission targets but also to ensure that all-electric solutions are viable during operation. Combined they ensure:

- Affordability of bills in housing and non-domestic buildings
- Energy resilience
- Additional benefits realised such as shift of peak load demand from the grid, and potential connectivity with electric vehicles strategies.

How to read Table 37 and Table 38:

- **All targets refer to all-electric solutions**. Only all-electric solutions are advised as a primary energy type use in all cases. Combustion deriving energy and emissions on-site, such as from gas, oil, other organic fossil and non-fossil fuels, will not be possible to offset in the future with PV or additional electricity generation on-site. Where required, for example for specific industrial processes, labs, etc the amount of fuel expected to be consumed needs to be estimated and reported in terms of predicted emissions. These will need to be offset separately with a payment or carbon offset certificates. Such use of fuels should be limited and only where it cannot be avoided.
- Space heating demand includes only the amount of energy expected to be required by the building for space heating, **without considering any delivery system efficiencies**. What that means is that this is the actual energy that will need to be delivered in the building for heating and it directly evidences the level of insulation and quality of fabric. Fabric first for buildings requiring energy for space heating should always be a priority and is the longer lasting energy efficiency solution.
- The remaining energy consumption targets refer to total amount of energy that will be required from the grid per year and per m^2.
  Regulated energy: This is calculated for compliance with the Building Regulations and should always be reported.
  Unregulated energy use: Targets are defined by the user behaviour, and installed appliances' energy efficiency. While it can be reported by the developer's consultant as an estimate, current 'targets' presented in the table can be used in support of interpretation of reported estimates. Unregulated energy use targets shown in the table assume an 85-100* % A+ rated energy-efficient appliances install in all models and appropriate reduction measures and controls. These estimates are not a 'hard' target as in the case of space heating demand and regulated energy consumption target but needs to be considered from an energy balance perspective.
- The remaining energy consumption targets refer to total amount of energy that will be required from the grid per year and per m^2.
  Regulated energy: This is calculated through means of compliance with Building Regulations and reported through SAP/IES or similar.
  Unregulated energy: This is predicted using SAP/IES/PHPP and CIBSE guidance documents based on the building type and use. It is not reported for compliance with the Building Regulations, but it is important for the net zero carbon.

Table 37 - Key Performance Indicators (KPIs) - Housing

KPI	Impact	Key: Minimum CGC Standards	Key: Zero Carbon
Space heating demand Through energy modelling kWh/m².year: 35 (Minimum CGC Standards) / 15 (Zero Carbon)			
Total energy use (regulated and unregulated) Through energy modelling kWh/m².year: 50 (Minimum CGC Standards) / 35 (Zero Carbon)			
Fossil fuel free Fossil fuels such as oil and natural gas shall not be used to provide space heating, hot water or used for cooking.	**Impact**		
Measurement and verification Meter, monitor and report on energy consumption and renewable energy generation post-completion for the first five years.	Energy demand reduction (without/with PV)	43%/59%	60%/105%
Running cost increase Should be less than a scheme compliant with Building Regulations Part L 2013 using a gas boiler.	Increase in peak electricity grid demand	+ 65%	+ 28%
GWP – refrigerants If a system is installed that includes refrigerant, the refrigerant shall have a global warming potential of no more than 10.	Carbon emissions reduction	28%	101%
Renewables Roof area covered in PV: 40% (Minimum CGC Standards) / 80% (Zero Carbon)	Construction capital cost increase compared to a Part L 2013-compliant building (materials and M&E additional costs only).	6%	11%
Storage Store needs to be sized so the load is balanced and achieves the following: ▪ A performance target of 60% load variation across the day	Running energy costs per house per year (+ increase, - reduction)	(-) £200 to £500	(-) £275 to £885[78]

Space heating demand

Expected energy demand for heating is currently predicted by using the Standard Assessment Procedure (SAP).

SAP is a steady state simulation method, which uses predictive occupancy levels and does not consider impact of dynamic effects.

The space heating demand noted within the housing KPIs refers to the energy required for heating and excludes the efficiency of the technology providing that heat (gas boiler, heat pump, etc).

It needs to be made clear that the space heating demand addresses the 'fabric-first' approach, which requires minimising energy 'wastage' which can occur through low airtightness.

The impact of systems such as mechanical ventilation heat recovery (MVHR) is accounted for within the KPIs set.

Carbon emissions reduction compared to Part L 2013

Carbon factors for electricity from the electricity grid are constantly changing as the electricity grid continuous to decarbonise. New factors are expected to be introduced for the assessment period running up to 2025 in the new SAP 10.1 (currently not used for compliance). The scenarios examined lead to the following carbon emissions reduction paths (using current data).

Average CO_2e reductions achieved – Housing	%	
Current Building Regulations carbon emission factors	20-30	110-130
SAP 10.1 carbon factors	70-89	130-150

[78] To achieve such high energy savings, a minimum 70% of all renewable energy generated through an min 80% roof PV coverage need to directly be used by the occupier

Table 38 - Key Performance Indicators (KPIs) – Non-domestic

KPI	Metric	Minimum CGC Standards	Zero Carbon	Impact	Minimum CGC Standards	Zero Carbon
Space heating demand Through energy modelling	kWh/m^2.year	35	15			
Total energy use (regulated and unregulated) Through energy modelling	Office kWh/m^2.year	75	55			
	School kWh/m^2.year	85	65			
	Retail kWh/m^2.year	130	85			
	Leisure kWh/m^2.year	125	92			
	Innovation hub kWh/m^2.year	90	65			
Fossil fuel free Fossil fuels such as oil and natural gas shall not be used to provide space heating, hot water or used for cooking.						
Measurement and verification Meter, monitor and report on energy consumption and renewable energy generation post-completion for the first five years.				Energy demand reduction (without/with PV)	53%/64%	65%/88%
Running cost increase Should be less than a scheme compliant with Building Regulations Part L 2013 using a gas boiler.				Increase in peak electricity grid demand	-10%	-23%
GWP – refrigerants If a system is installed that includes refrigerant, the refrigerant shall have a global warming potential of no more than 10.				Construction capital cost increase compared to a Part L 2013-compliant building (materials and M&E additional costs only).	3 %	6 %
Renewables	Roof area covered in PV	15%	30%	Running costs per building per m2 per year (+ increase, - reduction)	Figure 23	Figure 23
Storage A battery capacity of 3.5kWh per 100m2 install can be used. Please undertake a detail peak load analysis to optimise performance.						

How the standards proposed relates to the current version of the Building Regulations (Approved Document L 2013 and the approved current Standard Assessment Procedure).

Space heating demand

Needs to be assessed using dynamic simulation methods, especially in more complex non-domestic buildings.

Carbon emissions reduction compared to Part L 2013

Carbon factors for electricity from the electricity grid are constantly changing as the electricity grid continuous to decarbonise. New factors are expected to be introduced for the assessment period running up to 2025 in the new SAP 10.1 (currently not used for compliance). The scenarios examined lead to the following carbon emissions reduction paths (using current data).

Average CO2e reductions achieved – Non-domestic	%	
Current Building Regulations carbon emission factors	20-35	30-50
SAP 10.1 carbon factors	50-65	60-75

10. General considerations (Q13-Q17)

Short introduction:

Section 10 responds to questions 13 to 17. Overall, the approaches followed within the models used within this report, using on-site solutions for each building to achieve higher energy efficiency and low-carbon standards, is recommended for most of the new proposed buildings for CGC.

Centralised technologies as in the case of district heating networks, especially high temperature distribution, are not advised at this stage considering the building densities expected as well as other limitations. Caution is advised against wind turbines within the urban environment based on space requirements, noise/vibration, and complex payment structures if CGC was to directly benefit from such a project.

A few good practice examples have been provided. A loose definition of net zero, zero carbon or similar has been noted for most of the other exemplar sites. We recommend that the UKGBC definition of net zero[79] is used to understand the different boundary conditions. Current research looked into zero-carbon operation only.

All buildings should be accompanied by building user guides and manuals, which, if possible, should also be provided in electronic forms. Additional aids in terms of visualising the individual buildings' performances can also be used as in the case of smart meters and smart screens within the buildings (enhancing the sense of doing the right thing or having control over one's energy use). It is also important to introduce additional transparency in terms of energy balances and bills.

Initiating and funding renewable energy and low-carbon energy projects will heavily rely on the exact development proposal and the business plan. CCC has a key role to play in supporting and developing the right strategy for the community. Through public/private partnerships, CCC and communities can become stakeholders to these new plans.

The current approach recommended by this research allocates the additional capital cost to development costs. This is expected to be absorbed by the developers, as they comply with the energy and carbon performance thresholds recommended for CGC future phases.

In that sense, the savings and benefits are locked in each building. Additional costs relating to maintenance, replacement and repairs are allocated to the user/owner.

Initiating, financing and maintaining local renewable energy generation groups is associated with community/district-based solutions which have not been explored within this study.

A detailed list of opportunities is provided within this section.

[79] Net-Zero-Carbon-Buildings-A-framework-definition.pdf (ukgbc.org)

10.1 Summary of findings – Section 10

Section 10 – Responds to Q13-Q17
Q13. What renewable and/or low-carbon energy schemes may not be considered appropriate for new North East Chelmsford development? Q14. Are there any good practice examples of renewable and low-carbon energy schemes, especially for strategic scale developments and garden community/village developments that could be relevant for North East Chelmsford? Q15. What options are there for assessing and communicating information on the overall environmental performance of the land uses benefitting from the renewable and low-carbon energy schemes? For example, ways to certify the performance of new homes and to provide buyers with information on the environmental impact of their new home and its potential running costs? Q16. What are the most appropriate strategies for promoting greater acceptance among developers, investors and potential future occupants of the need for energy generated from local renewable and low-carbon energy schemes? This should include a consideration of the opportunities for community stewardship/ownership of the renewable and low-carbon energy technologies identified as potentially suitable. The study should examine different methodologies of initiating, financing and maintaining local renewable energy generation groups including cooperative ownership and if there could be a mechanism in place allowing house buyers to purchase shares. Q17. What opportunities are there for promoting renewable energy/low-carbon local enterprise initiatives, employment and training schemes e.g., at the proposed employment area/s – in line with one of the actions in the Green Infrastructure Action Plan (see Table 6.4, Economy theme) - and at Anglia Ruskin University and Writtle University College.

Section 10 - Evidence and summary response

To meet a net zero carbon target, both in terms of regulated and unregulated energy use (operation net zero), most buildings will need to move to all-electric solutions. This is due to the fact the large-scale and popular technologies such as photovoltaic panels and wind turbines support the decarbonisation of the national electricity grid. What this means is that grid electricity is becoming ‘greener’ and therefore all-electric buildings can claim a ‘low-carbon’ during operations status easier.

Additional care is advised in terms of renewable energy generation technologies that include on-site wind turbines or high temperature district heating solutions. Both options have the potential to lock-in these options as part of future development plans even if their benefits do not materialise.

Please note that the majority of the ‘net zero/low-carbon’ developments use several different zero-carbon definitions. In almost all cases this includes regulated energy only during operations. Some good practice examples can be found within this section.

Maintaining simple and consistent messages in terms of the environmental benefits of CGC is critical to its success. In order to build trust with the stakeholders involved, the targets pursued should materialise in real life.

Energy and carbon performance monitoring is a simple way of not only communicating but also confirming ‘successes of the development with prospective buyers and investors. Monitoring and confirming energy and carbon performance of previous development phases is key.

Any certification proposed should not supersede or ‘hide’ energy and carbon performance targets behind allocated credits that may be hard to review or understand. The exact targets should be reported separately by the developer, explaining which elements have been considered (regulated and unregulated, embodied carbon, whole-life carbon).

A detailed list of opportunities is provided within this section.

Question 13. What renewable and/or low-carbon energy schemes may not be considered appropriate for new North East Chelmsford development?

The CGC is a development that aspires to meet the garden community principles. Therefore, an approach of maximum optimisation in land use, minimum disruption of soil and the environment and minimum losses of energy is preferable.

To meet a net zero carbon target, both in terms of regulated and unregulated energy use (operation net zero), most buildings will need to move to all-electric solutions. This is due to the fact the large-scale and popular technologies such as photovoltaic panels and wind turbines support the decarbonisation of the national electricity grid. What this means is that grid electricity is becoming ‘greener’ and therefore all-electric buildings can claim a ‘low-carbon’ during operations status easier.

CGC modelling undertaken in previous sections indicated the importance of energy demand through design and energy efficiency first. The remaining energy demand was covered using heat pumps and energy generation on-site using photovoltaic panels on the roof.

The below solutions are not recommended at this point, unless explicitly reviewed and analysed with appropriate monitoring, cost and quality controls in place and only when outputs indicate larger benefits than on-site PV installations.

Please note: renewable and low-carbon technologies and systems continuously evolve. The policy direction is clear in terms of transitioning into a more ‘sustainable, net zero and green’ economy. CGC will be developing for the next 15 years with additional changes to the technologies and systems we use today expected. This section does not ‘ban’ technologies or systems but discusses some of the current challenges.

A) Additional care is advised in terms of specifying renewable energy generation technologies that include on-site wind turbines, or high temperature district heating solutions to the CGC. The reason for this note is due to:
   - Location limitations, additional space requirements, noise and the complexity of allocating the benefits directly to the residents of the CGC for the installation of wind turbines
   - Distribution losses, infrastructure requirements, provisions for future expansion, space requirements for centralised main energy hub and complex payment structures for high temperature district heating solutions.

Both options have the potential to lock-in these options as part of future development plans even if their benefits do not materialise.

B) Systems that have the potential to impact on the Garden Community principles, eg by affecting local environments (soil heat pollution through heat losses, noise, vibrations or impact on visual experience) need to be carefully examined on their merits prior to any approval for use.
C) Combined heat and power (CHP)

Combined heat and power units could be used in the case of back-up generation in critical operations buildings. They usually rely on pellets or other forms of biofuels and are sometimes considered ‘renewable energy’ generators. Combustion of hydrocarbons lead to the production of CO_2 which can affect net zero targets as well as air quality.

The technology itself could require a small energy centre and a distribution network. Concerns have been raised in terms of fuel supplies and their impact for example on agriculture (unintended change in the use of land)[80].

Transitioning CHP units to alternative technologies in the future (eg green hydrogen boilers) would require additional capital expenditure and a 'phasing out' plan.

The use of CHP units needs to be carefully examined on its expected merits, if such a technology is proposed for CGC.

D) Centralised district heat networks

While there are benefits in centralised solutions, as for example in the case of district heating networks, there are limitation in terms of distribution energy losses, infrastructure requirements, running costs and the user experience (complex payment structures, high standing charges, lack of information about the pricing structure and lack of being able to switch supplier).

Centralised heat distribution systems can be supported by a centralised renewable energy generating source, which for example could be a solar supported heat pump cascade, ensuring both direct use of renewable energy generation as well as the extraction of renewable heat from the environment.

Communal, smaller, heat networks can be used to support more complex new non-domestic building and mixed estates. Low temperature and ambient loop networks have started to emerge as communal solutions for heat pump-dominated new developments.

Due to the phasing complexity of such systems, standing service charges and the potential to lock-in future development special care should be paid when examining their benefits against other more decentralised solutions.

E) Heat and energy from waste (or industrial processes)

The idea of 'waste heat' recovery from a process that would release heat into the environment is not a new one.

If there are waste heat sources within the vicinity of the development, from where carbon free heat can be extracted, a detailed technical study will need to be undertaken.

This should investigate energy loads available from the heat source, expected life of the heat source, cost and technical feasibility of the solutions, benefits, risks and advantages.

Usually transporting that heat to the site will require the establishment of a heat network, so similar limitations as described under the centralised heat networks description might apply.

F) Biomass

Biomass boilers burn biological matter (wood pellets, chips, logs and other) and mainly produce heat for use in heating systems. There are challenges around supply and store of feed, efficiencies achieved, combustion by-products, location and connection to a district heat network. A detailed assessment as to their benefits over the use of another type of technology such as a heat pump will need to be produced if such systems were to be considered for CGC.

Question 14. Are there any good practice examples of renewable and low-carbon energy schemes, especially for strategic scale developments and garden community/village developments that could be relevant for North East Chelmsford?

[80] Sustainability criteria | Energy (europa.eu)

The following schemes have been identified as developments that share some of the CGC aspirations[81].

- ETOPIA Homes, Corby, is a scheme of 47 modular homes equipped with energy-saving technologies such as: a combined solar photovoltaic and thermal panel, heat pump, inter-seasonal storage and smart home equipment – to deliver a net zero carbon standard on site. Completed homes have been tested and are achieving an EPC rating of up to 105/100 (92 and above is very energy efficient).
- Rayne Park, Norwich is the largest low-energy Passivhaus development in the UK. It is also one of the largest in Europe, brought forward by Norwich Regeneration. The scheme will see 112 of the 172 new homes certified to the Passivhaus standard. The homes will benefit from a 70% reduction in heating bills. It will also include a range of properties from 1-bed apartments to 5-bed family houses as well as 57 affordable homes.
- Marmalade Lane, Cambridge is a custom-built cohousing community delivered by GHA developer member TOWN. This development, made up of 42 custom-build homes, has been designed with a fabric-first approach delivered with off-site manufactured closed timber panels, supplied by Swedish builder Trivselhus, combined with heat pumps to supply heating and hot water.
- Tallack Road in Leyton comprises a mix of 50 new affordable and private flats and houses. Delivered under the London Plan policy for low-carbon homes, this development is the first to use a large-scale communal air source heat pump feeding an ambient temperature heat network and individual heat pumps. Combined with solar photovoltaic panels, this provides a predicted 57% reduction in carbon emissions on site.

Most of these schemes define net zero carbon in a different way. The concept of 'net', which is not explored in detail in this report, provides the option of renewable energy procurement and carbon offsetting to compensate for remaining carbon emissions. What this means is that emissions predicted from the site, after some minimum performance standards have been met by the buildings under review, are offset off-site sometimes through a carbon offset fund operated by boroughs and local authorities.

It is expected that CGC will need to use a similar mechanism in the case of residual emissions. It needs to be noted that most of the current exemplar projects try to use individual building solutions, especially in the case of housing, as this minimises the risk exposure to the user and liabilities.

Another interesting low-carbon scheme, which predated the current heat pump-oriented strategies is the Hanham Hall development[82] which was completed in 2015. It has been used as a roadmap within the housebuilding industry for future sustainable, energy-efficient living.

The Hanham Hall development follows the Zero Carbon Hub's[83] zero-carbon homes definition. It encompassed the principles of energy demand reduction through a passive design, fabric-first approach, supplemented by energy-efficient services and a robust almost five-year post-construction performance monitoring programme.

Please note that the majority of the 'net zero/low-carbon' developments use several different zero-carbon definitions. In almost all cases this includes regulated energy only during operations.

The current report produced for CGC is looking into regulated and unregulated energy use during operations but does not include embodied carbon or whole-life carbon assessment elements.

[81] https://goodhomes.org.uk/news/pioneering-low-carbon-housing-building-for-2050

[82] HTA Design - Hanham Hall

[83] Welcome to the Zero Carbon Hub website! | Zero Carbon Hub

Further research is advised to be undertaken if a net zero ‘construction’ definition is sought[84].

Question 15. What options are there for assessing and communicating information on the overall environmental performance of the land uses benefiting from the renewable and low-carbon energy schemes? For example, ways to certify the performance of new homes and to provide buyers with information on the environmental impact of their new home and its potential running costs?

All new buildings are required to have an energy performance certificate (EPC). This is produced at an as-build stage and presents estimates in terms of regulated energy and carbon performance of the building. EPC’s are not always easily understood by the building occupants, but they communicate the standards the building was constructed to (energy efficiency) and energy cost.

The current CGC aspiration is to follow the garden community principles, meaning that visibility in terms of the benefits realised through the standards used is of high importance and needs to be strongly supported.

The overall development is expected to be built in phases. In order to create coherency and consistency in terms of environmental and sustainability standards realised, it is advised that energy and carbon performance thresholds identified within this report are respected and maintained throughout.

As technologies and methods evolve, it is expected that different energy strategies (supply/demand controls, energy stores, decentralised distribution systems) may be occupied to deliver the targets. This could create a complex technology-driven landscape for CGC.

Maintaining simple and consistent messages in terms of the environmental benefits of CGC is critical to its success. In order to build trust with the stakeholders involved, the targets pursued should materialise in real life.

Energy and carbon performance monitoring is a simple way of not only communicating but also confirming successes of the development with prospective buyers and investors. London Plan 2021 Policy SI 2 sets out the ‘be seen’ requirement for all major development proposals to monitor and report on their actual operational energy performance for at least five years post-construction. The ‘be seen’ policy helps to understand the performance gap and identify ways of closing it while ensuring compliance with London’s net zero carbon target. Guidance has been published to explain how to comply with this policy as well as a reporting template which planning applicants will be expected to use.[85]

All buildings should be accompanied by building user guides and manuals, which, if possible, should also be provided in electronic forms. Additional aids in terms of visualising the individual buildings’ performances can also be used, as in the case of smart meters and smart screens within the buildings (enhancing the sense of doing the right thing or having control over one’s energy use).

It is also important to introduce additional transparency in terms of energy balances and bills. This is particularly important in terms of expected standing charges, available contracts with providers in the area and explanation of billing structures if more community-based energy systems are to be used. In addition, information in terms of long-term impact of the different measures, lifecycle assessments and simplified explanation of the scope of CGC will further assist with communicating the benefits realised to stakeholders involved.

[84] Net-Zero-Carbon-Buildings-A-framework-definition.pdf (ukgbc.org)
[85] ‘Be seen’ energy monitoring guidance | London City Hall

Certification schemes:

Home Quality Mark (HQM) or Passivhaus are possible options for environmental performance assessment and certification of housing (and non-domestic buildings in the case of Passivhaus).

HQM, developed by the Building Research Establishment (BRE), aims to indicate to households high standards for running costs, health and wellbeing benefits and environmental footprints associated with living in the home. HQM measures the delivery processes of the home, the surroundings and provision of living spaces.

Non-domestic buildings can be certified through BREEAM, LEED, WELL and other similar national and international environmental performance assessment standards[86].

Any certification proposed should not supersede or 'hide' energy and carbon performance targets behind allocated credits that may be hard to review or understand. The exact targets should be reported separately by the developer, explaining which elements have been considered (regulated and unregulated, embodied carbon, whole-life carbon).

Handover:

BSRIA soft landings: Soft landings is a building delivery process which runs through the project, from inception to completion and beyond, to ensure all decisions made during the project are based on improving operational performance of the building and meeting the client's expectations. BSRIA provides a range of services to help implement soft landings successfully throughout all stages of a project[87].

As part of building user guides, information on the energy-efficient design and how to use the buildings effectively could be issued to residents upon occupation. To inform residents of ongoing energy and water consumption details, automated summary emails of building management system (BMS) data outputs could be issued monthly, allowing residents to understand their impact compared to others and manage heating/cooling effectively. Smart meters in the homes would provide instant feedback on consumption to homeowners.

The CGC – Garden community and net zero champion

To be able to create a coherent communication and engagement environmental performance strategy for CGC it is important that one keeps track of the different project aspirations, deliverables and achievements.

Measures occupied during different phases may vary, as well as additional green credentials achieved. In order to capture the evolution of the designs, the considerations at each stage and the outputs achieved it is recommended that a garden community and net zero (GCNZ) champion role is assigned to a CCC officer, fully responsible for undertaking all actions necessary to ensure compliance with standards and co-ordinate the extraction of learnings and knowledge. They will be best placed to also develop the detailed communication strategy.

Question 16. What are the most appropriate strategies for promoting greater acceptance amongst developers, investors and potential future occupants of the need for energy generated from local renewable and low-carbon energy schemes? This should include a consideration of the opportunities for community stewardship/ownership of the renewable and low-carbon energy technologies identified as potentially suitable. The study should examine different methodologies of initiating, financing and maintaining local renewable energy generation groups including

[86] Note the Local Plan requires that non-domestic buildings above 500sqm are required to meet a 'Very Good' BREEAM standard.
[87] Soft Landings Framework or Guides, Building Design Process UK | BSRIA

cooperative ownership and if there could be a mechanism in place allowing house buyers to purchase shares.

The current study examined localised renewable energy generation and store options – on a building level. The reasons the measures were set at a building level included:

- Maximum optimum use of space, by utilising photovoltaic panels on the roof area (within the existing footprint of the building).
- Direct benefit allocation to the occupant of the building. The energy generated is used directly by the occupant and reduces their energy bills.
- Flexibility in terms of time of use (energy) and benefits realised from night-time electricity tariffs using battery systems.
- Responsibility of maintaining and servicing the installed technologies transferred directly to the user.
- Simplicity in terms of controls and system infrastructure required compared to community-based and more interconnected network solutions.
- Resilience in the case of future development design/strategy changes.
- Clarity over performance standards and ability to compare and review against predicted performance.

While this is true at the time of writing this report, it does not mean that other strategies cannot be occupied by CGC moving forward to achieve the energy and carbon performance targets set within this study.

Such measures can include local community based decentralised electricity distribution networks, community-based battery store cascades, centralised heat and hot water stores and advanced supply/demand smart controls that can direct renewable energy generation live to the consumers that might require it the most (rather than being exported to the grid. Such systems are usually set up on a building block level).

CCC has a key role to play in supporting and developing the right strategy for the community. Through public/private partnerships CCC and communities can become stakeholders to these new plans. The current approach recommended by this research allocates the additional capital cost to development costs. This is expected to be absorbed by the developers, as they comply with the energy and carbon performance thresholds recommended for CGC future phases.

In that sense, the savings and benefits are locked in each building. Additional costs relating to maintenance, replacement and repairs are allocated to the user/owner.

Initiating, financing and maintaining local renewable energy generation groups is associated with community/district-based solutions, which have not been explored within this study.

What needs to be noted is that exploring and reviewing such methods needs to be part of the business case or optioneering of such systems when proposed for CGC. Key to such systems' success would be clarity over the exact benefits achieved, cost-benefit analysis, analysis of risk exposure and liability protective structures in place.

Especially in the case of 'shares', or systems that imitate current financial products and systems, additional consideration should be given to financial product regulatory frameworks, operators, platforms, forecasting, etc.

It is not advised, unless there is a robust framework, to introduce very complex liability and high-risk systems without achieving buy-in from all stakeholders involved in current and future CGC development plans.

Question 17. What opportunities are there for promoting renewable energy/low-carbon local enterprise initiatives, employment and training schemes, eg at the proposed employment area/s –

in line with one of the actions in the Green Infrastructure Action Plan (see Table 6.4, Economy theme) - and at Anglia Ruskin University and Writtle University College?

The opportunities deriving from progressing with meeting a net zero carbon (energy) CGC status are plenty and in support of the Green Infrastructure Action Plan. Key opportunities are listed below:

- Create an exemplar site with minimum environmental impact fully compliant with the garden community principles and the commitment for net zero carbon.
- Countryside stewardship (soil, water, habitats, species, landscape) by following a holistic and well-thought through development strategy. The requirement from developers to pay attention to environmental impact, and the green credentials of the development will lead to increased engagement with planners and local communities.
- Public, public/private, and private partnerships exploring smart demand/control and supply decentralised energy systems as per the recommendations made within this report.
- Improved user experience with electric vehicles and properties that don't use fuel combustion will lead to better indoor and external air quality, as well as noise reduction and less complexity without a centralised network distribution (gas).
- Maximise best use of land - renewable energy generation technologies incorporated within the development/building's footprint allowing for land that would have to be used for solar farms etc to be reduced.
- Anglia Ruskin University and Writtle University College will have the opportunity to learn from the smart village approach, as the infrastructure of energy store and controls, interconnectivity of the elements and potential areas of research such as post-occupancy buildings' performance monitoring and review can open new research opportunities for these academic institutes.
- Engagement and participation of communities is expected, as energy bills affordability is realised, and the exemplar standards used along with the Garden Community principles in combination provide an exceptional marketing opportunity as the place to be and experience high-quality of life.
- Increased energy efficiency is often accompanied by high construction quality and it is expected that the new development standards will be high and appropriate to establish improvements over the health and wellbeing of the communities residing within.
- The installations of heat pumps, PV and control systems will create a number of new jobs relating to these installed systems and services. This is exportable knowledge that CGC can spearhead. Talent is also expected to be retained within the community as lifecycle elements will come into play as buildings and systems get older.

Please note:

These opportunities can only be realised by not only adhering to suggested standards and the net zero carbon approach, but also by ensuring that all design standards used are present during construction.

While a fabric-first approach is the foundation of meeting the energy and carbon targets, there is heavy reliance on new systems (heating, hot water, energy generation and controls). While these new buildings do not have to feel more complex, they will inheritably be more complex, requiring quality structured maintenance and general repair regimes.

11. Overall project main conclusions

For future energy and carbon performance to be met in terms of net zero carbon, all-electric solutions will need to be considered for all new development within the CGC – Exceptions may include processes or building uses where combustion needs to occur. Such special circumstances will need to be evaluated on their merits.

All new housing in CGC will need to demonstrate a minimum space heating energy demand (technically feasible and cost-viable solutions to be considered only). This needs to be accompanied by detailed energy thresholds targeted and solutions proposed for these targets to materialise. The thresholds will be required to fall within the ranges provided within **Table 37 and Table 38.**

Total predicted energy consumption targets for each building will need to be produced to demonstrate the overall expected performance. For unregulated energy use, estimates like the ones presented within the report can be used, Appendix B – Housing and non-domestic buildings model specifications, or else the developers/consultants will need to produce their own estimates and support them with appropriate evidence.

Regulated energy consumption, total per year and all electric, for most buildings will need to be produced and extracted from the official and legally accepted simulation software (SAP/IES/SBEM and other approved solutions). Please see Table 37 and Table 38 for alignment.

All buildings will need to be able to generate renewable energy through PV installed on their roofs. This could exceed on occasions 50% of the roof area. All buildings should be delivering renewable energy generation benefits directly to users/occupiers to ensure energy bills affordability and cost reduction. Appropriate energy stores need to be used; approximate sizes are provided within the report and include 2-5kWh for new housing and ~3.5kWh per 100m^2 for non-domestic buildings.

All buildings will need to contain means to store heat (hot water, thermal mass, phase changing materials) to cover part of their needs and store surplus of renewable energy generation in the form of electrical energy store (batteries). The systems can be based in individual buildings or be centralised/combined on a block of buildings level.

The energy store on site (electricity) would provide the opportunity for proper business cases to be developed and evaluated so that CCC can decide the level of direct intended involvement or the type of investors that such an endeavour might attract.

Applying different energy standards at different phases of the development will translate to houses of the same type that will perform differently based on their year of construction.

Using high energy efficiency and carbon performance targets can assist in meeting Future Homes Standard (2025) in advance and create a levelled approach across the whole CGC. While the details around the Future Homes Standard are not known at the time of this report writing, it is expected that all new homes built from 2025 will produce 75-80% less carbon emissions than homes delivered under current building regulations. At the same time these new homes are expected to have moved away from the combustion of fossil fuels (eg gas boiler).

Lifecycle and whole lifecycle studies will need to be produced and submitted by the developers/ consultants at a planning permission stage, demonstrating the impact of the capital construction choices across the life of the buildings suggested for development.

Monitoring of the performance of the new buildings developed at each phase (five years minimum for a large development) will ensure that standards used during their design do achieve the energy and carbon performance targets set, increasing transparency and market confidence over the quality of these buildings. The development process should also be tracked with challenges, opportunities, lessons learnt and other useful information captured for the different building typologies especially during early development phases.

What is important to remember?

We examined three potential roadmaps, Table *30*. **We recommend that the best roadmap to follow would be introducing the minimum CGC standards for decision making on detailed planning applications until 2025 and then continuing with the zero carbon requirements as presented within Table 37 and Table 38 (Figure 24).**

Towards Zero Carbon – Roadmap 2

This roadmap follows some of the latest thinking and best practice in construction of net zero carbon buildings at later phases of the development (2025-2030, 2030-2036).

In effect, this roadmap allows for trialling some lower standards first (current to 2025), obtain feedback and gradually build to the higher standards.

Figure 24 – Proposed roadmap to zero carbon, please used standards from Table 37 *and* Table 38 *(orange and green marked columns, in the different development phases).*

It is very important to note that capital cost is not the driving factor for this recommendation. The main reason for the delaying of the zero-carbon standards is so development can adjust and does not go through a steep learning curve.

The zero-carbon standards include mandatory minimum amount of energy generation per building and storage on site. In effect they reflect latest and best industry practice.

The zero-carbon pre-2025 developments will need to be carefully recorded in terms of process and performance outcomes, opportunities, challenges and risks, to inform future development plans.

Our standards are not based on specific technologies, but no fossil-fuel based systems should be used post-2025 for the targets to be realised.

Finally, a net zero champion will need to be introduced by CCC to the Consortium to specialise on the planning applications for the location and track the development as it progresses ensuring that high-quality and community satisfaction standards are achieved.

12. Overall project recommendations

The project outputs provide clear instruction on how net zero carbon can be met on site, and how this can change during the different phases. There are some elements that the research team considered as especially important, which are a direct output of research and experience with similar projects that we would like to be noted. Therefore, a set of general recommendations are produced and provided below:

Quality controls

- Design aspirations can be compromised during implementation due to value engineering, changes in terms of strategy or limitations that were not identified in advance. It is strongly recommended that standards that are submitted during planning application are followed exactly on-site with appropriate collection of evidence to ensure compliance.
- Replacements of elements on site, variations from original plans, removal and/or reduction in quantities of technologies such as PV need to communicated back to the energy and carbon assessors to advise on impact.
- Post-construction shortfalls against CGC requirements (maybe through a Section 106) will need to be corrected through a developer obligation to provide necessary actions to offset deviations from the target.

Simulation software

- Conducting energy efficiency and carbon emission studies required the use of appropriate methods and software (like SAP for housing). In order to achieve the targets and aspirations presented within this report it is not enough to have an EPC rating. All SAP (or similar) input and assumptions will need to be maintained and included in the building user manual.
- The energy efficiency and carbon emission assessors will need to provide a breakdown of the key threshold metrics noted:
  a) Space heating demand, excluding the impact of the heating and hot water services efficiency. This should only account for the energy demand as a result from the fabric, airtightness and ventilation (only when there is heat recovery) systems.
  b) Total expected per year annual energy consumption. This should be detailed in terms of regulated and unregulated energy demand and should not include the contributions of energy generation technologies such as in the case of photovoltaic panels. This will include the efficiency of services such as heat pumps.
  c) Total expected per year renewable energy generation in terms of PV installations.
- While hot water store systems might be accounted for, electrical energy storage is a new area of interest. Assumptions around the total capacity of installed electrical energy store needs to be submitted along with the assessment that at least 50% of the total per building renewable electrical energy generation per year can be used directly on site.

Centralised system solutions

- Appropriate strategic assessments and business cases will need to be developed in the case of centralised energy store and management systems. This is critical for such systems to be implemented so all requirements are clearly set out before initiating development. These systems are usually complex requiring a lot of in-advance master planning and consideration as they have the ability to lock in future development plans.

Controls and feedback

- Monitoring of a percentage of development in terms of actual performance, surveys and community engagement activities will need to be occupied at initial project phases especially if the same high standards are to be used across all phases. This will allow user experience feedback from early phases to be secured to inform future phases and will assist in engaging with the community.

- In order to provide early feedback and adjust the development to the post-2025 tightening of standards, we believe it is important that at least 10% of all buildings to be developed currently and by 2025 should be ‘zero carbon’, and therefore meet the post-2025 standards as proposed and described (Table 37, Table 38) within the report.

Appendices

Appendix A – Renewable, low carbon and decentralised energy - regulations and policy links (as assessed in October 2020)

House of Commons Library extract[88]

Renewable Energy

Electricity provides a relatively small proportion of the UK's energy consumption. However, the evolution of technologies that produce UK electricity, and the importance of electricity for the future of the UK energy sector, has meant that electricity is often the focus of policy.

Energy policy in the UK is the responsibility of the Department of Business, Energy and Industrial Strategy (BEIS). Although there are numerous regulators for specific parts of the energy sector, much of the energy market is regulated by Ofgem. Historically, parts of energy generation, transportation, and supply were run by the public sector. All aspects of the market are now privatised; generation and supply are competitive, and transportation through networks is regulated as the operators are monopolies.

The energy policy of successive Governments has centred around three objectives of security, affordability, and decarbonisation. This is sometimes referred to as the energy 'trilemma'. Since 2017, energy policy has largely been made in line with the Government's Clean Growth Strategy. An Energy White Paper was announced in 2018 by the then Secretary of State for BEIS Greg Clark and is expected to set out future plans for energy policy when published later this year (Energy white paper: Powering our net zero future, December 2020[89]).

Renewable Heat (Small Scale)

Renewable Heat Incentive (April 2017)[90]: From 2011, support known as the Renewable Heat Incentive (RHI) has been available to non-domestic customers (and from 2014 domestic customers) to install renewable heat generating technologies.

Low-carbon power (Large Scale)

Support for low-carbon power (April 2020)[91]: This paper sets out details of the Government's primary mechanism for supporting new low-carbon power infrastructure, known as the contract for difference (CfD) scheme. The Library also has papers on some specific low-carbon technologies including, Tidal Lagoons (June 2018), Geothermal in the UK (June 2018), and Planning for onshore wind (July 2016).

CCUS (Large Scale)

Carbon Capture Usage and Storage – CCUS (March 2020)[92]: CCUS is a set of processes that capture carbon dioxide and either store it or reuse it in industrial processes. This paper sets out background to the technology, and details how successive Governments have supported CCS.

Electric Vehicles and Infrastructure

Electric Vehicles and Infrastructure (January 2020)[93]: electric vehicles (EVs) are a policy area for both BEIS and the Department for Transport.

[88] https://commonslibrary.parliament.uk/research-briefings/cbp-8980/
[89] https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future
[90] https://commonslibrary.parliament.uk/research-briefings/sn06328/
[91] https://commonslibrary.parliament.uk/research-briefings/cbp-8891/
[92] https://commonslibrary.parliament.uk/research-briefings/cbp-8841/
[93] https://commonslibrary.parliament.uk/research-briefings/cbp-7480/

This paper explains how successive governments have planned for infrastructure and provided vehicle grants and incentives to encourage and accommodate EVs. It also sets out how the electricity grid is preparing to accommodate any increased demand from EV charging and looks at comparative emissions from EVs and conventional vehicles.

Biofuels

Future of the British bioethanol industry (January 2019)[94]: bioethanol is a fuel produced from plant sources. It can provide an alternative to fossil fuels, eg as a transport fuel.

Table 39 - UK Statutory Instruments on Renewable Energy (October 2020)

UK Statutory Instruments on Renewable Energy (October 2020)	
The Electricity (Guarantees of Origin of Electricity Produced from Renewable Energy Sources) (Amendment) (EU Exit) Regulations 2018	2018 No. 1093
The Renewables Obligation (Amendment) (Energy Intensive Industries) Order 2017	2017 No. 1289
The Non-Domestic Rating (Renewable Energy Projects) (Amendment) Regulations 2017	2017 No. 1132
The Promotion of the Use of Energy from Renewable Sources (Amendment) Regulations 2013	2013 No. 829
The Non-Domestic Rating (Renewable Energy Projects) Regulations 2013	2013 No. 108
The International Renewable Energy Agency (Legal Capacities) Order 2011	2011 No. 2438
The Renewable Heat Incentive (Amendment to the Energy Act 2008) Regulations 2011	2011 No. 2195
The Promotion of the Use of Energy from Renewable Sources Regulations 2011	2011 No. 243
The Electricity (Guarantees of Origin of Electricity Produced from Renewable Energy Sources) (Amendment) Regulations 2010	2010 No. 2715
The Civil Jurisdiction (Application to Offshore Renewable Energy Installations etc.) Order 2009	2009 No. 1743
The Criminal Jurisdiction (Application to Offshore Renewable Energy Installations etc.) Order 2009	2009 No. 1739
The Renewable Energy Zone (Designation of Area) (Scottish Ministers) Order 2005	2005 No. 3153
The Renewable Energy Zone (Designation of Area) Order 2004	2004 No. 2668
The Electricity (Guarantees of Origin of Electricity Produced from Renewable Energy Sources) Regulations 2003	2003 No. 2562
The Electricity (Guarantees of Origin of Electricity Produced from Renewable Energy Sources) (Amendment) (EU Exit) Regulations 2018	2018 No. 1093
The Renewables Obligation (Amendment) (Energy Intensive Industries) Order 2017	2017 No. 1289
The Non-Domestic Rating (Renewable Energy Projects) (Amendment) Regulations 2017	2017 No. 1132
The Promotion of the Use of Energy from Renewable Sources (Amendment) Regulations 2013	2013 No. 829

[94] https://commonslibrary.parliament.uk/research-briefings/cbp-8980/

Table 40 - UK Statutory Instruments on Heat Networks (October 2020)

UK Statutory Instruments on Heat Networks (October 2020)	
The Heat Network (Metering and Billing) (Amendment) Regulations 2015	2015 No. 855
The Heat Network (Metering and Billing) Regulations 2014	2014 No. 3120

Table 41 - UK Statutory Instruments on Carbon Capture (October 2020)

UK Statutory Instruments on Carbon Capture (October 2020)	
The Carbon Capture Readiness (Electricity Generating Stations) (Amendment) (Wales) Regulations 2019	2019 No. 294 (W. 72)
Rheoliadau Parodrwydd i Ddal Carbon (Gorsafoedd Cynhyrchu Trydan) (Diwygio) (Cymru) 2019	2014 No. 3120

Table 42 - UK Statutory Instruments on Biofuels (October 2020)

UK Statutory Instruments on Biofuels (October 2020)	
The Biofuels and Hydrocarbon Oil Duties (Miscellaneous Amendment) Regulations 2016	2016 No. 976
The Hydrocarbon Oil and Biofuels (Road Fuel in Defined Areas) (Reliefs) (Amendment) Regulations 2015	2015 No. 550
The Biofuels and Other Fuel Substitutes (Payment of Excise Duties etc.) (Amendment) Regulations 2014	2014 No. 471
The Hydrocarbon Oil and Biofuels (Road Fuel in Defined Areas) (Reliefs) Regulations 2011	2011 No. 2935
The Biofuel (Labelling) (Amendment) Regulations 2009	2009 No. 3277
The Hydrocarbon Oil, Biofuels and Other Fuel Substitutes (Determination of Composition of a Substance and Miscellaneous Amendments) Regulations 2008	2008 No. 753
The Biofuels and Hydrocarbon Oil Duties (Miscellaneous Amendments) Regulations 2007	2007 No. 3307
The Biofuels and Other Fuel Substitutes (Payment of Excise Duties etc) (Amendment) Regulations 2007	2007 No. 1640
The Biofuel (Labelling) (Amendment) Regulations 2005	2005 No. 3355
The Biofuel (Labelling) Regulations 2004	2004 No. 3349
The Biofuels and Other Fuel Substitutes (Payment of Excise Duties etc.) Regulations 2004	2004 No. 2065
The Biofuels and Hydrocarbon Oil Duties (Miscellaneous Amendment) Regulations 2016	2016 No. 976
The Hydrocarbon Oil and Biofuels (Road Fuel in Defined Areas) (Reliefs) (Amendment) Regulations 2015	2015 No. 550

Appendix B – Housing and non-domestic buildings model specifications

Residential

	Minimum NCGC standards (until 2025 - depending on roadmap selected)	Best practice
Key Performance Indicators (KPI)	Indicative design requirements to comply with KPIs	
Space heating demand	**< 35 kWh/m²/yr.** • External wall U-value < 0.18 W/m².K • Ground floor U-value < 0.15 W/m².K • Thermal bridge free junctions • Double-glazed windows • Airtightness < 3 m³/h/m² at 50 Pa • Good quality MVHR within 5m of external wall	**< 15 kWh/m²/yr.** • Efficient form factor: < 0.8-1.2 • Proportion of windows: 10-25% • External wall U-value < 0.13 W/m².K • Ground floor U-value < 0.10 W/m².K • Thermal bridge free junctions • Triple-glazed windows • Airtightness < 1 m³/h/m² at 50 Pa • High quality MVHR within 2m of external wall
EUI Target	**< 50 kWh/m²/yr.** • Heating system analysis required - individual heat pump for heating and hot water would meet the target	**< 35 kWh/m²/yr.** • Heating system analysis required - individual heat pump for heating and hot water would meet the target
Fossil Fuel Free	• No gas supply	
Overheating	• Prioritise passive design to mitigate overheating, including external shading • Assess against TM59	
Measurement and Verification	• Adequate sub-metering from key energy uses and renewables, electric vehicles, heating fuel consumption • Post-occupancy energy monitoring with comparison to predictions • Reporting of energy data 5 years post-completion	
Renewables	• Maximize PV on roof allowing for access and maintenance -at least 40% of the roof must be covered in PV	• At least 80% of the roof is covered in PV, it is expected that energy generation of PV on roof meets the total energy consumption of the building
Batteries	• none	• 2 kW – 5 kW for a 3 bed terrace

Office

	Minimum NCGC standards (until 2025 – depending on roadmap selected)	Best practice
Key Performance Indicators (KPI)	Indicative design requirements to comply with KPIs	
Space heating demand < 15 kWh/m²/yr (TFA)	**< 35 kWh/m²/yr.** • External wall U-value < 0.18 W/m².K • Floor U-value < 0.15 W/m².K • Ground floor U-value < 0.15 W/m².K • Thermal bridge free junctions • double-glazed windows • Airtightness < 3 m³/h/m² at 50 Pa	**< 15 kWh/m²/yr.** • Efficient form factor: < 1-2 • Proportion of windows: 25-40% • External wall U-value < 0.13 W/m².K • Floor U-value < 0.10 W/m².K • Ground floor U-value < 0.10 W/m².K • Thermal bridge free junctions • Triple-glazed windows • Airtightness < 1 m³/h/m² at 50 Pa
EUI Target	**< 70 kWh/m²/yr.** • Mixed mode ventilation • Energy efficient lighting – 100 lumens per circuit watt • 90% efficiency AHU or MVHR • Central AHU 1.2-1.5 W/l/s • A/C set points 20-26 °C • Demand control ventilation • Energy efficient equipment and small power • Analysis of low carbon heating options	**< 55 kWh/m²/yr.** • Mixed mode ventilation • Energy efficient lighting – 100 lumens per circuit watt • 90% efficiency AHU or MVHR • Central AHU 1.2-1.5 W/l/s • A/C set points 20-26 °C • Demand control ventilation • Energy efficient equipment and small power • Analysis of low carbon heating options required – a highly efficiency air source heat pump or ground source heat pump for heating and hot water would meet the target
Fossil Fuel Free	• No gas supply	
Overheating	• Prioritise passive design to mitigate overheating, including external shading • Assess against TM59	
Measurement and Verification	• Adequate sub-metering from key energy uses and renewables, separate landlord and tenant energy use meters • Post-occupancy energy monitoring with comparison to predictions • Reporting of energy data 5 years post-completion	
Renewables	• Maximize PV on roof allowing for access and maintenance -At least 40% of the roof is covered in PV	• 80% of the unshaded roof is covered in PV. This is expected to meet 70% of the energy consumption of the building over the course of the year
Batteries	• none	• 3.5kWh per 100m²

Office					
	GIFA (m^2)	Total Predicted Energy Consumption/Generation per m2 per fuel type (kWh/m2/yr)			
			Baseline	Package 1	Package 2
Phase 1	0	Gas	43.4	0.0	0.0
Phase 2	750	Electricity regulated	78.0	44.3	30.9
Phase 3	375	Electricity unregulated	65.0	30.0	24.0
Total	1125	Electricity generated through PV	0.0	-22.5	-45.0
		Net electricity use	143.0	51.8	9.9
		EUI	186.4	74.3	54.9

School	GIFA (m^2)				
		Total Predicted Energy Consumption/Generation per m2 per fuel type (kWh/m2/yr)			
			Baseline	Package 1	Package 2
Phase 1	0	Gas	58.3	0.0	0.0
Phase 2	2651	Electricity regulated	25.0	44.6	24.6
Phase 3	16483	Electricity unregulated	48.0	40.5	40.5
Total	19134	Electricity generated through PV	0.0	-22.5	-45.0
		Net electricity use	73.0	62.6	20.1
		EUI	131.3	85.1	65.1

Retail					
	GIFA (m^2)	Total Predicted Energy Consumption/Generation per m2 per fuel type (kWh/m2/yr)			
			Baseline	Package 1	Package 2
Phase 1	0	Gas	57.3	0.0	0.0
Phase 2	2250	Electricity regulated	36.3	57.4	42.9
Phase 3	1125	Electricity unregulated	158.8	73.0	43.5
Total	3375	Electricity generated through PV	0.0	-22.5	-45.0
		Net electricity use	195.1	107.9	41.4
		EUI	252.4	130.4	86.4

Leisure					
	GIFA (m^2)	Total Predicted Energy Consumption/Generation per m2 per fuel type (kWh/m2/yr)			
			Baseline	Package 1	Package 2
Phase 1	0	Gas	124.3	0.0	0.0
Phase 2	5700	Electricity regulated	54.6	115.0	81.4
Phase 3	1000	Electricity unregulated	13.3	10.6	10.6
Total	6700	Electricity generated through PV	0.0	-22.5	-45.0
		Net electricity use	67.9	103.1	47.0
		EUI	192.2	125.6	92.0

Innovation hub	GIFA (m^2)	Total Predicted Energy Consumption/Generation per m2 per fuel type (kWh/m2/yr)			
			Baseline	Package 1	Package 2
Phase 1	8100	Gas	43.4	0.0	0.0
Phase 2	15150	Electricity regulated	97.5	49.2	35.8
Phase 3	20625	Electricity unregulated	81.3	40.0	30.0
Total	43875	Electricity generated through PV	0.0	-22.5	-45.0
		Net electricity use	178.8	66.7	20.8
		EUI	222.2	89.2	65.8

Appendix C – UK PN Quotes

UK Power Networks
Delivering your electricity

Registered Office
Newington House
237 Southwark Bridge Road
London SE1 6NP

Company:
UK Power Networks
(Operations) Limited

Registered in England and Wales No: 3870728

Sam Saunters
Utility Results C/O Currie & Brown
32 Blackfriars Road
LONDON
SE1 8PB

Date: 19 April 2021

Our Ref: 8200042542 / QID 3000033044

Dear Saunters

Site Address: (IDNO) North East Chelmsford Garden Village, Chelmsford, CM3 3PS

Thank you for your recent enquiry regarding the above premises. I am writing to you on behalf of Eastern Power Networks plc the licensed distributor of electricity for the above address trading as UK Power Networks.

I am pleased to be able to provide you with a budget estimate for the work.

It is important to note that this budget estimate is intended as a guide only. It may have been prepared without carrying out a site visit or system studies. No enquiry has been made as to the availability of consents or the existence of any ground conditions that may affect the ground works. It is not an offer to provide the connection and nor does it reserve any capacity on UK Power Networks electricity distribution system.

Budget estimate:

The budget estimation for the works required to provide 27.5MVA to the above mentioned site is:

Description

The proposed POC will be at a new 60MVA 132/11kV Grid substation to be installed within the existing BR Springfield Grid site.

The establishment of the new 132/11kV site will only be possible following the decommissioning of the existing Network Rail connection and will require works on the 132kV circuits that presently supply the site to accommodate a three-phase supply.

The site will be supplied by six dedicated breakers

Point Of Connection at Primary Substation

£ 5,300,000.00 (exclusive of VAT) if the Point Of Connection (POC) is at our BR Springfield Grid Substation.

Assumptions

This budget estimate is based on the following assumptions:

- The most appropriate Point of Connection (POC) is as described above.

- A viable cable or overhead line route exists along the route we have assumed between the Point of Connection (POC) and your site.
- In cases where the Point of Connection (POC) is to be at High Voltage, that a substation can be located on your premises at or close to the position we have assumed.
- Where electric lines are to be installed in private land UK Power Networks will require an easement in perpetuity for its electric lines and in the case of electrical plant the freehold interest in the substation site, on UK Power Networks terms, without charge and before any work commences.
- You will carry out, at no charge to UK Power Networks, all the civil works within the site boundary, including substation bases, substation buildings where applicable and the excavation/reinstatement of cable trenches.
- Unless stated in your application, all loads are assumed to be of a resistive nature. Should you intend to install equipment that may cause disturbances on UK Power Networks' electricity distribution system (e.g. motors; welders; etc.) this may affect the estimate considerably.
- All UK Power Networks' work is to be carried out as a continuous programme of work that can be completed substantially within 12 months from the acceptance of the formal offer.

Please note that if any of the assumptions prove to be incorrect, this may have a significant impact on the price in any subsequent quotation. You should note also that UK Power Networks' formal connection offer may vary considerably from the budget estimate. If you place reliance upon the budget estimate for budgeting or other planning purposes, you do so at your own risk.

Post estimate call

I will contact you within the next few days to discuss your estimate, to ensure you understand the work we will do for the estimated price, your responsibilities, any dependencies and the likely timescales for the work. UK Power Networks are always looking to improve our service offering and as such, the post estimate call may be recorded for training purposes. We will not share the recorded call with anyone outside of our connections business and it will be deleted as soon as we have completed the training review. However, if you do not want us to record the call please let me know at the beginning of the call.

If you would like to proceed

If you would like to proceed to a formal offer of connection then you should apply for a quotation. Please refer to our website click here for `The connection process' which details our application process.

To help us progress any future enquiry as quickly as possible please quote the UK Power Networks Reference Number from this letter on all correspondence.

Any Questions?

If you have any questions about your budget estimate or need more information, please do not hesitate to contact me. The best time to call is between the hours of 9am and 4pm, Monday to Friday. If the person you need to speak to is unavailable or engaged on another call when you ring, you may like to leave a message or call back later.

Yours sincerely

Mr. Alessandro Di Franco
Centenary House, 161 Bidder St,
London, E16 4ET
07875 110 142
alessandro.difranco@ukpowernetworks.co.uk

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Delivering your electricity

Registered Office
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Budget estimate:

The budget estimation for the works required to provide 22MVA to the above mentioned site is:

Description

The proposed POC will be at a new 60MVA 132/11kV Grid substation to be installed within the existing BR Springfield Grid site.

The establishment of the new 132/11kV site will only be possible following the decommissioning of the existing Network Rail connection and will require works on the 132kV circuits that presently supply the site to accommodate a three-phase supply.

The site will be supplied by six dedicated breakers

Point Of Connection at Primary Substation

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Assumptions

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- You will carry out, at no charge to UK Power Networks, all the civil works within the site boundary, including substation bases, substation buildings where applicable and the excavation/reinstatement of cable trenches.
- Unless stated in your application, all loads are assumed to be of a resistive nature. Should you intend to install equipment that may cause disturbances on UK Power Networks' electricity distribution system (e.g. motors; welders; etc.) this may affect the estimate considerably.
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Please note that if any of the assumptions prove to be incorrect, this may have a significant impact on the price in any subsequent quotation. You should note also that UK Power Networks' formal connection offer may vary considerably from the budget estimate. If you place reliance upon the budget estimate for budgeting or other planning purposes, you do so at your own risk.

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Yours sincerely

Mr. Alessandro Di Franco
Centenary House, 161 Bidder St,
London, E16 4ET
07875 110 142
alessandro.difranco@ukpowernetworks.co.uk

Appendix D – Battery storage and peak load

Battery storage calculations

To form the basis of the calculations, an annual solar irradiance calculation was performed for the Chelmsford location. This provided hourly solar energy per m^2 which informed the output from the PV panels.

In this calculation we assessed the output for five different orientations with 30° incline panels, and a horizontal panel. The outcome of these calculations are as follows:

PV Output (kWh/m^2/yr)					
W (30°)	SW (30°)	S (30°)	SE (30°)	E (30°)	Hor. (0°)
140.7	164.8	173.3	161.3	136.0	150.6

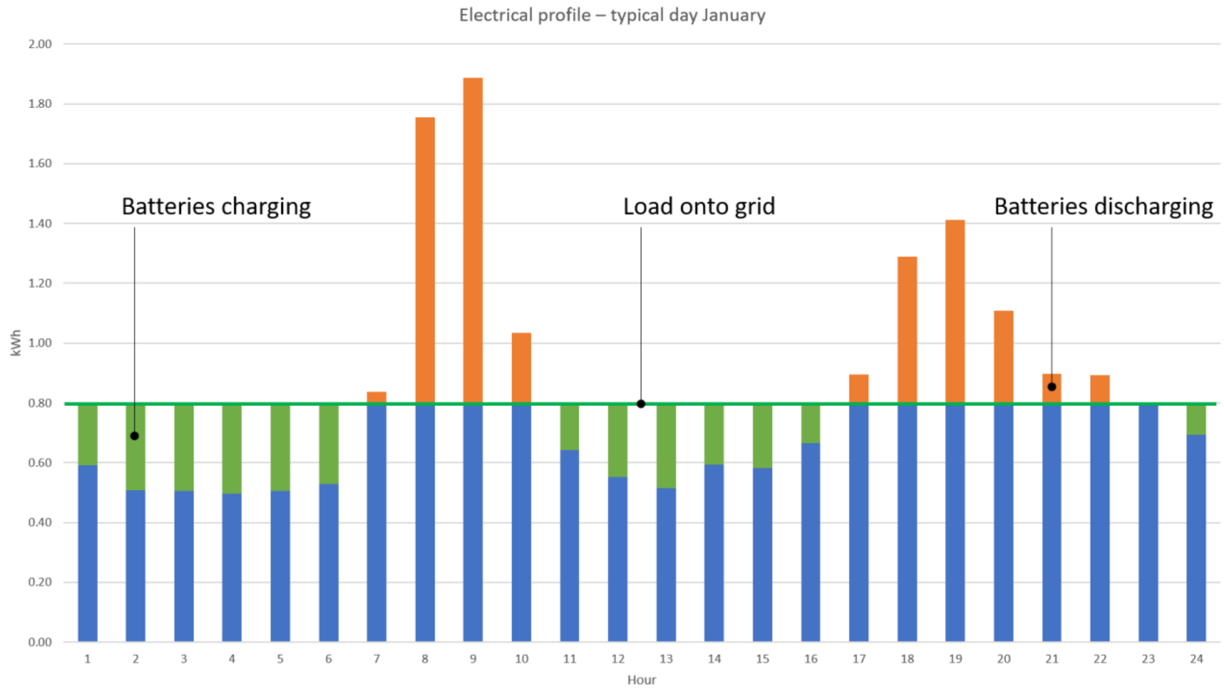
As the orientation and the angle of the PV panels cannot be confirmed at this stage of the development, we have assumed the horizontal output for inclusion in our calculations. This allows flexibility in the final architecture while remaining relevant to the scope of this study.

Consideration to a blend of orientations should also be considered to provide optimum support to the grid, as this spreads the load across the day rather than all panels peaking at the same time.

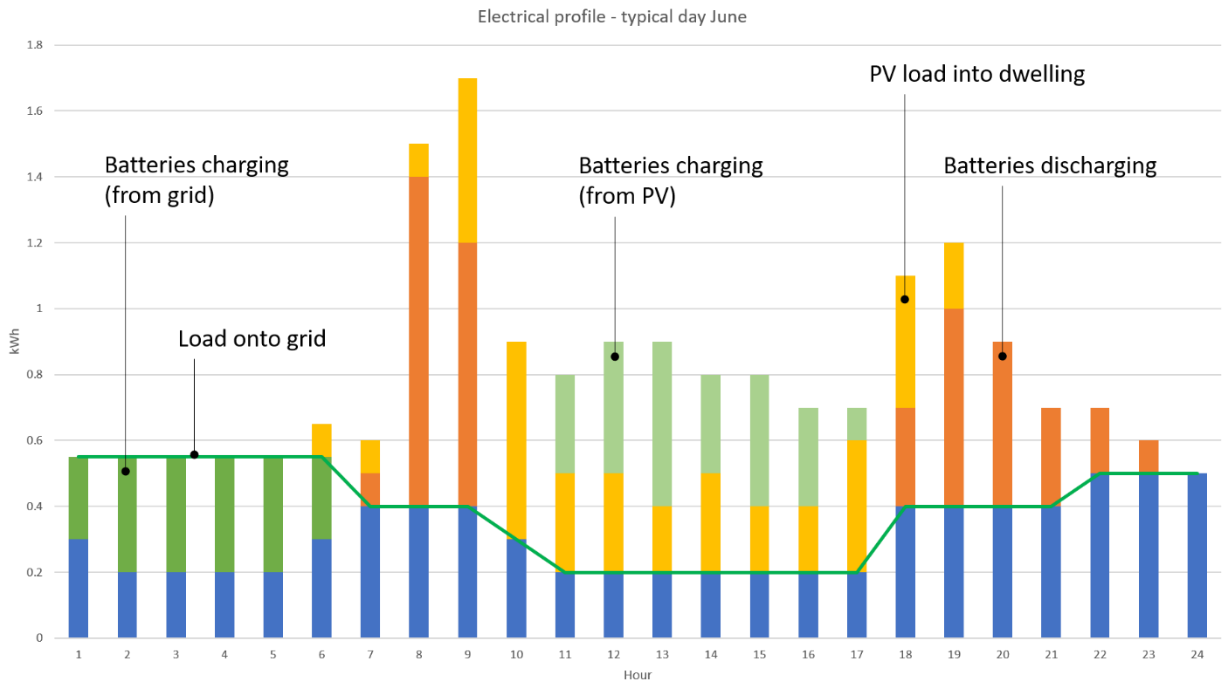
Our calculation for residential was based around a three-bed dwelling to provide an indication of performance for the whole development. As detailed in the packages, the ‘small’ PV array equated to $10m^2$ and the ‘large’ PV array equated to $30m^2$. It was then possible to calculate the hourly and annual generation from the PV array for each option.

This information was then used to understand how battery storage could assist with load management for the dwelling. The small PV array was included when assessing ‘load smoothing’ and the large PV array was included when assessing ‘grid independence’.

The intent of ‘load smoothing’ is to remove peak demand from the grid and provide a more consistent load across a full 24hr period. This is achieved in winter months purely from the battery (there will be limited contribution from PV) and in summer months as a combination of PV and battery storage. The following graphs demonstrate how this performance is achieved for a typical day in January and July.



As can be seen from the January graph, the load required by the dwelling fluctuates from around 0.5kW to 1.9kW. By adding a 2kWh battery, it is possible to charge the battery during low demand period and discharge the battery during peaks, to flatten the load onto the grid to a constant 0.8kW.



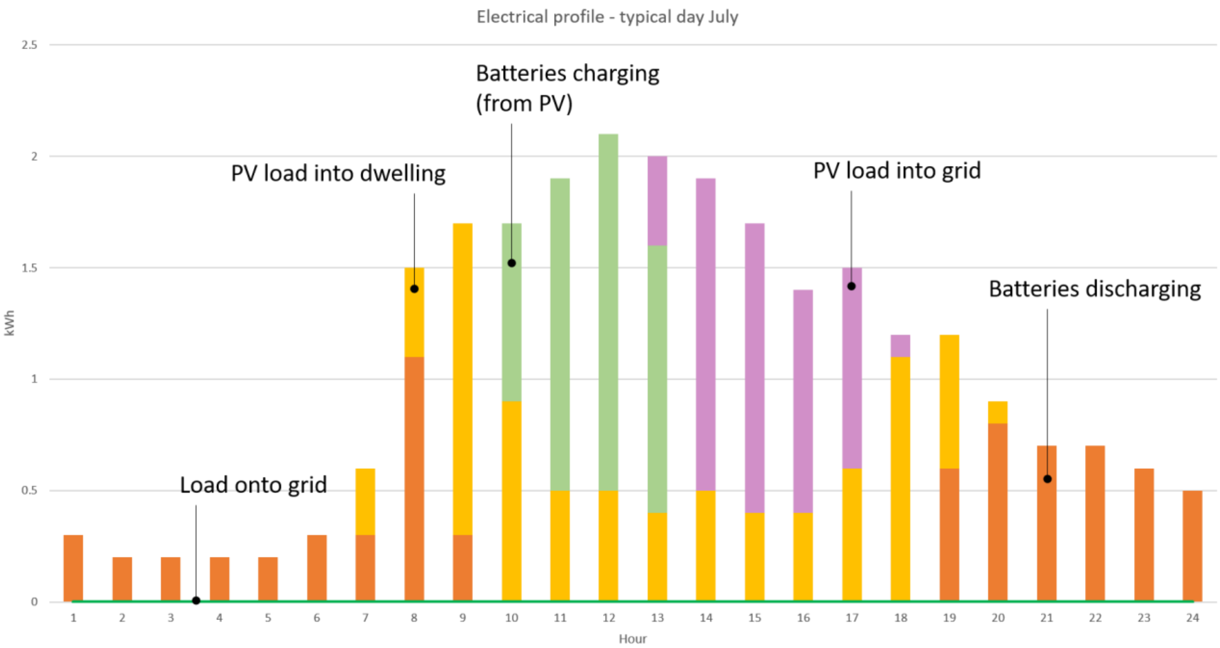
Smoothing the load for summer period is more challenging than in winter. This is due to the load profile having a slightly wider range – 0.2 to 1.7kW, and also due to the energy produced by the PV driving down the midday demand.

The average load onto the grid is significantly lower than in winter, but a fluctuation remains during the day of around 0.35kW. A major benefit is still achieved for the grid, as the highest grid load is during typical non-peak periods.

There is sufficient PV energy generated during the middle of the day to cover all of the demand; however, this would then leave the batteries insufficiently charged for the evening peak. Therefore, the PVs are used for direct power and to charge the batteries, with a base load still provided by the grid.

This analysis confirmed that a 2kWh battery can potentially reduce the peak entirely during winter months and by over 70% in summer months. Allowing for variations in use, we recommend a performance target of 60% load variation across the day.

For the larger PV array, this was assessed against enabling the building to perform entirely independently from the grid for prolonged periods of the year. The performance for a typical summer day is detailed below.



This graph shows how the PV charges the battery during the day, ready for discharging during the night-time period. During daylight hours the PV will meet the load directly. Once the battery is fully charged, any excess power can be supplied back into the grid.

The size of the battery will determine what period of the year the building will be able to function independently from the grid. A 5kWh battery will enable approximately four months' independence. If this is increased to 10kWh then approximately seven months' independence may be achieved.

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