PICK EVERARD

Net Zero Carbon Feasibility Report

Trinity Road Council Office Redevelopment

Cotswold District Council

COTSWOLD DISTRICT COUNCIL

Issue Number 01
07/06/2021

Document History

Issue	Date	Comment	Author	Chk'd
01	07/06/2021	Issue of draft report for internal review	TOR	JHE

PICK EVERARD

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1.0 Executive Summary

Pick Everard were appointed by Cotswold District Council to provide sustainability & energy consultancy services in relation to the council headquarters building, located at Trinity Road, Cirencester, GL7 1PX. This report provides an assessment of the operational energy consumption and embodied carbon of three potential options for the proposed scheme:

- Option 1 – Partial Conversion
- Option 2 – Full Conversion
- Option 3 – Full Site New Development

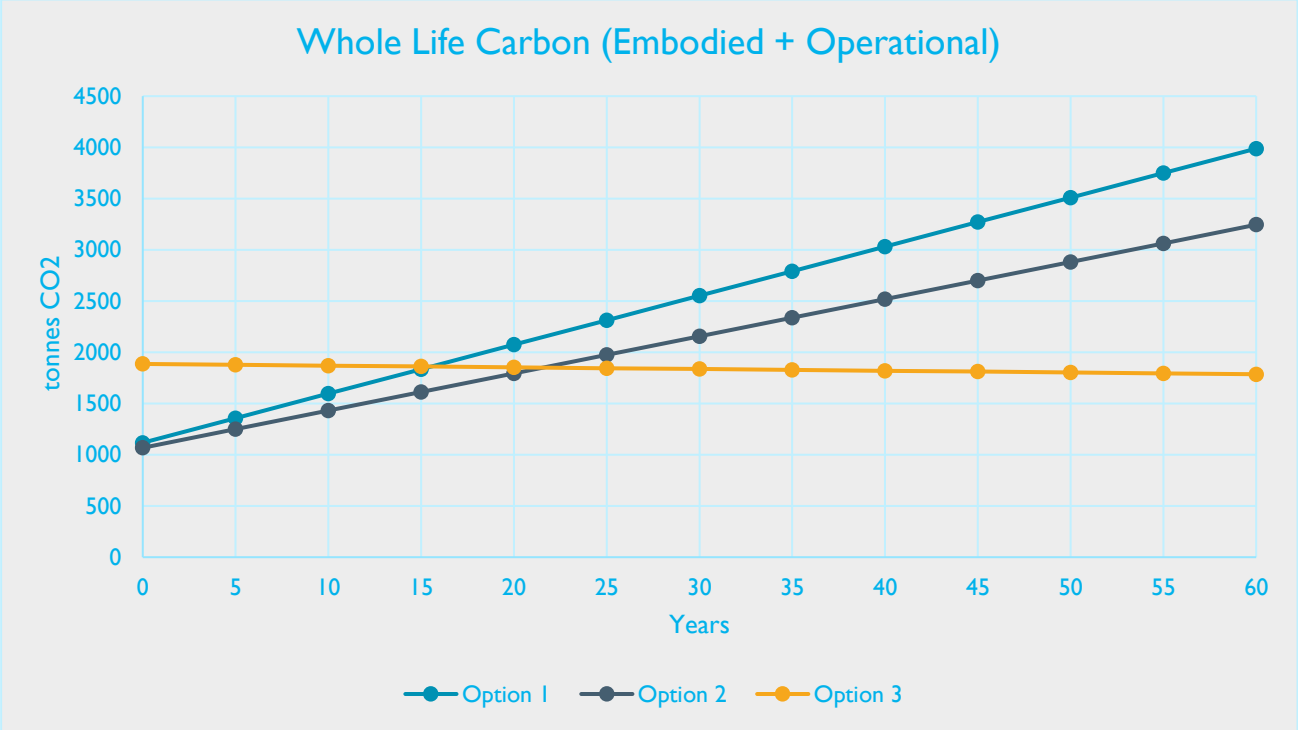
The following table provides a summary of the estimated carbon emission operational energy use and embodied carbon in construction for the three options:

	Option 1	Option 2	Option 3
Operational Energy Use before PV Generation (kWh/year)	470,268	385,272	106,149.71
Net Operational Energy Use (kWh/year)	351,844	266,848	-1669.30
Net Energy Use Intensity (kWh/m^2/year)	66.83	65.28	-3.29
Net Carbon Emissions from Operational Energy Use (tCO_2/year)	47.851	36.290	-1.67
Total Embodied Carbon (tCO_2)	1117.23	1067.9	1866.21
PV Generation (kWh/year)	118,424	118,424	118,424

The above results show that, of the three options currently tabled, only Option 3 represents a scheme that has the potential to be NZC in operation, based on the offset of CO_2 emissions provided by the PV array proposals outlined in the Energy Audit & Survey Report.

Option 3 actually offers the possibility of offsetting some additional carbon as the estimates show it would be carbon negative in operation (i.e., annual PV generation energy exceeds the annual operational energy requirements). However, Option 3 also has the highest embodied carbon in construction of any of the options.

Over a 60-year period Option 3 presents the lowest whole life carbon use. The graph below is for comparative purposes as it doesn't account for further decarbonisation of the grid, replacement of equipment or further fabric works on the basis they would be the same for all three options.



The following additional PV array capacity would be required to achieve operation net zero carbon for options 1 and 2:

	Option 1	Option 2
Additional Array Capacity Required (kWp)	428	324
Additional Array Area Required (m^2)	1956	1483
Revised Total Array Capacity Required (kWp)	582	468
Revised Total Array Area Required (m^2)	2614	2142

It is recommended that, once the council has come to a resolution on which of the three options is preferred, a whole life carbon assessment of the building is undertaken including detailed thermal modelling and quantification of embodied carbon.

With respect to the offsetting of the embodied carbon contained within the construction materials required, we recommended the use at the next stage of the UK-GBC 'Renewable Energy Procurement & Carbon Offsetting – Guidance for Net Zero Carbon Buildings' in relation to renewable energy procurement, carbon accounting, carbon offsetting and verification of net zero buildings. The council may decide to set a price for operational carbon emissions following the example of other councils to enable whole life cost calculations that include the cost of carbon over a determined period.

2.0 Introduction

Pick Everard were appointed by Cotswold District Council to provide sustainability & energy consultancy services in relation to the council headquarters building, located at Trinity Road, Cirencester, GL7 1PX. Following their declaration of a climate emergency, Cotswold District Council has introduced high aspirations for their current and future property portfolio. The purpose of this report is to outline and appraise the suitability of different energy efficiency interventions and design measures that are available to the proposed scheme in order to achieve net zero carbon (NZC) in operation. There are presently three different development options being considered for the site, and the applicability of these interventions/design considerations will vary according to which option is ultimately chosen:

- **Option 1 – Partial Conversion**

  The majority of the existing offices will be retained for council use, with the south block and link building being converted into residential accommodation, housing 16 no. one-bedroom apartments. A first-floor extension will be constructed to the rear of the south block.

- **Option 2 – Full Conversion**

  All of the existing buildings will be converted into residential accommodation. The atrium infill structure and link building will be demolished to improve the openness and visual appeal of the site/environment. An additional 5 no. two-bedroom terraced houses will be built in the north east of the site. A first-floor extension will be constructed to the rear of the south block. The south block will be converted into 5 no. three-bedroom houses and 4 no. one-bedroom flats.

- **Option 3 – Full-site New Development**

  The majority of the existing council buildings will be demolished, with the south block being retained to maintain the aesthetic aspect from Trinity Road. A first-floor extension will be constructed to the rear of the south block. The south block will be converted into 5 no. three-bedroom houses and 4 no. one-bedroom flats. The rest of the site will consist of entirely new build structures, being a mix of 22 no. two-bedroom houses, 4 no. three-bedroom houses and 8 no. one bedroom duplexes.

2.1 Site Context

The council office building located at Trinity Road houses the main offices for Cotswold District Council and is located approximately 600 metres south-southeast ('As the crow flies') from the centre of Cirencester. The following image shows an aerial satellite view of the existing site, with the approximate site boundary shown as a dashed red line:

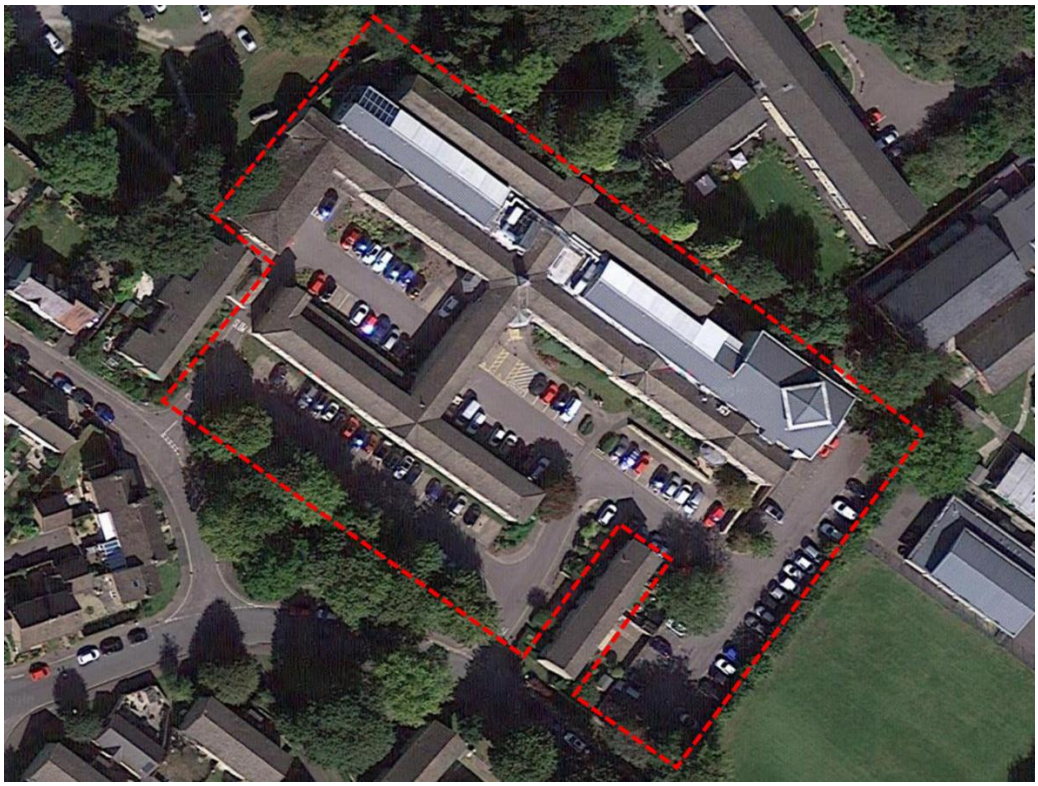


Figure 1 – Aerial satellite view of the existing site

Cirencester is a market town in Gloucestershire with an estimated population of 17,000 in 2019 (Source – Office for National Statistics). Cirencester is located in the southwest region of England and experiences a temperature 'Oceanic' climate (Köppen Cfb) similar to most of the United Kingdom.

The Trinity Road Council Office building is an historic building, originally constructed in the 1800s to be used as the Cirencester Workhouse. There is a single Grade II listed structure within the site curtilage, though this does not form a significant portion of the site accommodation. The main building is predominantly set out over two storeys and has solid Cotswold stone walls and pitched roofs. The building underwent significant refurbishment during 2000 and, at some point in the past, an atrium infill was added between the two wings of the north portion of the building. One wing of the building is let to third party tenants made up of various different organisations. Carbon emissions reports prepared by the Council from the year 2018/19 indicate that this particular building accounted for approximately 32 % of the Council's carbon emissions for that year. It has been acknowledged that the building is inherently inefficient in terms of energy performance due to its layout (form factor) and construction.

3.0 Current Building – Energy Performance

The Display Energy Certificate (DEC) for the building was accessed from the Energy Performance of Buildings Data England and Wales online records. The most recent DEC was lodged on the 28th of February 2019, as shown below:

Cotswold District Council, Council Offices, Trinity Road GL7 1PX

Display Energy Certificate

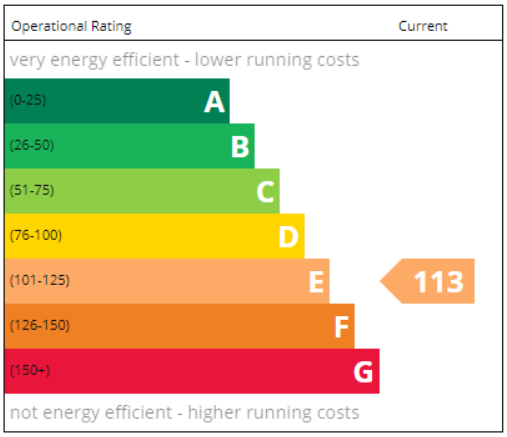


Figure 2 – Most recent DEC for current Cotswold District Council Offices

The DEC shows an operational rating of E-113. E-100 is considered to be the benchmark value, showing that this building slightly underperforms in terms of energy use & running costs when compared to other buildings of its type and size.

The other main points of note from the latest DEC are as follows:

- The main heating fuel of the building is natural gas.
- The building was assessed on the basis of a total useful floor area of 5,222 m^2.
- CO_2 emissions associated with electricity use were estimated to be 237 tonnes per year.
- CO_2 emissions associated with heating use were estimated to be 206 tonnes per year.
- Annual thermal fuel (heating) usage was estimated to be 203 kWh/m^2/year.
- Annual electrical fuel usage was estimated to be 82 kWh/m^2/year.
- No contribution from renewables was made.

The 'Energy Audit and Survey Report' produced by Inspired Efficiency in April 2020 summarised the energy profile of the building as follows:

Service	Description	Estimated Proportion of Usage
Lighting	Predominantly T5 fluorescent lighting with many areas having already been converted to LED. Some 2D and CFL fittings to WCs and circulation spaces.	5 %
Heating	Heating provided large gas boilers located in the basement plant room providing heating to perimeter radiators around the building. Separate gas boiler serving tenanted areas.	54 %
Hot Water	Hot water provided from electrical point of use units in most areas of the main council offices. Appears to be fed from the combi gas boilers to the tenanted areas.	10 %
IT Equipment	PC workstations on desk throughout, printers, copiers, and server room in IT department.	12 %
Other Small Power	Kitchen appliances, lift, alarms, plug in heaters, appliances and chargers and the like.	12 %
Air Conditioning	Split unit AC to some internal meeting rooms. Major AC system to oversized server room.	7 %

Table 1 – Summary Profile of Main Energy Consuming Equipment

The following table, also taken from the 'Energy Audit and Survey Report' produced by Inspired Efficiency, provides a schedule of energy saving recommendations for the existing building that were previously made, along with the associated cost and CO_2 emissions savings:

Energy saving recommendation	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	% Energy Reduction	Estimated capital cost (£)	Simple Payback (years)	CO_2 savings ($tCO_2e/yr.$)
Remove water coolers	110	£15	0.01%	Nil	Immediate	0.03
Consider install Electric Vehicle Charging Points	-	N/A	N/A	N/A	N/A	N/A
Power management to workstations and computers to support positive energy behaviours	8,190	£1,085	0.62%	£1,800	1.66	2.52
Install 'SavaWatt' devices on fridges and freezers	840	£111	0.06%	£300	2.70	0.26
Reduce size of IT server room to match revised racks and reduce cooling requirement	9,360	£1,240	0.71%	£4,000	3.23	2.88
Install PIR motion sensors on selected lighting circuits	6,342	£840	0.48%	£2,837	3.38	1.95
Fit timed fused spurs to hot water heaters	1,944	£258	0.15%	£1,080	4.19	0.60
Change existing lighting for low energy lamps/fittings	47,683	£6,523	3.62%	£49,782	7.88	14.65
Install 144kWp PV system on roofs of building	118,424	£15,688	8.99%	£160,000	10.20	36.38
Replace north side atrium roof with solid insulated panels	71,082	£2,092	5.40%	£120,000	57.36	13.08
Install insulated internal wall linings to solid walls	56,865	£1,674	4.32%	£180,000	107.56	10.46

4.0 Assessing Operational Energy Use and Embodied Carbon of the Proposed Options

The London Energy Transformation Institute (LETI) have produced reference documents which will be used to aid in determining the requirements for achieving NZC across all three of the different scheme options. The two documents of note are:

- LETI Climate Emergency Design Guide
- LETI Embodied Carbon Primer

The carbon emissions associated with the different schemes can be split into two broad categories:

1. Carbon Emissions from Operational Energy Use – The carbon emissions arising from the energy consumption by the building end-users to operate the building. This includes regulated loads (heating, ventilation, air-conditioning/comfort cooling, domestic hot water (DHW) use, and lighting) and unregulated loads (small power plug loads, catering equipment, lifts, security systems etc.).
2. Embodied Carbon Emissions – The carbon emissions released during the production, transport, and installation of building materials, and during their disposal at end of life.

Both of these elements will be assessed in turn to determine the potential emissions reductions and offset requirements in each case.

4.1 Operational Energy – Methodology

The annual operational energy usage of the proposed scheme across all options has been estimated based on a number of key pieces of information and assumptions:

- Figures for gas and electricity consumption for the building taken from the last DEC (Jan 19)
- Adjustments made for the proposed site layout, based on the proportion of the total useful floor area of the scheme that the retained areas, converted areas and new build areas will make up.
- LETI Energy Usage Intensity (EUI) targets in kWh/m^2/year.
- Standard Assessment Procedure (SAP) 10.1 carbon factors (an all-electric solution is proposed in each case). This provides a more representative carbon factor of the current electricity grid which has been substantially decarbonised over recent years compared to outdated values used in Building Regulations.
- A target of 50 % reduction in space heating consumption for retained and converted areas, based on the proposed improvements to the building fabric.
- Incorporating energy savings measures in the Energy Audit and Survey Report from 'Inspired Efficiency'.

- Replacement of the current gas boiler plant with an electric air source heat pump (ASHP) to provide space heating and hot water.
- The use of ASHP to provide space heating and hot water for all new build areas, with a baseline seasonal coefficient of performance (SCoP) of 3.0.
- Electricity generation from PV based on the figures provided in the Energy Audit and Survey Report from 'Inspired Efficiency'.

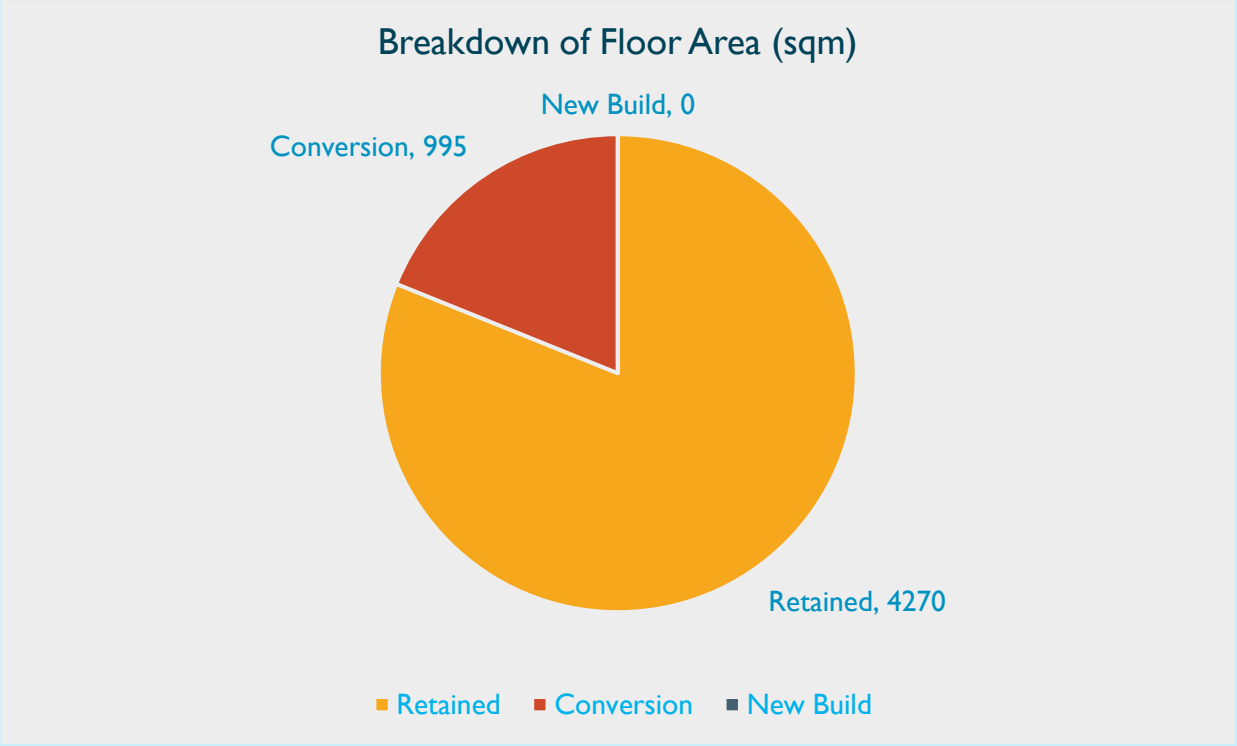
4.2 Embodied Carbon - Methodolgy

The embodied carbon within the building materials used for construction within the proposed scheme across all options has been estimated based on a number of key pieces of information and assumptions:

- LETI target figures for embodied carbon for new building materials were applied to the retained, converted, and new build areas as applicable.
- The typical proportions of embodied carbon within these figures (e.g., 15 % of the embodied carbon in commercial offices is found within the mechanical, electrical, and plumbing (MEP) materials)
- Adjustments made for the proposed site layout, based on the proportion of the total useful floor area of the scheme that the retained areas, converted areas and new build areas will make up.
- An assumption that, for converted areas and retained areas, a full MEP replacement, full new internal finishes and a partial façade upgrade will take place.
- An assumption that, for converted areas and retained areas, all substructure, superstructure, and façade will be retained (other than where demolition takes place).
- Embodied carbon for the proposed PV array is included (derived from One Click LCA software, based on a standard product) as this has been found to be significant on other projects.
- Embodied carbon for the façade upgrade materials has been based on a typical insulated plasterboard product for internal lining of the existing Cotswold stone walls, using a take-off of linear meterage for walls requiring upgrading and assumed floor-to-ceiling heights. Final embodied carbon calculations were undertaken using One Click LCA software.

4.3 Option 1 – Partial Conversion

Option 1 involves the majority of the existing offices being retained for council use, with the south block and link building being converted into residential accommodation, housing 16 no. one-bedroom apartments. A first-floor extension will be constructed to the rear of the south block. The breakdown of floor areas for option 1 is as follows:



4.3.1 Operational Energy Use & Associated Carbon Emissions

Calculations were undertaken using the above information & assumptions to estimate the annual operational energy use of the entire scheme under Option 1. The following results were observed:

Estimated Annual Operational Energy Demand (kWh)	Estimated Annual PV Generation based on 144 kWp Array (kWh)	Estimated Net Annual Operational Energy Use (kWh)	Estimated Net Annual Carbon Emissions from Operational Energy Use (tCO_2)
470,267	118,424	351,844	47.851

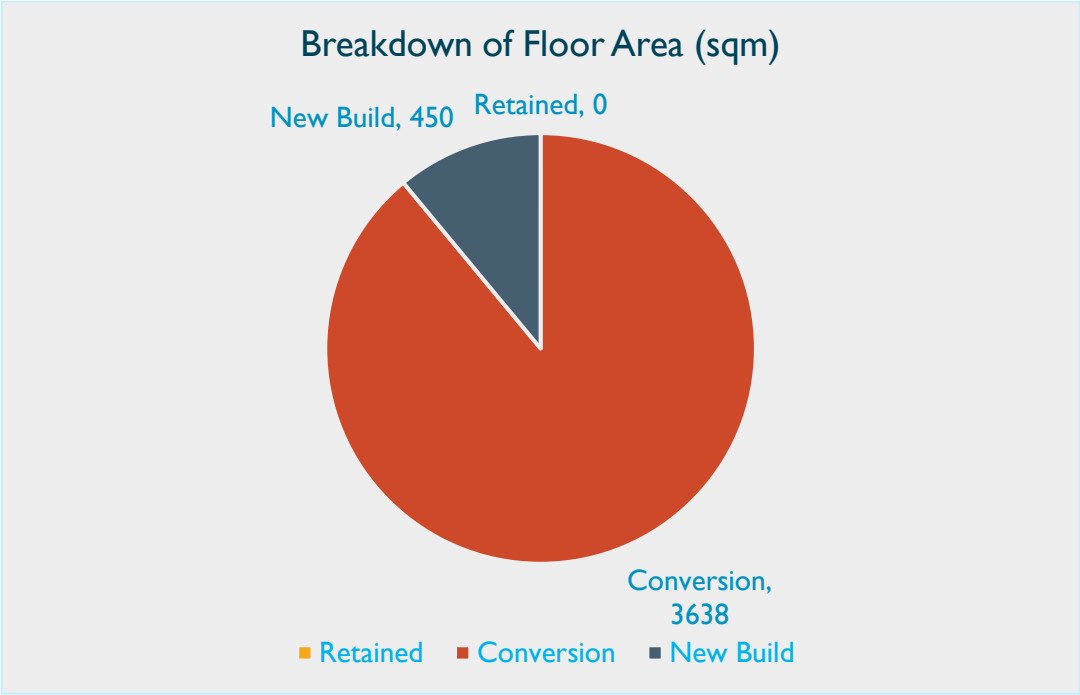
4.3.2 Embodied Carbon

Calculations were undertaken using the above information & assumptions to estimate the total embodied carbon for new construction materials required for the entire scheme under Option 1. The following results were observed:

Embodied Carbon for Construction Materials (tCO_2)	Embodied Carbon for Proposed PV Array (tCO_2)	Total Embodied Carbon for Option 1 (tCO_2)
757.230	360.000	1117.23

4.4 Option 2 – Full Conversion

Option 2 involves converting the entirety of the existing offices into residential buildings, with the exception of the atrium infill and link building (between the north block and south block), which will be demolished. A first-floor extension will be constructed to the rear of the south block, with the building itself being converted into five no. three bedroom houses and four no. one-bedroom flats. Five no. two-bedroom terraced houses will also be constructed in the north east area of the site. The breakdown of floor areas for option 2 is as follows:



4.4.1 Operational Energy Use & Associated Carbon Emissions

Calculations were undertaken using the information & assumptions listed in section 4.1.1 to estimate the annual operational energy use of the entire scheme under Option 2. The following results were observed:

Estimated Annual Operational Energy Demand (kWh)	Estimated Annual PV Generation based on 144 kWp Array (kWh)	Estimated Net Annual Operational Energy Use (kWh)	Estimated Net Annual Carbon Emissions from Operational Energy Use (tCO_2)
385,272	118,424	266,848	36.290

4.4.2 Embodied Carbon

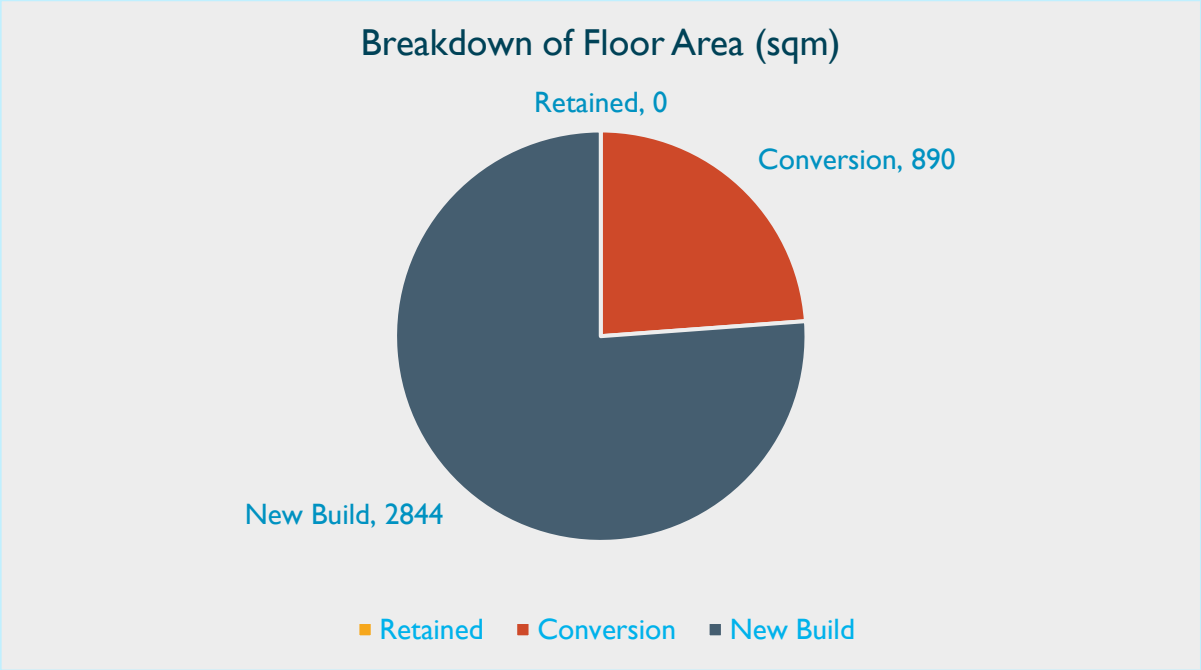
Calculations were undertaken using the information & assumptions listed in section 4.1.1 to estimate the total embodied carbon for new construction materials required for the entire scheme under Option 2. The following results were observed:

Embodied Carbon for Construction Materials (tCO_2)	Embodied Carbon for Proposed PV Array (tCO_2)	Total Embodied Carbon for Option 2 (tCO_2)
707.900	360.000	1067.9

4.5 Option 3 – Full Site New Development

Option 3 involves the demolition of the majority of the existing council building. The south block is retained to provide an aesthetic continuity to the site as viewed from Trinity Road. A first-floor extension will be constructed to the rear of the south block, with the building itself being converted into five no. three bedroom houses and four no. one-bedroom flats.

- 22 no. two-bedroom houses, each with an area of 90 m².
- 4 no. three-bedroom houses, each with an area of 116 m².
- 8 no. duplexes, each with an area of 50 m².



4.5.1 Operational Energy Use & Associated Carbon Emissions

Calculations were undertaken using the information & assumptions listed in section 4.1.1 to estimate the annual operational energy use of the entire scheme under Option 3. The following results were observed:

Estimated Annual Operational Energy Demand (kWh)	Estimated Annual PV Generation based on 144 kWp Array (kWh)	Estimated Net Annual Operational Energy Use (kWh)	Estimated Net Annual Carbon Emissions from Operational Energy Use (tCO_2)
106,150	118,424	-1669.30	-1.67

4.5.2 Embodied Carbon

Calculations were undertaken using the information & assumptions to estimate the total embodied carbon for new construction materials required for the entire scheme under Option 3.

Embodied Carbon for Construction Materials (tCO_2)	Embodied Carbon for Proposed PV Array (tCO_2)	Total Embodied Carbon for Option 3 (tCO_2)
1526.210	360.000	1866.21

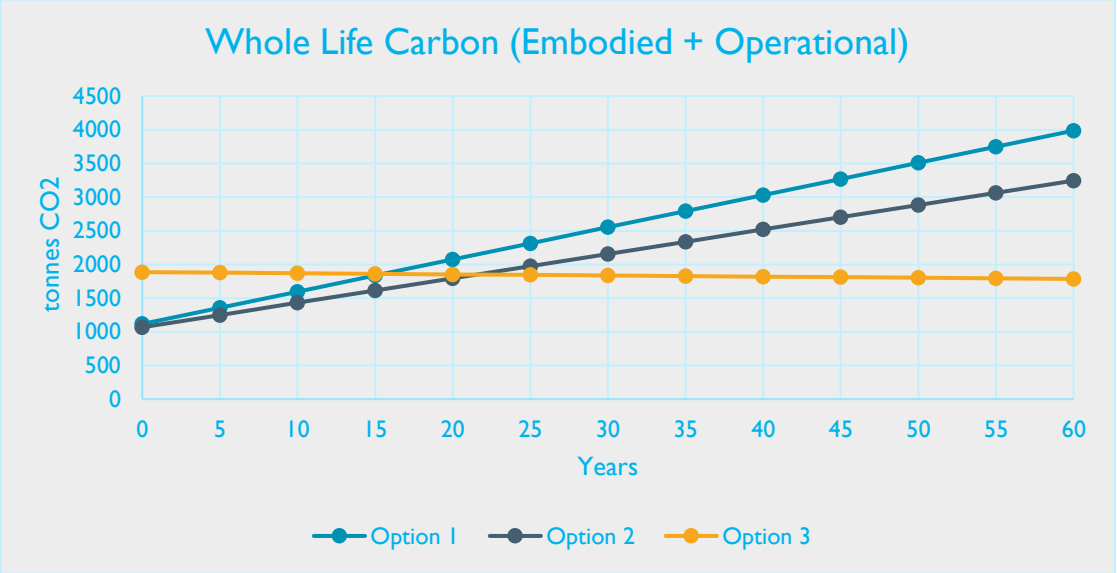
5.0 Route to achieving NZC in Operation and Offsetting Embodied Carbon

The following table provides a summary of the estimated carbon emission operational energy use and embodied carbon in construction for the three options:

	Option 1	Option 2	Option 3
Net Operational Energy Use (kWh/year)	351,844	266,848	-1669.30
Net Carbon Emissions from Operational Energy Use (tCO_2/year)	47.851	36.290	-1.67
Total Embodied Carbon (tCO_2)	1117.23	1067.9	1866.21
PV Generation (kWh/year)	118,424	118,424	118,424

The above results show that, of the three options currently tabled, only Option 3 represents a scheme that has the potential to be NZC in operation, based on the offset of CO_2 emissions provided by the PV array proposals outlined in the Energy Audit & Survey Report. This result is in line with expectations, as the replacement of existing buildings built 150-200 years ago with almost entirely new build, highly energy efficient dwellings offer the best route to achieving very low operational energy requirements. This option actually offers the possibility of offsetting some additional carbon as the estimates show it would be carbon negative in operation (i.e., annual PV generation energy exceeds the annual operational energy requirements). However, Option 3 also has the highest embodied carbon in construction of any of the options. Again, this is the expected result as this option requires the highest quantity of new building materials.

Over a 60-year period Option 3 presents the lowest whole life carbon use. The graph below is for comparative purposes as it doesn't account for further grid decarbonisation or replacement of equipment on the basis they would be the same for all options or future fabric works required in options 1 and 2.



In order for a NZC in operation proposal to be achieved for Options 1 and 2, additional reductions in energy demand would need to be found. There are a number of potential measures that could be explored:

- Additional improvements to the existing building fabric.
- Demand reductions from change in usage patterns (particularly relevant to Option 1)
- Exploration of further energy efficient and renewable technology options
- Installation of additional PV array capacity

It is acknowledged that all of the above come with additional costs and indeed additional embodied carbon, both of which needs to be considered carefully. The retention of the existing building, either in whole or in part, presents additional challenges in terms of achieving energy efficiency in operation. However, it does offer options with lower embodied carbon and the retention of a building that is considered a heritage asset to the town of Cirencester is also significant.

Arguably the simplest route to achieving NZC in operation for Options 1 and 2 would be the inclusion of additional PV array capacity. Additional calculations have shown that, in order to achieve this, the following additional array capacity would be required:

	Option 1	Option 2
Additional Array Capacity Required (kWp)	428	324
Additional Array Area Required (m^2)	1956	1483
Revised Total Array Capacity Required (kWp)	582	468
Revised Total Array Area Required (m^2)	2614	2142

It should ne moted that the above figures are estimates only and are based on the PV details given in the Energy Audit & Survey Report. There are higher performance products currently available on the market that may offer a more cost-effective solution when scaled up. If this is the preferred route to explore, it is recommended that the options for PV location are considered carefully:

- Roof mounting (sub metering and additional inverter requirements, particularly with private dwellings, should be considered)
- Ground mounted array (it has been noted previously that the council may have access to land adjacent to the site that would be suitable).
- Building integrated photovoltaics (BIPV)
- PV car ports/shades

As mentioned previously, it is also important to consider the additional embodied carbon that will result from a larger PV array, and how best to account for and potentially offset this.

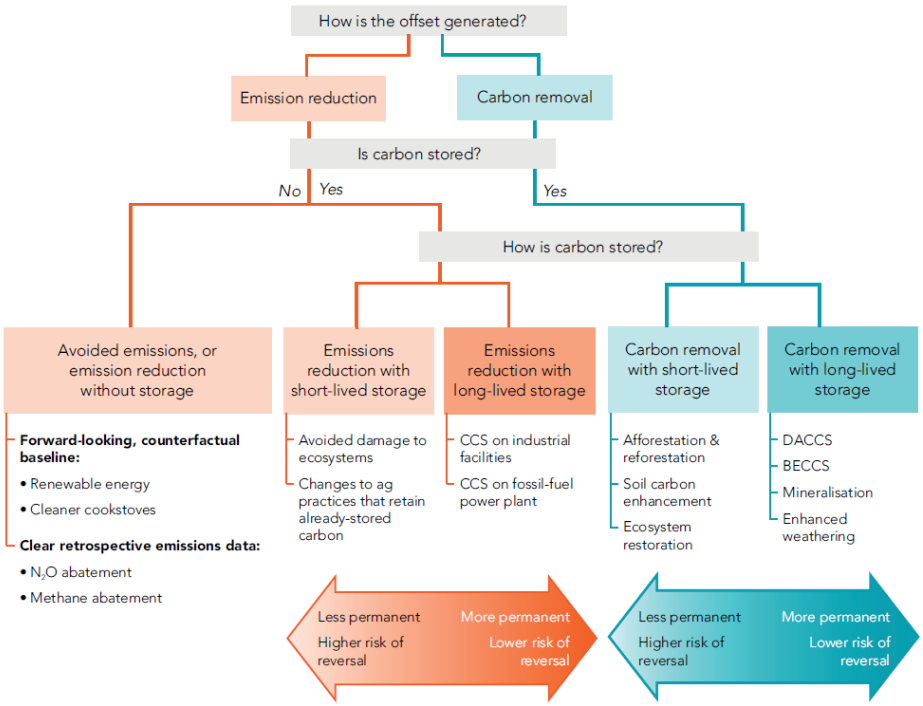
There could also be opportunities to explore the use of ground source heat pumps if a ground investigation determines its potential suitability.

It is recommended that, once the council has come to a resolution on which of the three options is preferred, a whole life carbon assessment of the building is undertaken. This will require a degree of detailed modelling that will only be possible with greater design surety and more detailed information. A detailed thermal model (which can be updated and become more details as the design progresses) offers much greater confidence in terms of the expected operational energy of the building/s. Similarly, a detailed assessment of embodied carbon based on robust design drawings, models and specifications offers greater confidence in terms of the quantities of embodied carbon that would need to be accounted for and offset.

With respect to the offsetting of the embodied carbon contained within the construction materials required, it is recommended that the council refers to the following two documents produced by the UK Green Building Council (UK GBC):

- 'Net Zero Caron Buildings: Levels of Performance' (March 2021)
- Renewable Energy Procurement & Carbon Offsetting – Guidance for Net Zero Carbon Buildings

These documents give guidance on fossil fuel use, renewable energy procurement, carbon accounting, carbon offsetting, evolving performance standards and the verification of net zero buildings. The following flow chart, taken from the latter document, shows the taxonomy of carbon offset credits:



The council may decide to set a price for operational carbon emissions following the example of other councils to enable whole life cost calculations that include the cost of carbon over a determined period.

The document lists a number of voluntary carbon markets that are available to Cotswold District Council, including 'Gold Standard', the 'Verified Carbon Standard' and the UN 'Clean Development Mechanism'. Additional certifications that work in conjunction to these carbon standards are also available, which certify the wider social and environmental benefits of these carbon offset credits. A full appraisal of embodied carbon offsetting is beyond the scope of this report.

It is also recommended that further avenues to reduce the embodied carbon of the preferred option for the scheme is explored. For example, the embodied carbon of Option 3 could be reduced significantly if it were deemed possible to retain the waste from the demolition of the existing council building and reuse it in the construction of the new buildings. For example, this could be in the form of recycled aggregates in the construction of new foundations and footings, and the re-use of the Cotswold stone for the facades of the new dwellings. This would require careful co-ordination and early engagement from an architect and structural engineer.