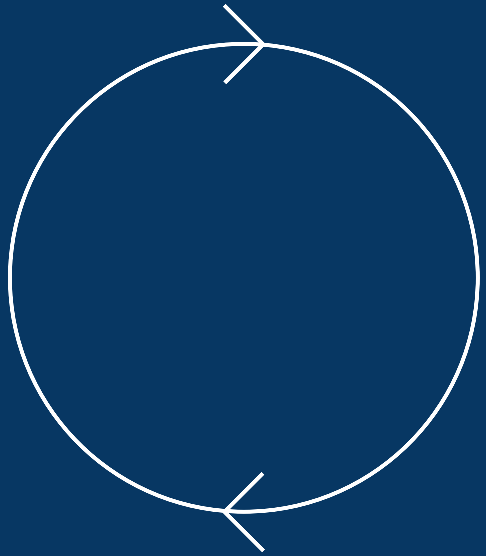
LINEN QUARTER BID

Bedford House

Opportunities to improve circularity and reduce building related emissions



PROJECT REPORT

Dark Matter Labs / 2021

Contents

Glossary

Building passports - A database containing all building related data throughout the lifecycle of a building and could include material passports.

Circular economy - An economy based on the principles of designing out waste and pollution, keeping products and materials in use and regenerating natural systems.

Circular economy statement - A document to demonstrate how a development will incorporate Circular Economy measures into all aspects of the design, construction and operation processes.

Carbon dioxide equivalent (CO_2e) - A metric to compare the emissions from various greenhouse gases on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential.

Digital twin - A virtual representation that serves as the real-time digital counterpart of a physical object or process.

Environmental Product Declarations (EPD) - An internationally recognised standard for declaring constituent materials and quantifying the environmental impact of a product across its lifecycle.

Embodied carbon - The carbon emissions associated with materials used in a building throughout its life cycle, including their production, transportation and on site installation as well as disposal at end of life.

Energy use intensity (EUI) - The total delivered energy (sometimes called energy consumption) that is required by the building per unit area (gross internal area), over the course of a year.

Green procurement - A process whereby an organisation seeks to procure goods, services and works with a reduced environmental impact throughout their life cycle.

ICE database - The Inventory of Carbon and Energy (ICE) is an open embodied carbon database for building materials.

Material banks - Stocks of valuable materials that have been recovered from deconstructed buildings or components.

Material flow analysis - An analytical method to quantify flows and stocks of materials or substances in a defined system.

Material passports - A database containing all material related data throughout the lifecycle of a product or component.

Operational carbon - The carbon emissions emitted from in-use operation and maintenance of a building.

Urban metabolism - A model to facilitate the description and analysis of the flows of the materials and energy within cities

Virgin materials - Materials sourced directly from nature in their raw form, such as wood or metal ores. Manufacturing products using virgin materials uses much more energy and depletes more natural resources, as opposed to producing goods using recycled materials.

Executive summary

Supporting circularity at Bedford House

Context

The built environment is responsible for over 40% of the UK's total emissions and over 60% of total waste. It therefore represents a vital component of Belfast's Net-zero Carbon Roadmap and its targeted 80% reduction in emissions by 2030. As part of this, public and commercial buildings have a reduction potential of 4 million tCO_2e.

Belfast also faces unprecedented challenges in overcoming risks posed by climate change. The built environment can contribute to creating a connected network of healthy, resilient, active and safe communities within the city as part of Belfast's Bolder Vision.

As we emerge from the COVID-19 pandemic and governments formalise their net zero strategies, the time is ripe for placing the climate at the heart of built environment decision-making, to support a regenerative, inclusive and just transition and recovery. Bedford House and the Linen Quarter can play a vital role within this.

The circular opportunity

Transitioning to a circular economy can help to reduce demand for virgin materials, minimise waste, reduce emissions and support the regeneration of nature. In turn, it can create local green jobs, secondary material markets, and localised nutrient cycles, whilst contributing to local climate resilience. This applies at multiple scales for Bedford House, the Linen Quarter community, and Belfast more widely.

Process

This report has been produced based on findings from a circularity and environmental impact analysis for an office building in Belfast. It includes an analysis of material, energy and water flows associated with operating the building and the resulting emissions, as well as emissions associated with occupants' food consumption and travel. From this, several practical opportunities have been identified to increase material circularity and reduce building related greenhouse gas emissions.

Unusual occupancy rates, due to COVID-19, during the analysis period have impacted energy use and waste figures. It is therefore a preliminary analysis where continued monitoring can help to verify findings.

Opportunity areas

Energy use - switch to a zero-carbon renewable electricity supplier, reduce demand and consider on-site solar PV

Water use - install low flow fittings; improve water usage monitoring and consider rainwater harvesting

Materials - monitor all materials and waste; reuse furniture, equipment and floor finishes in future fit-outs

Food systems - develop low-carbon, local menu for café; continue to monitor and report food waste

Mobility & logistics - provide secure on-site cycle storage, changing facilities and maintenance equipment

Space utilisation & performance - measure internal environment (ventilation, noise and light) and occupancy

Public realm - engage with wider community to support active travel, biodiversity and green infrastructure

Community - connect to local reuse and repair platforms and local procurement networks

Recommended next steps

1. Continue monitoring all materials and food (entering and leaving site); and energy and water usage
2. Convene Bedford House stakeholders to review and identify further opportunities
3. Co-develop a Circular Economy Strategy for Bedford House, including a Green and Circular Procurement Strategy

1.

Introduction

Project overview

Introduction
Contributing to a circular Belfast

Context

Belfast is changing and so are the places people live, work, and relax. Systemic change is being led by governments, investors, clients, and consumers. Belfast is becoming an international sustainable city, transitioning to a more circular economy. Climate change responses will continue to positively change environmental attitudes and our management of natural resources. This includes our city office buildings – places to work and relax.

The built environment is at the driving edge of the city's sustainability journey. This vision for sustainable buildings and office space is in keeping with Belfast City Council's Metropolitan Plan, Resilience Strategy, Net Zero Carbon Roadmap and the city's Bolder Vision for Belfast.

Linen Quarter BID have commissioned Dark Matter Labs to produce this circularity analysis of Bedford House. The report helps to understand and improve the district's structural environmental footprint and how natural resources flow through office buildings in the city. In doing so, ensuring our built environment not only maximises commercial and operational returns (including length of service and long-term value), but also plays a leading role in Belfast's sustainability journey - for the benefit of all.

Bedford House as a case study

This case study illustrates the practical and commercial benefits of moving towards a sustainable built environment. It considers related issues such as tenant requirements, circular fit out, and supply chains and offers others a template to help them on their own journey towards becoming more sustainable, efficient, and profitable.

The illustrated report is for landlords, tenants, office developers and investors looking to gain a practical insight to the value of creating and promoting a local sustainable built environment for Belfast and beyond. We hope it can be used as a thought piece, a reference guide or as part of your company's or organisation's own personal sustainable journey.

We would like to sincerely thank Ulster Estates and the many stakeholders who have contributed to this report and analysis, including: Gareth McMurray at Bedford House; Steven McGlinchey at Lehding; and Janet Lynch at Arup. We hope it will make an important contribution to the debate and help regenerate and further establish the Linen Quarter area as Belfast's sustainable business district.

We would encourage you to join us on our city's sustainable journey.

Image: Bedford House - Gareth McMurray.

Context
Bedford House

History

Bedford House was constructed in 1970s, when reinforced concrete structures were typical, contributing to its characteristic monolithic façade, deep internal T-beam floor structure, and large internal columns. In the last ten years, the late Desmond Gilpin had a grand vision for modernising the building, providing a premium working environment as well as reducing its associated environmental impact. Taking back ownership of the internal floor plates, and offering a turn-key design service to all incoming tenants enabled a more tailored programme of refurbishment and more efficient services throughout the building.

Sustainability related measures implemented as part of this modernisation include:

- Installation of air source heat pumps - VRF HVAC system
- Heat recovery ventilation to exceed CIBSE guidelines
- Restructuring of the mains water and plumbing designs
- Installing domestic hot water systems with heat-pump energy reclamation
- Installation of a Building Management System (BMS) for monitoring HVAC performance and energy use
- In-house managed Planned Preventative Maintenance package
- Access to green initiatives, in partnership with Linen Quarter BID

At the same time, a number of new facilities contribute to a highly desirable, modern workplace, including:

- A bespoke conference suite facility with state of the art VC systems
- The Skytrain gymnasium - a unique facility in Belfast

In addition, Desmond prioritised the creation of a grand reception area, creating a granite-clad atrium space considered one of the finest in Belfast.

Further improvements currently in development include:

- Completion of vacant floor redevelopment
- Installation of EV charge points in the car park, for both internal and external customers
- New incoming transformer installations to increase efficiency, reliability and free more lettable area
- Replacement of any legacy equipment nearing end of life

As the commercial office landscape changes and investors, developers and tenants increasingly value circular, resilient and high performing spaces, there's an opportunity for Bedford House to build on these successes and help guide the way as a sustainable and desirable workspace at the heart of Belfast.

Image: Bedford House reception - Gareth McMurray

Context
Circular economy

What is a circular economy?

"A circular economy is a systemic approach to economic development designed to benefit businesses, society, and the environment. In contrast to the 'take-make-waste' linear model, a circular economy is regenerative by design and aims to gradually decouple growth from the consumption of finite resources."

- Ellen MacArthur Foundation

A circular economy is an economic model where technical materials are kept in use at their highest value for as long as possible, before being reused or recycled. Biological materials are used at their highest value before their nutrients are returned to the biosphere. It's underpinned by a transition to renewable energy sources. Economic activity therefore builds and rebuilds overall system health. The model is based on three principles:

1. Design out waste and pollution
2. Keep products and materials in use
3. Regenerate natural systems

The opportunity

The built environment is responsible for a significant proportion of the UK's total materials use, greenhouse gas emissions and waste generation. Transitioning to a circular economy is a vital component of the net-zero pathway, in reducing emissions supporting new green jobs, creating secondary material markets and contributing to local resource and climate resilience.

400million
tonnes of materials used by the UK's construction industry each year[1]

62%
of the UK's total waste comes from building construction, demolition and excavation[2]

13thousand
green jobs could be created in Northern Ireland by transitioning to a circular economy[3]

6%
of the UK's total annual carbon emissions come from energy use in office buildings[4]

Sources
1. UKGBC
2. DEFRA, 2018
3. The Case for a Circular Economy Strategy for Northern Ireland - Eunomia, 2017
4. UKCCC

Image: Bedford House - Gareth McMurray

Context of the analysis

Material and energy flow analysis

Material and energy flow analysis tracks resource flows through a system, comparing relative magnitudes; identifying wastes; and analysing the resulting environmental impacts. The analysis can be done at different scales - from the city scale (urban metabolism); to an industrial process; to a sector. Visualising these flows helps to identify opportunities to improve circularity and minimise environmental impact throughout the system.

City

Circular Cities Program Krakow - Construction sector analysis

Metabolic and Innowo mapped material flows for Krakow's construction sector, identifying key opportunities to promote more circular construction practices.

Manufacturing process

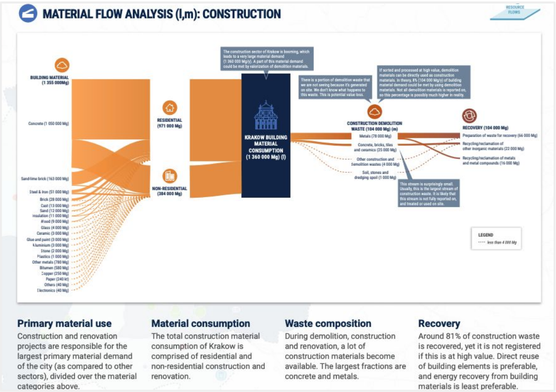
Useful Projects - Weinerberger bricks material flow analysis

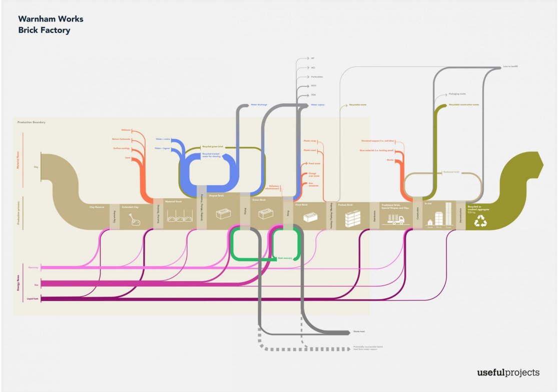
This mapping identifies life-cycle stages and specific flows where material leakage or loss of value occurred and proposes more circular approaches.

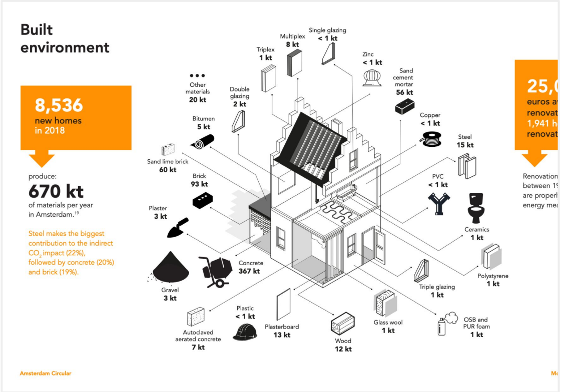
Sector

Amsterdam Circular Monitor - Built environment analysis

As part of the *Circular Monitor* project, Amsterdam is tracking progress and identifying opportunities to transition to more circular practices, in the built environment.







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Circularity Analysis

Analysis of material, water and energy flows at Bedford House

Overview
Circularity analysis

Introduction

The aim of the circularity analysis is to identify opportunities that support a circular economy, whilst reducing environmental impact from operating, maintaining and refurbishing Bedford House. It seeks to identify some practical steps that can be taken to introduce more circular practices at Bedford House, and offices in Belfast more broadly. Continued monitoring of material, energy and water flows, to assess the likely impact of individual actions, will help to inform subsequent stakeholder engagement on these respective measures identified.

Context

Due to the timing of the research, in respect to the pandemic and its ongoing impact on operations and occupancy of Bedford House, the analysis has been restricted by data availability. It therefore represents a preliminary assessment, based on available data. For some aspects, the data does not reflect the operation of the building under full occupancy. Where this is the case, the relevant time period has been stated and, where available, data has been compared to what would be expected in a typical office building under normal operation. As a result, it is advised that findings are considered indicative until ongoing monitoring of energy, water and material flows can be verified to reflect operations post-pandemic.

Focus and scope

The analysis considers flows of energy, water and materials and their ensuing environmental impacts, focussing primarily on greenhouse gas emissions from manufacture of materials (embodied carbon) and from electricity use and heating (operational carbon). It also considers indirect emissions from food consumption and travel.

ENERGY

Operational energy use

WATER

Operational water use

MATERIALS

Materials used in operating, maintaining and refurbishing

FOOD SYSTEMS

Food consumption and food waste

MOBILITY & LOGISTICS

Impacts from transport to and from the building

SPACE UTILISATION & PERFORMANCE

Performance and use of the internal space

Building layers

The research focuses on material flows arising from: stuff (furniture, appliances, fixtures); space (partitions, finishes) and services, as illustrated below. The supporting systems which the building is a part of, or contributes to (i.e. utilities, food, mobility and spatial performance), also form part of the focus.

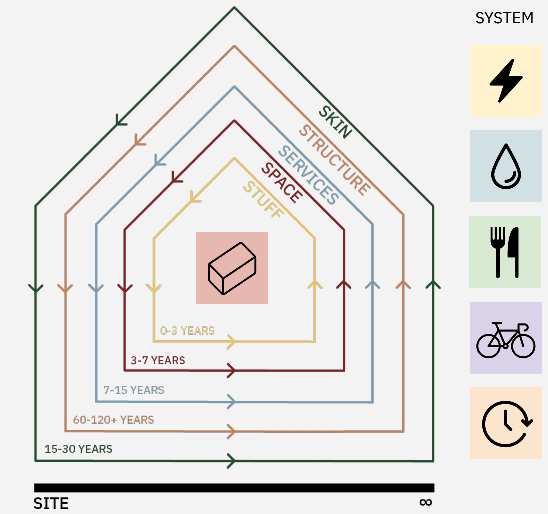
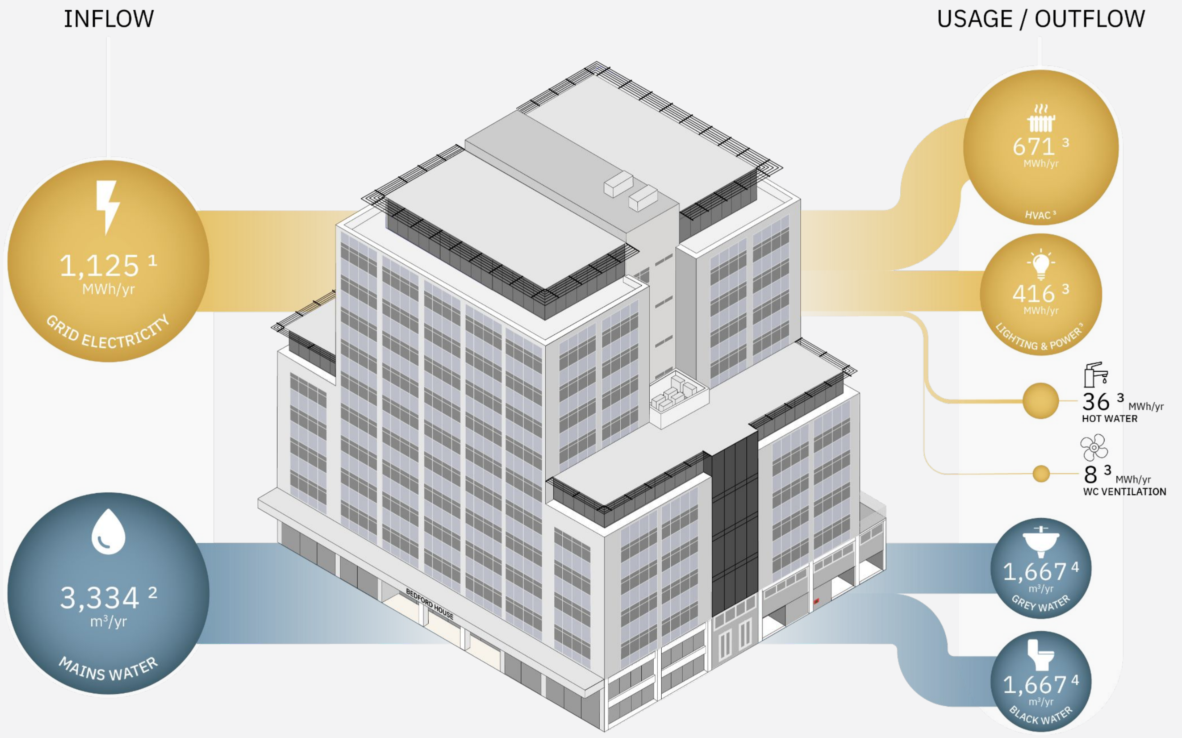


Diagram adapted from Stewart Brand's *How Buildings Learn*

Circularity analysis
Energy and water use

Annual energy & water use breakdown



Analysis period
Electricity: 2019 - 2020
Water: Nov 2018 - Oct 2019

Electricity & water usage metrics

	Current Performance	Typical Benchmark	2030 Target
Energy (EUI)	86[1] kWh/m²/yr	130 kWh/m²/yr	55[5] kWh/m²/yr
Heating	51[1] kWh/m²/yr		15[5]
Water	9.5 l/p/day	16 l/p/day	10[6] l/p/day

Operational carbon

CO_2 content of electricity	302 gCO_2e/kWh
Operational carbon	340 tCO_2e/yr

Breakdown of electricity and water usage at Bedford House and comparison of performance indicators to selected climate related targets. A lack of data for electricity usage before 2019 means this does not reflect usage at full building occupancy.

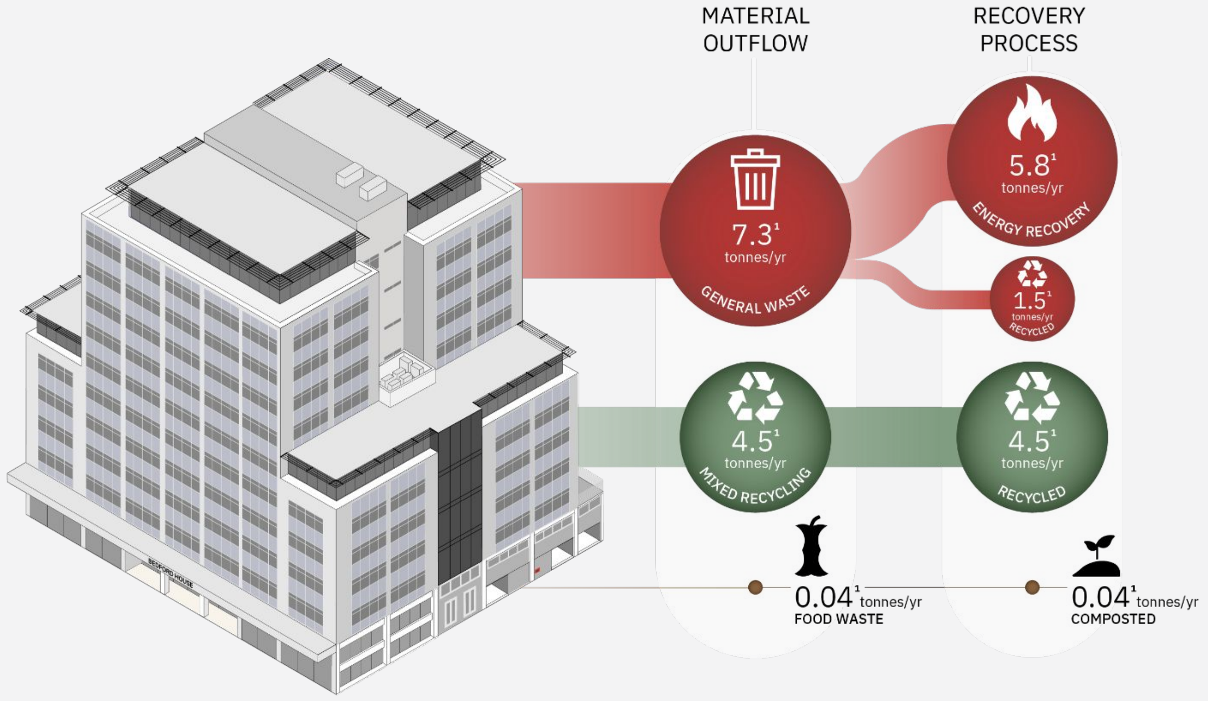
1. & 3 electricity use measured by BMS, 2019 - 2020 - building not fully occupied at time
2. Annual water usage Nov 2018 - Oct 2019
4. Approximation based on ratio of basins:WCs
5. LETI 2030 net zero operational carbon target (heating target = space heating demand)
6. RIBA 2030 climate challenge target

Circularity analysis

Material flows - commercial waste

Commercial waste (recorded)

Figure 1

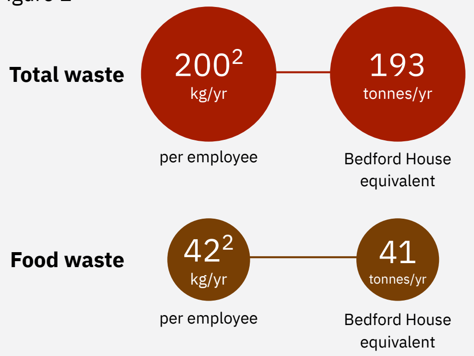


Analysis period
Jul 2020 - Jun 2021

Note: Data not representative of waste from fully occupied building, for comparison see typical waste figures in *Figure 2*.

Typical office waste[1]

Figure 2



Breakdown of commercial waste recorded at Bedford House. Waste collection data was only available for the period July 2020 - June 2021, when the building was not fully occupied. As a result, waste produced is significantly lower than expected in an office of this size. For comparison, a typical office of this size may generate 193 tonnes annually[2], approximately 15x that recorded. Similarly food waste is significantly lower than expected. As monitoring continues, areas for waste reduction can be targeted within specific areas of building operations.

Note: Circle areas not proportional between Figures 1 & 2

1. Bedford House waste & recycling collection data
2. Cundall, 2013 - *CO_2 emissions due to office waste*

Circularity analysis
Material flows - refurbishment

Facade system — 2,952 m^2
78t Glass, Aluminium
2,080t CO_2e[1]

Internal doors — 234
5t Timber, 9t Glass, 4t Steel
30t CO_2e

Internal walls & partitions — 4,482 m^2
36t Plasterboard, 11t Steel
29t CO_2e

Wall finishes — 4,100 m^2
53t Granite, 33t Plasterboard, 4100 m^2 Paint
21t CO_2e

Floor finishes — 13,000 m^2
10.4t Bitumen, 9t Latex, 6.5t Nylon
193t CO_2e

Ceiling finishes — 13,000 m^2
104t Plasterboard, 13,000 m^2 Paint
132t CO_2e

Desks & tables — 1,019
17t Timber, 18t Steel
148t CO_2e

Laptops — 840
Aluminium, Plastics, Copper, Cobalt
210t CO_2e

Task chairs — 1,054
13t PVC, 5.5t Steel
60t CO_2e

Other equipment
4 Tills

Armchairs — 34
544kg PU, 534kg Steel, 136kg Textile
11t CO_2e

Waste bins — 24
Plastics, Steel

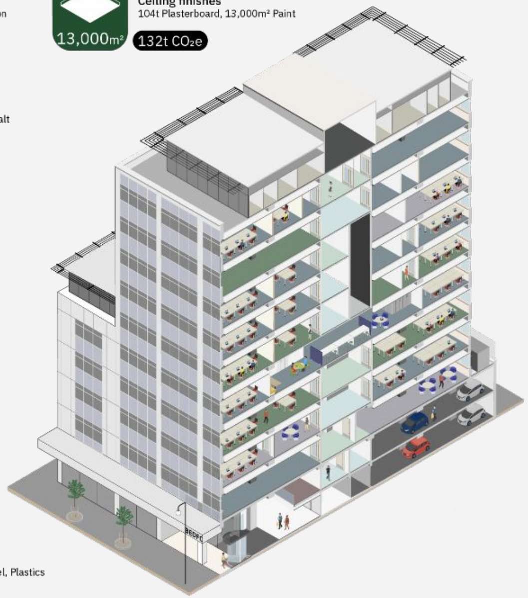
Space dividers — 313m
2.4t Aluminium, 1.7t Steel, 700kg PU
37t CO_2e

VRF heat pumps — 34
Steel, Aluminium, Plastics
394t CO_2e (Total HVAC)

Water heaters — 31
Steel, Glass

Heat recovery ventilation — 250
Galvanised steel, Aluminium

AC units — 250
Copper, Aluminium, Stainless steel, Plastics



Dishwashers — 22
396kg Steel, 176kg Stainless steel, 132kg Bitumen, 110kg Polypropolene
3.5t CO_2e

Sinks — 27
405kg Ceramic
621kg CO_2e

Ovens — 2
30kg Steel, 8kg Glass
200kg CO_2e*

Hand basins — 65
915kg Ceramic
1.5t CO_2e

Coffee machines — 2
0.6kg Glass, 2kg Polypropolene
50kg CO_2e*

WC — 58
2.4t Ceramic
3.5t CO_2e

Boiling water taps — 21
Stainless steel, Steel, Plastics
1t CO_2e*

Urinals — 13
208kg Ceramic
312kg CO_2e

Hand dryers — 44
145kg Zinc, 44kg ABS, 35kg Iron
440 kg CO_2e

Kitchen sinks — 2
16kg Stainless steel
98kg CO_2e

Security system — 296
Sensors, Keypads, Door locks, Panels
1.5t CO_2e*

Showers — 22
660kg Ceramic, 33kg Stainless steel
1.2t CO_2e

CCTV cameras — 114
5.7t CO_2e*

Lighting fittings — 2,684
16t Steel, 1t PCB, 805kg Polycarbonate
424t CO_2e

Fire protection system — 983
Smoke detectors, Alarm panels, Call points
9.8t CO_2e

Lighting controls — 546
ABS, Steel
2.7t CO_2e*

Fire dampers — 35
525kg Galvanised steel, 70kg Plastics
1.2t CO_2e

IT & AV points, data connections — 2,263
ABS, Steel, Glass, Aluminium
11t CO_2e*

Building Element Category (RICS NRM)
- Superstructure
- Internal Finishes
- Fittings, Furnishings & Equipment
- Services

X tonnes — Approximate embodied CO_2e, from EPDs (where available)

* Approximation using ICE embodied carbon database

Cycle period
10-15 years

Circularity & emissions analysis
Material flows - Refurbishment

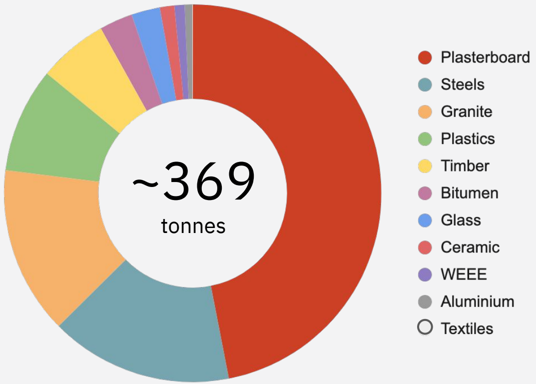
Over the last 7 years, most floors at Bedford House have been refurbished, with internal finishes, fittings, furnishings, equipment and services replaced throughout. The only elements retained and reused in this process were the building structure and windows, as part of the façade system. All other materials were processed as waste. No data was available on amount or composition of this waste, so for the purpose of the analysis, waste material was assumed to be equal to that of new materials and products installed.

The charts below omit the materials and embodied carbon associated with the HVAC system and façade, due to lack of sufficiently reliable data.

Plasterboard and steel represent a significant proportion of material inputs. For embodied carbon, internal finishes; furniture and IT equipment; heating, ventilation and air conditioning; and light fittings and controls account for 95% of the total.

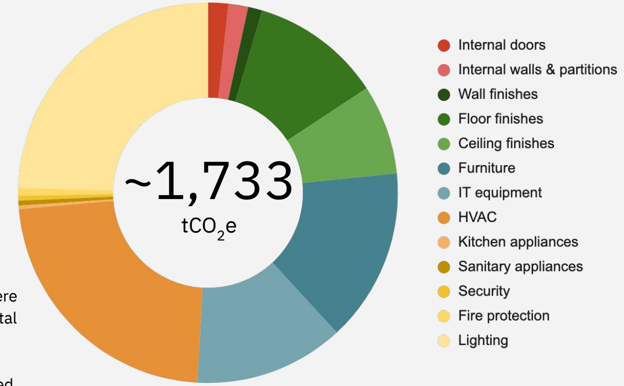
Materials

Approximation of input materials for refurbishments



Embodied carbon*

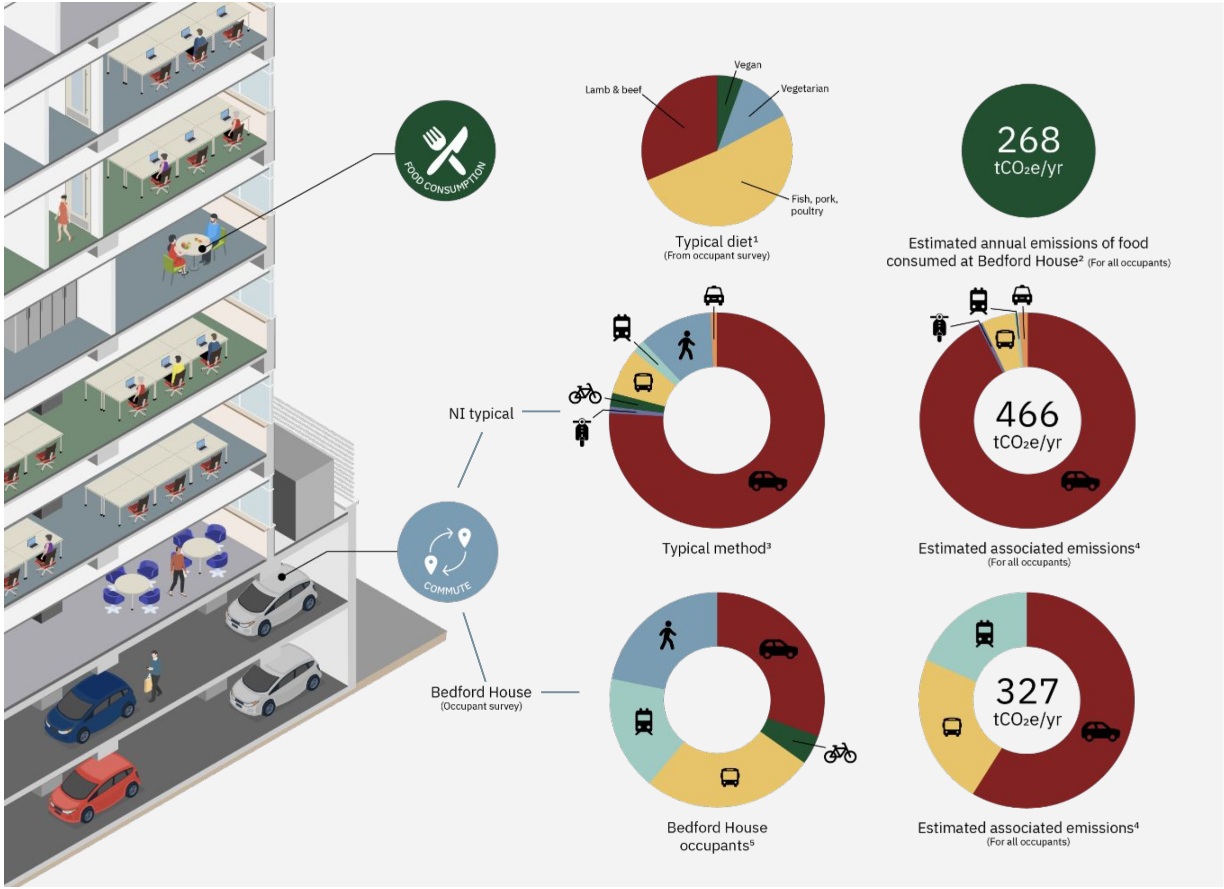
Approximation of embodied carbon of materials used in refurbishments



*Embodied carbon values were estimated using Environmental Product Declarations for equivalent products. Where unavailable, the ICE embodied carbon database was used.

Emissions analysis

Food and travel related emissions



Emissions from occupants' food consumption on premises and commuting to Bedford House have been estimated based on a small sample of occupants and the typical emissions arising from food and travel. These indirect emissions can represent a significant proportion of total building related emissions. It's therefore important to consider approaches to support their reduction, for instance by offering low-carbon and local food on-site or providing secure cycle storage facilities to encourage cycling.

Food consumption

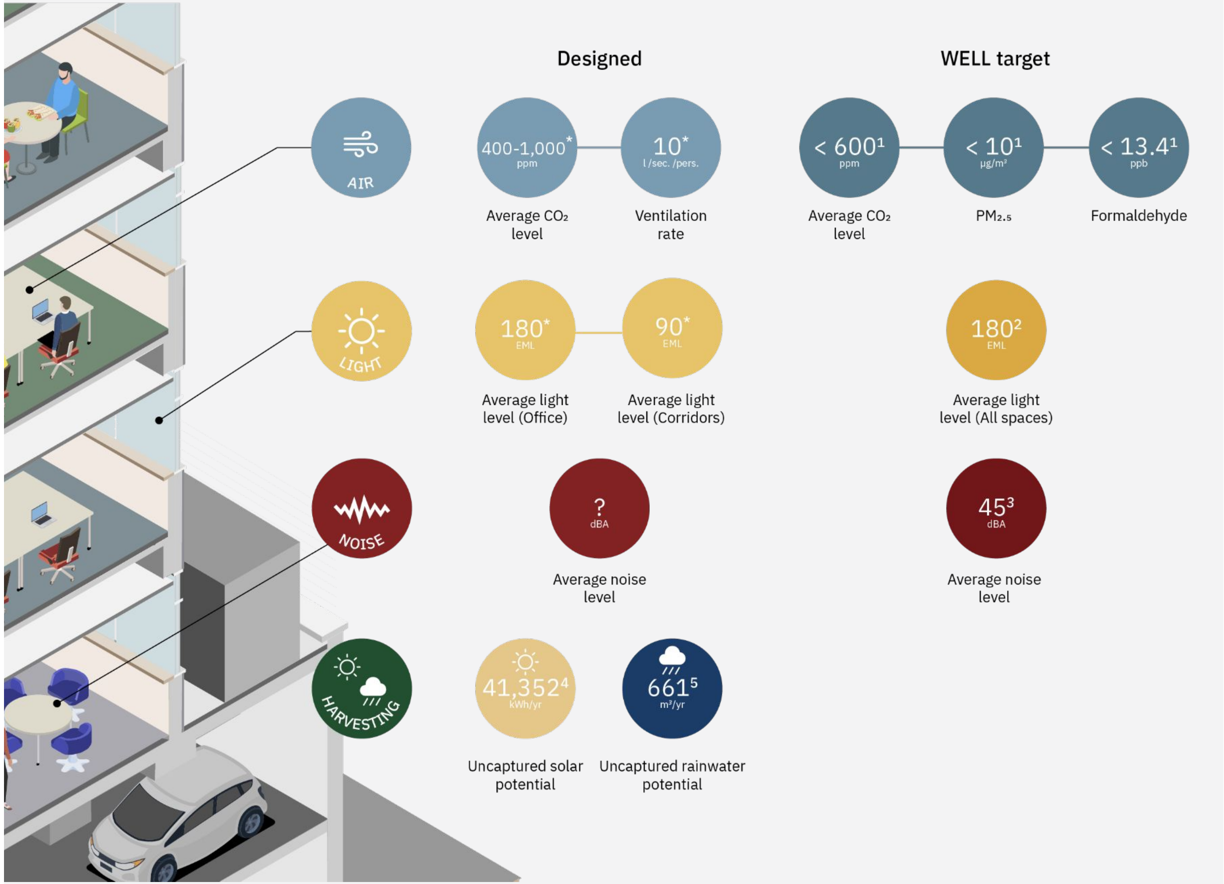
Of those responding to the survey, the majority of occupants consume meat as part of a typical meal. From the options shown, lamb and beef are the most carbon intensive, whilst a vegan diet is the least. Emissions from a typical UK diet have been used to approximate total food related emissions for all Bedford House occupants.

Commuting

Commuting related emissions have been calculated for typical urban commuting patterns based on data form the Northern Ireland travel survey (upper rings), compared with those from the survey respondents (lower rings).

1. Based on survey responses (sample = 21)
2. Estimation, assuming 3 meals per week consumed on-site, 46 week per year, emissions based on UK average for total GHG emissions from food consumption per person each year - Carbon Independent
3. Travel Survey for Northern Ireland 2017-19 - Typical urban commute
4. Estimated travel related emissions for all occupants, assuming emission by transport type from UK BEIS, assuming 3 commutes per week, 46 weeks per year
5. Based on survey responses (sample = 21)

Performance analysis
Spatial performance



Internal environment

The internal environment of offices - ventilation, indoor noise and light levels - has a significant impact on cognitive performance and wellbeing of building occupants. Studies have shown a 60-100% higher cognitive function for workers in high performing buildings.[6] Additionally, ensuring sufficient ventilation has become increasingly important since the pandemic. CO_2, ventilation rate, light levels and noise are not currently monitored at Bedford House, although ventilation and lighting has been designed to outperform CIBSE requirements.

Space utilisation

Optimising spatial utilisation is a key consideration for overall building circularity. Shared and flexible spaces allow utilisation of materials and products to be maximised. Data isn't currently collected on occupancy and spatial utilisation but could help inform optimisation strategies.

Harvesting potential

Solar photovoltaic and rainwater harvesting potential were calculated to represent approximately 4% and 20% of annual electricity and water consumption respectively.

1. WELL building performance standard - select requirements for maximum scoring on air quality
2. WELL building performance standard - select requirement for Circadian Lighting Design (electric & daylight)
3. WELL building performance standard - select requirement for maximum scoring on maximum noise levels in open work spaces
4. Estimate of uncaptured solar potential - calculation methodology in appendix
5. Estimate for uncaptured rainwater - calculation methodology in appendix
6. COGFX study - Impact of Buildings on Cognitive Performance

* Designed performance - unverified

Circularity analysis
Summary of key findings

01. ENERGY

LETI 2030 target ($55\ kWh/m^2/yr$)

86 $kWh/m^2/yr$
Energy use intensity[1]

340 tCO_2e/yr
Associated operational emissions[1]

41 MWh/yr
Uncaptured solar potential

02. WATER

RIBA 2030 target (10)

9.5 l/p/day
Water use

661 m^3/yr
20% of annual usage
Uncaptured rainwater

03. MATERIALS

193 tonnes/yr
Expected annual commercial waste*

369 tonnes
Construction waste from retrofit & refurb

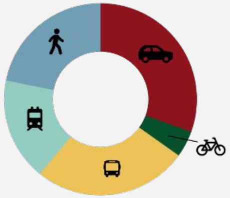
1,733 tCO_2e
Approx. retrofit & refurb embodied CO_2e

04. FOOD SYSTEMS

41 tonnes/yr
Expected annual food waste[2]

268 tCO_2e/yr
Approx. food consumption emissions

05.MOBILITY & LOGISTICS



Commuting method[3]

327 tCO_2e/yr
Approx. commuting related emissions[3]

06. SPATIAL PERFORMANCE

WELL target (600 ppm)

700 ppm
Ventilation (Designed)

WELL target (180 EML)

180 EML
Average light level (Designed)

1. Data not representative of building at fully occupancy
2. Estimated using data from a different building
3. Based on sample of 21 building occupants

3.

Findings & Opportunities

Opportunities to improve circularity at Bedford House

Implementing more circular practices
Circularity principles

Circularity in the built environment

Circularity principles can be applied at all stages of building operation, maintenance, fit out and refurbishment to minimise demand for virgin materials, maximise resource efficiency of existing materials and minimise environmental impact throughout a building's life cycle.

Circularity hierarchy

The circularity hierarchy can help guide decisions faced in the operation, maintenance and refurbishment of the building, or products and equipment used in the building. Wherever possible, reuse existing, or procure reused products. Ensure reuse of products or components no longer useful in the building. Where new products or equipment are necessary, maximise reused content and future reusability, before maximising recycled content and recyclability.

Core principles

1

Conserve resources, increase efficiency and source sustainably and ethically

- Minimise quantity of material used
- Minimise use of energy, water and land, minimise carbon intensity
- Source sustainably - reusable, sustainably sourced materials

2

Design to eliminate waste and for ease of maintenance

- Design for longevity, adaptability and flexibility
- Design for disassembly
- Design out operational and municipal waste

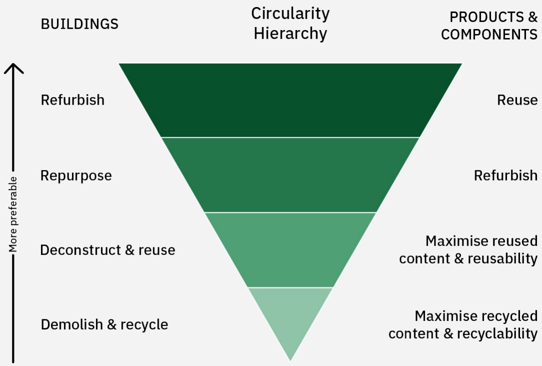
3

Manage waste sustainably and at the highest value

- Reuse or if not, recycle construction and demolition waste
- Recycle operation and municipal waste
- Design for disassembly

Principles adapted from *Design for a Circular Economy Primer* - Mayor of London

Circularity hierarchy



Hierarchy adapted from *Design for a Circular Economy Primer* - Mayor of London

Implementing more circular practices
Example circularity indicators

Circular Construction in Regenerative Cities (CIRCuIT) is an ongoing research project identifying how circular construction approaches can be scaled and replicated across Europe to enable cities to build more sustainably and transition to a circular built environment.

Through the project, the consortium has developed a set of circularity indicators that could help guide circularity reporting and analysis in the built environment. They represent circularity metrics at a building level, providing a basis for full building circularity analysis.

01. BUILDING DESIGN

a) **Dematerialisation**
% of material that has not been used due to redesign

b) **Design for disassembly**
% building that can be disassembled at end of life

c) **Design for adaptability**
% of the building that can be adapted at end of life

02. MATERIALS INPUTS

a) **Renewable content**
% of building formed of renewable components

b) **Reused content**
% of building formed of reused components

c) **Recycled content**
% of building formed of recycled components

03. CIRCULAR POTENTIAL

a) **Transformation capacity**
Design allows for adaptation to another function

b) **Reuse potential**
% of products which can be reused at the end of life

c) **Recycling potential**
% of products which can be recycled at the end of life

04. LIFESPAN & IN-USE PERFORMANCE

a) **Intensiveness of use**
Hours occupied vs total occupiable capacity

05. MATERIAL OUTFLOWS & RECIRCULATION

a) **Residual value**
Forecasted total value from material recirculation

b) **Total material arisings (whole life)**
Total waste material from the building across its lifetime

c) **% reused, remanufactured, recycled**
% of materials which were reused, remanufactured or recycled at end of life

Implementing more circular practices

Overview of circular initiatives

ENERGY

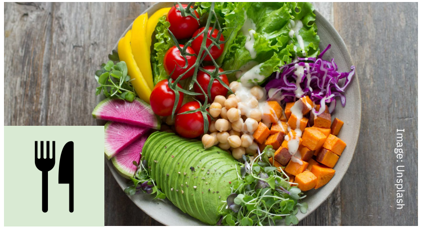
Minimising energy demand and integrating renewable, zero-carbon energy sources and storage - photovoltaics, heat pumps, battery storage and smart energy demand management.

WATER

Minimising water use with low flow fittings, greywater recycling and usage monitoring. Maximise on-site collection through rainwater harvesting.

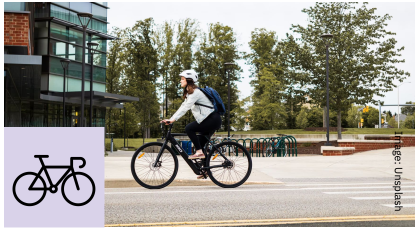
MATERIALS

Maintaining existing products and materials, repairing, reusing and refurbishing over buying new. Responsibly sourcing low-impact, non-toxic, renewable materials with high reused or recycled content.



FOOD SYSTEMS

Providing locally sourced and low-carbon food on-site, minimising food waste through excess food sharing schemes and connecting to nearby composting networks for localised nutrient cycles.



MOBILITY & LOGISTICS

Promoting active travel to the building by providing secure cycle storage, changing facilities and maintenance equipment. Making use of local, low-carbon delivery services.

SPACE UTILISATION & PERFORMANCE

Maximising use of space with flexible working areas, shared spaces and utilisation monitoring. Measuring and improving air quality, noise and light levels to improve health and wellbeing of occupants.

PUBLIC REALM

Circular principles integrated in the design and maintenance of public spaces. Using low-impact, reused and reusable materials; planting to support biodiversity and implementing sustainable urban drainage.

COMMUNITY

Local reuse and sharing platforms for products and materials contribute to a localised circular economy, supporting new jobs and reducing transportation impacts.

Implementing more circular practices

Suggestions from Bedford House tenants

Q1: What changes at Bedford House could encourage you to use lower-carbon commuting methods (e.g. walking or cycling)?

“Enhanced cycle storage and facilities, changing facilities, basic bike maintenance facilities e.g. pump”

“Better cycling facilities”

“Electric bike hire, electric car charging, cycling schemes and bicycle maintenance packages, incentives for walking”

“Safe bike access”

Q2: What changes at Bedford House or café could encourage you to eat lower-carbon meals more often (e.g. vegan or vegetarian)?

“More options for vegans. Greater selection of local products.”

“Greater selection of lower-carbon meals in Bedford House cafe”

“More vegan and vegetarian options which are appealing”

“Plant based, more vegan options, locally sourced foods”

“More vegan or vegetarian food on offer in cafe”

“Company promotions to staff”

Q3: What do you think could have the biggest impact on improving material circularity at Bedford House?

“Improved waste recycling, promoting reusable cups for takeaway in Bedford House cafe”

“Increase bin options in offices (e.g. add compost bin)”

“Raise awareness, lobbying for regulatory change”

“Use local materials with low embodied carbon”

“Ensure rubbish is separated for recycling”

“Increased emphasis on energy and waste”

“More recycling provision in offices”

“Continue to use online methods”

Q4: What do you think could have the biggest impact on reducing environmental impact at Bedford House??

“Promoting active travel, enhanced cycle facilities Consider opportunities for solar power generation, grey water collection”

“Help lower its carbon emissions, reduce waste and create healthy, high-quality environments for working and living.”

“Offset carbon emissions, utilise energy efficient plant and renewables - Air source heat pumps, PV etc”

“Improved bike infrastructure from park and rides (outside bedford house control)”

“energy supply, ensure electricity is from renewable source”

“Get the recycling back up and running again. Food box”

“Recycling, heating and energy use”

“Prioritise renewable energy”

“More efficient energy use”

“Renewable energy options”

“Electric charging points”

Implementing more circular practices
Opportunities at Bedford House

01. ENERGY

1. Renewable, zero-carbon energy supplier
2. Energy audit of building & demand reduction
3. Rooftop photovoltaics & on-site energy storage
4. Zonal heating & occupant comfort feedback

02. WATER

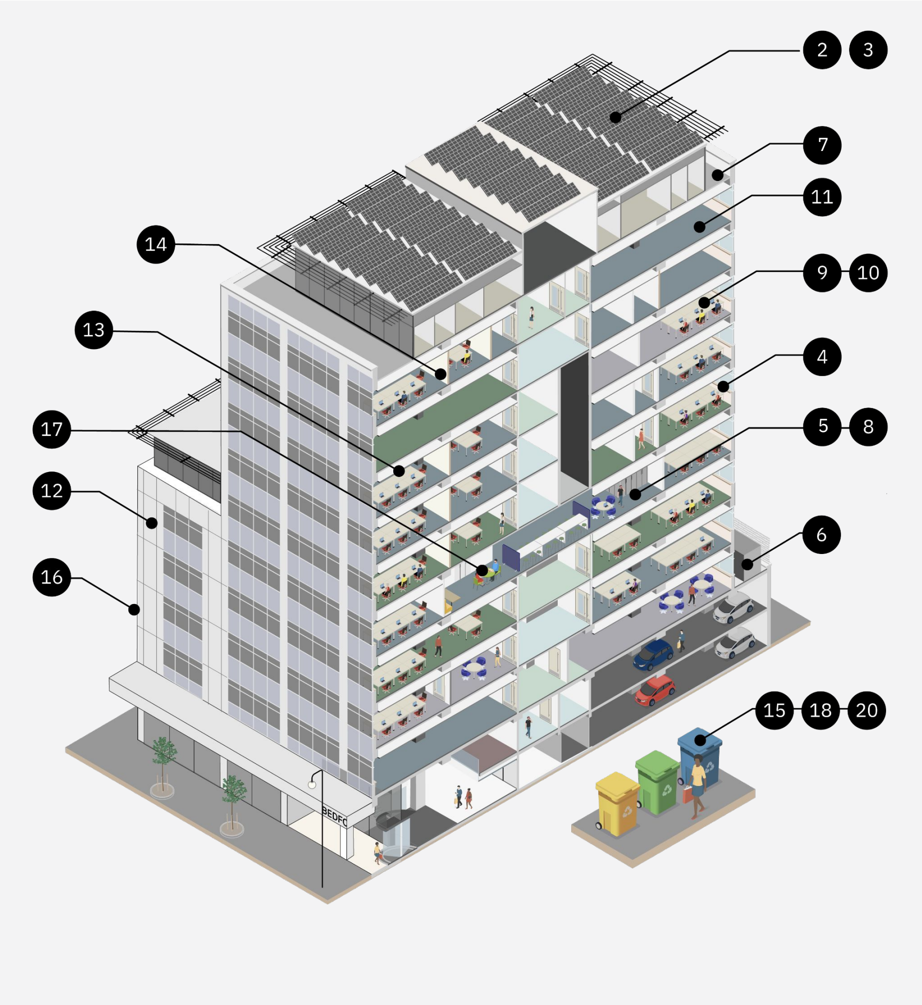
5. Low flow fittings & appliances
6. Greywater recycling
7. On-site rainwater harvesting
8. Smart water meter & sensors

03. MATERIALS

9. Furniture repair & reuse
10. Furniture & equipment leasing
11. Carpet recycling & leasing
12. Façade refurbishment & leasing
13. Lighting-as-a-service
14. Demountable partitions
15. Granular waste & recycling data
16. Building & materials passports

04. FOOD SYSTEMS

17. Low-carbon, locally procured on-site food
18. Local composting network
19. Excess food sharing network
20. Food waste reporting



Implementing more circular practices
Opportunities at Bedford House

05.MOBILITY & LOGISTICS

- **21** Secure, on-site cycle storage & maintenance tools
- **22** EV charging points
- **23** Bicycle & EV car sharing club
- **24** Parking for cargo bike deliveries
- **25** Use local, low-carbon delivery services

06. SPACE UTILISATION & PERFORMANCE

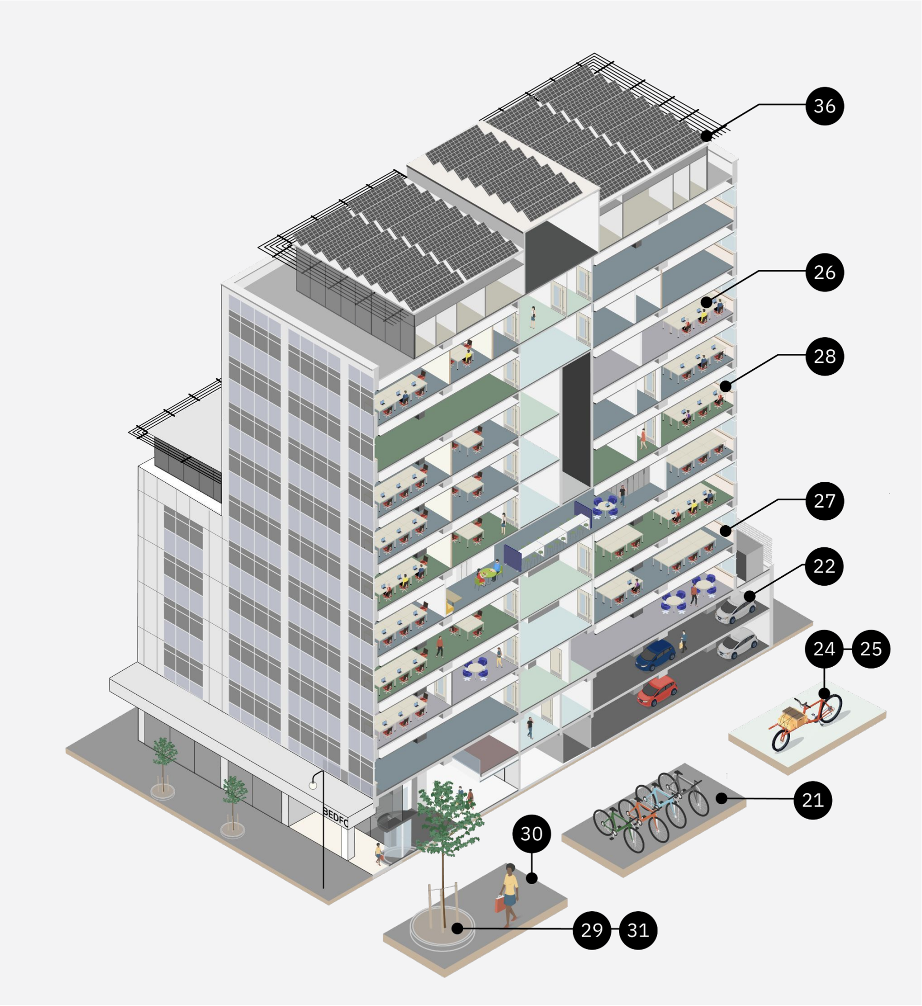
- **26** Flexible working & bookable shared spaces
- **27** Community use outside hours or low occupancy
- **28** Internal sensors - air quality, noise, light

07. PUBLIC REALM

- **29** Green infrastructure, SUDs & permeable surfaces
- **30** Active travel - pedestrianisation & cycle lanes
- **31** Support local biodiversity - planting, beehives
- **32** Temporary pop-up community events (e.g. repair café)

08. COMMUNITY

- **33** Support local product sharing platform
- **34** Community owned energy infrastructure
- **35** Local & circular procurement strategy
- **36** Connect to local material bank & reuse hub



Implementing more circular practices

Long-list of opportunities

	#	OPPORTUNITY	⟳	↓ CO_2	↓ £	CASE STUDY	~ COST (£)	~ IMPACT	ASSUMPTIONS / NOTES
ENERGY	1	Switch to renewable, zero-carbon energy provider		●		Fuel mix disclosure NI	-	-295 tCO_2e /yr	302 gCO_2e/kWh for current fuel mix
	2	On-site electricity generation - rooftop photovoltaics		●	●	South Bank Tower	£45,000, 6.5yr payback	-12.5 tCO_2e /yr	302 gCO_2e/kWh, 41 MWh/yr capacity
	3	Energy storage		●	●	Solar PV & storage	£40,000	As above	-
	4	Zonal heating & comfort feedback		●		Mesa	-	Reduction CO_2e	Manufacturer claimed 20% heating energy saving
WATER	5	Rainwater harvesting	●			PRONI Belfast	£20-35,000	-661 m^3 water/yr	⅕ of annual water usage
	6	Greywater recycling	●		●	Brunel Building - London	£120,000	-30-50% water/yr	Water cost saving £3,500 /yr
	7	Low flow taps & appliances	●		●	22 Granton Street		-15% water/yr	Assumed 30% reduced water use from taps
	8	Smart water meter & sensors	●			22 Granton Street	-	Reduction water	-
MATERIALS	9	Furniture repair & reuse	●	●	●	Rype Office	50%+ saving	Up to -256 tCO_2e	-
	10	Furniture & equipment leasing	●	●	●	Ahrend	15% saving	Up to -100 tCO_2e	Based on 40% embodied carbon saving
	11	Carpet recycling & leasing	●	●	●	Interface; DESSO		Up to -39 tCO_2e	Based on 20% embodied carbon saving
	12	Façade refurbishment	●	●	●	Arup	~⅓ cost of new	Up to -2,000 tCO_2e	-
	12b	Façade leasing	●	●	●	Façade leasing - TU Delft	-	Reduction CO_2e	-
	13	Lighting-as-a-service	●	●		Signify - light as a service	Spread over lease	Reduction CO_2e	-
	14	Demountable partitions	●	●		Cepezed - D(emountable)	Reduction	Reduction CO_2e	-
	15	Granular material use data collection	●	●		Digital Twin	-	Reduction CO_2e	Monitoring to identify improvements
	16	Building & material passports	●	●		BAMB	-	Reduction CO_2e	-
FOOD	17	Low-carbon, local procurement for on-site food		●		EAT - Planetary Health Diet	-	Reduction CO_2e	-
	18	Local composting network for food & compostable waste	●	●		Kompost	-	Reduction CO_2e	-
	19	Excess food sharing network	●			OLIO	-	Waste reduction	-
	20	Food waste data collection, reporting & target setting	●		●	WRAP food waste data	-	Reduction CO_2e	-

Implementing more circular practices

Long-list of opportunities

	#	OPPORTUNITY	⟳	↓ CO_2	↓ £	CASE STUDY	~ COST (£)	~ IMPACT	ASSUMPTIONS / NOTES
MOBILITY & LOGISTICS	21	Secure on-site cycle storage & maintenance equipment		●		Cycle storage	~ £100 per bike	Reduction CO_2e	-
	22	EV charging		●		Everun	~ £2,000 per charger	Reduction CO_2e	-
	23	Bicycle & EV car sharing club		●		Shared bikes	-	Reduction CO_2e	-
	24	Parking for cargo bike deliveries	●	●		Last-mile delivery hubs	-	Reduction CO_2e	-
	25	Use local, low-carbon delivery services (when available)	●	●		Oxford eco delivery	-	Reduction CO_2e	-
SPACE	26	Flexible & bookable shared spaces	●	●	●	Flexible office space	-	Increase utilisation	-
	27	Community use outside office hours or when low occupancy	●	●	●	Mixed-use building - Poland	-	Increase utilisation	-
	28	Internal environment sensors - air quality, noise, light				Indoor sensors	~ £50 per sensor	Improved health	-
PUBLIC REALM	29	Green infrastructure, SUDs & permeable surfaces			●	Belfast green infra. plan	-	Reduce flooding	-
	30	Active travel in public realm - pedestrianisation & cycle lanes		●		Barcelona Superblocks	-	Reduction CO_2e	-
	31	Biodiversity support - planting, bee hives				Belfast harbour garden	-	Increase biodiversity	-
	32	Temporary pop-up community events	●			Repair cafe Belfast	-	Support circularity	-
COMMUNITY	33	Support local product & equipment sharing platform	●			ReTuna	-	Support circularity	-
	34	Community owned energy infrastructure		●		Community Energy NI	-	Reduction CO_2e	-
	35	Local procurement strategy	●	●		Green procurement	-	Reduction CO_2e	-
	36	Connect to local material bank & reuse hub	●	●		Globechain	-	Support circularity	-

4.

Case Studies

International examples of circular best practice

Case study 1
1 Triton Square - London

Office refurbishment
Arup, British Land, Lendlease, Dentsu Aegis Network

The partners collaborated to transform a 1990s office building to match modern working requirements. The building’s embodied and operational carbon have been minimised through innovative approaches to refurbishment and by reusing as many of the existing materials and components as possible. On top of reduced construction costs and a faster development process than typical refurbishments, the building achieved a BREEAM Outstanding sustainability rating at design stage.

Strategies implemented

- Refurbished facade saving 19,000 tonnes CO_2
- Reuse of 3,300 m^2 limestone, 35,000 tonnes concrete and 1,900 tonnes steel
- 99.5% waste diversion
- 500 m^2 green roofs
- 500 cycle spaces

Outcomes

- 56% embodied carbon saving from typical new build
- 43% lower operational carbon than typical commercial building
- 66% cost saving of refurbished facade
- 30% faster completion vs typical new build

Image: Arup

Case study 2

338 Euston Road - London

Office refurbishment
British Land, Nex Architects, Rype Office

British Land worked with Nex to complete a Grade 'A' office refurbishment at 338 Euston Road using circular economy principles. The building offers 4,400 m^2 of workspace for 1,080 people over 9 floors. The project retained 70% of embodied carbon, compared to a typical category B fit-out, at the same cost as a conventional category A fit-out. The floors where existing materials and furniture had been repurposed, ended up being let out 6 months faster than the floors where a conventional category A model had been used.

Strategies implemented

- Retained and refurbished majority of mechanical and electrical equipment
- Reuse of timber fit-out in kitchens, joinery and furniture
- 75% of breakout and meeting room furniture refurbished
- Recycled PET carpets
- LED lighting

Outcomes

- 70% of embodied carbon retained
- Remanufactured 250 pieces of furniture
- 6 months quicker to let than conventional fit-out

Case study 3

Kristian August Gate 13 - Oslo

Office refurbishment
Asplan Viak, Futurebuilt, Haandverkerne

Kristian Augusts Gate 13 represents one of the first buildings in Norway to consider reuse of materials and circular practices at scale. The eight-storey office building from the 1950s was initially destined for demolition before the developer decided to preserve the structure and refurbish the building, with the intention of using 50% reused materials and representing a significant emissions reduction compared to building new. The refurbishment as well as a newly built extension was created from reusable materials coming from various local "donor buildings".

Strategies implemented

- Reuse of façade panels from another building
- Reuse of hollow core slabs from another building
- Brick wall constructed from reuse bricks
- Reused windows
- Ceiling tiles reused for sound insulation

Outcomes

- BREEAM “Very good” certification
- New internal vertical spaces spanning multiple floors
- Exemplar pilot project for Norway

Image: Food Architects


Image: Schoonschip, Buiksloterham – Spectral

Case study 4
Circular Buiksloterham - Amsterdam

Circular neighbourhood
Metabolic, Studioninedots, DELVA Landscape Architects

A former industrial area Buiksloterham, Amsterdam-Noord, is being developed into a sustainable and circular district to live and work. It will form part of a living lab to support experimentation and research within the community to develop a resilient and circular local economy, powered by renewable energy, supporting high biodiversity.

2034 ambitions
- Energy self sufficiency, with fully renewable supply
- 100% circular material flows, zero waste
- 100% resource recovery from wastewater
- Regenerated ecosystems and self renewing natural capital
- Zero-emission local mobility
- Strong, entrepreneurial local economy
- Healthy, safe and active local environment

Case study 5
Building D(emountable) - Delft

New build office
cepezed

A modern, sustainable and fully demountable structure in the center of Delft. The four-storey structure is incredibly lightweight, with material use kept to a minimum. Internally, the spaces are completely flexible in layout, with all building components modular and dry mounted. The building comprises a steel supporting structure and prefabricated laminated veneer lumber making up the floors and roof. The screed is bio-based and easily removable, with the flooring made from partly recycled PVC. Glass is mounted directly to the steel frame with reversible fixings.

Strategies implemented

- Fully reversible assembly
- Bio-based materials for flooring and roof structure
- Heat recovery ventilation
- Prefabrication of steel and timber structure
- Gas free

Outcomes

- 6 month construction process
- Fully demountable building
- Fully flexible internal space plan

Image: Lucas van der Wee


Image: Filip Dujardin

Case study 6
People's Pavilion - Eindhoven

Temporary pavilion
Arup, Bureau SLA, Overtreders W

Designed and built for Dutch Design Week in 2017, the People's Pavilion was a temporary structure made entirely from borrowed materials and with a nearly zero carbon footprint. Designed with easily reversible connections without the need for nails or glue, the pavilion was formed from standard wooden beams, strapped together with steel strips normally used to bind pallets. The seven-metre-tall columns were made of prefab concrete foundation piles, with steel rods from a demolished office building reused as cross bracing. The glass roof was borrowed from a greenhouse supplier, while the glass lower façade was saved from a demolished office building.

Strategies implemented
- Shingles from recycled plastic
- Disassemblable borrowed wooden structure
- Fully reversible connections using straps
- Lower façade reused from demolished office building
- Lighting and heating system borrowed

Outcomes
- Near zero carbon footprint
- 600 person capacity temporary building
- Fully reused materials and components

5.

Recommendations

Practical next steps to improve circularity and reduce building related emissions

Recommendations

A circular economy strategy for Bedford House

Bedford House has the opportunity to lead the way in demonstrating how circular principles, applied to an office building, can support a regenerative, inclusive and sustainable local economy and green recovery. Both as part of the Linen Quarter's sustainability vision and Belfast's Resilience Strategy and Net Zero Carbon Roadmap. Adopting circular strategies can help to reduce the environmental impact of the building, support local green jobs, contribute to local climate resilience and improve wellbeing of building occupants and the wider community.

Circular Economy Statement

A Circular Economy Statement can be a useful first step in developing a circular strategy for Bedford House. It helps demonstrate how a development incorporates circular economy measures into all aspects of the design, construction and operation process. This can guide circularity initiatives and set targets across different aspects of building operations.

They can help to:

- consider strategies to facilitate the transition towards a circular built environment
- report against numerical targets that will facilitate monitoring of waste and recycling
- recognise opportunities to benefit from greater efficiencies that can help to save resources, materials and money.

Guiding initiatives

A number of guiding initiatives can be used as part of defining a circularity strategy:

Engage Bedford House stakeholders
Convene all building stakeholders: tenants, landlord, building management, BID and representatives from the local community, to input to and co-develop the circularity strategy to ensure inclusivity and broad buy-in.

Circularity hierarchy
Require consideration of a circularity hierarchy (pg 20) in all material related procurement decisions.

Records of material flows
Maintain standardised records of all materials entering and leaving the site. In time, identify priority areas and work with specific department to minimise and align with waste management plans.

Green & circular procurement strategy
Develop a site-wide green and circular procurement strategy for all departments: facility management, cleaning, stationery, food & catering, construction, IT systems, building services.

Energy & water monitoring
Continue to monitor energy and water use at Bedford House and set reduction targets.

Pre-refurbishment/pre-demolition audit
Conduct audits before all construction works to identify reuse potential, and minimise their environmental impacts.

Recommendations

Next steps

This analysis and report presents a number of opportunities to introduce more circular practices at Bedford House and simultaneously contribute to some of the wider measures necessary for climate crisis mitigation in the built environment. Before formalising these steps, we recommend Bedford House convenes a series of workshops with key stakeholders, including tenants, landlord, building management, Linen Quarter BID and representatives from the local community to identify, prioritise and co-develop this circularity vision for Bedford House.

Priority areas

Based on the analysis of circularity opportunities at Bedford House, we consider the following priority areas of opportunity:

ENERGY

1. Ensure electricity is from renewable, zero-carbon provider
2. Conduct energy audit & assess feasibility of installing solar PV and battery storage

WATER

3. Monitor water use and grey vs black water waste
4. Assess feasibility of greywater recycling & rainwater harvesting

MATERIALS

5. Monitor all materials entering & leaving building
6. Implement circularity hierarchy for all material & product procurement

FOOD SYSTEMS

7. Introduce a low-carbon, local food menu at Bedford House cafe
8. Monitor and report all food waste, set reduction targets

MOBILITY & LOGISTICS

9. Provide secure cycle storage and maintenance equipment on-site
10. Transition to low-carbon delivery services

SPACE UTILISATION & PERFORMANCE

11. Monitor space utilisation & introduce measures to maximise
12. Monitor internal environment - air, noise & light

PUBLIC REALM

13. Requires a longer-term approach involving convening local stakeholders and identifying opportunities to support active travel, increase biodiversity and introduce sustainable drainage in the wider public realm.

COMMUNITY

14. Partner with local reuse hubs / material banks for any products or materials that cannot be reused at Bedford House or for procuring reused items.

6. Appendix

Methodology

Calculations, sources and assumptions

Pg#	DESCRIPTION	METHODOLOGY & ASSUMPTIONS
p12	2030 EUI & heating targets	LETI Net zero Operational Carbon
p12	2030 Water use target	RIBA 2030 Climate Challenge
p12	Fuel mix	PowerNI fuel mix
p14	Facade embodied carbon	Assuming facade represents 160 kg CO_2e /m^2, based on similar, typical office buildings
p14	EPDs for similar products (where available)	Similar products selected from EPD database or manufacturer website
p14	Where EPDs not available, general emissions data used	Materials selected from ICE database
p16	Food consumption related emissions	Source: 2.2 tCO_2e per person per year, assume 3 meals per week in office, 46 weeks per year
p16	Commute related emissions	Estimated travel related emissions for all occupants, assuming emission by transport type from UK BEIS, assuming 3 commutes per week, 46 weeks per year
p16	Northern Ireland typical commuting patterns	Travel Survey for Northern Ireland - 2017-2019
p17	WELL building performance standard	WELL v2 pilot
p17	Solar potential	Assuming a 50 kWp photovoltaic system on 400m2 of roof space, using average solar irradiation in Belfast, costing approx. £50,000
p17	Rainwater harvesting potential	Assuming runoff coefficient 0.5 for flat roof, 1400m2 surface area, annual average rainfall 944mm
p26	RWH & GWR cost & performance	Independent review of the costs and benefits of rainwater harvesting and grey water recycling options in the UK - Ricardo

Bedford House

Opportunities to improve circularity and reduce building related emissions

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