Architecture & Design Scotland
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SCOTTISH FUTURES TRUST

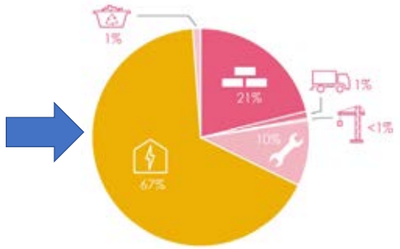
Shared Learning Event

Construction Embodied Carbon

Introduction

LEIP – Learning Estate Investment Programme

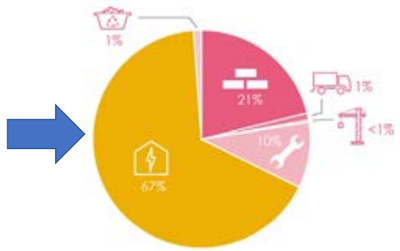
LEIP Phase 1 +2
- Operational energy 1st priority



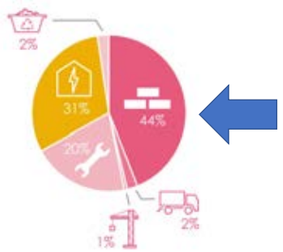
Priorities
- Address the Performance Gap
- Reduce Energy Consumption
- Set an Operational Target figure
- Tie target to OBF model

Energy Consumption kWh/sqm/p.a.	Energy Funding %
A 67- 83	100%
B 84- 99	90%
C 100 - 115	60%
D 116 -130	30%
E 131+	0%

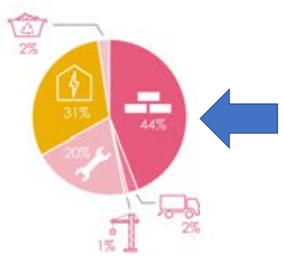
LEIP Phase 1 +2
- Operational energy 1st priority



LEIP Phase 3
- Embodied Carbon next priority



LEIP Phase 3
- Embodied Carbon next priority



Priorities
- Set a realistic CEC Target figure
- Building only – as sites differ
- RICS Stages A1-A5
- Tie target to OBF model
- Encourage reuse/refurbishment

Band A	**< 600**	**100%**
Band B	601 – 666	90%
Band C	667 – 733	60%
Band D	734 – 800	30%
Band E	> 800	0%

Source: LETI Climate Emergency Design Guide

Context

This Shared Learning Event was the second of 2024, and was designed to promote discussion and sharing of best practice. The theme for this event was 'Construction Embodied Carbon'. It was hosted and facilitated by Scottish Futures Trust (SFT) alongside Architecture and Design Scotland (A&DS).

The event was open to all Local Authorities across Scotland to provide an open forum to discuss initiatives, share ideas and challenges. It was held on MS Teams on 20th Aug 2024 and brought together 130 delegates from Local Authorities across Scotland, including representatives from Scottish Government Learning Directorate. It featured presentations from:

- Leanne Hannah from ARMILA Sustainability Services
- Lindsey Mitchell & Golnaz Ighany from BDP on Chryston High School Extension
- Alan Paul & John Peden from Fife Council on Fife Council's journey towards Net Zero and Passivhaus

Background

The Learning Estate Investment Programme (LEIP) is a joint programme between Scottish Government and COSLA, managed by SFT.

This innovative funding programme offers up to 50% of the capital equivalent funding to local authorities using outcome based funding over 25 years if criteria are met.

LEIP Phases 1 & 2 primarily addressed the Operational Energy use, while a Construction Embodied Carbon (CEC) target was introduced in LEIP Phase 3.

LEIP = Outcome Based Funding model (OBF) given over 25 years on successful evidence of Outcomes;

Some are **static** and some **dynamic** over the 25 years;

- **Condition** – keep your school in condition A/B for 25 years
- **Operational Energy** – target less than 67kWh/m2/pa
- **Digital Infrastructure** – provide infrastructure to deliver 11GBps
- **Economic Growth** – demonstrate jobs created through Construction
- **Embodied Carbon** - target less that 600kg CO2e/m2 (Phase 3 only)

For Operational and Embodied Carbon outcomes, evidence will determine annual revenue funding on sliding scale. Energy is dynamic but CEC is determined at Handover.

Impact:

- Carbon is now (another) design criteria
- Early decisions could have an impact on LA funding level.
- Carbon Plan is "live" until Handover – when funding determined.

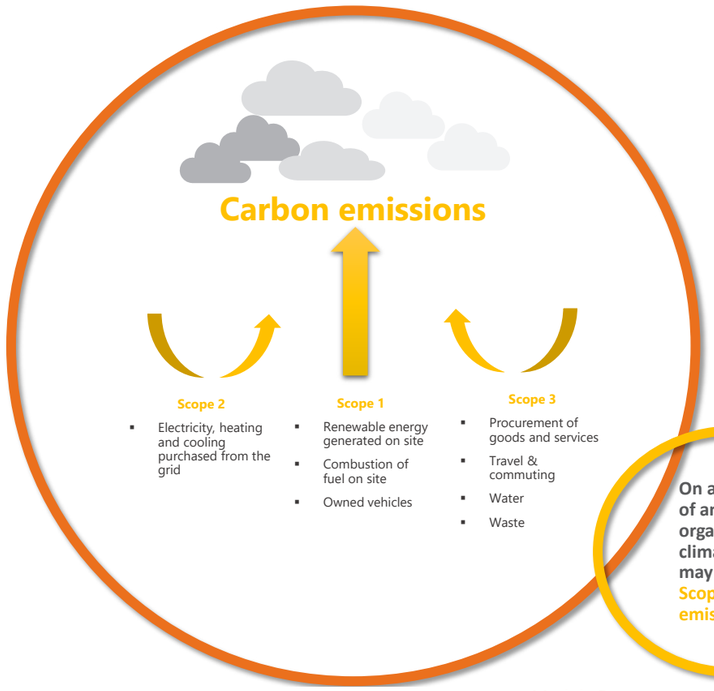
Design:

- Will it rationalise the designs of new schools?
- Consider long spans, transfer structures, cantilever features
- Tension between energy and CEC targets – what is the balance?

Cost metric adjustment:

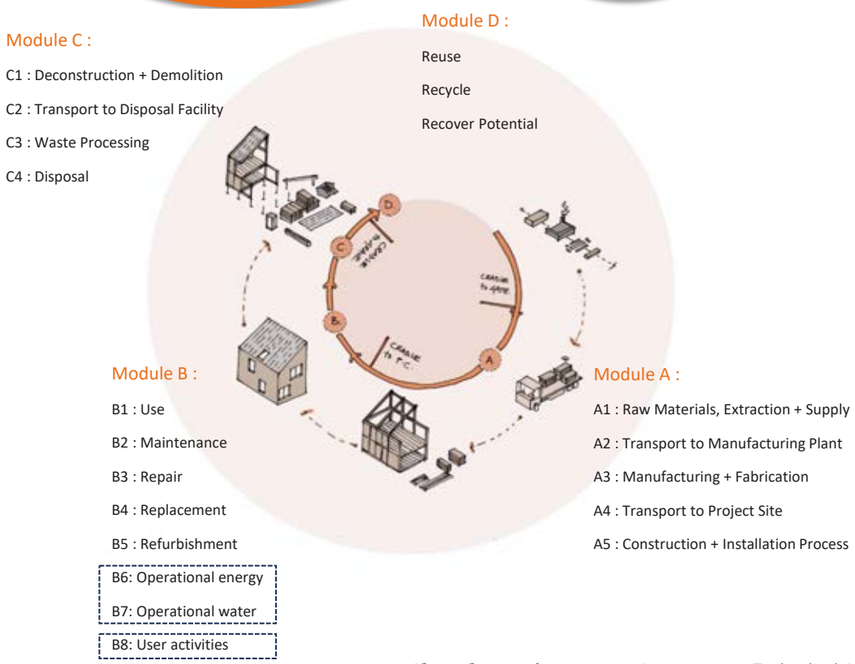
- Metric has been adjusted to take account of structural options- but "Green Steel" is now regarded as cost-neutral option?
- Refurbs >50% GIFA automatically Band A without evidencing.

Construction Embodied Carbon



Scottish Government has reported that, on average, **60% of an organisation's climate impact may relate to Scope 3 emissions** and now require public body Procurement Strategies to

"prioritise and take account of climate and circular economy in their procurement activity".



Leanne Hannah
ARMILA Sustainability Services

Leanne Hannah is founder and Managing Director of ARMILA Sustainability Services Ltd. Leanne is an experienced consultant who specialises in sustainable development and has a passion for supporting the responsible delivery of low environmental impact projects that enhance user health and social wellbeing.

Scottish Government's recent updates to public procurement policy and climate reporting requirements, now requires public bodies to **consider and act on opportunities to improve environmental wellbeing and to report on targets for reducing direct and indirect emissions of Greenhouse gases:**

- **Scope 1** - Direct operational emissions arising from owned or controlled sources and owned vehicles
- **Scope 2** - Indirect emissions from purchased electricity, heating and cooling
- **Scope 3** - Other indirect emissions such as procurement of goods and services, staff commuting, business travel, water and waste

Scottish Government requires public bodies to report annually on: **"targets for reducing direct and indirect emissions of greenhouse gases".**

Whole Life Carbon is:

Operational carbon + Embodied carbon

For new buildings, RIBA report that embodied carbon contributions can account for as much as 70% of a building's total carbon emissions over its lifecycle.

Carbon Stages

The construction industry accounts for the emissions associated with buildings in terms of the BS EN 15978 life cycle stages.

Whole Life Carbon - 'Cradle to Cradle'

- Product Stage – Modules A1 to A3
- Construction Stage – Modules A4 and A5
- Use Stage – Modules B1 to B8
- End of Life Stage – Modules C1 to C4
- Benefits Beyond the Boundary – Module D

Minimising Embodied Carbon

The ability to influence embodied carbon is at its greatest right at the very start of the project, where the most significant contributions are often made.

Adopting a whole life approach presents an opportunity to measure and mitigate embodied carbon during every life cycle stage, including design, delivery, use and end of life.

Consider the waste hierarchy principles:

- Prevention
- Reuse
- Recycle
- Recover

Measuring and Mitigating Embodied Carbon

Whole Life Carbon Strategy:

- **Define the scope and agree boundary** e.g. Construction Embodied Carbon only (i.e. modules A1-A5) and excluding external space and non-fixed FFE.

Construction Embodied Carbon

- **Agree targets and objectives from the very start** e.g. compliance with LEIP or NZPSB Standard metrics.
- **Alignment with credible methodologies** e.g. RICS PS WLC Assessment.
- **Use of robust, IMPACT compliant calculation tools** e.g. One Click LCA, iterative assessment process undertaken by experienced individual.
- **Accuracy of data** e.g. use of BIM materials library, specifications, Bill of Quantities.
- **Credible sources of information** e.g. EPDs, ICE database CIBSE TM65.
- **Align Life Cycle Costing and Life Cycle Carbon activity** e.g. integrated whole life cost and carbon reporting to inform options appraisal activity.

Construction embodied carbon
Product Stage (A1-A3) + Construction Stage (A4+A5)

- Identify biggest contributors
- Reduce volume of materials (waste hierarchy)
- Optimise opportunity for reuse, think circular
- Optimise the use of recycled content
- Optimise the use of natural materials
- Design for longevity, robustness and resilience
- Source locally
- Adopt responsible construction practices
- Identify biggest contributors, for a typical school these could be:

    - Structural steel frame
    - Concrete for substructural elements
    - Insulation

- Optimise design and 'design out waste', saving as much as a 15% reduction in 'upfront' embodied carbon:

    - Optimise column grid
    - Consider steel grade
    - Optimise secondary beam spacing
    - Limit weight of frame by limiting transfer structures and cantilevers
    - Limit secondary steel use e.g. timber infill in lieu of SFS
    - Promote use of cellular beams e.g. Westok Cellular Beams
    - Reduce pad foundation thickness, consider RC instead of mass

- Identify biggest contributors, for a typical school these could be:

    - Structural steel frame could contribute around 20 – 25% to the total 'upfront' carbon figure
    - Optimise use of EAF steel
    - Encourage early supply chain viability testing to ensure product availability
    - Obtain Environmental Product Declarations from supply chain
    - Concrete use in structural elements could contribute around 15-20% to the total 'upfront' carbon figure
    - Optimise use of recycled mix and cement free options
    - Consider logistics and any programme impact
    - Consider vibro stone columns and other 'innovative' options to traditional concrete piles, where more than a 70% carbon reduction could be achieved
    - Encourage early supply chain viability testing to ensure product availability and locality

Whole life embodied carbon
Consider the impact on the Use Stage (B1-B5)

- Identify biggest contributors, for a typical school these could be high emitters or replacement items:

    Air Source Heat Pumps – optimise size and efficiency and utilise refrigerants with Global Warming Potential as close to zero as possible.

    MVHR – optimise system efficiency, consider if some areas could operate comfortably with natural ventilation.

    Photovoltaic panels – this will increase 'upfront' embodied carbon, however, it is usually expected that the incorporation of this technology will deliver **whole life carbon reductions** over the life cycle of the building. To maximise this opportunity, a fabric first approach and an ambitious operational energy target should be adopted.

    Design for longevity – optimise service life, ensure robust finishings, design for resilience.

    Think circular – promote circular design practices, ensuring high replacement items can be reused / recycled.

- Plan to mitigate Construction Stage impacts:

    Mitigate diesel consumption – prioritise grid connection and plug in options and consider the use of diesel replacements such as responsibly sourced HVO.

    Mitigate transport impacts – require contractors to work with supply chain and waste management providers to ensure deliveries are minimised and clean fleet options prioritised. Promote use of local supply chains.

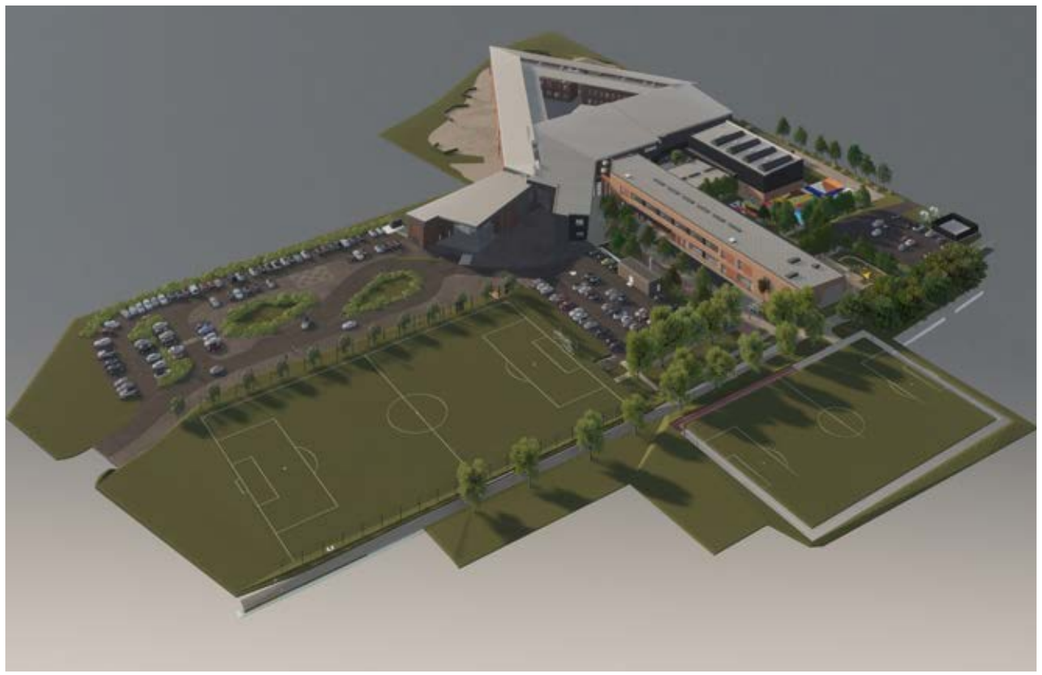
    Implement resource efficiency strategy
    - Promote efficient use of resources during construction stage e.g. reclaimed materials on site, waste reduction and diversion from landfill; Promote circular supply chain use and encourage supplier takeback; and promote efficient use of resources on site e.g. efficient site cabins.

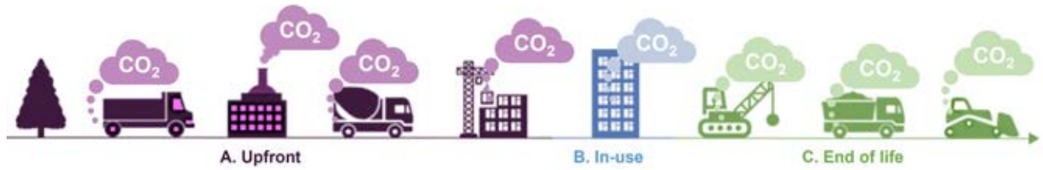
    Monitor and report - Monitor and report site impacts on a regular basis e.g. utilise SmartWaste reporting tools

Useful Resources

- **One Click LCA Planetary** - a free embodied carbon measurement tool
- **RICS Whole Life carbon assessment for the built environment**
- **RIBA Embodied and whole life carbon assessment for architects**
- **IStructE Guide - How to calculate embodied carbon**
- **LETI Embodied Carbon Primer**

Chryston High School Extension





Lindsey Mitchell & Golnaz Ighany

BDP

Lindsey Mitchell is Architect Director at BDP and Golnaz Ighany is Director of Sustainability within Architecture at BDP.

Chryston sits 13km to the North-East of Glasgow within North Lanarkshire Council region. The project itself is an extension to the existing Chryston High School which was constructed in 2012. The 2012 build was a tandem build on the site of the existing Chryston High School which largely determined the placing of the 2012 building on the site. The existing school is almost full to capacity and because of the house building programme in the North of Glasgow there is a need in North Lanarkshire to extend the school. The site extends to 5.8 hectares, but the development site is 2.28 hectares, and is largely surrounded by residential development.

Project Brief

- Expand high school to accommodate additional 500 pupils
- Accommodate an integrated early years facility for 64 children
- Enhance the social dining experience for young people & staff
- Community provision to be considered
- Most departments to expand

Design Strategy

- The extension footprint is concentrated on the land directly south of the existing school.
- The design works with existing topography to minimise the removal of material from site.
- The extension contains a double height link space that connects the existing building to the new two storey teaching block.
- The extension also includes a sports block which contains new changing facilities, a fitness suite and a double-height games hall.

Design Status

- Planning Approval August 2024
- Target start date on site November 2024
- Target completion October 2026

Early Stages

The project team went through a significant round of optioneering with North Lanarkshire Council at the start of the project to try and establish the best fit for the site and the operation of the school. Whilst this is often an architecturally led process, in this case owing to the carbon assessment it was a whole team approach, with the team looking at massing to try and determine the optimal structural solution and also looking at what the structure actually is in order to determine what the preferred option would be.

The project has been procured via Hub South-West and Tier 1 Contractor BAM was onboard at the early stages which in this case, because of the carbon assessment, was extremely beneficial especially in terms of material considerations. BAM were able to reach out to the supply chain to ensure that by the time the project got to site the materials would be available and the market was ready for the project.

Pragmatic Approach to Design

The project team looked at a number of configurations with the council in order to ensure there is a pragmatic approach to design; there are no large overhangs and the spans have all been

Chryston High School Extension

assessed at the early stage of Hub Stage 1 to ensure that there is a measured approach to the structure to minimise any wastage.

Communication of Proposal

In terms of the carbon assessment from the designers point of view it's really important to:

1. Clearly identify scope (at the early stage for those assessing the embodied carbon in the project)

2. Support requirement for detail at an early stage

3. Whole team approach to level of information provided

4. Ensure specified products align with intent to reduce carbon (collecting EPD's right from the early stage of the project to align with the clients ECR's)

Climate and social Action Design Framework (CADF)

This framework is a tool that aims to accelerate BDP's goal of achieving Whole Life Net Zero Carbon across all projects. Aligned with UN Sustainable Goals, it enables the identification of specific Key Performance Indicators (KPIs) for each project and facilitates the establishment of clear, measurable targets from early design stages to post-occupancy. It allows BDP to set targets, tracks performance while enhancing communication, feedback and response with clients, design teams and consultants, fostering a knowledge-sharing platform that drives innovation for a resilient future.

One part of the tool is to gather data and performance metric. BDP try to gather operational embodied carbon data and break that down through elements and stages of design. So at an early stage they can set their targets and are able to go through the different stages and track how they are performing in relation to their targets.

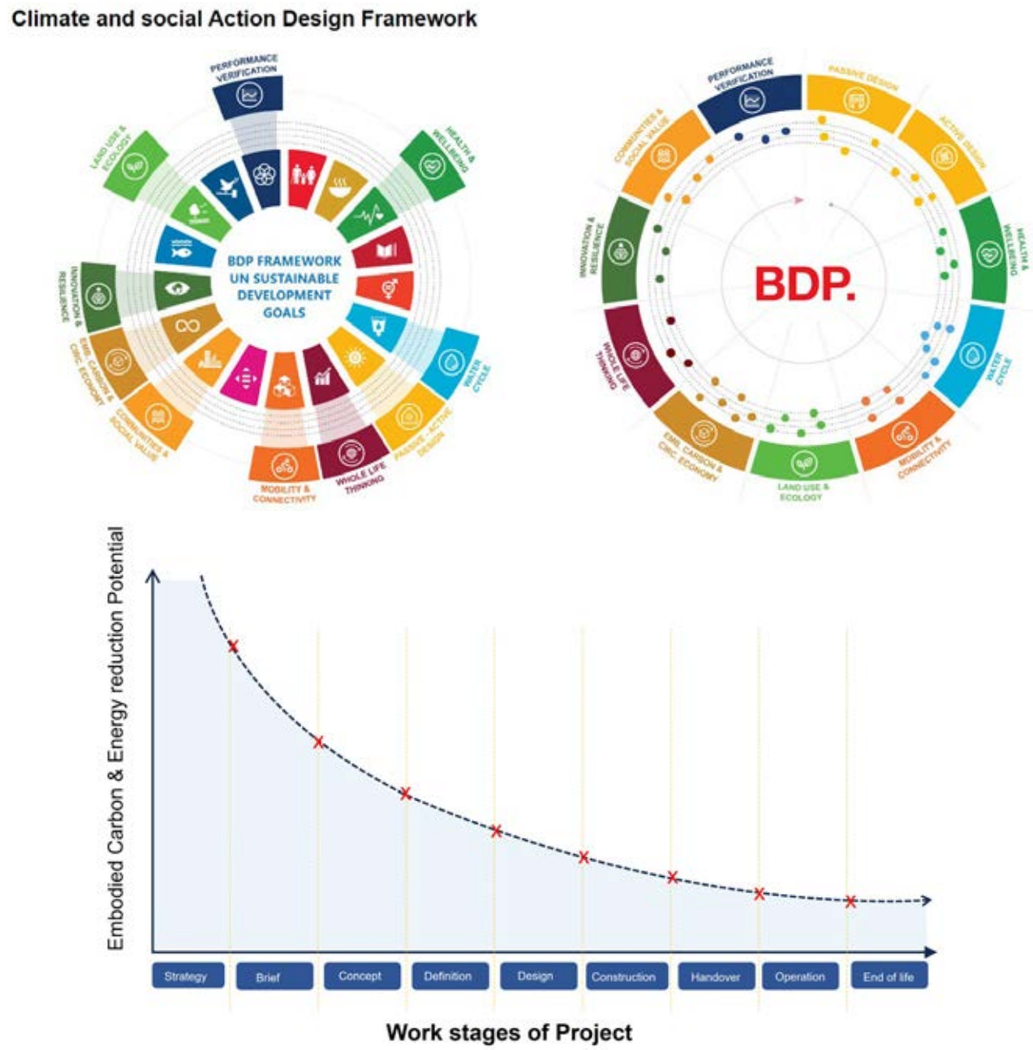
Carbon confidence

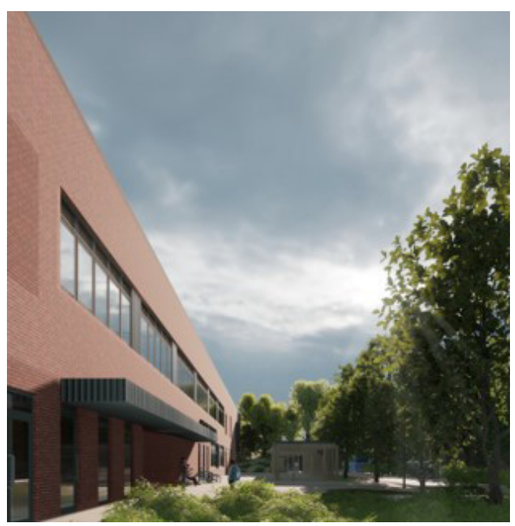
From early stage in the design process the accuracy of materials varies greatly from actual carbon emission, therefore at the early stage of design BDP are adding an additional 15% contingency factor for their projects because there is a high level of uncertainty of the materials quantity. As the project progresses that contingency factor will be reduced and hopefully when the project is on site it is minimal. The more EPD's (Environmental Product Declaration) you have the easier it is to reduce that uncertainty. BDP commented that many manufacturers are very well geared up for providing EPD's at an early stage, whereas other manufacturers don't know what an EPD is. "There is a general upskilling as we go; an upskilling of the design team as well as the industry generally."

The diagram overleaf shows there is plenty of opportunity to reduce carbon at the early stages of design, hence why BDP work with their sustainability colleagues very early into the project. The graph shows the potential of carbon reduction opportunity at the early stage; the vertical axis shows how the potential of that carbon reduction dramatically diminishes when the curve drops proportionally as the project moves away from the early stages, so it is very important to involve all the consultants early on.

In-house tools

BDP have created Carbon Budgeting tools which gives more responsibility to each discipline; assigning them a budget for each element. It is interactive and can be customised based on every project they work through. All consultants have a responsibility to gather information and feed into the LCA model. They have also created an interactive dashboard to track the carbon performance, which is an interactive way to quickly show the clients how this budgeting of the carbon elements is changing.





Fife Council's journey towards Net Zero and Passivhaus

"In creating our innovative Dunfermline Learning Campus, we want to provide a lasting educational legacy for future generations, supporting and improving the whole learning environment whilst also helping us meet our net zero obligations."

Alan Paul

Alan Paul & John Peden

Fife Council

Alan Paul is Head of Property Services at Fife Council and John Peden is a certified Passivhaus designer and Lead Professional Architect in the Place Directorate within Fife Council.

Dunfermline Learning Campus is a collaboration between Fife Council, Fife College, and the Scottish Government. The schools' build was through hub East Central Scotland with BAM Construction as the T1 construction partner. The campus co-locates pupils, students, and staff from St Columba's RC High School, Woodmill High School, and Fife College, in modern, fit-for-purpose, and low-carbon facilities.

The new schools are equipped with innovative internal spaces, including a 'Learning Lab' with performance analysis tools, media studios, recording booths, and extensive creative project spaces. The campus also features learning plazas, breakout booths, digitally enabled learning spaces, and a range of outdoor facilities designed to promote holistic development and wellbeing.

Project Overview

- Structural Frame: Hybrid precast concrete frame, Cross Laminated Timber (CLT) and Steel
- Construction Cost: £112 million
- Number of pupils: 2514
- Gross internal floor area (GIFA): 26,666 m2
- Treated floor area (TFA): 23,186 m2
- Form factor: 1.7
- Build start date: 2022
- Completion date: 2024
- School handover June 2024
- Certification: Aiming for Passivhaus Classic

Site Overview

- Site 60 acres
- Replaced 2 major secondary schools
- Partnering with Fife College
- School buildings 27000 m2
- College estate 20 000 m2

Project Key Drivers

- Partnership
- Ambition
- Community Wealth Building
- Sustainability

Net Zero Public Sector Building Standard

Dunfermline Learning Campus was a pathfinder project for the Scottish Governments' **Net Zero Public Sector Building Standard.**

- Good form factor was an important early consideration. The building is large, and the project team were keen to keep the form as compact as possible. Form factor is 1.68.
- The building combines two construction types for different elements of the building. The choice of precast concrete frame and glulam frame aimed to help with the achievement of airtightness targets and improve the adoption of airtightness on site. However, the use of hybrid building envelope frames introduced challenges.

Fife Council's journey towards Net Zero and Passivhaus

- Primary energy demand on this typology of building can be challenging. It was important for the design team to understand the profiles of use for the high demand spaces, such as home economics and design & technology, to input accurate energy figures from accurately developed usage profiles.
- As well as the operational carbon targets, embodied carbon targets were aiming for a budget of under 650kg/CO2e/m2, as per RIBA 2025 Target and the Net Zero Carbon Public Sector Building Standard. Embodied carbon achieved of 626kg/CO2e/m2.
- Internal comfort and natural light levels are an important consideration, and internal courtyards allow natural light to penetrate deep into the building.

Site Wide Key Facts

Ecology

- 15% Overall site area reserved for natural habitat to enhance biodiversity of the site
- Approx. 6000 native trees planted

Transport

- 282 Cycle Spaces
- 24 EV Charging Points (+ Infrastructure for 74 more)
- 17 Bus Parking Spaces
- 4 Bus Stops
- Approx 2.5km of footpaths and cycleways

Drainage

- Rain Gardens collect and retain surface water and enhance biodiversity
- Enhanced RWOs to protect from severe weather

Community

- 745m2 Area, 6% of building footprint allocated to growing spaces
- 15% of site area to benefit local wildlife

Wellbeing

- MVHR to meet Passivhaus standards
- Openable windows for summertime temperature control
- Operational energy will meet SFT LEIP band A target

Waste

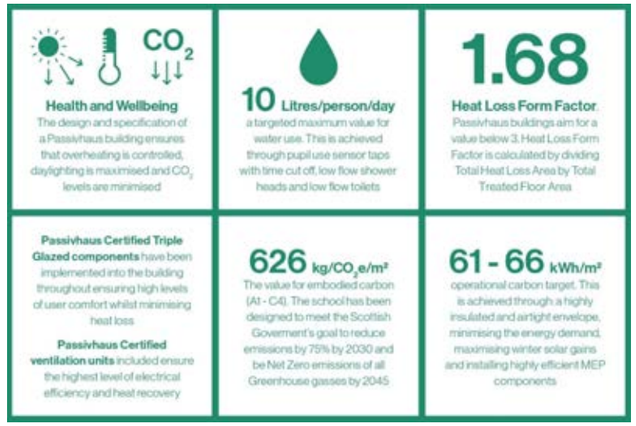
- 75% reduction in operational emissions by 2030 with climate adaption embedded
- Drainage for extreme rainfall, strategic tree planting for wind reduction/shading

Community Wealth Building

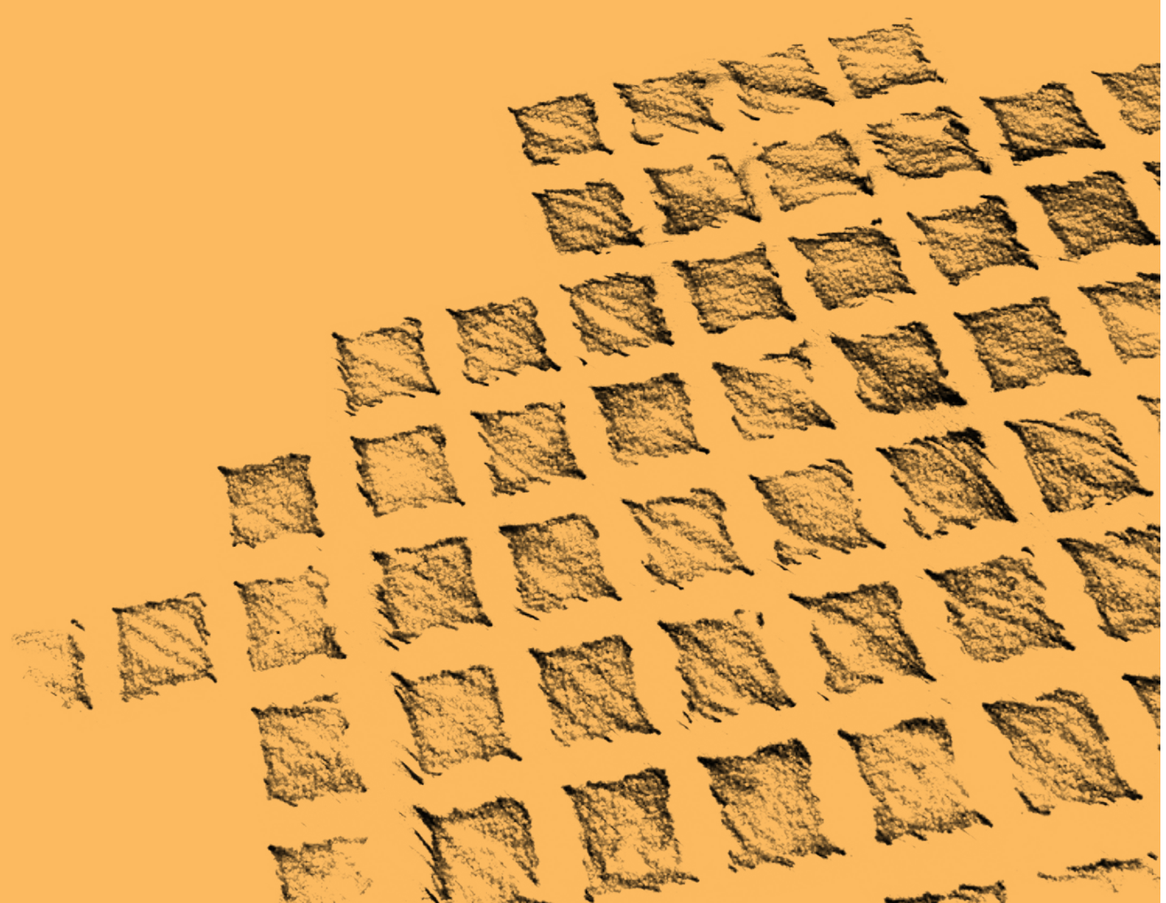
- 1883 weeks of apprenticeships
- 1150 hours supporting young people at work
- 640 hours volunteering with local community groups
- 80 local people employed on site
- Social Local Economic Value £35m
- £74,618 donated to local community groups
- 868 weeks of training opportunities

Freeport

Dunfermline Learning Campus is the largest Passivhaus building in the UK and its inclusion as part of Fife council's proposal towards the Forth Green Freeport, illustrates the huge ambition for the project as this learning campus will accommodate the future workforce of Freeport.



Further Support



Further Support

As well as a forum for Local Authorities to join together, the Shared Learning Events are designed to complement support that is available on any aspect of the LEIP, from SFT's Learning Estate Infrastructure Team and wider stakeholders as appropriate. For relevant contacts at SFT and A&DS please see below;

SFT Contacts

Steven Anderson

Steven.Anderson@scottishfuturestrust.org.uk

Stephen Long

stephen.long@scottishfuturestrust.org.uk

Sarah Burnett

sarah.burnett@scottishfuturestrust.org.uk

A&DS Contacts

Lesley Riddell Robertson

lesley@ads.org.uk

Danny Hunter

danny.hunter@ads.org.uk

Credits and Acknowledgements

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SCOTTISH FUTURES TRUST

Get in touch:

www.ads.org.uk
@ArcDesSco
T: 0131 556 6699
E: info@ads.org.uk

www.scottishfuturestrust.org.uk
@SFT_Scotland
T: 0131 510 0800
E: mailbox@scottishfuturestrust.org.uk