STBA
SUSTAINABLE TRADITIONAL BUILDINGS ALLIANCE

S·P·A·B

STBA & SPAB ANNUAL CONFERENCE: 6TH - 13TH OCTOBER 2020

EMBODIED CARBON & LIFE CYCLE ASSESSMENT

Peter Cox FRSA

Managing Director,
Carrig Conservation International Ltd.

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Overview

1. Introduction to Life Cycle Assessment (LCA)
2. Embodied vs Operational energy
3. Typical methodology for LCA
4. Case Studies
    a. Villa Dammen, Norway
    b. USA
    c. UK
5. The Next Steps

INTRODUCTION

The Built Environment accounted for 22.7% of Ireland's total greenhouse gas emissions in 2017

Climate Action Plan 2019

To be Enshrined in Law

Carbon proofing all government decisions and major investments

Enterprise and Services

Embed **decarbonisation** and waste management measures across **all enterprises and public service bodies**

CO_2

Public Sector

Reduce emissions from the **public sector by** **30%** by 2030

Every public body will adopt a **Mandate** for **Climate Action in 2019**

Improve energy efficiency of **public sector buildings** **50%** by 2030

What do these three buildings have in common?

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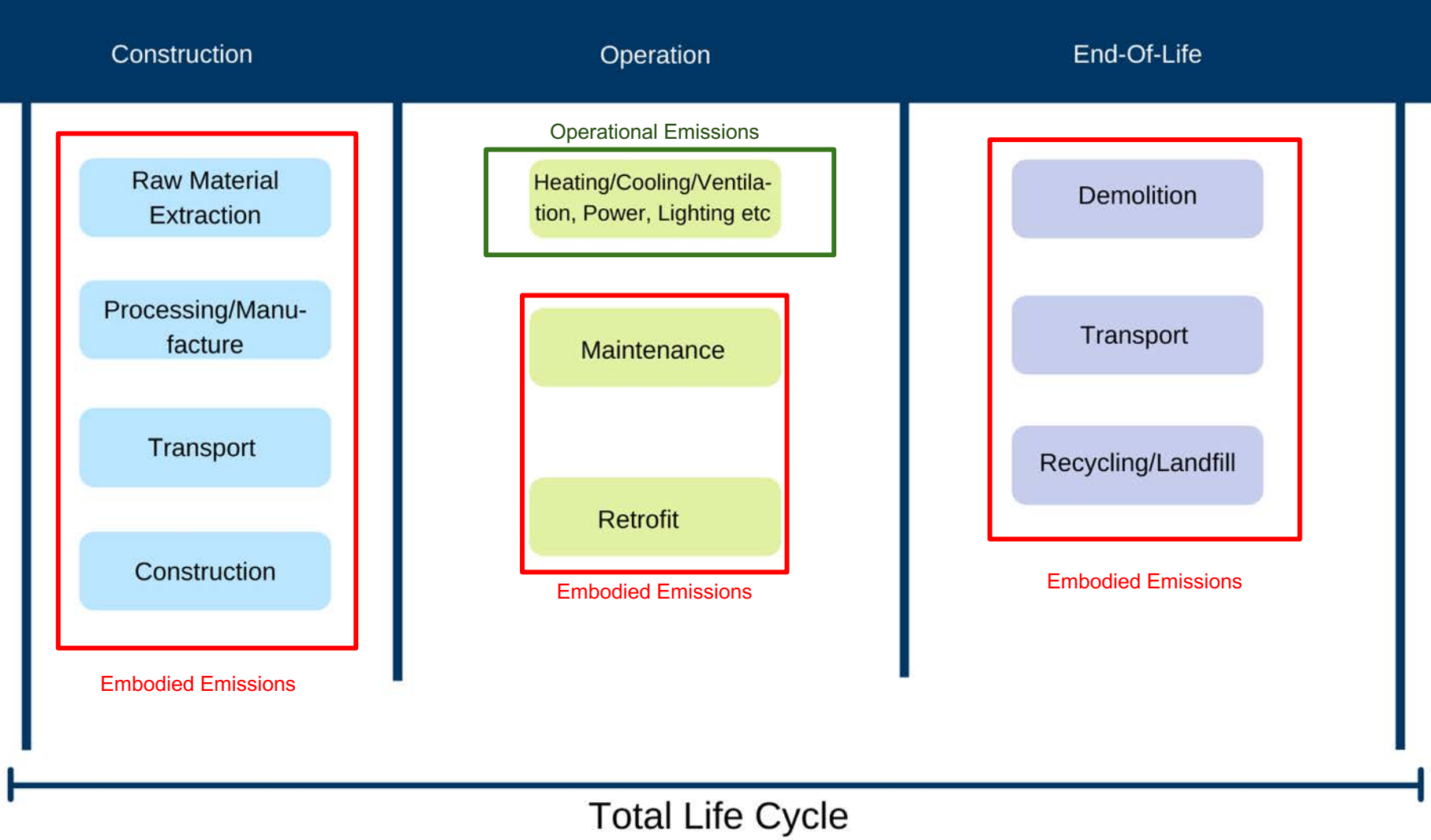
LIFE CYCLE ASSESSMENT

An assessment of the environmental performance of materials, from the raw extraction and manufacturing to the disposal and recycling. It is the ‘cradle-to-grave’ approach of environmental assessment of buildings we must take.


Construction
Operation
End-Of-Life
Raw Material Extraction
Processing/Manu-facture
Transport
Construction
Embodied Emissions
Operational Emissions
Heating/Cooling/Ventila-tion, Power, Lighting etc
Maintenance
Retrofit
Embodied Emissions
Demolition
Transport
Recycling/Landfill
Embodied Emissions
Total Life Cycle

LIFE CYCLE ASSESSMENT

Embodied Carbon

The carbon emitted during extraction, manufacture, transportation and construction of buildings as well as maintenance and end-of-life emissions.

Operational Carbon

The carbon emissions that result from the day-to-day use of a building through energy consumption

REFERENCE STUDY PERIOD

Time periods that are broadly representative of the service life of different buildings types. The fixed RSP for domestic buildings is 60 years, which allows comparison across different LCA studies (Sturgis and Papakosta, 2017).

LIFE CYCLE ASSESSMENT

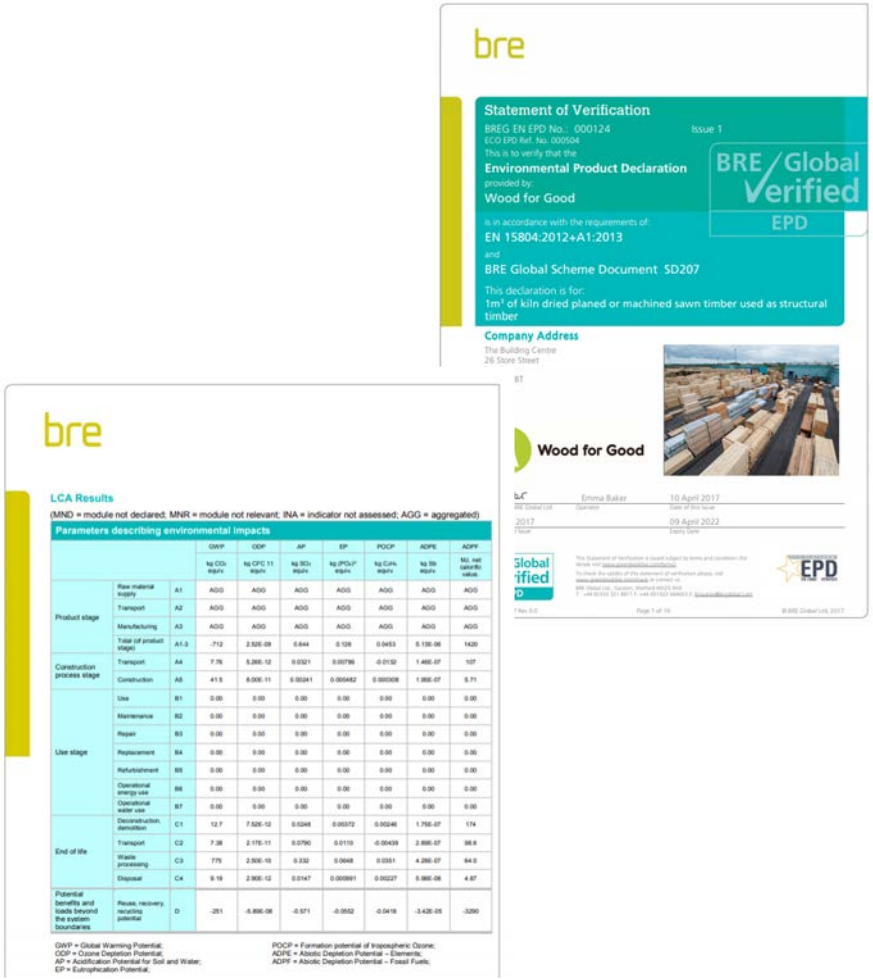
Refurbish

Time Zero with Refurbish cases starts at time of retrofit not at time of initial construction. Only current and future carbon emissions are accounted for, not the carbon which has already been emitted

New Build

Time Zero with New build begins with the demolition of an existing building and includes everything after that.

ENVIRONMENTAL PRODUCT DECLARATIONS



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Statement of Verification

BREG EN EPD No.: 000124 Issue 1

ECO EPD Ref. No. 000504

This is to verify that the

Environmental Product Declaration

provided by:

Wood for Good

BRE Global Verified EPD

is in accordance with the requirements of:

EN 15804:2012+A1:2013

and

BRE Global Scheme Document SD207

This declaration is for:

1m³ of kiln dried planed or machined sawn timber used as structural timber

Company Address

The Building Centre
26 Store Street

Wood for Good

Emma Baker 10 April 2017

2017 09 April 2022

EPD

bre

LCA Results

(MND = module not declared; MNR = module not relevant; INA = indicator not assessed; AGG = aggregated)

Parameters describing environmental impacts

			GWP	ODP	AP	EP	POCP	ADPE	ADPF
			kg CO_2 equiv	kg CFC 11 equiv	kg SO_2 equiv	kg $(PO_4)^{3-}$ equiv	kg C_2H_4 equiv	kg Sb equiv	MJ, net calorific value
Product stage	Raw material supply	A1	AGG	AGG	AGG	AGG	AGG	AGG	AGG
	Transport	A2	AGG	AGG	AGG	AGG	AGG	AGG	AGG
	Manufacturing	A3	AGG	AGG	AGG	AGG	AGG	AGG	AGG
	Total (of product stage)	A1-3	-712	2.52E-09	0.844	0.126	0.0453	5.13E-06	1420
Construction process stage	Transport	A4	7.76	5.26E-12	0.0321	0.00786	-0.0132	1.46E-07	107
	Construction	A5	41.5	8.00E-11	0.00241	0.000482	0.000308	1.85E-07	5.71
Use stage	Use	B1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Maintenance	B2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Repair	B3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Replacement	B4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Refurbishment	B5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Operational energy use	B6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Operational water use	B7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
End of life	Deconstruction, demolition	C1	12.7	7.52E-12	0.0248	0.00372	0.00246	1.75E-07	174
	Transport	C2	7.38	2.17E-11	0.0790	0.0110	-0.00439	2.89E-07	98.6
	Waste processing	C3	775	2.50E-10	0.332	0.0648	0.0351	4.28E-07	64.0
	Disposal	C4	9.19	2.90E-12	0.0147	0.000891	0.00227	5.88E-08	4.87
Potential benefits and loads beyond the system boundaries	Reuse, recovery, recycling potential	D	-251	-5.89E-08	-0.571	-0.0552	-0.0416	-3.42E-05	-3290

GWP = Global Warming Potential;
ODP = Ozone Depletion Potential;
AP = Acidification Potential for Soil and Water;
EP = Eutrophication Potential;
POCP = Formation potential of tropospheric Ozone;
ADPE = Abiotic Depletion Potential – Elements;
ADPF = Abiotic Depletion Potential – Fossil Fuels;

Document which details the LCA of a product based on different parameters:

- Global Warming Potential (GWP)
- Ozone Depletion Potential (ODP)
- Acidification Potential (AP)
- Eutrophication Potential (EP)

Prepared by LCA Consultants or EPD operators such as BRE in accordance with EN 15804:2012+A1:2013 (2014)

ENVIRONMENTAL PRODUCT DECLARATIONS

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- The International EPD System Database
- IGBC EPD Database
- The EPD Registry

A general google search of a product EPD can find ones not registered on these sites

DATABASES

- Inventory of Carbon and Energy (ICE)
- BRE Green Guide
- Wrap Embodied Carbon Database

ICE

- Easily accessible
- Provided environmental impact in CO_2eq
- Many commonly used materials
- Only three LCA modules

European consumption – Includes European production and imports – At world average recycled content

Materials	Embodied Carbon – kgCO2e/kg
Aluminium General, European Mix, Inc Imports	6.67
Aluminium sheet, European Mix, Inc Imports	6.58
Aluminium foil, European Mix, Inc Imports	7.47
Aluminium extr Inc Imports	
Aluminium, cas Imports	

Materials	Embodied Carbon – kgCO2e/kg
Straight-run bitumen	0.191
Polymer modified bitumen (PMB)	0.326
Bitumen emulsion	0.222

CALCULATING EMBODIED EMISSIONS

[Quantity of Material × Emission factor of material × Material Waste Factor] × No. of replacements within RSP = Embodied Emission of Material

Sum of all material embodied emissions = Building Embodied Emissions within RSP

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CALCULATING DEMOLITION EMISSIONS

C&D Recovery Rates × Emissions Intensity of C&D + Landfill Recovery Rates × Emissions Intensity of Landfill

= Demolition Emissions

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CALCULATING OPERATIONAL EMISSIONS

CO_2e emissions intensity of fuel × Quantity of fuel used = Operational Emissions of a particular fuel in one year

Operational emissions of each fuel per year × Reference Study Period = Building operational emission within RSP

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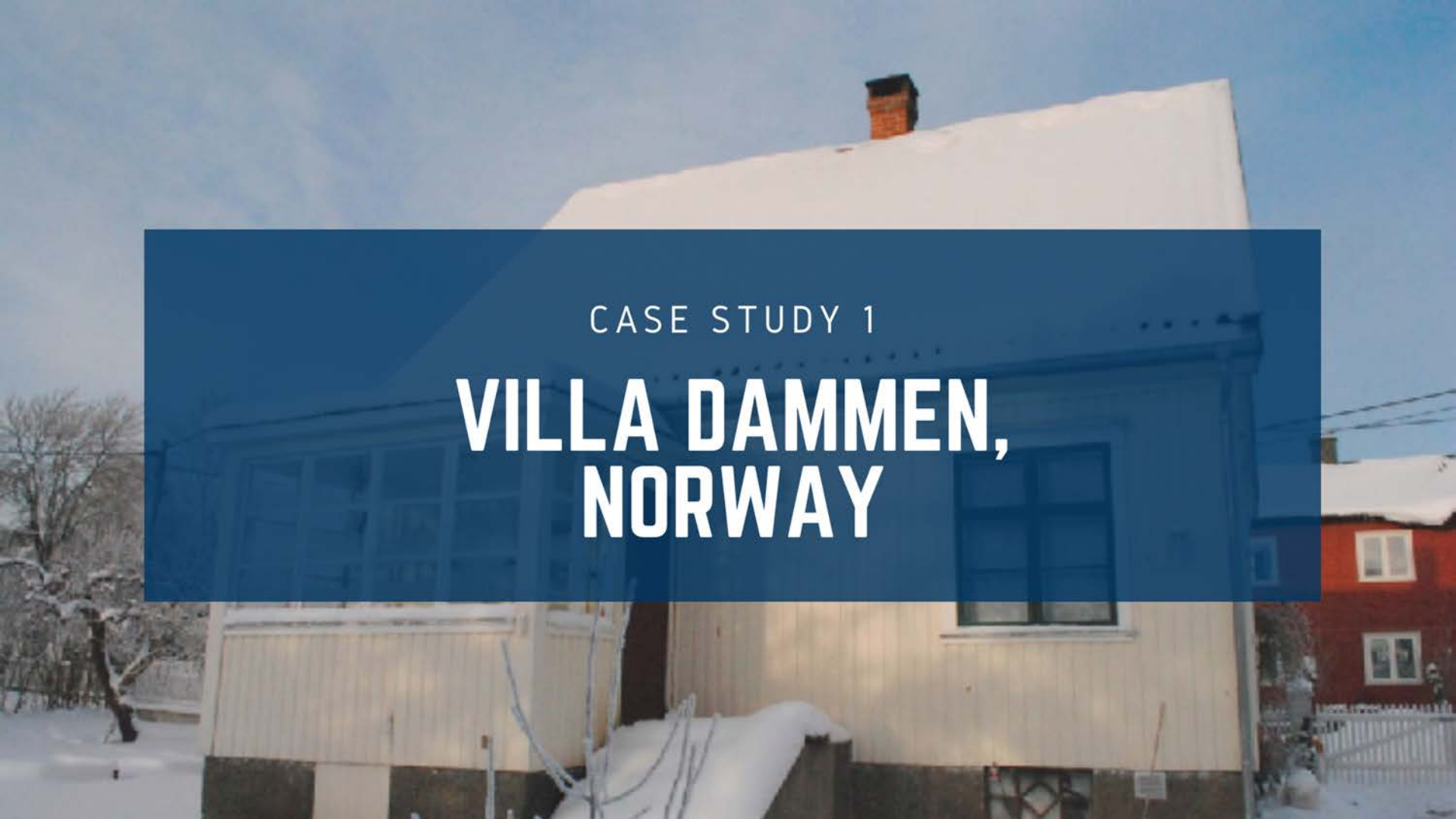


CASE STUDY 1

VILLA DAMMEN, NORWAY

VILLA DAMMEN

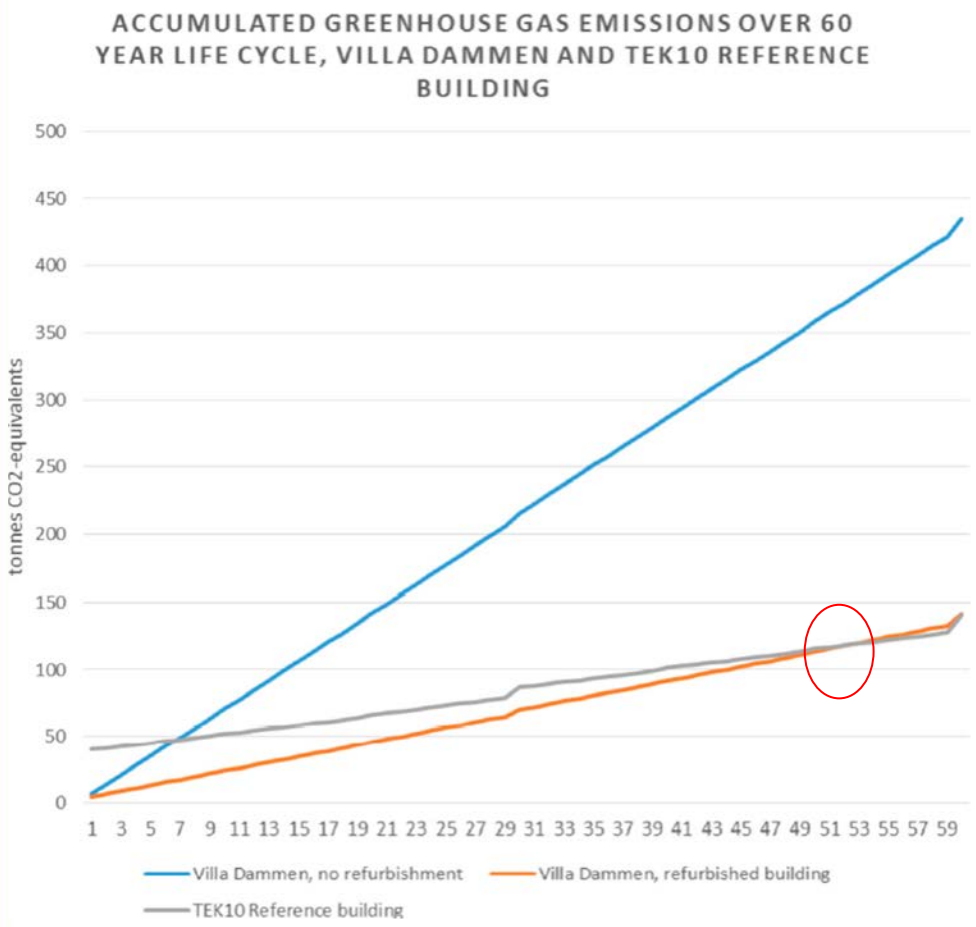
- 1936 timber frame house
- Energy retrofitted in 2014
- Interventions included weatherproofing windows and doors, insulating the pipes and domestic water heater and installation of a wood burning stove.
- The occupants also altered their heating management by using temperature zones during heating season and reducing the set point temperature when the house was unoccupied.

(Berg and Fugleseth, 2018)

LCA RESULTS

1. Base Case
2. Refurbishment
3. Demolition and New build

- Refurbishment saves 295 tonnes CO_2e compared to Base Case
- New build emissions only 8% lower within 60 years compared to Refurbishment
- New Build takes ~ 52 years for the low operational emissions to outweigh the high embodied emissions compared to Refurbishment



CONCLUSIONS

- The type and quantity of materials used in energy efficiency refurbishments and new construction are a deciding factor in the overall environmental impact of projects.
- By sourcing local materials, life cycle emissions can be reduced
- Data on materials used in refurbishment of historic buildings should be strengthened
- City planning authorities should be educated in life cycle approaches
- Occupier behaviour has an important role in energy savings of historic buildings

CASE STUDY 2

USA

LARGE SCALE US STUDY

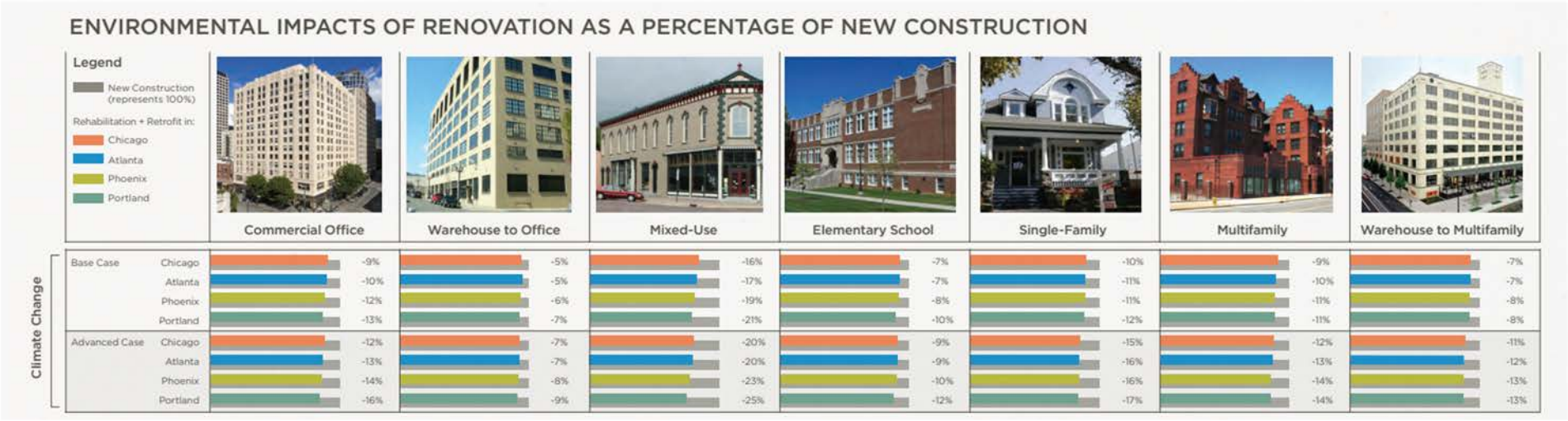
- 6 different typologies across four different climates in US
- Building reuse versus new construction
- Renovated, best renovated, new build, best new build.
- For period of 75 years
- Four indicators: climate change, human health, ecosystem quality and resource depletion

(Frey *et al*., 2011)

LCA RESULTS

Building reuse almost always yields fewer environmental impacts than new construction when comparing buildings of similar size and functionality.

In terms of human health and ecosystem quality, the conversion performs worse than new construction.



CONCLUSIONS

- ‘Reuse matters’
- Improve life cycle inventory data
- A better understanding of material impacts
- Quantity and type of materials used matter
- Balance between carbon and other indicators is required.

CASE STUDY 3

ENGLAND

2 ENGLISH CASE STUDIES

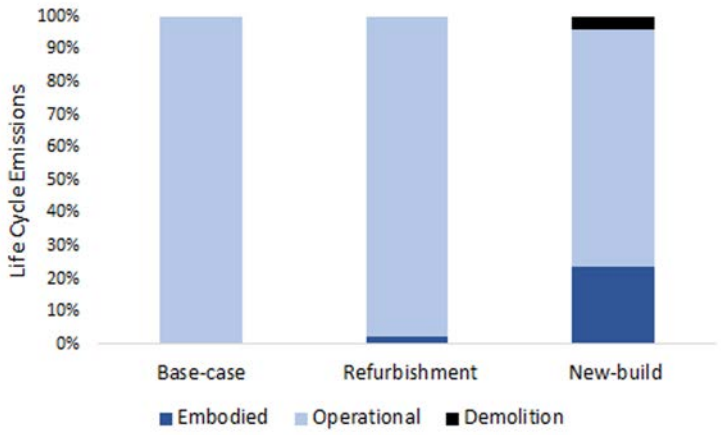
- Case Study 1. Victorian Terrace Refurbishment
- Case Study 2. Chapel Conversion
- Compared to a standard new build meeting 2019 building regulations
- Carbon emissions and costings compared between each case study and the new build

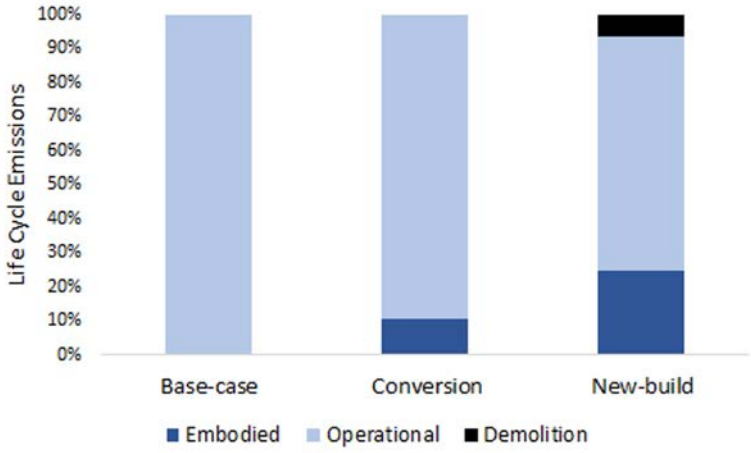
(Duffy, A., Nerguti, A., *et al.*, Forthcoming Report)

LCA RESULTS

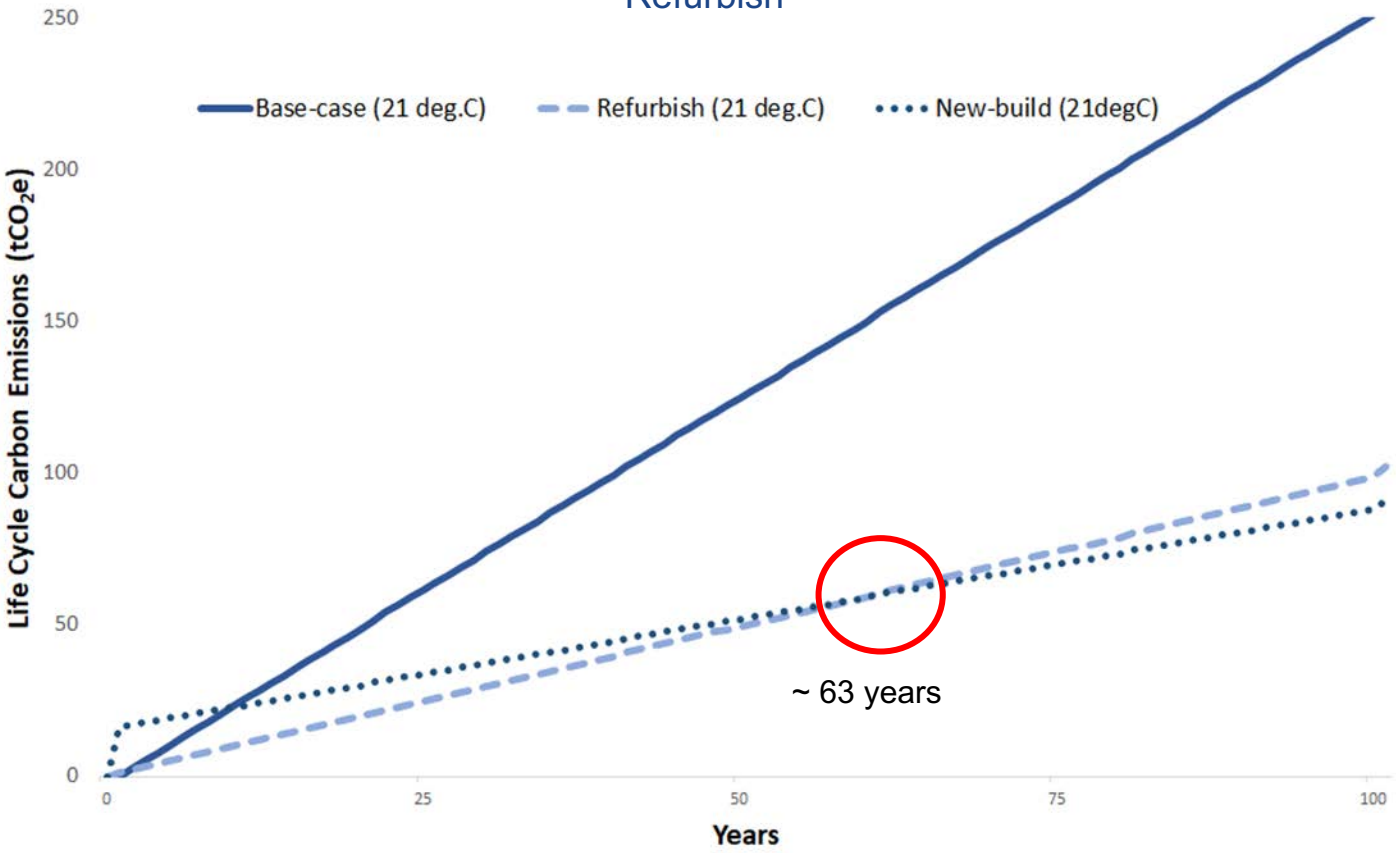
1. Base Case - no refurbishment
2. Refurbishment
3. Demolition and New build

- The Victorian Terrace Refurbishment and the Chapel Conversion together saved 266 tonnes of carbon compared to the Base-case
- The demolition of the Victorian Terrace Refurbishment and the Chapel Conversion account for 4.1% and 6.27% of the respective New-build's total carbon emissions





Refurbish



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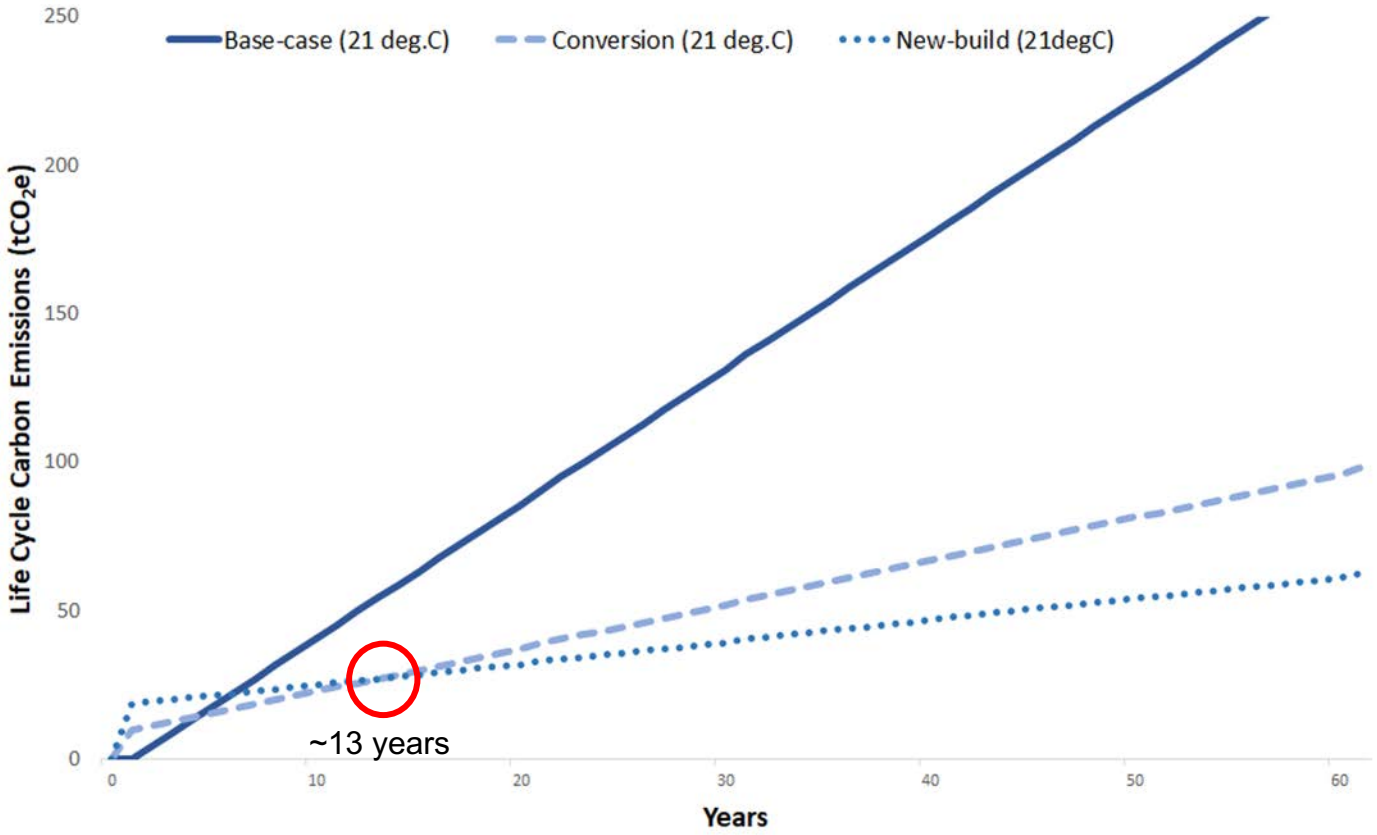
Conversion



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CONCLUSIONS

- Deep energy efficient refurbishment of historic buildings is necessary if they are required to achieve performances similar to new buildings
- The quantity and type of materials matter
- A simple to use LCA tool which is designed for the concept design stage is required
- EPDs should become mandatory for all building materials
- More data on refurbishments should be made available.

THE NEXT STEP

An LCA tool is required

- Easy to use
- Applicable to traditional & historic buildings
- Useful if not essential for concept design stage

Planning process should allow for LCA so that the most sustainable decision is made. For this you need:

- A suitable tool
- Suitable guidelines on sustainable historic refurbishment materials
- All materials used in the building and construction sector in Ireland must have EPDs

Embodied carbon must be included in planning policy as well as operational carbon

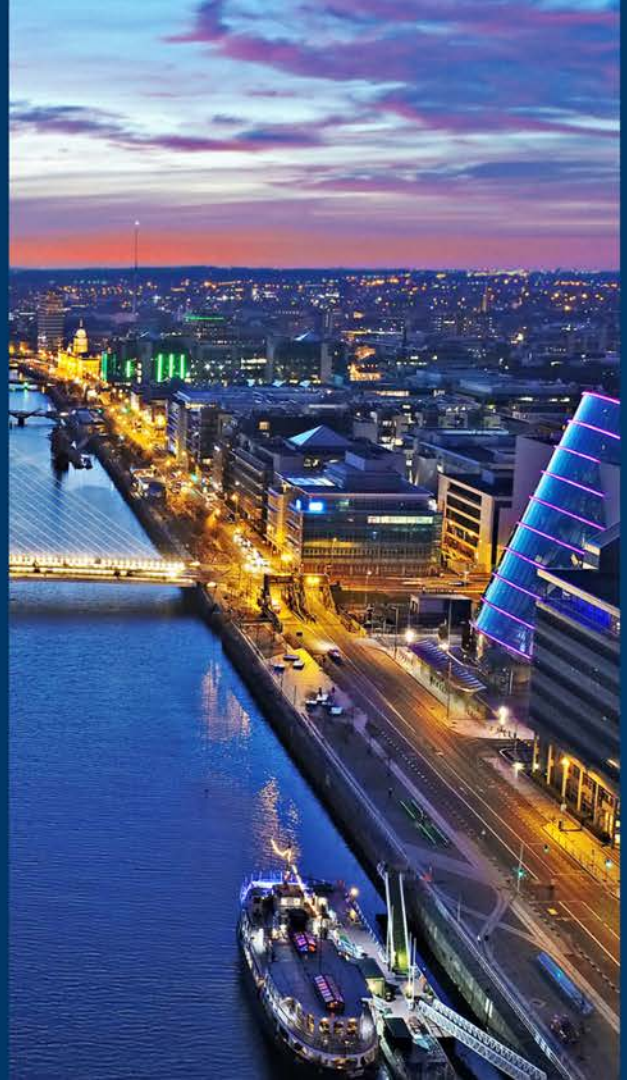
Design for reuse.

Value of waste must be recognised.

Tax incentives must be introduced to encourage material re-use.

City and County Councils could provide the skills to facilitate sustainable decisions.

We need radical policies changes to enforce this



WHAT CAN YOU DO

Be aware of the carbon footprint of materials that you use/specify

If you can’t find EPDs, request them from the companies.

Donate Data

Sell sustainability

THANK YOU FOR YOUR TIME!

QUESTIONS?

REFERENCES

Berg, F. and Fuglseth, M. (2018) 'Life cycle assessment and historic buildings: energy-efficiency refurbishment versus new construction in Norway', Journal of Architectural Conservation, 24(2), pp. 152-167.

Duffy, A., Nerguti, A., Engel Purcell, C. and Cox, P. (Forthcoming Report) 'Understanding Carbon in the Historic Environment', Historic England Research Report Series, pp. 78.

Frey, P., Dunn, L., Cochran, R., Spataro, K., McLennan, J. F., DiNola, R., Tallering, N., McDaniel, E., Haas, D. and Heider, B. (2011) The Greenest Building: Quantifying the Environmental Value of Building Reuse, Washington, D.C.: Preservation Green Lab

IGBC EPD Database: https://www.igbc.ie/epd-search/

Sturgis, S. and Papakosta, A. (2017) Whole Life Carbon for the Built Environment. London: Royal Institute of Chartered Surveyors (RICS). Available at: https://www.rics.org/uk/upholding-professional-standards/sectorstandards/building-surveying/whole-life-carbon-assessment-for-the-built-environment/.

The International EPD System Database: https://www.environdec.com/EPD-Search/

The EPD Registry**:** https://www.theepdregistry.com/

Bringing Carbon Upfront, WorldGBC

Interesting Article:

The Case for… Never Demolishing another Building, The Guardian, 2020