

A nighttime photograph of a stone bridge with multiple arches spanning a river. The bridge is illuminated by streetlights, and the lights create starburst effects in the water. In the background, a large, ornate church with a dome and two towers is visible, also illuminated. The sky is a deep purple and blue, and the water reflects the lights and the buildings.

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**Framework for the automation
of Embodied Carbon calculations
for Interior Architecture**
by Léa Laurent

Research goal

FF+E: Furniture, Fixtures + Equipment

What is the impact of interior equipment on the carbon footprint of a building ?

Construction stage vs life expectancy (60 years)

How can architects calculate it ?

Revit workflow: using Environmental Product Declarations (EPDs) data to assess the carbon footprint value for FF+E.



Agenda

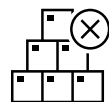


Embodied Carbon



Proposed new workflow: Revit and EPDs

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Testing the workflow with an exemplar project



Results & Interpretations



Conclusions

Embodied Carbon

The Carbon Dioxide (CO₂) and greenhouse gas emissions generated by the manufacture and use of a building.

- Impact of one molecule of carbon dioxide (CO₂) over a certain timeframe (100 years).
- Measured in kilogram of carbon dioxide equivalent per kilogram (kgCO₂e)

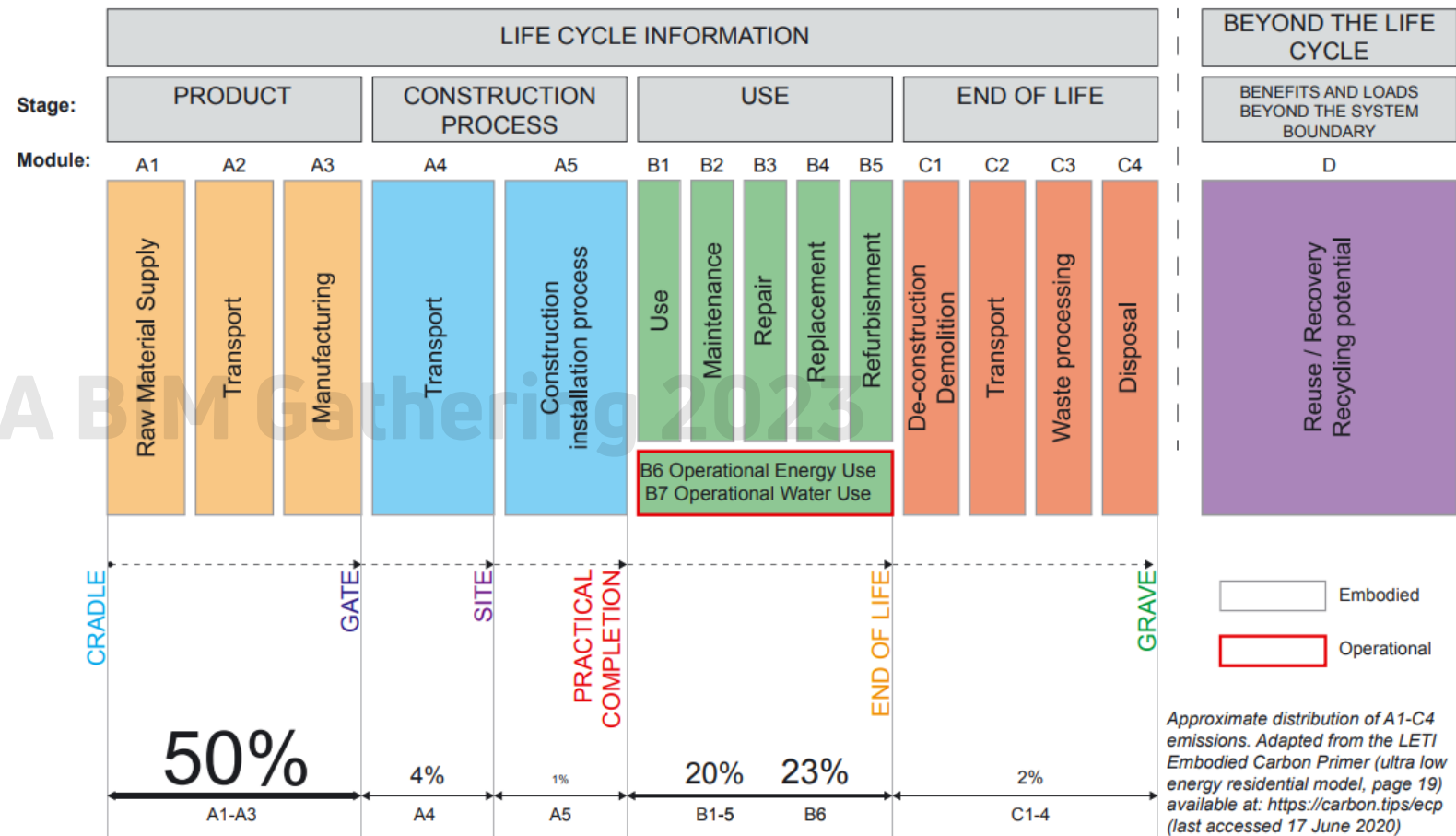


Illustration of BS EN15978 life cycle stages

Life Cycle Assessments (LCAs)

- Typical life expectancy: 60 years
- LCA tools: FF+E usually not included

Interior design

- Interiors can be refurbished every 2 to 15 years on average (restaurants very often, healthcare more sparse)
- Carbon footprint at construction completion will be higher than FF+E but what about over its lifespan ?

Project materials scope

Building parameters

- Foundations and substructure
- Ground Slab
- Structure
- Enclosure
- Finishes
- Services
- Default values

Building type, size and number of floors

Irish reference building 2021

Building type

Industrial production buildings

Total gross floor area (GFA) 8271 m²

Number of above ground floors 2

Calculation period 60 years

+ More options

Scenarios

Baseline scenario

Not applied

Comparison scenario

Not applied

Building dimensions



Height	7.2	m
Width	100.0	m
Depth	45.5	m
Internal floor height	3.3	m
Maximum column spacing distance	30.0	m
Load bearing internal walls	0.0	%
Number of staircases	1	
Total number of floors	2	
Shape Efficiency Factor	1.1	
Gross internal floor area (GIFA)	8067.3	m ²

+ More parameters

Building structures

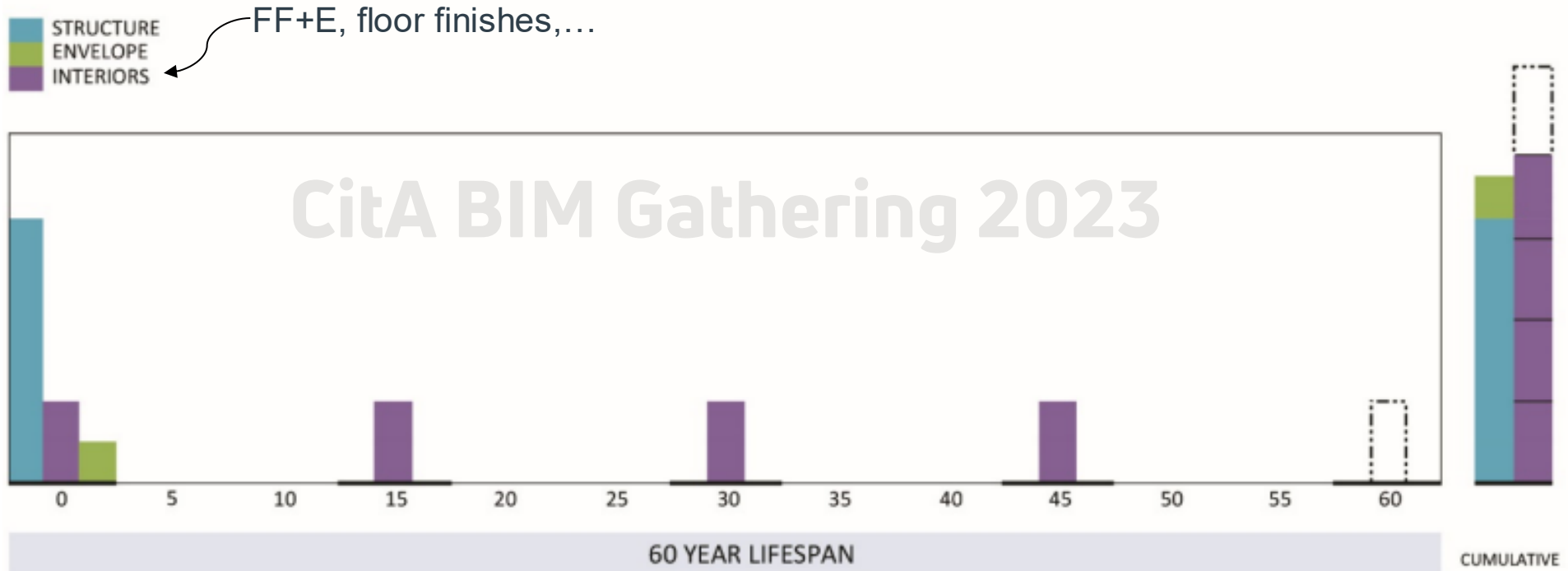
Edit areas if necessary.

Structure	
Floor slabs	4136.0 m ²
Columns	86.0 m
Beams	364.0 m
Load bearing internal walls	0.0 m ²
Balconies	0.0 m ²
Staircases	7.2 m
Enclosure	
Underground walls	0.0 m ²
External walls	965.0 m ²
Cladding	965.0 m ²
Windows	1048.0 m ²
External doors	83.0 m ²
Roof slab	4136.0 m ²
Roofs	4136.0 m ²
Finishes	
Internal walls	1257.0 m ²
Floor finishes	8067.0 m ²
Ceiling finishes	8067.0 m ²

Carbon footprint & FF+E

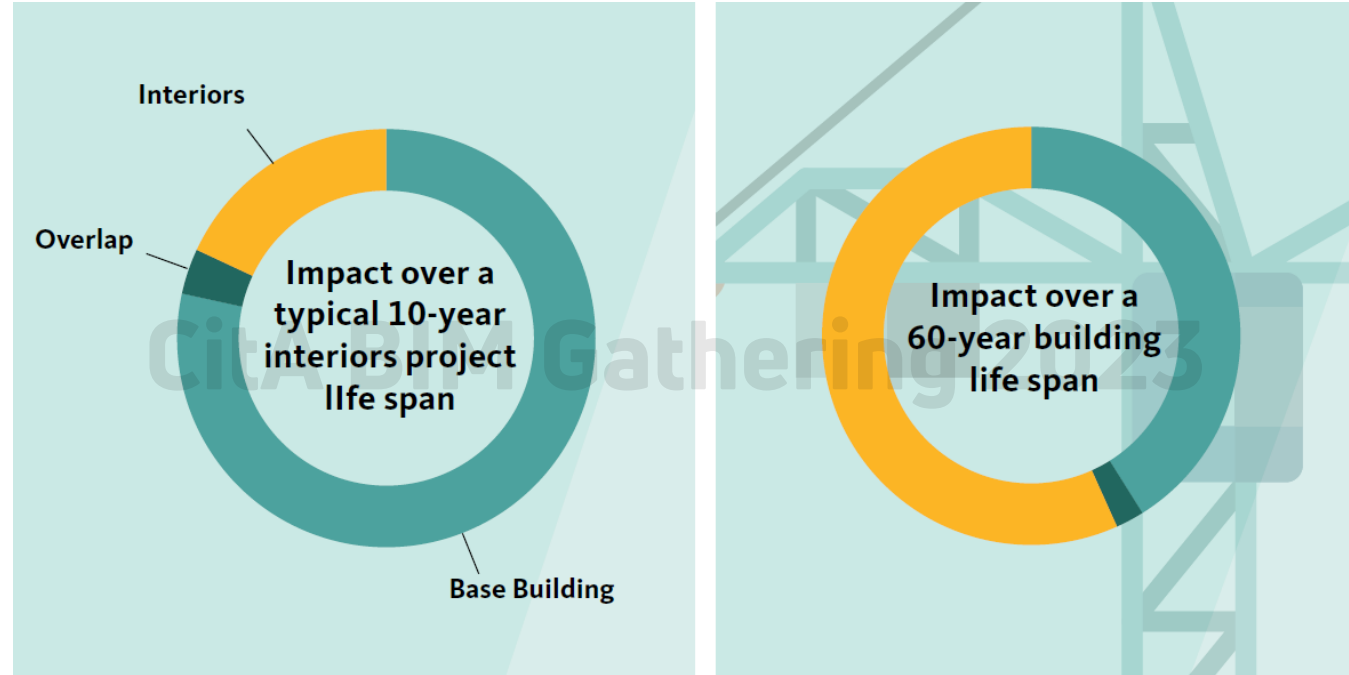
CONCEPTUAL CARBON TIMELINE

Office building with an estimated 60 year life span and regular 15 year tenant improvement upgrades



Glaser K. et al. (2020), *Designing For the future, Interior Life Cycle Analysis*, published by One Workplace, written by Hawley Peterson Snyder)

Carbon footprint & FF+E



Briefel D. et al (2021), *Quantifying embodied carbon*, published by Gensler Research Institute

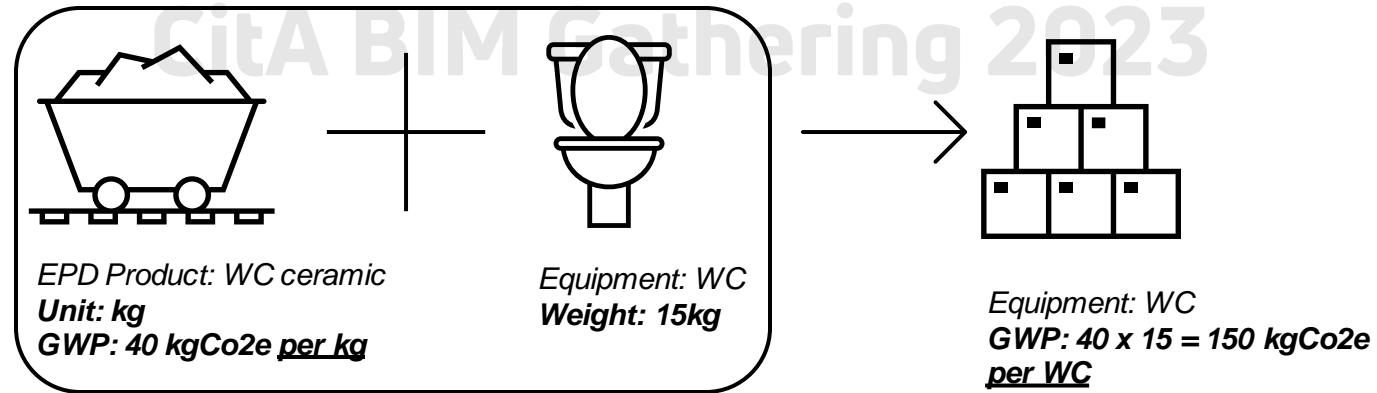
Environmental Product Declarations (EPDs)

- Document created by a supplier or manufacturer assessing a product's carbon footprint.
- For one unit of the product.
- It is verified by a third party.
- An EPD can be created for any type of product or system.
- This project focuses only the **Global Warming Potential**.

Impact Category	Units	Total	Material Acquisition & Pre-Processing	Construction	Installation	Use	End-of-life
Global Warming Potential	kg CO2 eq	44.9	18.1	4.09	6.65	0.994	15.1
Biogenic carbon	kg CO2 eq	-16.2	-27.0	0.0316	0.0186	0.178	10.6
Acidification potential	kg SO2 eq	0.151	0.0913	0.0174	0.0216	3.51x10 ⁻³	0.0175
Photochemical ozone creation potential	kg O3 eq	1.46	0.601	0.250	0.388	0.0415	0.182
Eutrophication potential	kg N eq	1.42	1.24	0.0166	0.0247	0.0309	0.103
Ozone depletion potential	kg CFC-11 eq	3.58 x10⁻⁶	1.29 x10 ⁻⁶	5.52 x10 ⁻⁷	1.01 x10 ⁻⁶	8.81 x10 ⁻⁸	6.37 x10 ⁻⁷

Calculation

Impact Category	Units	Total	Material Acquisition & Pre-Processing	Construction	Installation	Use	End-of-life
Global Warming Potential	kg CO2 eq	44.9	18.1	4.09	6.65	0.994	15.1



Proposed Revit workflow

Product's actual weight or length ←

→ *GWP per 1 unit of product*

ADBCode	ADBDescription	Count	DAT1 EPD available	DAT2 EPD number	DAT0 Average Unit (per EPD unit)	DAT0 EPD Unit	DAT3 Global Warming Potential (kg CO2 eq)	Total Per Unit	DAT9 Comments
WCH001	WC/toilet pan with seat, 520-550 projection, hospital pattern, rimless pan, vitreous china.	2	Yes	S-P-04163	31.71	kg	2.57	162.9894	Generic EPD for 1kg of average ceramic bathroom product
WCH005	WC/toilet pan with seat, 750 mm projection, hospital pattern rimless pan, vitreous china, HTM64WCHD	27	Yes	S-P-04163	31.71	kg	2.57	2200.3569	Generic EPD for 1kg of average ceramic bathroom product
WCH901	WC, flush plate, stainless steel, dual, pneumatic	29	No		0.7	kg		0	
WKT902	WORKTOP, non-clinical 600D, worktop length to suit drawing as illustrated	1	No					0	

61212.11208

→ *Calculated parameter in Revit Schedule*

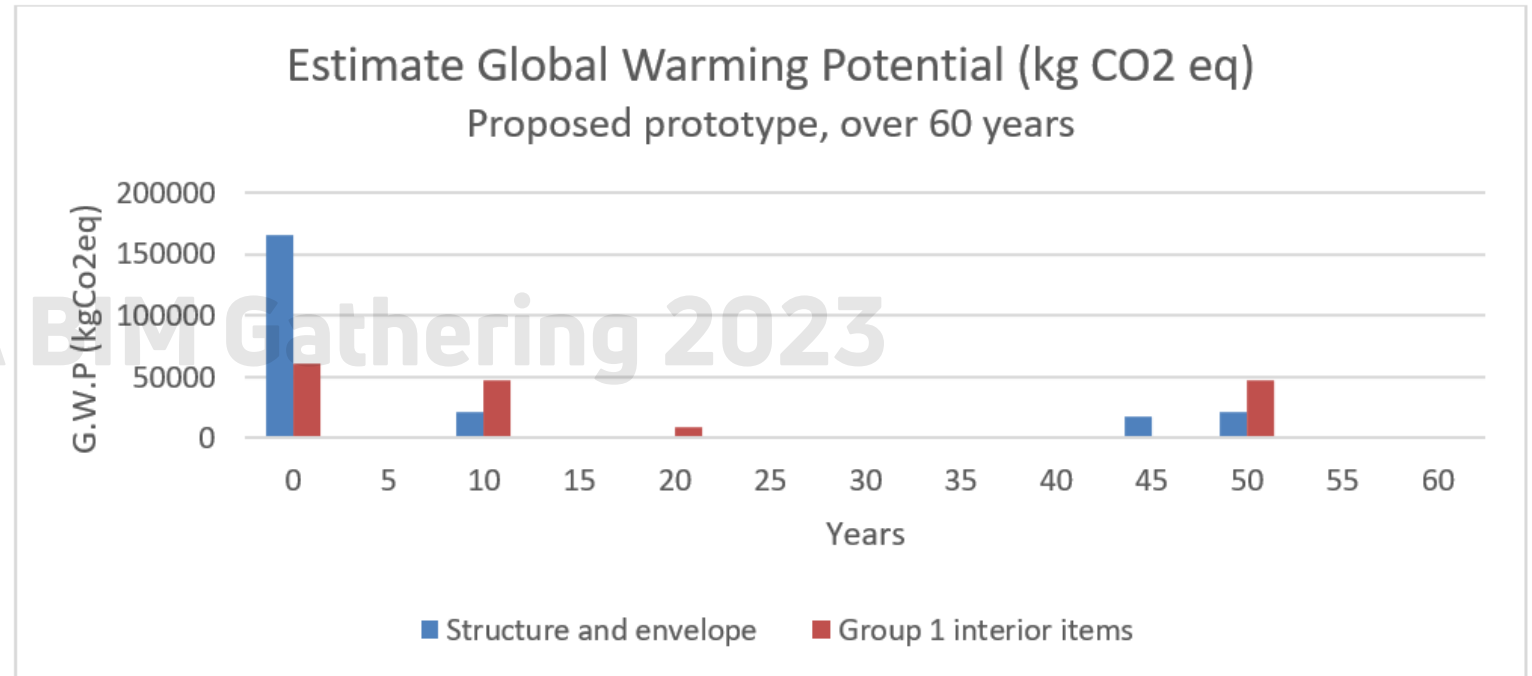
- FF+E (furniture and fitments)
- Group 1 items (specified by the architect and installed by the contractor)
- Typical building lifespan of 60 years

Exemplar project

Exemplar project:
Typical hospital ward

- 2025 m²
- 82 rooms (26 bedrooms)
- Total FF+E : 1325 items (less than there would be in reality)
- One Click LCA to calculate conceptual LCA of structure

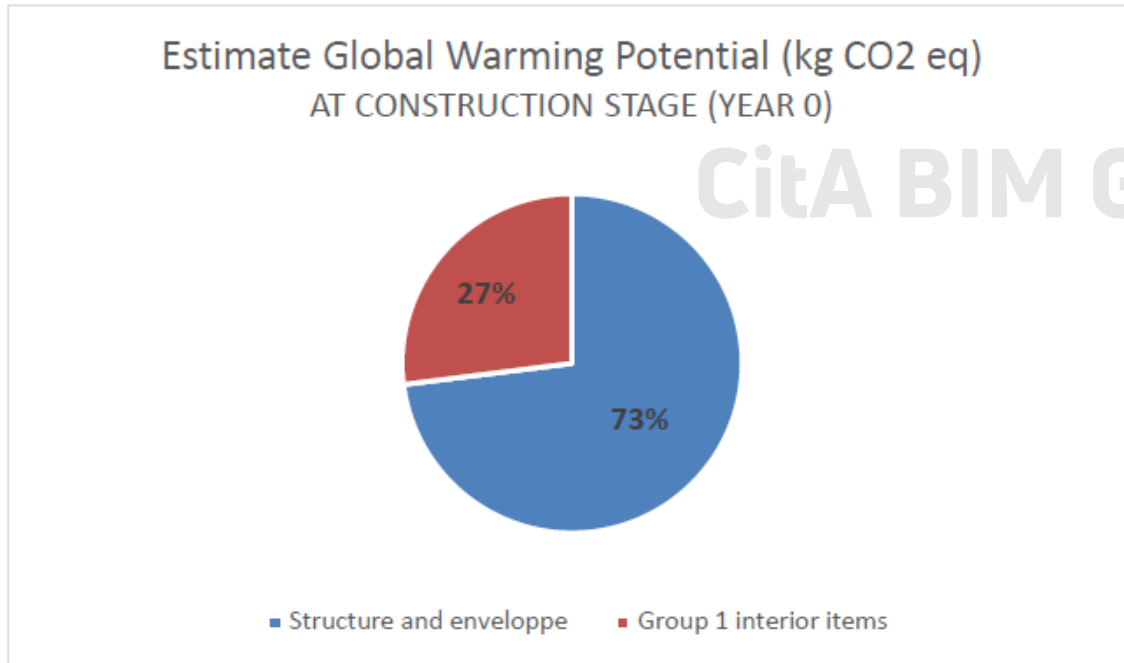
Results



Results

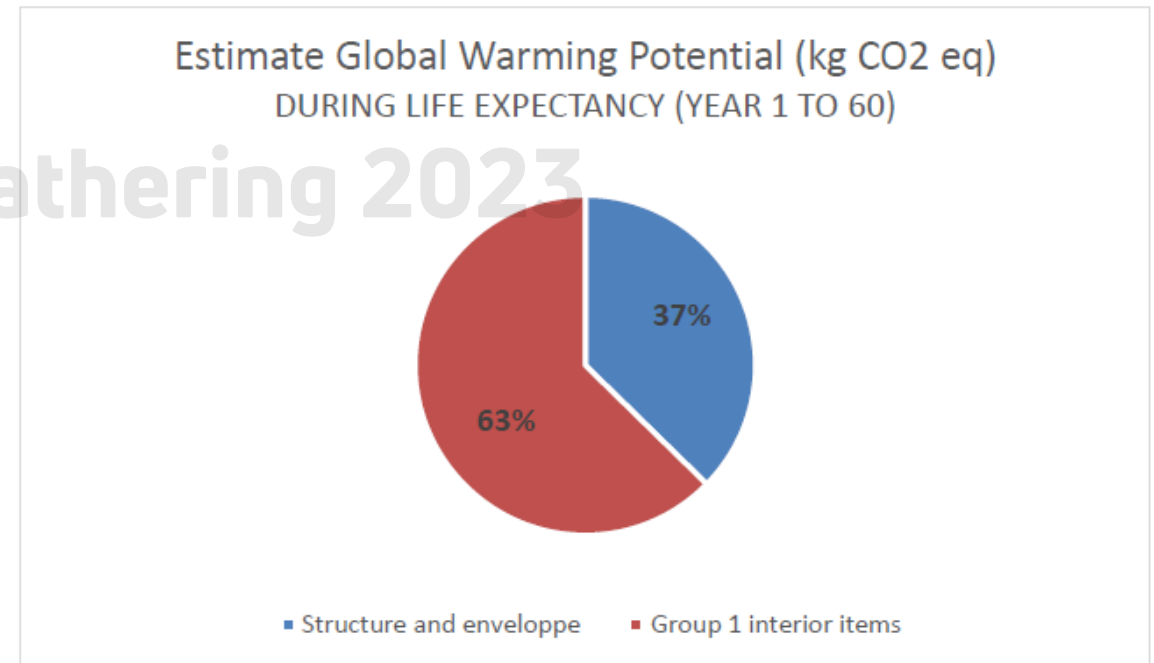
CONSTRUCTION STAGE

GWP calculated for structure & envelope and Group 1 items in example project



OPERATION AND MAINTENANCE PHASE

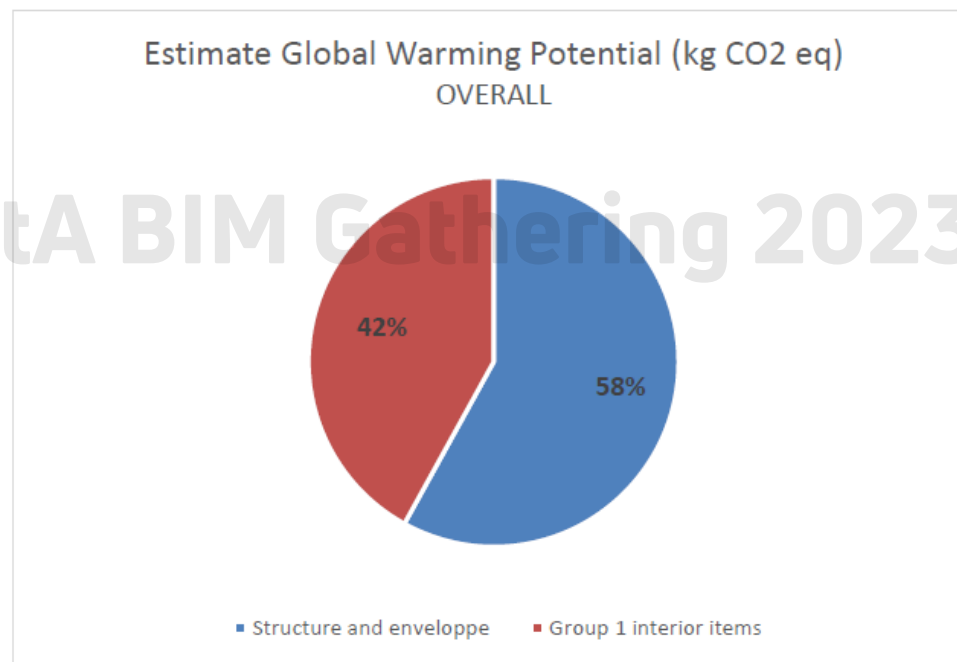
GWP calculated for structure & envelope and Group 1 items in example project



Results

PROPOSED LIFE EXPECTANCY (60 YEARS)

GWP calculated for structure & envelope and Group 1 items in example project)

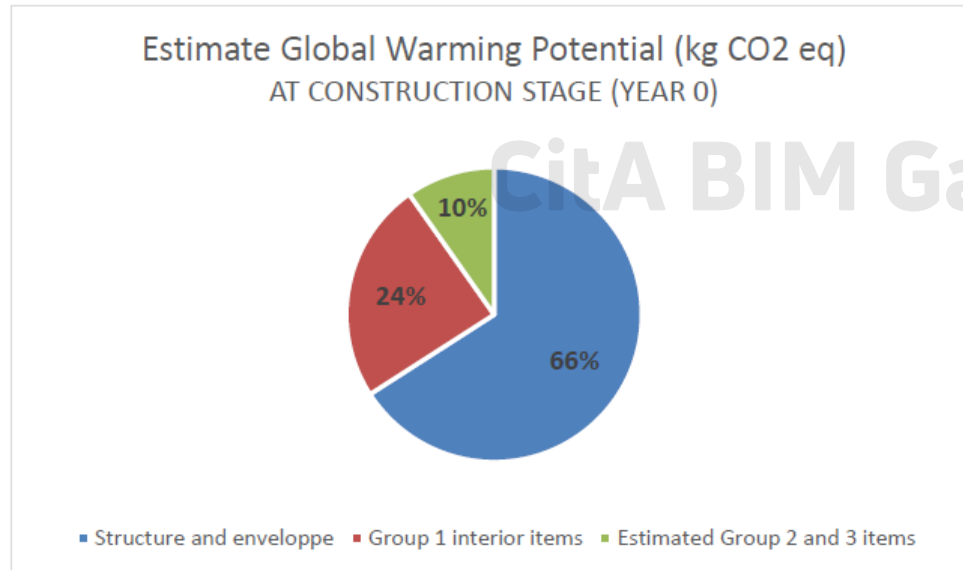


Pie chart, proposed prototype estimated GWP over 60 years (Excel), total

Results

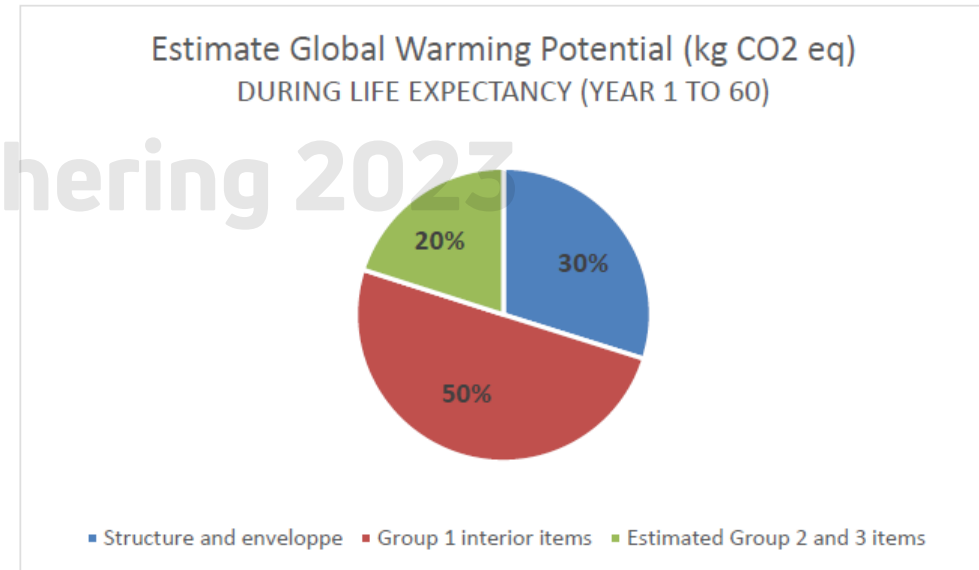
CONSTRUCTION STAGE

GWP calculated for structure & envelope and Group 1 items in example project



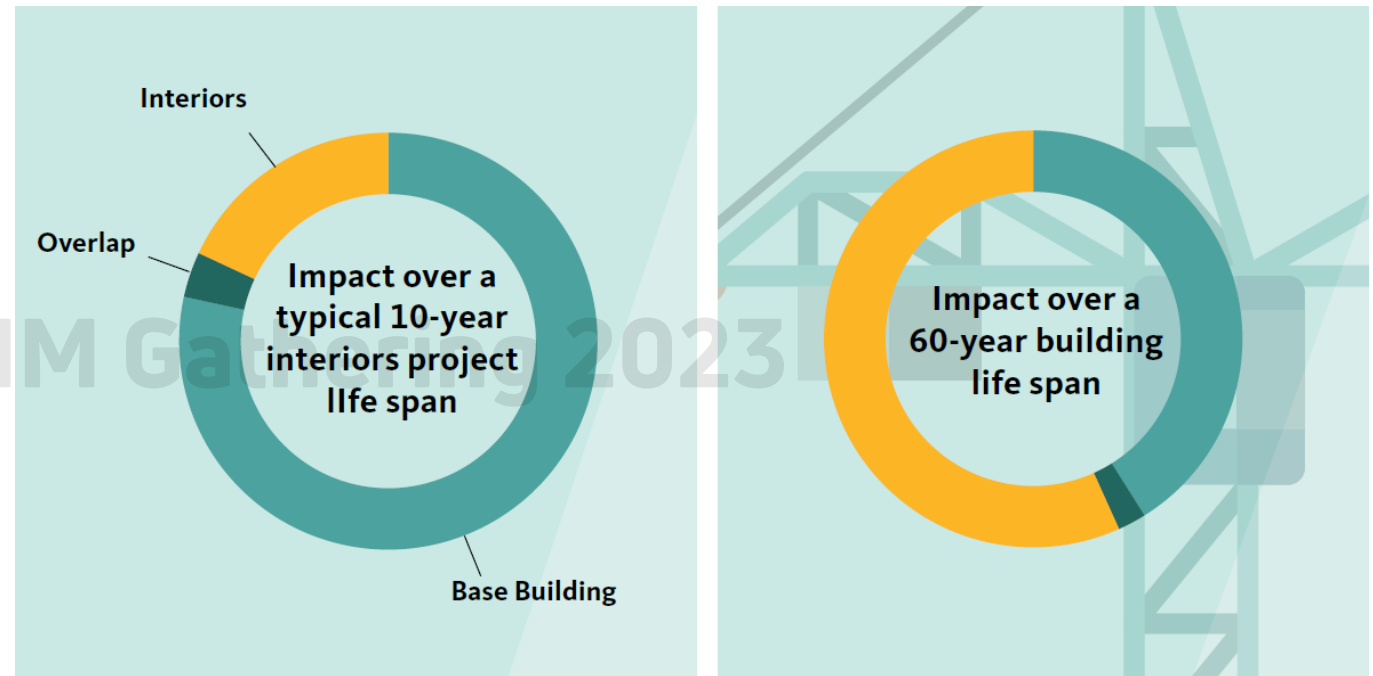
OPERATION AND MAINTENANCE PHASE

GWP calculated for structure & envelope and Group 1 items in example project



Conclusions

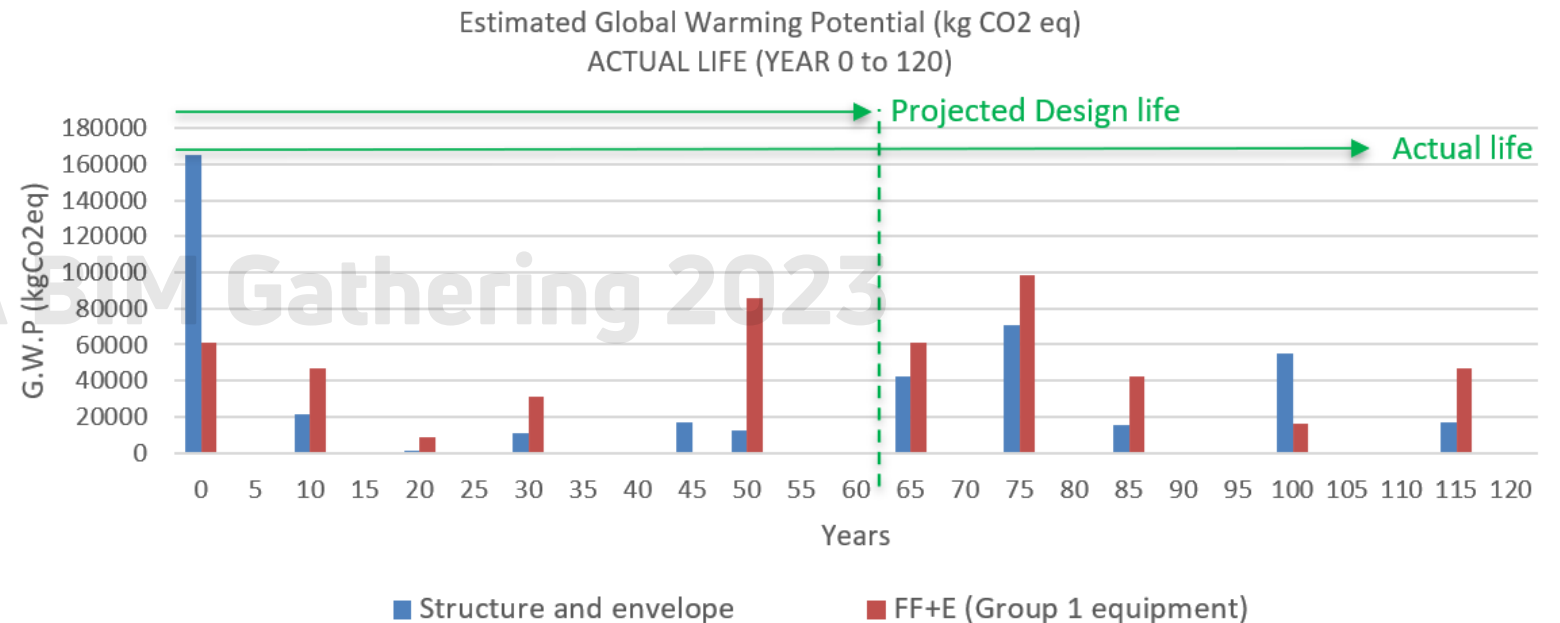
- FF+E has a significant impact on a building's carbon footprint over its lifetime.
- Indicative values from early design stages.
- Used in combination with a LCA tool for the structure & envelope, the information collected will be very valuable.



Briefel D. et al (2021), *Quantifying embodied carbon*, published by Gensler Research Institute

Limitations

- EPDs are tedious to read & still in infancy (not available for everything)
- Values need to be compared to other EPDs. There is no way of knowing if a product is “good” or “bad” just from its EPD.
- 60 years life expectancy: buildings are usually kept in use for much longer!



What next ?

- Test on a real / live project
- Train other users
- Healthcare is particularly suitable : repetition of rooms and equipment



Family Reviser
by DiRoots



BiM TOOLS
by Sofistik



Color Splasher
by BIM One



ParaManager
by DiRoots



PyRevit
by Eshan
Iran-Nejad



Model Checker
by Autodesk

**User friendly
Revit plugin
?**

Guardian
by Iconic BIM



Isolate Warnings
by Archisoft



Ideate Explorer
by Ideate



Dynamo
by Autodesk



ProSheets
by DiRoots



RTV Exporter Pro
by RTV Tools

Framework for the automation of Embodied Carbon calculations for Interior Architecture

Thank you !

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