



Gathering23

Accelerating BIM adoption

CITA

Research Question

Can BIM technologies calculate and visualise the global warming potential of building materials?

Research Purpose

CitA BIM Gathering 2023

-To investigate if the application of BIM tools can be leveraged to automate Global Warming Potential (GWP) to support decision-making in meeting the RIAI 2030 Climate Challenge and contribute to the decarbonisation of the built environment

Research Objectives

Objective 1: To critically review the synergy of BIM and Life Cycle Analysis (LCA) in the construction sector

Objective 2: To hypothesise a solution with the capacity to incentivise stakeholders to decarbonise the built environment

Objective 3: To progress the hypothesis from theory to application using rigorous testing

Objective 4: -To analyse and present findings of the application for the potential implementation in the built environment

BIM & LCA Literature Review Findings:

- **Support decision-making** in the early stages of design
- **Reduction of errors and inconsistencies** in LCA results
- **Improvement of GWP values** by combining LCA databases with the level of information need
- **Material libraries** for **quickly reviewing** and **visualising GWP impacts**
- **May facilitate environmentally friendly decisions to occur.** However, due to the task of **manually inputting LCA data** into BIM objects, real-time footprint analysis is not achievable without **an additional tool**
- **Reduction of effort** through **Revit and Dynamo to access GWP totals** and connect material databases
- **Reduction of human error** through automated **material mapping** for LCA using BIM software
- Introduction of ISO 22057 to standardise the **digitisation of EPDs providing data templates** for the use of Environmental Product Declarations (EPDs) for construction products in BIM

Research Methodology – Hypothesis

-For this study, Design Science Research (DSR) was adopted as this is a problem-solving paradigm that seeks to enhance human knowledge via innovative solutions to real-world problems.

-Approaching this research to join existing processes (**BIM with building material databases**) to automate GWP values (**innovative solution**) to tackle the decarbonisation of the built environment (**real-world problem**) is the reason for choosing this methodology.

H1 - The proposed tool/workflow will have the potential to deliver real-time lifecycle GWP calculation that will incentivise better decision-making in decarbonising the construction sector.

H2 – The model will be used as a verification tool to record and monitor the GWP totals of a building.

Research Testing

To investigate the proposed theories, the path for experimental research was organised into key stages:

- Preparation of **data sources** to be used in the study
- Creation of a **material library** and **shared parameters** based on GWP data
- Designing** and **modelling** an example to be utilised for research testing and experimentation for this study
- Creation of a **visual programming script** to **map EPD data** to building materials inside the model
- Creation of additional **visual programming scripts** used to **visualise the GWP data** of the model and **compare thresholds**

Stage 1 - Preparation

Before the research testing could commence, the following data sources were collated:

-Benchmark: The targets set out in the **RIAI 2030 Climate Challenge**

-Standards: Parameters based on **EN 15804** and **EN 15978**

- Material Database: **IGBC National Inventory of Generic Construction Materials Data / The Inventory of Carbon and Energy (ICE)**

-BIM Tools: **Revit, Dynamo**

RIAI-Embodied Carbon Threshold	Dwellings	Offices	Schools
2025 Target	800 kgCO ₂ e/m ²	970 kgCO ₂ e/m ²	675 kgCO ₂ e/m ²
2030 Target	625 kgCO ₂ e/m ²	750 kgCO ₂ e/m ²	540 kgCO ₂ e/m ²

IGBC National Inventory of Generic Construction Materials Data (NICCMD)		Date: 23-03-2022 Revision: 1 Author: Cambridge Architectural Research (CAR)/IGBC		
Product	GWP			
	number (n)	unit	kgCO ₂ e (A1 - A3)	
1	Average Cement for Ireland	1	tonne	725
2	CEM I produced in Ireland	1	tonne	763
3	CEM II/A-V (<20% PFA)	1	tonne	728
	CEM II/A-L (<20% Limestone)	1	tonne	698
	CEM II/A-S (<20% GGBS)	1	tonne	724
	CEM II A-D (<10% silica fume)	1	tonne	896
	CEM II/B-S (<35% GGBS)	1	tonne	617
4	Average CEM II	1	tonne	674
	CEM III/A (35-60% GGBS)	1	tonne	512
	CEM III/B (66-80% GGBS)	1	tonne	371
5	Average Aggregate for Ireland	1	tonne	5
6	Average hot rolled steel coil used in Ireland	1	tonne	2140
	Average cold rolled coil used in Ireland	1	tonne	2630
	Average galvanised steel value used in Ireland	1	tonne	2800
	Average organic coated steel used in Ireland	1	tonne	2830
	Average steel section and steel rail value for Ireland	1	tonne	1490
	Average reinforcing steel used in Ireland	1	tonne	737
7	Average aluminium sheet used in Ireland	1	tonne	2751
	average aluminium foil used in Ireland	1	tonne	6780
	Average aluminium extrusion used in Ireland	1	tonne	4855
8	Average float or coated glass used in Ireland	1	tonne	1323
9	Average facing brick imported from the UK (exc'l transport)	1	tonne	213
10	Average Irish C16 timber			
	o Sequestration	1	m3	-736
	o Fossil fuel emissions (A1-A3)	1	m3	104
	o GWP A1-A3 incl sequestration	1	m3	-632
11	Irish produced OSB	See Smartply EPD in EPD Ireland		

Stage 2 – Material Library and Shared Parameter Creation



Search

Project Materials: All ▾

- IGBC_Average float or coated glass used in Ireland
- IGBC_Average galvanised steel value used in Ireland
- IGBC_Average hot rolled steel coil used in Ireland
- IGBC_Average imported Chipboard Particleboard (640 kg/m3)
- IGBC_Average imported plywood
- IGBC_Average Irish C16 timber
- IGBC_Average organic coated steel used in Ireland
- IGBC_Average reinforcing steel used in Ireland
- IGBC_Average steel section and steel rail value for Ireland
- IGBC_Brick_Generic
- IGBC_CEM I produced in Ireland
- IGBC_CEM II A-D
- IGBC_CEM II/A-L
- IGBC_CEM II/A-S
- IGBC_CEM II/A-V
- IGBC_CEM II/B-S
- IGBC_CEM III/A (35-60% GGBS)
- IGBC_CEM III/B (66-80% GGBS)
- IGBC_Imported MDF (737 kg/m3)

Edit Shared Parameters

Shared parameter file: C:\Users\ryan\OneDrive\Desktop\GWP.txt

Parameter group: GWP

Parameters:

- Density (kg/m3)
- Density (ton/m3)
- GWP Construction Stage (A4-A5)
- GWP Declared On
- GWP End of Life Stage (C1-C4)
- GWP Product Stage (A1-A3)
- GWP Use Stage (B1-B7)
- Include in GWP Schedule
- Total GWP Building (kgCO2e/m2)
- UUID

Energy Analysis	
Density (ton/m3)	1.920000
GWP Product Stage (A1-A3)	0.213000
GWP Construction Stage (A4-A5)	0.000000
GWP Use Stage (B1-B7)	0.000000
GWP End of Life Stage (C1-C4)	0.000000
Include in GWP Schedule	<input checked="" type="checkbox"/>
UUID	N/A
IFC Parameters	

Stage 3 – Schedule Design & Modelling

- Material: Name
- Material: UUID
- Material: Volume
- Material: Density (ton/m3)
- Weight of Material (ton)***
- Material: GWP Product Stage (A1-A3)
- Material: GWP Construction Stage (A4-A5)
- Material: GWP Use Stage (B1-B7)
- Material: GWP End of Life Stage (C1-C4)
- GWP All Stages (A1-C4)***
- Total Material GWP (tonCO2e)***
- Total Material GWP (kgCO2e)***
- Building Gross Area (m2)
- GWP Footprint (kgCO2e/m2)***

*Denotes where formulae were used

<Global Warming Potential Schedule>						
A	B	C	D	E	F	G
Material: Name	Material: UUID	Material: Volume	Material: Density (ton/m3)	Weight of Material (ton)	Material: GWP Product Stage (A1-A3)	Material: GWP Construction Stage (A4-A5)
ICE_Concrete - Cast In Situ 25/30	N/A	9.76 m³	2.2	21.464685	0.119	0
ICE_Concrete_Block_215mm	N/A	23.65 m³	2.3	54.39362	0.093	0
ICE_Insulation - Mineral Wool	N/A	23.65 m³	0.025	0.591235	1.28	0
ICE_Plaster (Gypsum)	N/A	1.48 m³	1.12	1.655458	0.13	0
IGBC_Brick_Generic	N/A	12.12 m³	1.92	23.27101	0.213	0
Grand total: 17		70.65 m³		101.376008		

>Global Warming Potential Schedule<

	H	I	J	K	L	M	N
Material: GWP Construction Stage (A4-A5)	Material: GWP Use Stage (B1-B7)	Material: GWP End of Life Stage (C1-C4)	GWP All Stages (A1-C4)	Total Material GWP (tonCO2e)	Total Material GWP (kgCO2e)	Building Gross Area (m2)	Embodied Carbon Footprint (kgCO2e/m2)
0	0	0.119	2.554298	2554.297515	73.73	34.643938	
0	0	0.093	5.058607	5058.60666	73.73	68.609883	
0	0	1.28	0.756781	756.7808	73.73	10.264218	
0	0	0.13	0.21521	215.20954	73.73	2.918887	
0	0	0.213	4.956725	4956.725045	73.73	67.228062	
			13.54162	13541.61956		183.664988	

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Ryan Dempsey

Stage 4 – Mapping EPDs to Materials

EPD Ireland
Data set: Kingscourt Clay brick (00.03.003)

Process data set overview page
Data set: Kingscourt Clay brick (00.03.003)
Other versions: 00.03.001, 00.03.002

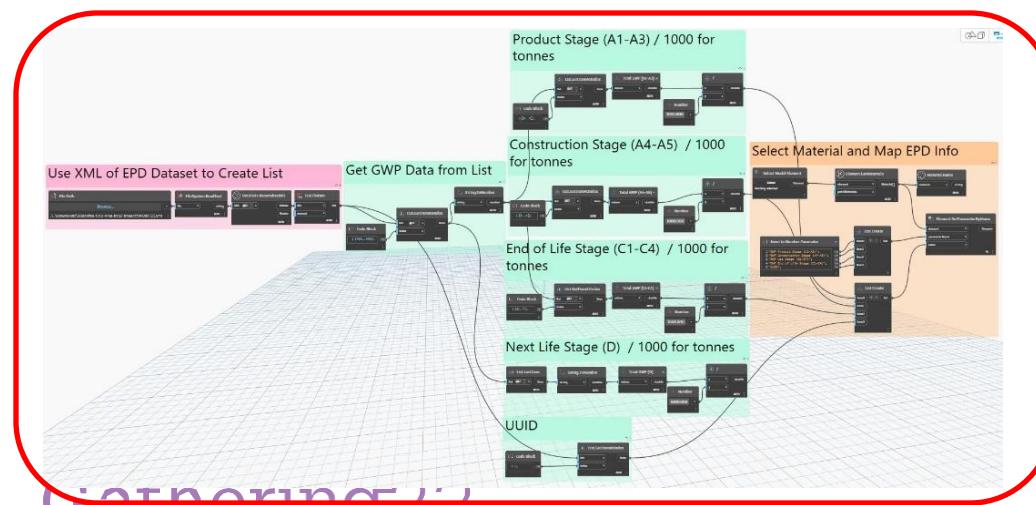
Process: Kingscourt Clay brick
Reference year: 2020
Production year: 2020
Location: IE

Material Properties: Kingscourt Clay brick, 1.8" x 1000.0 by 1000.0

Search Processes: Search Processes

```

    "LCIA method data set": {
      "name": "Global Warming Potential (GWP)",
      "description": "Potential for global warming",
      "unit": "kg CO2e",
      "version": "1.0"
    },
    "LCIA method data set": {
      "name": "Global Warming Potential (GWP)",
      "description": "Potential for global warming",
      "unit": "kg CO2e",
      "version": "1.0"
    }
  
```



Energy Analysis	
Density (ton/m ³)	1.970000
GWP Product Stage (A1-A3)	0.211410
GWP Construction Stage (A4-A5)	0.032829
GWP Use Stage (B1-B7)	0.000000
GWP End of Life Stage (C1-C4)	0.004850
Include in GWP Schedule	<input checked="" type="checkbox"/>
UUID	80a5efba-f2c3-4faa-bc02-b6aadf594989

Stage 5a – GWP Visualization

Reset Current View Element Override

Override elements that contain material with GWP value

Pull All Elements in Active View and Filtering by Material with the highest GWP value

Collected GWP Total Values from GWP Schedule

Last Item Pulls Material with highest value

Create Pie Chart from all materials in GWP schedule

User message to suggest changing material with highest GWP value

C14386626_Ryan_Dempsey_Global Warming Potential Review

To reduce GWP impact consider changing the following:

CLT

Global Warming Potential Breakdown

- Window Frame
- GBC_With produced GWP
- Glulam-Vertical
- IC_Insulation - Mineral Wool
- BG_MAT_Glue_Clar_E.GZ-01
- IC_Concrete_Block_215mm
- Aluminum_Black
- Rock Wool
- GBC_Insul_Gemec
- Glulam-Horizontal
- IC_Plaster (Gypsum)
- IC_Resine Board
- IC_Concrete - Cast In Situ
- BG_MAT_Metal_Aluminum-White_RMF-01
- CLT

33.986114

83.539078

28.01942

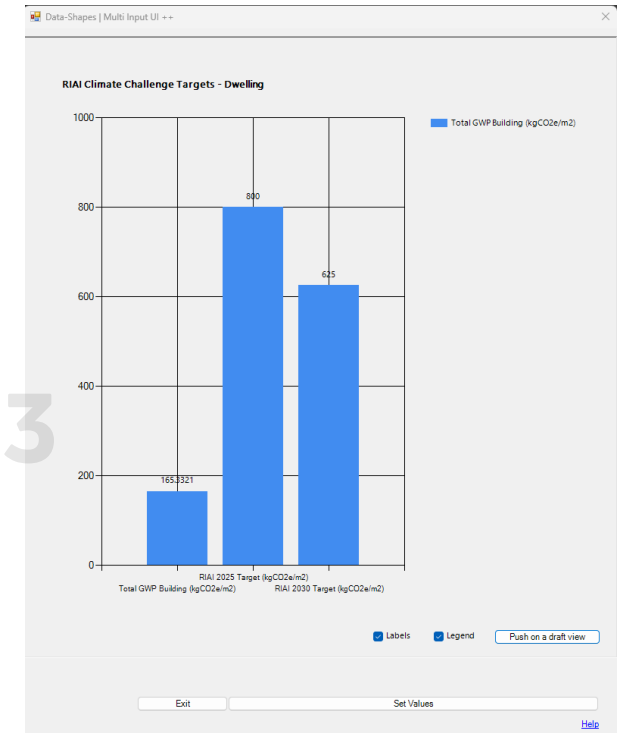
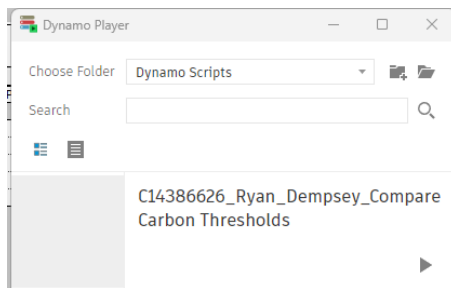
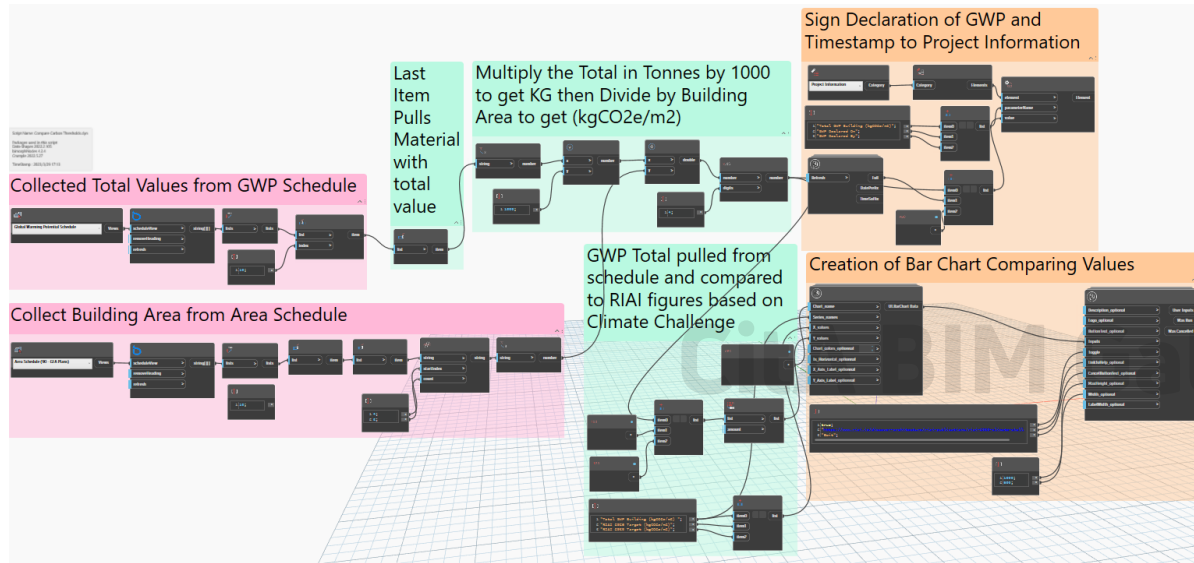
12.133666666666667

Labels Legend Push on a draft view

Set Values

3D model of a building with a red roof and green roof sections.

Stage 5b – GWP Targets Comparison & Declaration



Energy Analysis	
Total GWP Building (kgCO2e/m2)	165.332100
GWP Declared On	14/09/23 22:19:38
GWP Declared By	RD
IFC Parameters	

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Ryan Dempsey

Design Options

The screenshot displays the Autodesk Revit 2023.1 interface. The main window shows a 3D model of an apartment tower with a cutaway view. A 'Global Warming Potential Schedule' is open, displaying a table of material properties. A 'Dynamo Player' window is also visible, showing a list of scripts.

A	B	C	D	E	F
Material: Name	Material: UUID	Material: Volume	Material: Density (ton/m ³)	Weight of Material (ton)	Material: GWP Product Stage (
Aluminum_Black	N/A	0.35 m ³	2.7	0.955368	6.67
BG_MAT_Glass_Clear_E_GLZ-01	N/A	1.36 m ³	2.5	3.391135	1.44
BG_MAT_Metal_Aluminum-White_ERMF-01	N/A	1.88 m ³	2.7	5.081876	6.67
CLT - No Carbon Storage	N/A	315.03 m ³	0.5	157.517096	0.437
Glulam-Horizontal	N/A	35.08 m ³	0.5	17.538463	0.512
Glulam-Vertical	N/A	14.06 m ³	0.5	7.031948	0.512
ICE_Concrete - Cast In Situ 25/30	N/A	177.16 m ³	2.2	389.761018	0.119
ICE_Concrete_Block_215mm	N/A	29.31 m ³	2.3	67.408129	0.093
ICE_Insulation - Mineral Wool	N/A	116.87 m ³	0.025	2.921766	1.28
ICE_Plaster (Gypsum)	N/A	29.06 m ³	0.8	23.24844	0.39
IGBC_Brick_Generic	N/A	21.39 m ³	1.92	41.067373	0.213
IGBC_Irish produced OSB	N/A	15.49 m ³	0.32	4.958129	0.455
KC-FireLine Board	N/A	41.07 m ³	0.8	32.855728	0.39
Rock Wool	N/A	321.07 m ³	0.023	7.384699	1.12
Window Frame	N/A	0.06 m ³	2.7	0.163669	6.67
Grand total: 881		1119.26 m ³		761.284835	

Dynamo Player

- Choose Folder: Dynamo Scripts
- Search: []
- C14386626_Ryan_Dempsey_Co... Carbon Thresholds
- C14386626_Ryan_Dempsey_Cre... Materials from Excel (Generic Database)
- C14386626_Ryan_Dempsey_Glo... Warming Potential Review

Gath
Accelerat

Findings

- Template and material library provides a **starting point** for **early-stage GWP assessment**
- A proof-of-concept workflow with **schedules and visual aids** offering real-time lifecycle GWP calculation that may **influence decision-making**
- **Design Options** can be used to compare different materials and their environmental impacts
- By declaring GWP totals, the model **may be used as a verification tool** to record and track targets at project stages
- **Potential for automated material mapping** through **EPD datasets** and **XML files** through Revit and Dynamo. However, the density of materials used for testing **was not included in the dataset** and was found in the technical specification of the manufacturer. This proved one element of the **automated mapping process required manual input**
- Future work to investigate the impact of **ISO 22057** using **structured EPD data templates** for construction products in BIM to improve the process of automating material mapping for GWP calculation

-On a final note, this workflow was introduced to provide a **free alternative solution** for calculating and visualising GWP totals for users without experience in LCA and EPD terminology. It was never envisioned that this **could replace industry tools** for LCA calculations.

A nighttime photograph of a stone bridge with multiple arches spanning a river. In the background, a large, illuminated church with a dome and spires is visible. The scene is reflected in the calm water of the river. The sky is dark with some light clouds.

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THANK YOU