

# VISUALISING EMBODIED CARBON FOR BUILDING DESIGN

## GWP PROJECT VISUALISATION DASHBOARD

### TOTAL KG CO2e WITHIN ELEMENT

219.46K

#### OPTION 1 MATERIAL LIST

Material Name	Option 1 - Traditional
EPD_Mannok Block	72,493.64
ICE_Concrete 30n	42,796.30
EPD_Unilin Cavity Therm PIR	29,295.54
EPD_Gyproc Wallboard	25,496.49
ICE_Glass	13,420.25
ICE_Roofing Slates	10,243.64
ICE_Upvc	5,987.55
ICE_Plaster	5,245.94
ICE_Timber OSB (No Carbon Storage)	3,825.91
ICE_Softwood (No Carbon Storage)	3,512.49
ICE_Structural Steel	2,438.03
ICE_Polyethylene (Radon Barrier)	1,982.83
ICE_Lime W/ Sand Render	1,061.90
ICE_Fiberglass Quilt Insulation	772.23
EPD_Partel VCL	731.38
ICE_Hardcore	593.42
ICE_Concrete Cill	233.34
<b>Total</b>	<b>219,463.57</b>

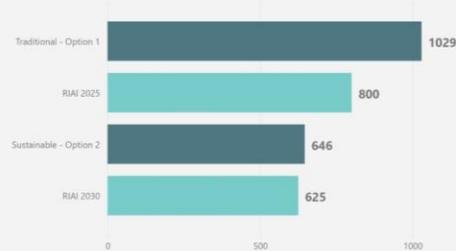
### TOTAL KG CO2e WITHIN ELEMENT

137.80K

#### OPTION 2 MATERIAL LIST

Material Name	Option 2 - Sustainable
ICE_Concrete 30n	18,480.88
EPD_Gyproc Wallboard	25,429.89
EPD_Mannok Block	23,942.71
ICE_Glass	13,420.25
ICE_Roofing Slates	10,235.90
ICE_Softwood (No Carbon Storage)	8,730.94
ICE_Upvc	5,846.14
ICE_Plaster	4,747.81
EPD_Unilin EPS 100	3,675.01
ICE_Timber OSB (No Carbon Storage)	3,231.05
EPD_Vastern Timber Cladding	1,298.77
ICE_Polyethylene (Radon Barrier)	1,065.53
ICE_Fiberglass Quilt Insulation	772.23
ICE_Hardcore	583.94
EPD_Partel VCL	553.10
ICE_Glulam	441.98
ICE_Concrete Cill	233.34
<b>Total</b>	<b>137,799.22</b>

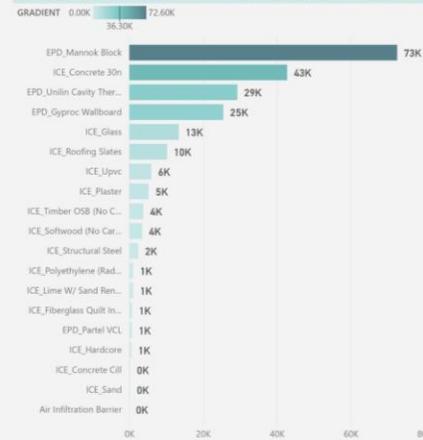
### RIAI TARGETS COMPARISON KGC02e/M2



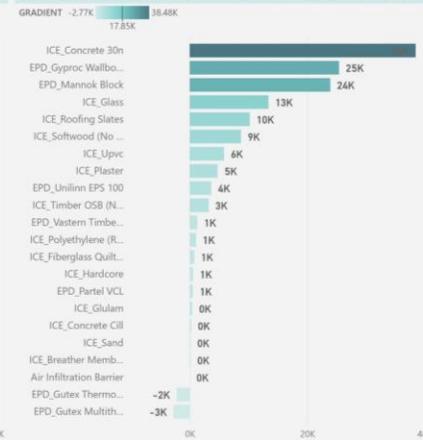
### INTERACTIVE 3D MODEL



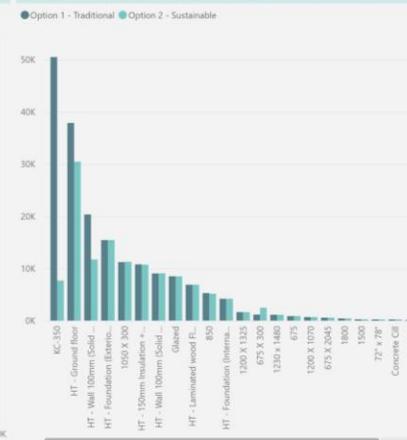
### OPTION 1 MATERIALS WITHIN SELECTED ELEMENT



### OPTION 2 MATERIALS WITHIN SELECTED ELEMENT



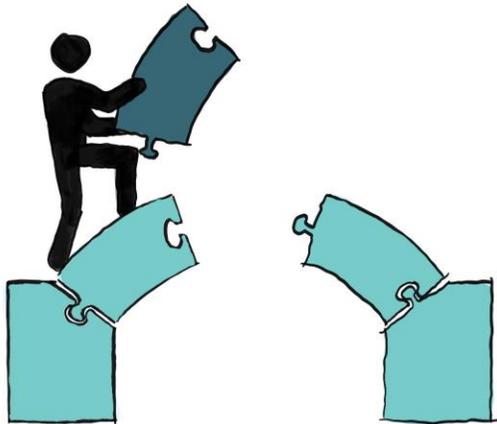
### OVERALL ELEMENT COMPARISON



# INTRODUCTION

## MOTIVATION BEHIND THIS STUDY

- GHG Emissions have risen by **9.2%** in the last **100 years**.
- **97%** of Irelands Building Stock is **Residential** According to SEAI and CSO
- Current methods are **Time Consuming** and require **Extensive Knowledge** and **Upskilling**
- Difficult to visualise the **Global Warming Potential** of buildings using current methods
- Expansion of **BIM**, Can this be automated **reducing workload** and **increase accuracy**?



MODELLING PROJECT



LIFE CYCLE ASSESSMENT



AMENDMENTS IN PROJECT



REVISED LIFE CYCLE ANALYSIS



DELIVERABLES



CAN THESE STEPS BE REMOVED?

# INTRODUCTION

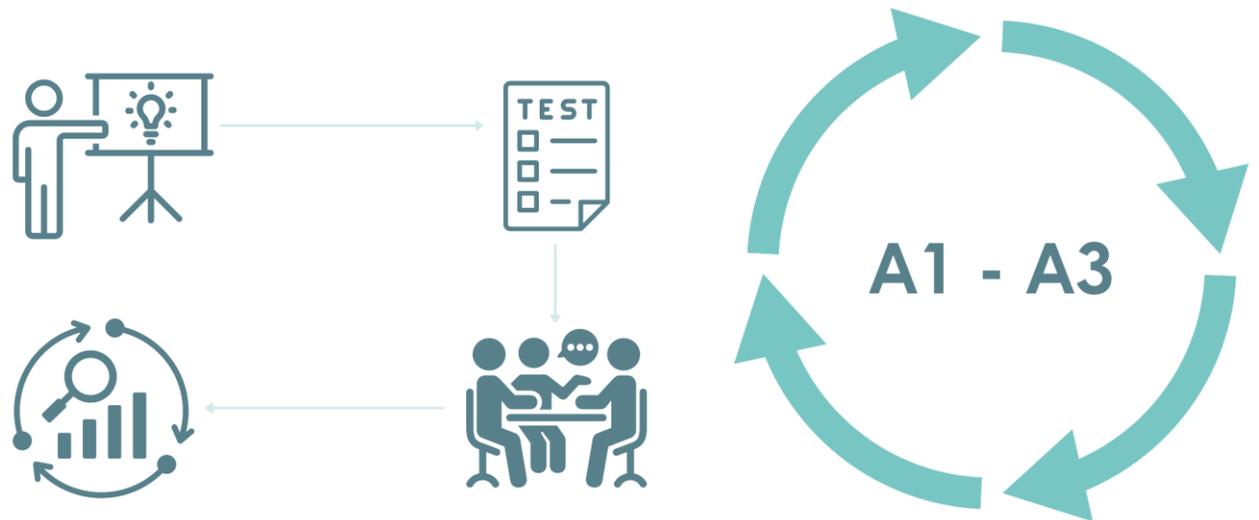
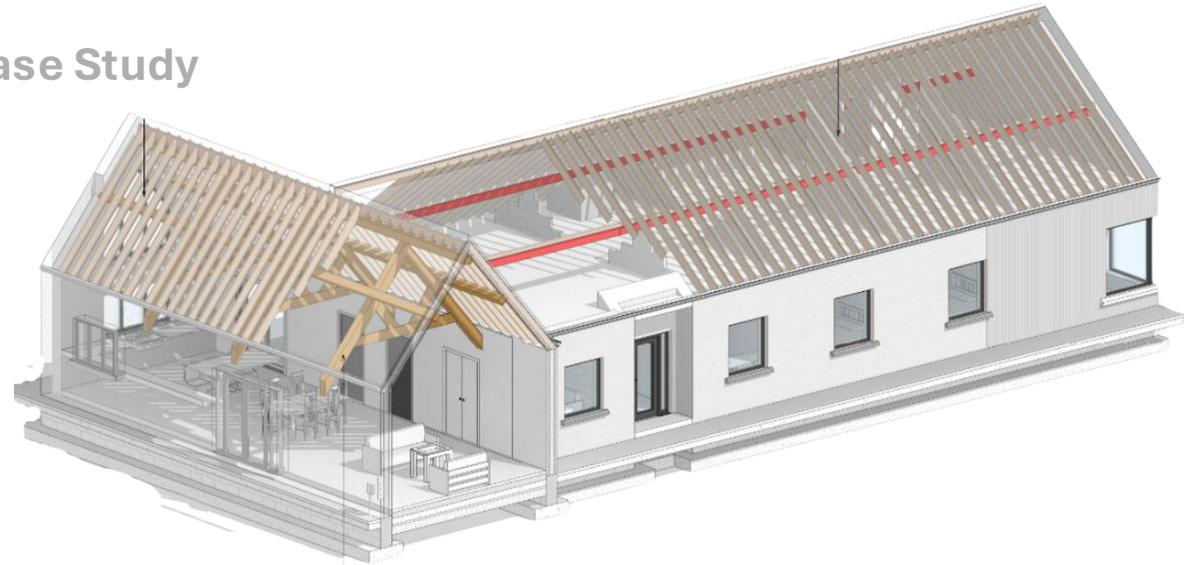
## THE SCOPE

- Focused on **Domestic Construction** in Ireland
- Test Subject based on a **One-Off Dwelling** in Ireland
- **GWP Stages A1-A3**, As this is where the most decisions must take place and most accurate data will be available from suppliers.
- The focus on **Embodied Carbon Reduction**

## OBJECTIVES OF STUDY

- **Desktop Research**, Identify Gap in existing research, by completing controlled Testing
- **BIM Workflow**, Create an Automated BIM Workflow
- **Material Comparison**, Using the Workflow Complete accurate material Comparisons
- **Field Testing**, Test workflow in the field with Professionals in the Built Environment

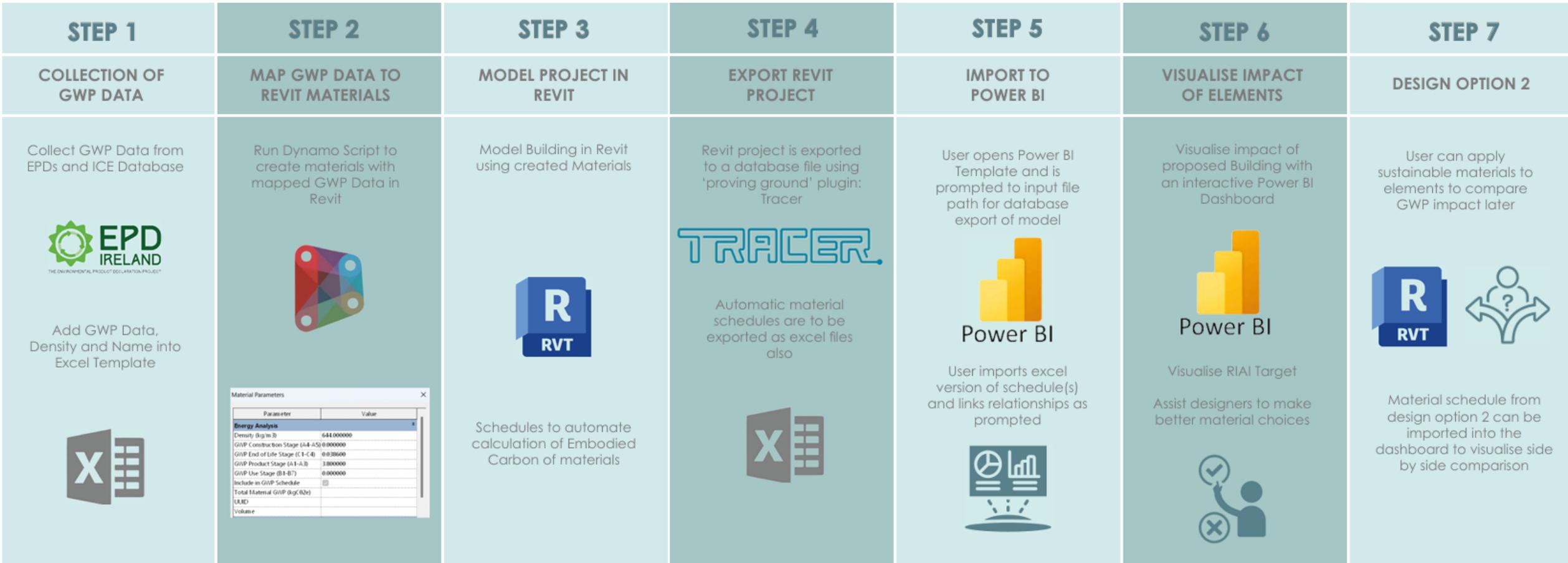
## Case Study





# METHODOLOGY

## PROPOSED METHOD & WORKFLOW



# CASE STUDY

## ABOUT AND WHY?

- **One off Dwelling** situated in Rural Ireland
- Constructed using **Traditional** Methods and building Materials
- The Aim is to **Test Methods** and create seamless **material comparisons**
- Identify using the **visualisation tool** where the problematic areas are in current material selection
- Compare **two options** to demonstrate change after identifying the problem areas.
- Are the RIAI Climate **Targets** being met?

### RIAI 2030 Target

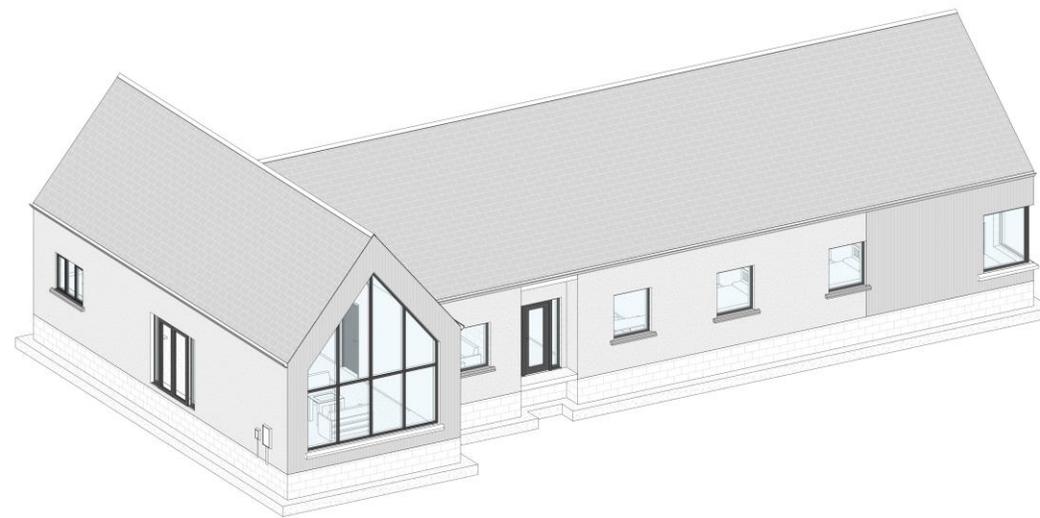
<625kgCO<sub>2</sub>e/m<sup>2</sup>

### RIAI 2025 Target

<800kgCO<sub>2</sub>e/m<sup>2</sup>

OPTION 1 : TRADITIONAL MATERIALS

OPTION 2: SUSTAINABLE SUBSTITUTES

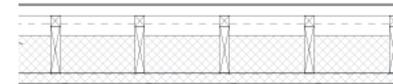


### EXTERNAL WALLS



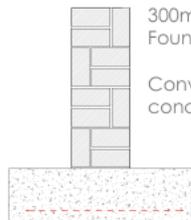
13mm Lime W/ Sand Render  
100mm Mannok Solid Concrete Block  
150mm Unilin Cavitytherm PIR Insulation  
100mm Mannok Solid Concrete Block  
Partel AVCL  
25x25mm Timber Battens @ 400 C/C  
12.5 Gyproc Wallboard with skim finish

### ROOF



8mm Tegral Thrutone Slate  
50mm Timber Batten System  
Roofing Membrane  
225 x 44mm C16 Timber Rafters  
150mm Unilin PIR Insulation Between Rafters  
62.5mm Insulated slab with skim finish

### FOUNDATION



300mm deep 30n Concrete Strip Foundation with A393 Steel mesh  
Conventional 100mm Mannok solid concrete Walls

### FLOOR



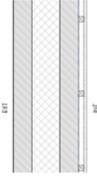
100mm Concrete Screed (Polished Finish)  
150mm Unilin Pir Insulation  
150mm 30n Concrete Sub-Floor  
RMB350 Radon Barrier  
50 Sand Blinding



# CASE STUDY

## EXTERNAL WALLS

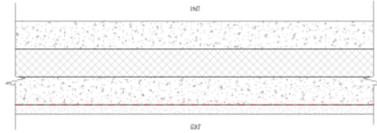
### OPTION 1



Materials	EC (kgCO2)
Mannok Block	31,469.06
Unilin Cavity Therm PIR	10,219.27
Gyproc Wallboard	6,134.76
Plaster	1,411.69
Sand Cement Render	1,061.90
Partel AVCL	191.51
<b>TOTAL</b>	<b>50,488.19</b>

## FLOOR

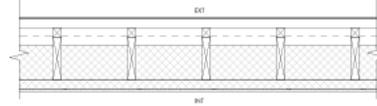
### OPTION 1



Materials	EC (kgCO2)
Concrete 30n	25,063.81
Unilin PIR Insulation	10,651.42
Radon Barrier (polyethylene)	1,082.83
Hardcore	593.42
DPM	348.13
Sand Blinding	118.68
<b>TOTAL</b>	<b>37,858.29</b>

## ROOF

### OPTION 1

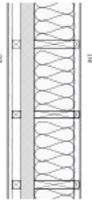


Note: NCS = No Carbon Storage

Materials	EC (kgCO2)
Slate	10,243.63
Unilin PIR Insulation	8,428.86
Gyproc Plasterboard	3,377.95
OSB (NCS)	3,124.28
Softwood Timber (NCS)	1,268.96
Partel AVCL	191.74
<b>TOTAL</b>	<b>27,357.25</b>

## EXTERNAL WALLS

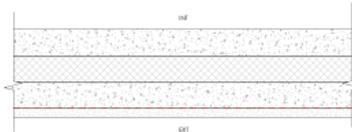
### OPTION 2 Full System Change



Materials	EC (kgCO2)
Gyproc Wallboard	6,159.72
Softwood Timber (NCS)	2,531.61
Vastern Timber Cladding	1,298.77
Plaster	885.79
Pro Clima AVCL	40.37
Permo eco11 Breather M	0.19
Gutex Thermoflex	-1,502.16
Gutex Multitherm	-1,764.32
<b>TOTAL</b>	<b>7,665.22</b>

## FLOOR

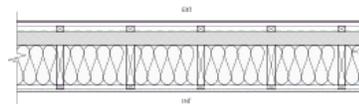
### OPTION 2 1 Material Change



Materials	EC (kgCO2)
Concrete 30n	25,063.81
Unilin EPS100 Insulation	3,731.37
Radon Barrier (polyethylene)	1,082.83
Hardcore	593.42
DPM	348.13
Sand Blinding	118.68
<b>TOTAL</b>	<b>30,914.35</b>

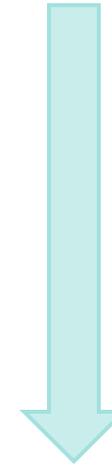
## ROOF

### OPTION 2 3 Material Change



Materials	EC (kgCO2)
Slate	10,243.63
Gyproc Plasterboard	3,377.95
OSB (NCS)	2,539.00
Softwood Timber (NCS)	1,268.96
Permo eco11 Breather M	0.93
Gutex Thermoflex	-719.60
Gutex Multitherm	-986.79
<b>TOTAL</b>	<b>15,724.08</b>

**PROBLEMATIC AREAS IDENTIFIED**



**INFORMED MATERIAL SUBSTITUTIONS**

# CASE STUDY

## VISUALISING THE COMPARISON

- Side by side Comparisons of Option 1 & Option 2
- Identifies RIAI Climate Target Compliance
- Identifies if The Problematic areas have been giving Attention

Option 1 - Traditional

219,463.57 kg CO2e

Option 2 - Sustainable

137,799.22 kg CO2e

Total Reduction

- 81,664.35 kg CO2e

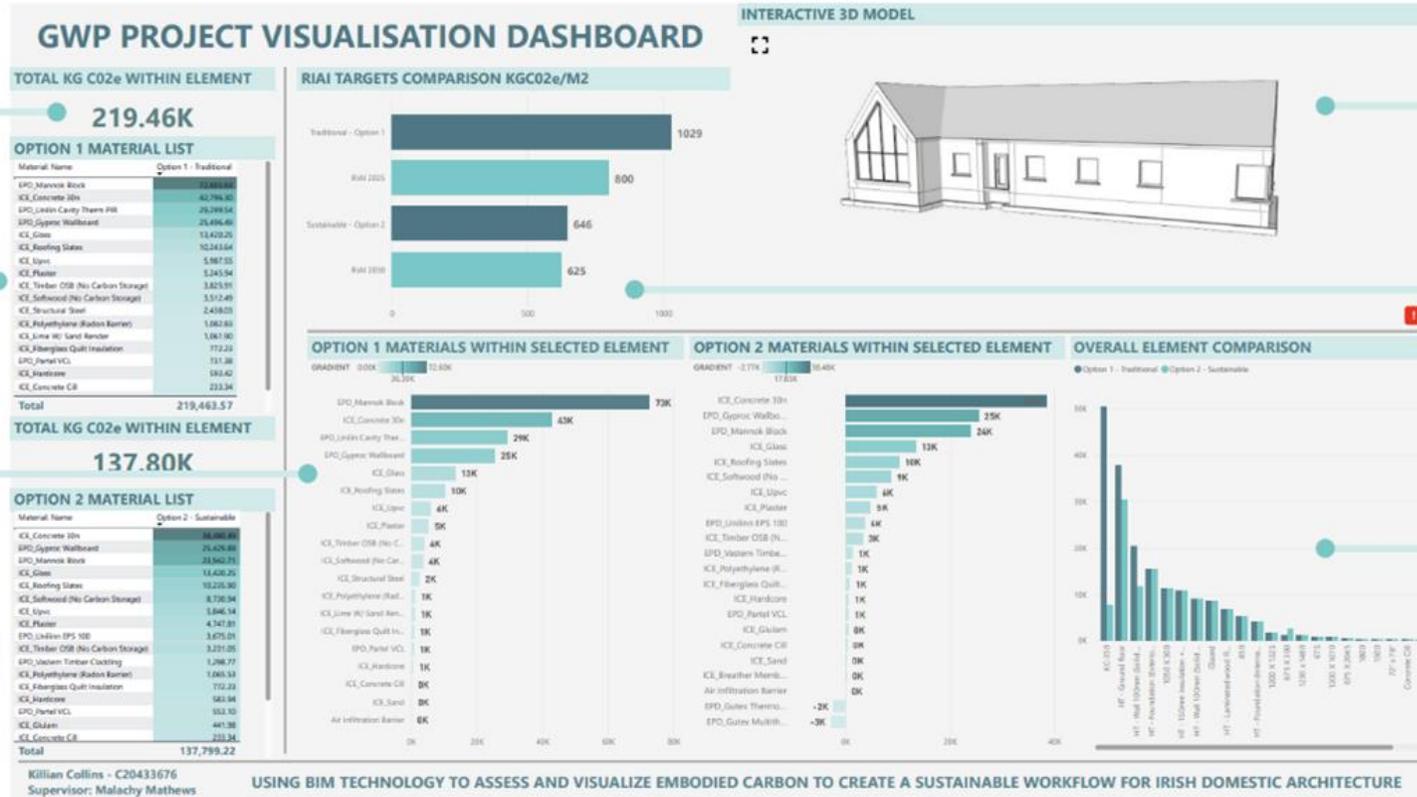
## TOTAL COMPARISON

### OVERALL DASHBOARD

**Total KgCO2e**  
Total Kg of Carbon Dioxide within Total Project / within element when selected

**Material List.**  
Material list with associated values coloured highest to lowest

**Material Barchart.**  
Material list within project in barchart format. Visualising highest to lowest material impact



**Interactive Model.**  
All elements can be selected and data will be visualised

**RIAI Targets.**  
Proposed designs embodied carbon footprint compared to RIAI targets

**Overall Element Comparison.**  
Shows the impact of the two options of all the named elements in the revit model

Killian Collins - C20433676  
Supervisor: Malachy Mathews

USING BIM TECHNOLOGY TO ASSESS AND VISUALIZE EMBODIED CARBON TO CREATE A SUSTAINABLE WORKFLOW FOR IRISH DOMESTIC ARCHITECTURE

# FOCUS GROUP

- **5 Built Environment Professionals** were approached
- All with different Levels and importance in the built environment
- The **Aim** is to test the methods on real life projects in the industry
- Gather **feedback** and **Comments** from professionals
- Analyse if this workflow has a **Place** within the Built Environment

## FOCUS GROUP

Participant	Role	Years of Experience	Qualification
1	Director / Architectural Technologist	22	Diploma
2	Lead Architect	15	Masters
3	Architectural Engineer/ MSc. Climate action and environmental policy	12	Masters
4	Senior Architectural Technologist	20	Level 8
5	Architect	11	Level 8

### 1. Organising Workflow



Organise and finalise workflow templates and instructions

### 2. Assign Focus Group



Randomise participants of Different Qualifications within the BE to take part in testing of workflow

### 3. Demonstration to Participants



Demonstrate workflow to participants

### 4. Workflow Testing



Participants had access to the workflow for a total of 6 weeks to demonstrate on one domestic project

### 5. Focus Group meeting and Feedback



### 6. Analyse Feedback and Findings



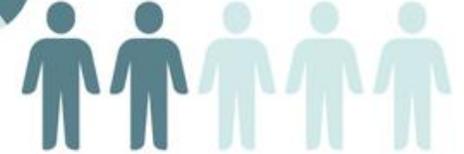
Analyse Feedback to alter the workflow. Categorise findings and identify pros and cons of each



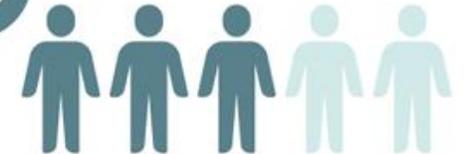
## ANALYSIS



'Was There Difficulty Gathering GWP Data and copying into the Excel Template Prior to running the data mapping script?'



'Did the Workflow Benefit Decision Making in Material Selection?'



'Is a Comprehensive Understanding of GWP Required in Benefiting From The Workflow in BIM Projects?'



'Was The Visualisation Dashboard Impactful to Visualise The Materials in the Project in Comparison to LCA Reports?'



# FINDINGS

## FINDINGS FROM CASE STUDY

1

### Data Mapping



Mapping EPD Data to Materials Within BIM was Automated when Creating the Materials Through this Process. This Eliminated Errors of Mapping Data to Existing Materials in Revit

2

### Automate LCA Process



LCA was Automated Through Formulas that Match the Basis of Calculation. This Eliminates the Time Spent on Separate LCA Using Current Methods

3

### Level of Detail



It Became Clear that the Level of Detail (LOD) Plays a Crucial Role in the Output of Data. The Higher Level of Detail the Model is, the More Accurate the Data Output will be

4

### Visualisation



Visualisation Within Revit was not Adequate for Identifying the Problem. The Creation of a Power BI Dashboard Allowed Greater Visualisation and Ability to Compare Materials

5

### Lack of Validated Data



Throughout the Data Mapping Phase a Lack of EPDs was Discovered. This Caused the use of the ICE Database Which Causes Inaccuracies Where Validated EPDs Cannot be Used

## FINDINGS FROM FOCUS GROUP

1

### Highlighted Problem



The Problematic Area that was Highlighted During the Focus Group Analysis was Manual Error Occurred During Gathering the Data Phase of the Workflow

2

### Knowledge Limits



Participants Agreed that the Tool Needs Designers to be UpSkilled to Understand the Data that is Embedded into the Materials to Allow for the Correct Selection of Materials.

3

### Impact of Visualisation



60% of Participants made Material Changes Due to Visualising the GWP. Overall From Feedback it was Found that Visualising the GWP was More Beneficial than Standard LCA Reports

4

### No Policies Push no Change



Participants Highlighted that Without Regulations Surrounding GWP Limits, They lack Change from Traditional Methods With the Focus Currently Being on Energy Efficiency

# CONCLUSION

## LIMITATIONS



Due to no Government Policies Regarding Embodied Carbon Requirements, Designers Still Use High Embodied Carbon Materials



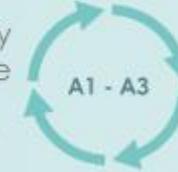
Only 5 Participants Tested the Workflow. A Greater Testing Field Will Develop Greater Evidence of its Place in the BE



Lack of Validated GWP Data. ICE Data Used Where Validated Manufacturers Data was Un-Available



GWP Stages A1 - A3 was Focused on Within This Study as These Figures are in Place Compared to the Other Stages where Estimates are to be Made



## FURTHER RESEARCH

The Development of Life Cycle Costing (LCC) Implementation. Lack of Policies Results in Clients Making Decisions Solely based on cost



To Expand Industry Testing and to Test on Large Scale Commercial Projects in The Industry.



To Implement on All GWP Stages With a Focus on Retrofit Projects



# VIDEO OF DASHBOARD

C20433676 Case Study\_GWP Comparison - Last saved: 4/25/2024 at 5:18 PM
Search
Killian Collins

File Home Insert Modelling View Optimize Help Format Data / Drill
Share

**GWP PROJECT VISUALISATION DASHBOARD**

**TOTAL KG CO2e WITHIN ELEMENT**

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ICE_Glass	13,429.23
ICE_Roofing Slates	10,243.64
ICE_Uptic	5,987.53
ICE_Plaster	5,245.94
ICE_Timber OSB (No Carbon Storage)	3,825.91
ICE_Softwood (No Carbon Storage)	3,512.49
ICE_Structural Steel	2,458.03
ICE_Polyethylene (Radon Barrier)	1,882.83
ICE_Lime W/ Sand Render	1,061.90
ICE_Fiberglass Quilt Insulation	772.23
EPD_Portal VCL	731.36
ICE_Hardcore	593.42

**Total** 219,463.57

**RIAI TARGETS COMPARISON KGC02e/M2**

Option	RIAI Target (KGC02e/M2)
Traditional - Option 1	1029
Sustainable - Option 2	646

**INTERACTIVE 3D MODEL**

**Data**

Visualizations

- Document
- DocumentParameter
- Element
- Element LOOKUP REFS...
- ElementParameterInteg...
- ElementParameterNum...
- ElementParameterRevellID
- ElementParameterText
- ElementParameterText (...)
- Option 1 Schedule
- Option 2 Schedule
- RIAI Targets

**OPTION 1 MATERIALS WITHIN SELECTED ELEMENT**

GRADIENT -0.00K to 72.60K

Material	CO2e Contribution (K)
EPD_Manhok Block	79K
ICE_Concrete 30n	43K
EPD_Unilin Cavity Ther...	29K
EPD_Gyproc Wallboard	25K
ICE_Glass	13K
ICE_Roofing Slates	10K
ICE_Uptic	6K
ICE_Plaster	5K
ICE_Timber OSB (No C...	4K
ICE_Softwood (No Car...	4K
ICE_Structural Steel	2K
ICE_Polyethylene (Rad...	1K
ICE_Lime W/ Sand Ren...	1K
ICE_Fiberglass Quilt In...	1K
EPD_Portal VCL	1K
ICE_Hardcore	1K
ICE_Concrete 0n	0K
ICE_Sand	0K
Air Infiltration Barrier	0K

**OPTION 2 MATERIALS WITHIN SELECTED ELEMENT**

GRADIENT -0.27K to 38.48K

Material	CO2e Contribution (K)
ICE_Concrete 30n	25K
EPD_Gyproc Wallboar...	24K
ICE_Glass	13K
ICE_Roofing Slates	10K
ICE_Softwood (No ...	9K
ICE_Uptic	6K
ICE_Plaster	5K
EPD_Unilin EPS 100	4K
ICE_Timber OSB (No C...	4K
EPD_Vastern Timbe...	1K
ICE_Polyethylene (R...	1K
ICE_Fiberglass Quill...	1K
ICE_Hardcore	1K
EPD_Portal VCL	1K
ICE_Glulam	0K
ICE_Concrete 0n	0K
ICE_Sand	0K
ICE_Breather Memb...	0K
Air Infiltration Barrier	0K
EPD_Gutex Thermo...	-2K
EPD_Gutex MultiB...	-3K

**OVERALL ELEMENT COMPARISON**

Legend: Option 1 - Traditional (Dark Blue), Option 2 - Sustainable (Light Blue)

**OPTION 2 MATERIALS WITHIN SELECTED ELEMENT**

GRADIENT -0.00K to 72.60K

Material	CO2e Contribution (K)
ICE_Concrete 30n	43K
EPD_Manhok Block	29K
EPD_Gyproc Wallboard	25K
ICE_Glass	13K
ICE_Roofing Slates	10K
ICE_Uptic	6K
ICE_Plaster	5K
ICE_Timber OSB (No C...	4K
ICE_Softwood (No Car...	4K
ICE_Structural Steel	2K
ICE_Polyethylene (Rad...	1K
ICE_Lime W/ Sand Ren...	1K
ICE_Fiberglass Quilt In...	1K
EPD_Portal VCL	1K
ICE_Hardcore	1K
ICE_Concrete 0n	0K
ICE_Sand	0K
Air Infiltration Barrier	0K

**OPTION 2 MATERIALS WITHIN SELECTED ELEMENT**

GRADIENT -0.27K to 38.48K

Material	CO2e Contribution (K)
ICE_Concrete 30n	25K
EPD_Gyproc Wallboar...	24K
ICE_Glass	13K
ICE_Roofing Slates	10K
ICE_Softwood (No ...	9K
ICE_Uptic	6K
ICE_Plaster	5K
EPD_Unilin EPS 100	4K
ICE_Timber OSB (No C...	4K
EPD_Vastern Timbe...	1K
ICE_Polyethylene (R...	1K
ICE_Fiberglass Quill...	1K
ICE_Hardcore	1K
EPD_Portal VCL	1K
ICE_Glulam	0K
ICE_Concrete 0n	0K
ICE_Sand	0K
ICE_Breather Memb...	0K
Air Infiltration Barrier	0K
EPD_Gutex Thermo...	-2K
EPD_Gutex MultiB...	-3K

**OVERALL ELEMENT COMPARISON**

Legend: Option 1 - Traditional (Dark Blue), Option 2 - Sustainable (Light Blue)

**OPTION 2 MATERIALS WITHIN SELECTED ELEMENT**

GRADIENT -0.00K to 72.60K

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ICE_Concrete 30n	43K
EPD_Manhok Block	29K
EPD_Gyproc Wallboard	25K
ICE_Glass	13K
ICE_Roofing Slates	10K
ICE_Uptic	6K
ICE_Plaster	5K
ICE_Timber OSB (No C...	4K
ICE_Softwood (No Car...	4K
ICE_Structural Steel	2K
ICE_Polyethylene (Rad...	1K
ICE_Lime W/ Sand Ren...	1K
ICE_Fiberglass Quilt In...	1K
EPD_Portal VCL	1K
ICE_Hardcore	1K
ICE_Concrete 0n	0K
ICE_Sand	0K
Air Infiltration Barrier	0K

**OPTION 2 MATERIALS WITHIN SELECTED ELEMENT**

GRADIENT -0.27K to 38.48K

Material	CO2e Contribution (K)
ICE_Concrete 30n	25K
EPD_Gyproc Wallboar...	24K
ICE_Glass	13K
ICE_Roofing Slates	10K
ICE_Softwood (No ...	9K
ICE_Uptic	6K
ICE_Plaster	5K
EPD_Unilin EPS 100	4K
ICE_Timber OSB (No C...	4K
EPD_Vastern Timbe...	1K
ICE_Polyethylene (R...	1K
ICE_Fiberglass Quill...	1K
ICE_Hardcore	1K
EPD_Portal VCL	1K
ICE_Glulam	0K
ICE_Concrete 0n	0K
ICE_Sand	0K
ICE_Breather Memb...	0K
Air Infiltration Barrier	0K
EPD_Gutex Thermo...	-2K
EPD_Gutex MultiB...	-3K

**OVERALL ELEMENT COMPARISON**

Legend: Option 1 - Traditional (Dark Blue), Option 2 - Sustainable (Light Blue)

**OPTION 2 MATERIALS WITHIN SELECTED ELEMENT**

GRADIENT -0.00K to 72.60K

Material	CO2e Contribution (K)
ICE_Concrete 30n	43K
EPD_Manhok Block	29K
EPD_Gyproc Wallboard	25K
ICE_Glass	13K
ICE_Roofing Slates	10K
ICE_Uptic	6K
ICE_Plaster	5K
ICE_Timber OSB (No C...	4K
ICE_Softwood (No Car...	4K
ICE_Structural Steel	2K
ICE_Polyethylene (Rad...	1K
ICE_Lime W/ Sand Ren...	1K
ICE_Fiberglass Quilt In...	1K
EPD_Portal VCL	1K
ICE_Hardcore	1K
ICE_Concrete 0n	0K
ICE_Sand	0K
Air Infiltration Barrier	0K

**OPTION 2 MATERIALS WITHIN SELECTED ELEMENT**

GRADIENT -0.27K to 38.48K

Material	CO2e Contribution (K)
ICE_Concrete 30n	25K
EPD_Gyproc Wallboar...	24K
ICE_Glass	13K
ICE_Roofing Slates	10K
ICE_Softwood (No ...	9K
ICE_Uptic	6K
ICE_Plaster	5K
EPD_Unilin EPS 100	4K
ICE_Timber OSB (No C...	4K
EPD_Vastern Timbe...	1K
ICE_Polyethylene (R...	1K
ICE_Fiberglass Quill...	1K
ICE_Hardcore	1K
EPD_Portal VCL	1K
ICE_Glulam	0K
ICE_Concrete 0n	0K
ICE_Sand	0K
ICE_Breather Memb...	0K
Air Infiltration Barrier	0K
EPD_Gutex Thermo...	-2K
EPD_Gutex MultiB...	-3K

**OVERALL ELEMENT COMPARISON**

Legend: Option 1 - Traditional (Dark Blue), Option 2 - Sustainable (Light Blue)

**OPTION 2 MATERIALS WITHIN SELECTED ELEMENT**

GRADIENT -0.00K to 72.60K

Material	CO2e Contribution (K)
ICE_Concrete 30n	43K
EPD_Manhok Block	29K
EPD_Gyproc Wallboard	25K
ICE_Glass	13K
ICE_Roofing Slates	10K
ICE_Uptic	6K
ICE_Plaster	5K
ICE_Timber OSB (No C...	4K
ICE_Softwood (No Car...	4K
ICE_Structural Steel	2K
ICE_Polyethylene (Rad...	1K
ICE_Lime W/ Sand Ren...	1K
ICE_Fiberglass Quilt In...	1K
EPD_Portal VCL	1K
ICE_Hardcore	1K
ICE_Concrete 0n	0K
ICE_Sand	0K
Air Infiltration Barrier	0K

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ICE_Timber OSB (No C...	4K
EPD_Vastern Timbe...	1K
ICE_Polyethylene (R...	1K
ICE_Fiberglass Quill...	1K
ICE_Hardcore	1K
EPD_Portal VCL	1K
ICE_Glulam	0K
ICE_Concrete 0n	0K
ICE_Sand	0K
ICE_Breather Memb...	0K
Air Infiltration Barrier	0K
EPD_Gutex Thermo...	-2K
EPD_Gutex MultiB...	-3K

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ICE_Softwood (No Car...	4K
ICE_Structural Steel	2K
ICE_Polyethylene (Rad...	1K
ICE_Lime W/ Sand	

# Gathering25

Realising vision, advancing automation

**CitA25**  
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**THANK YOU!**

KILLIAN COLLINS ACIAT