

# Exploring the Feasibility of Prefabricated Straw Panels in Ireland's Construction Industry

## Objectives

- 1 Research and conduct literature reviews to determine the advantages and challenges to straw
- 2 Use a case study building of social housing and redesign with prefabricated straw panels.
- 3 Test and compare construction details of both proposals for their thermal and hygrothermal properties
- 4 Test and compare environmental impact of proposals to determine potential reduction in annual carbon emissions.

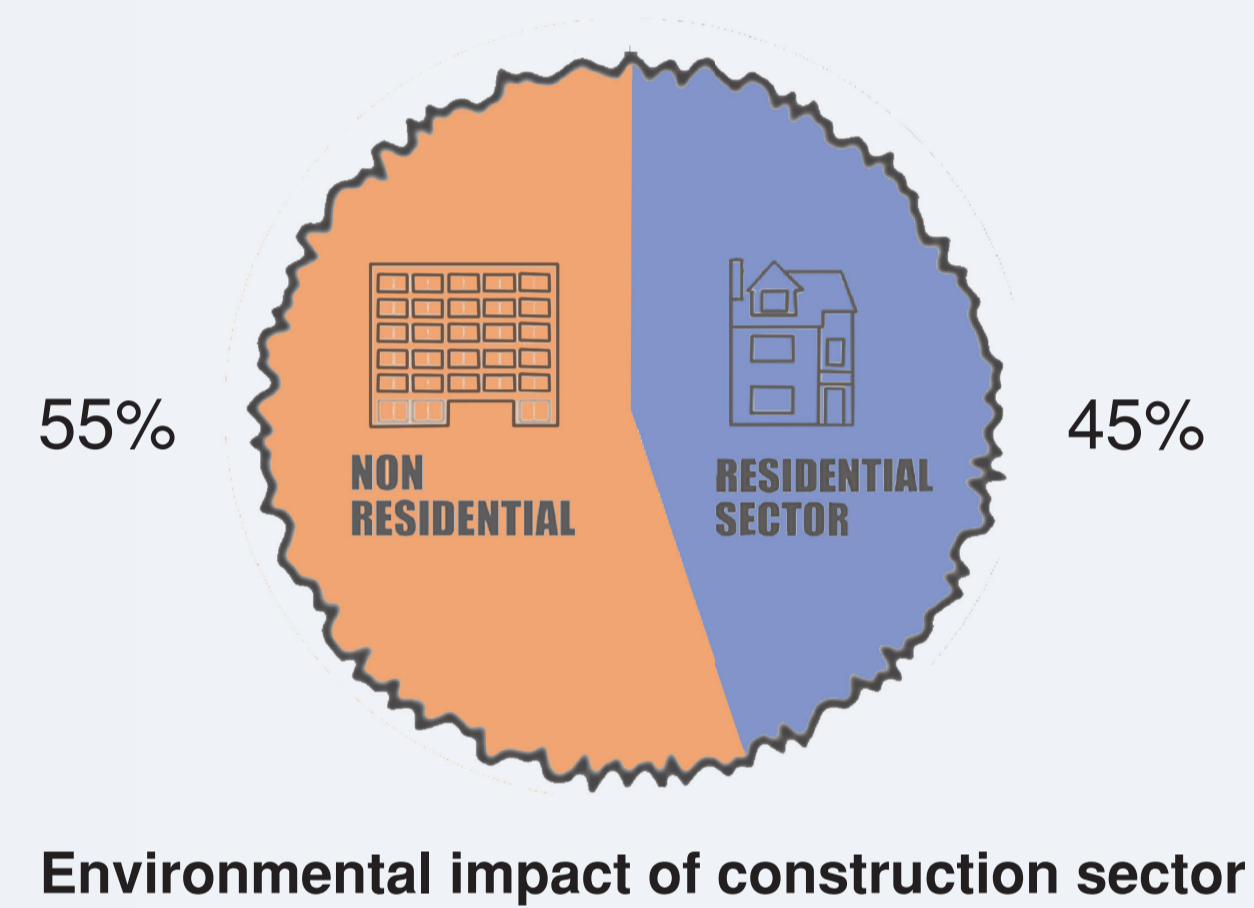
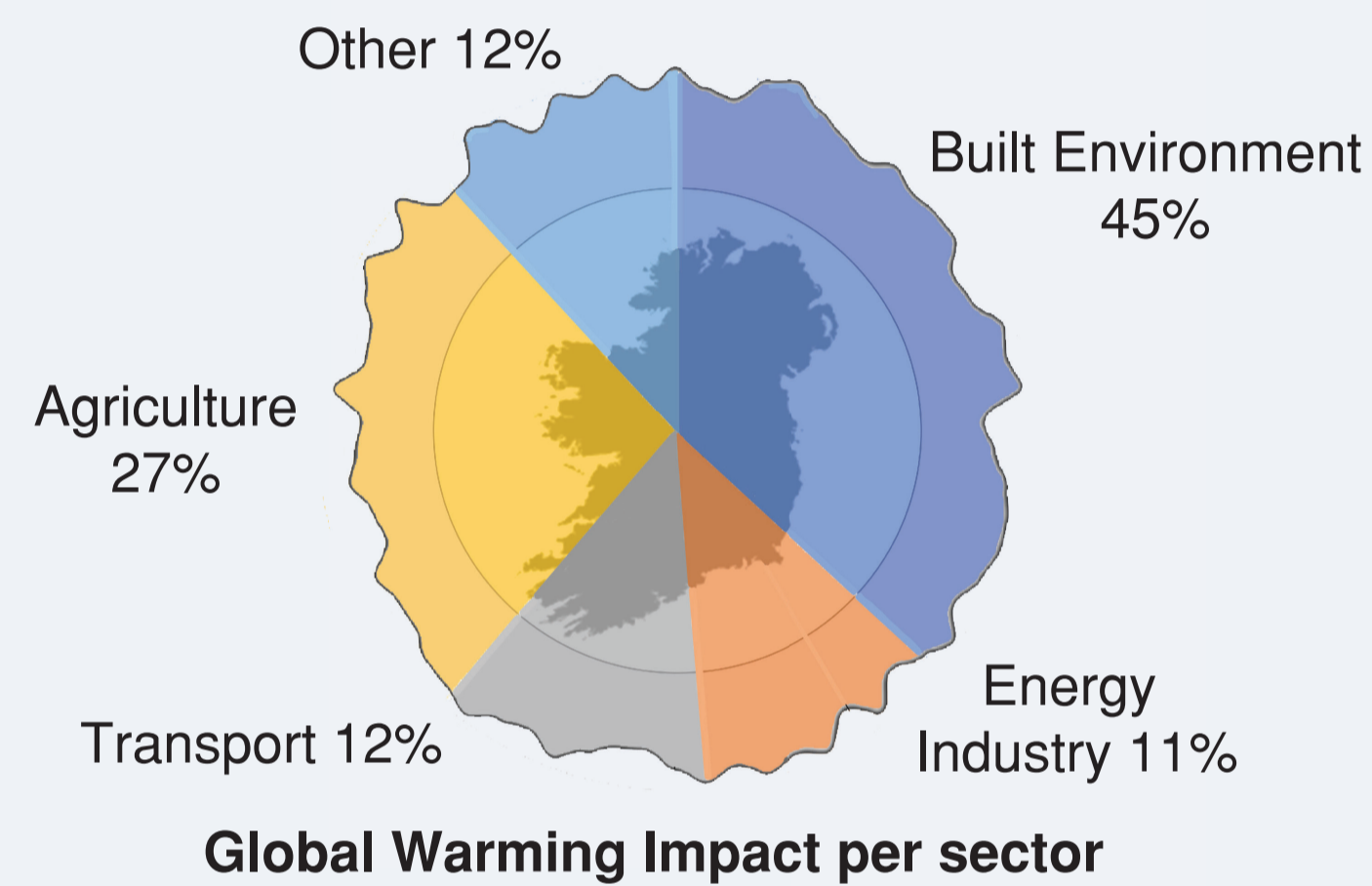


## Aims

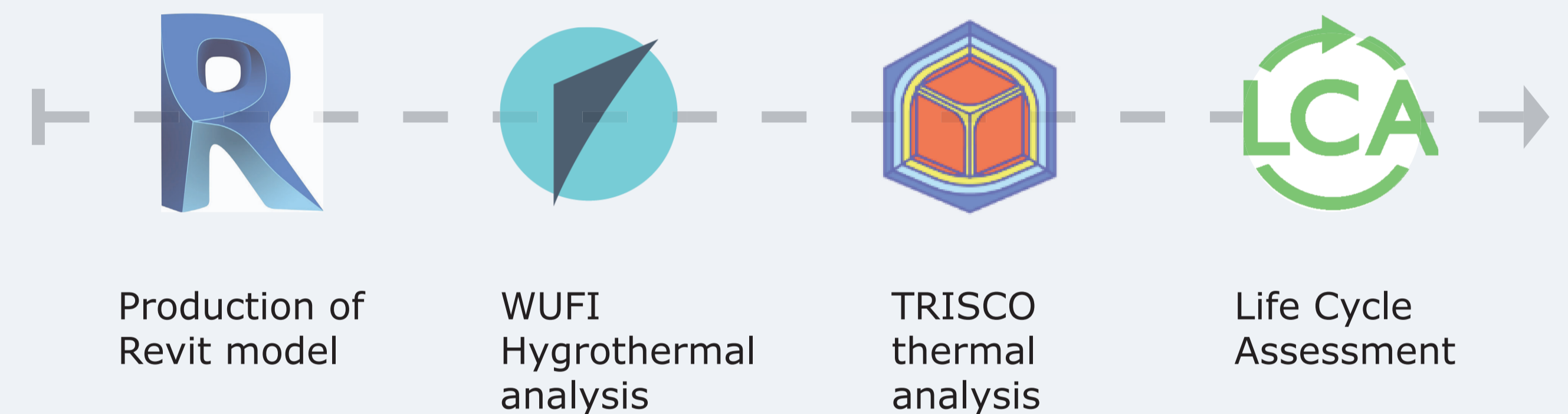
- 1 The aim of this research is to determine the reduction in carbon emissions by redesigning the chosen case study building, Moyola Court, using prefabricated straw panels
- 2 to quantify the potential reduction on annual carbon emissions if all that was proposed in Ireland's national development plan were construction with this method



## Motivation

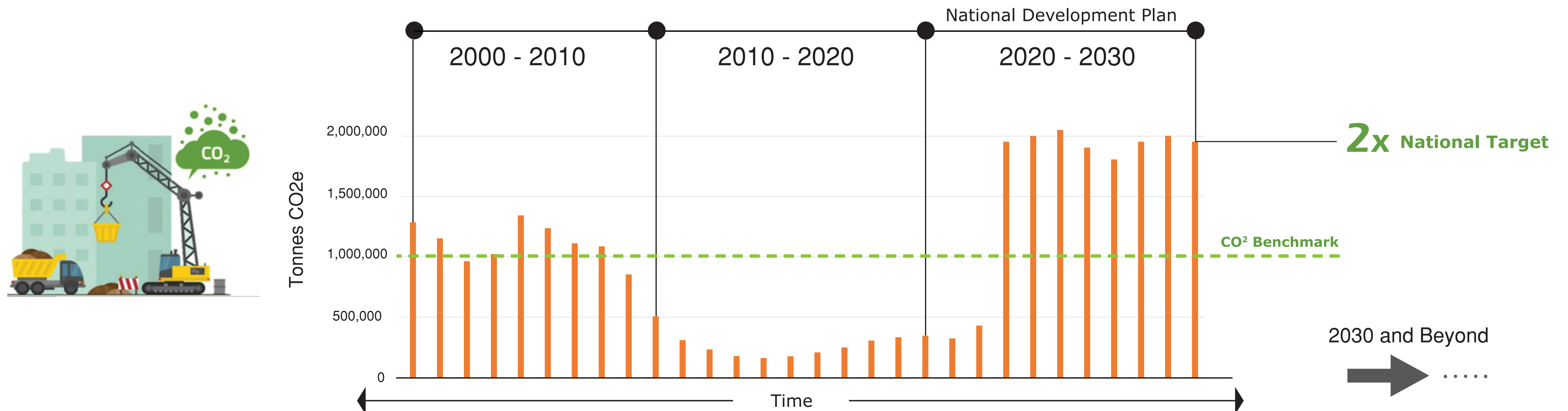


## Methodology



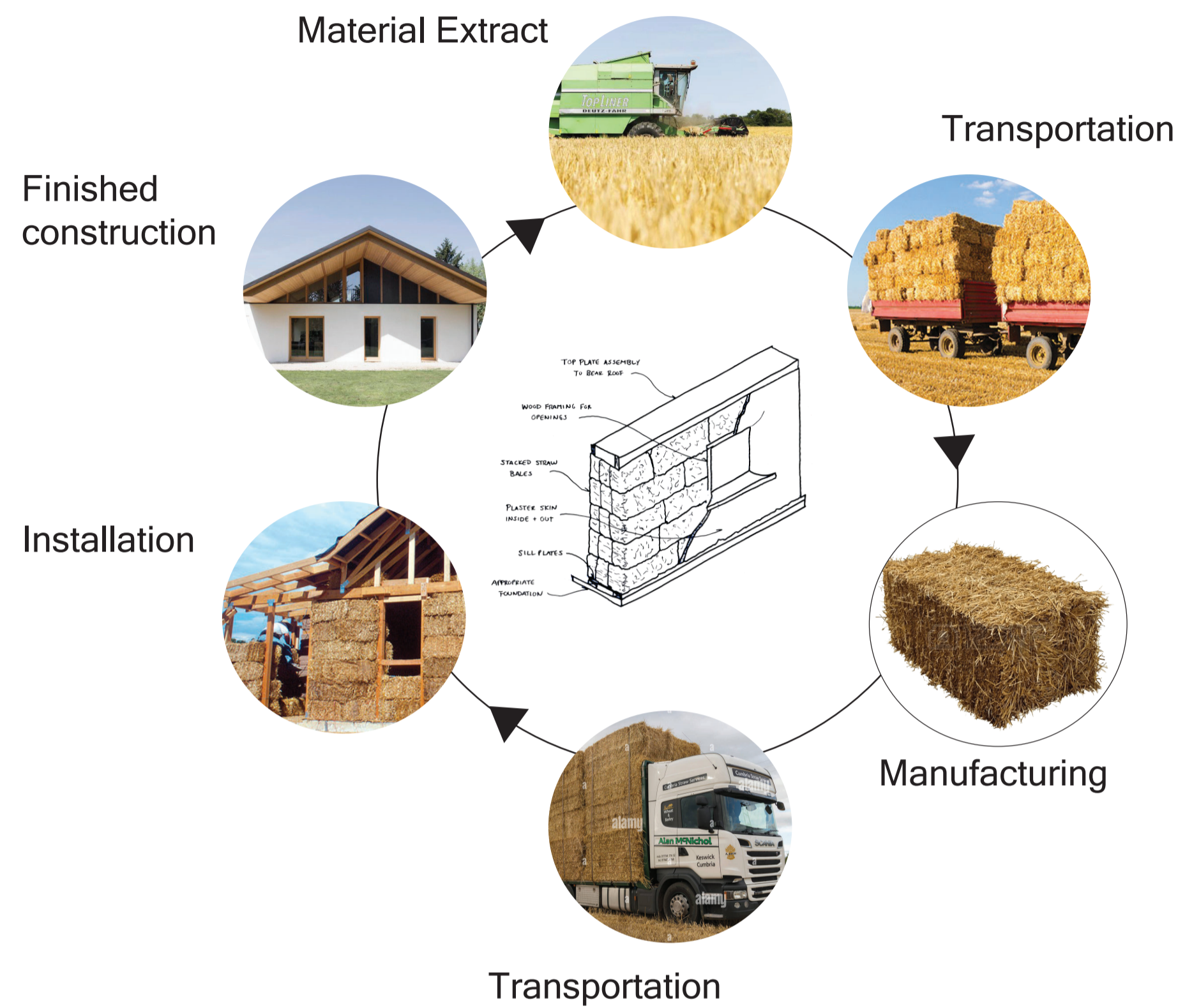
## Built Environment & National Context

Embodied Carbon of Residential Construction Sector

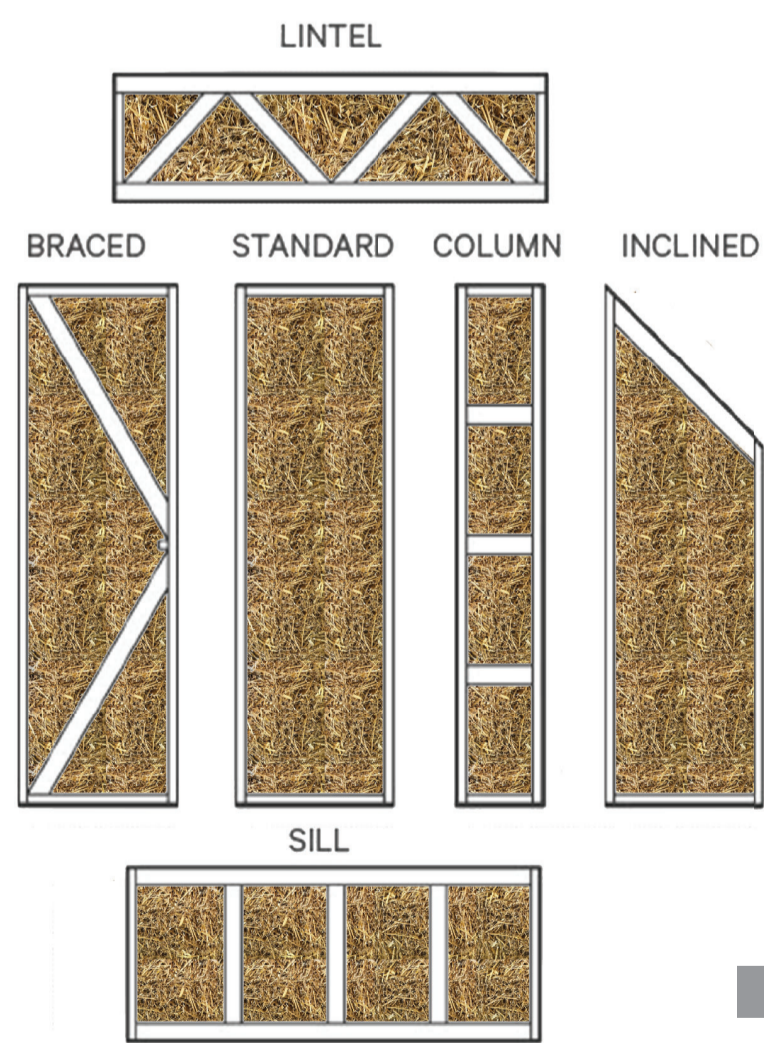


# Straw Insulation

## Material Processing



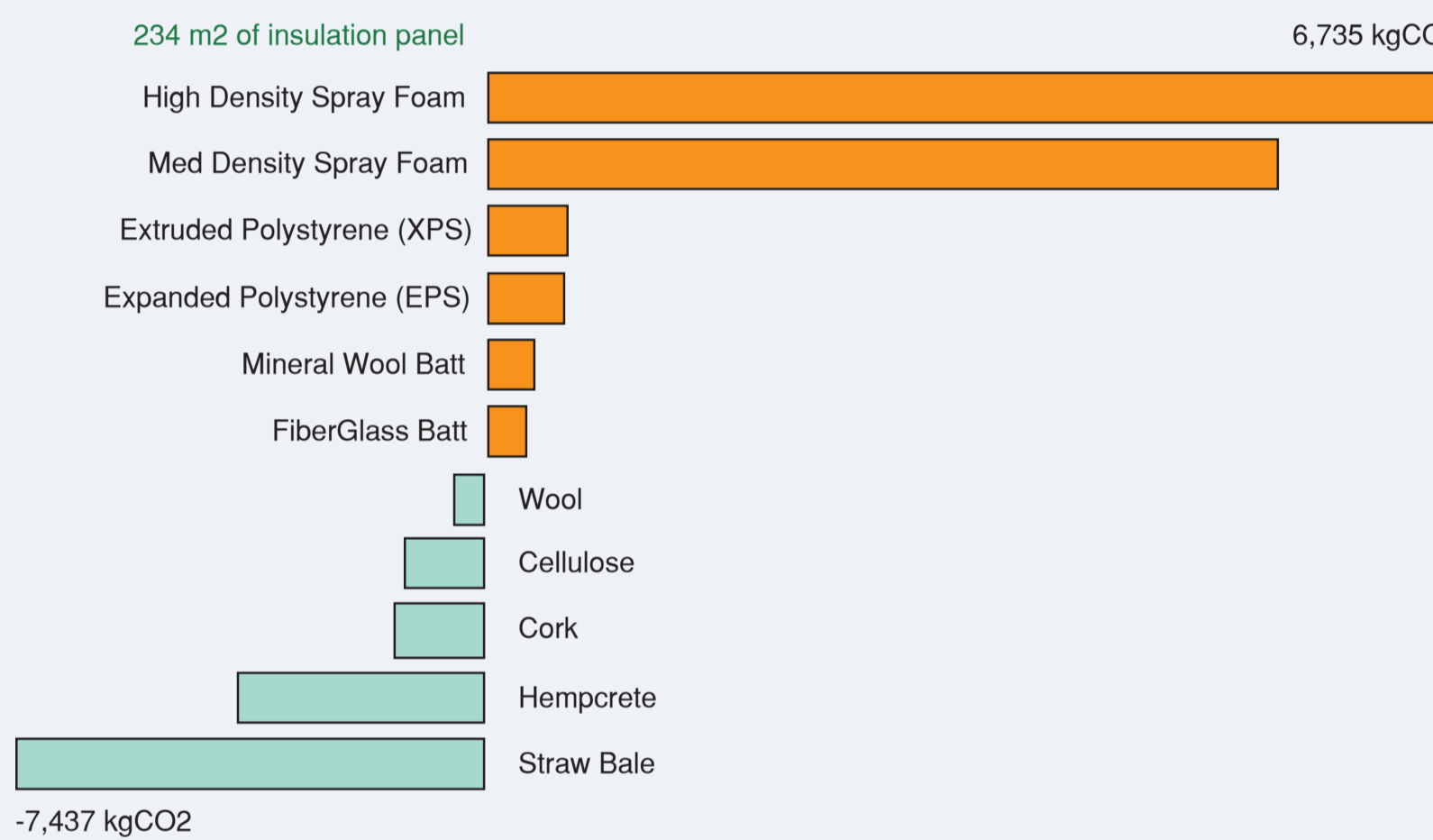
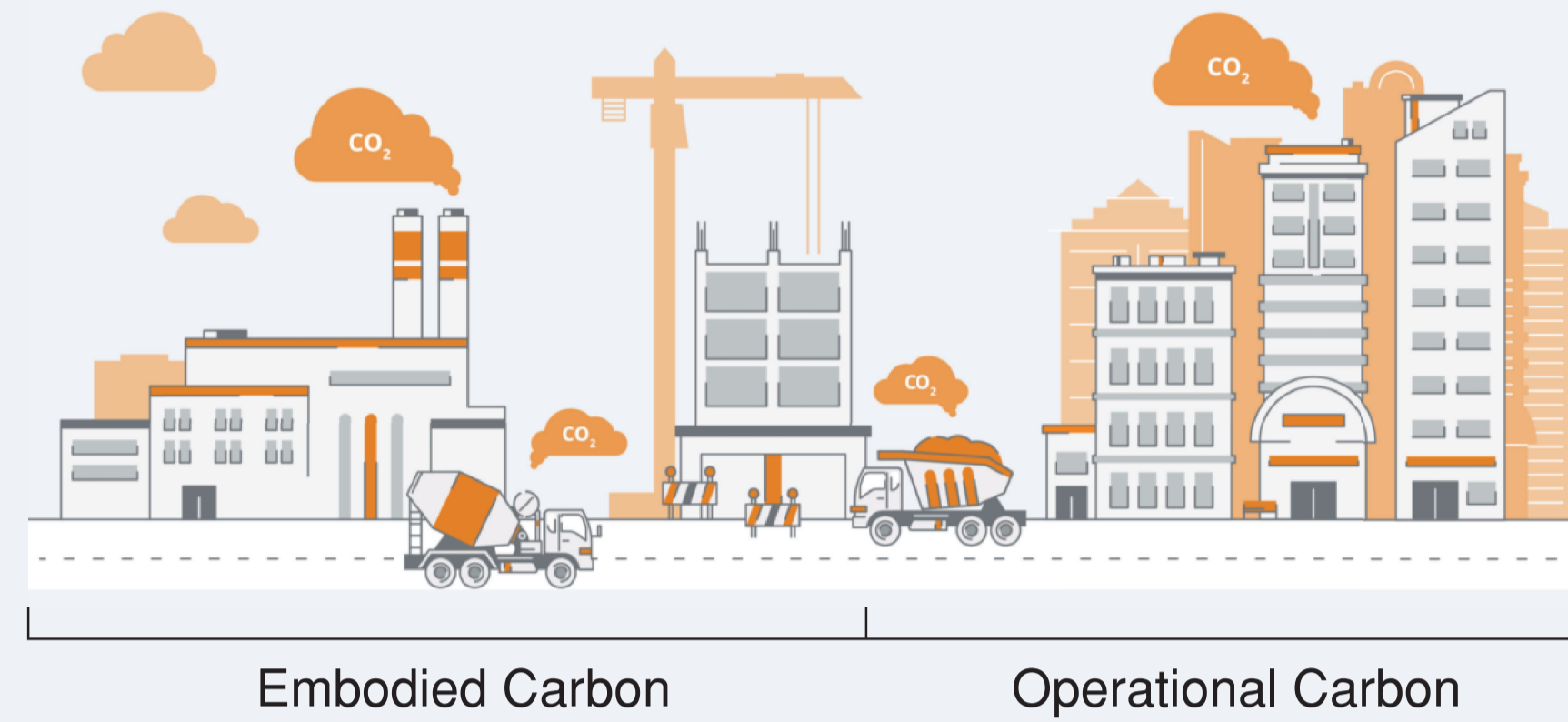
## Prefabricated Panels EcoCocon



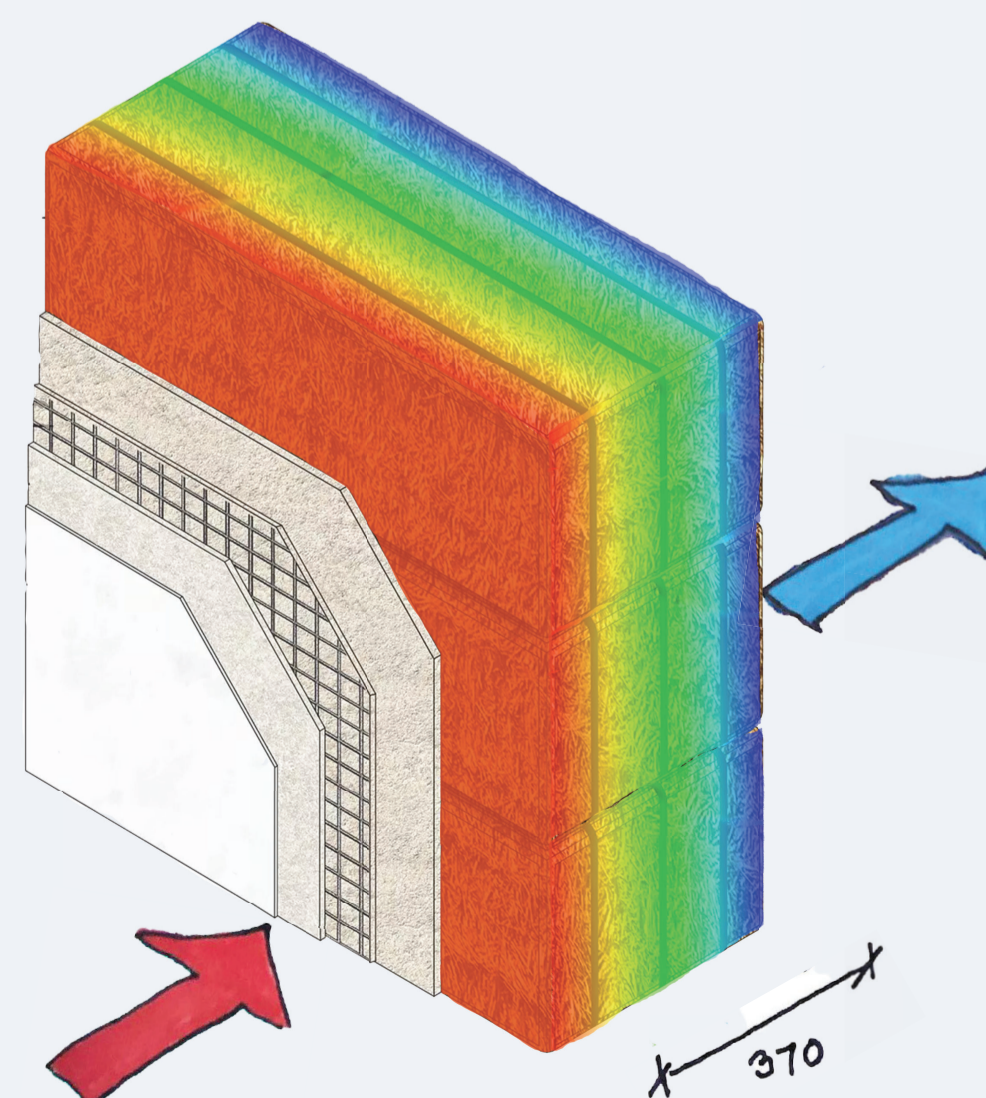
The product EcoCocon was chosen for this research due to the large amount of existing information. The aim of this research is to test for compliance within Ireland's built environment, therefore existing information was needed. Another product researched was **Modcell**, a UK based prefab straw panel capable of achieving similar results.

# Advantages to Straw

## Embodied Carbon



## Thermal Properties of lime rendered strawbale wall



**Thermal Conductivity:**  
Mean  $\lambda$  value: 0.065 W/mK  
Meeting ISO 10456 requirements, Test carried out by John Butler, 2022

# Challenges to Straw

## Hydrothermal Properties

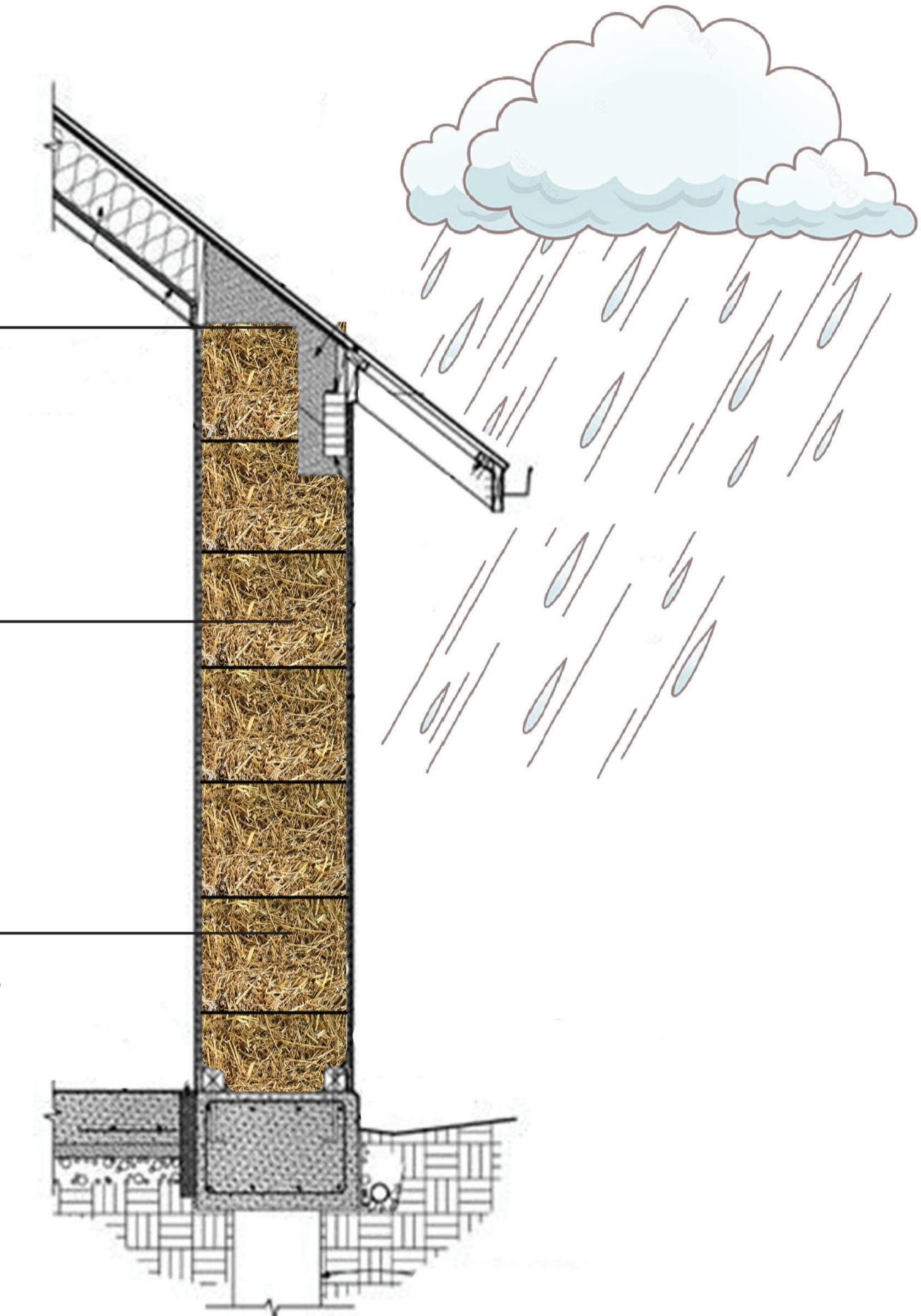
Out of a report for 174 strawbale buildings

102 Building owners reported moisture damage

29 reported moisture damage due to leaky roof

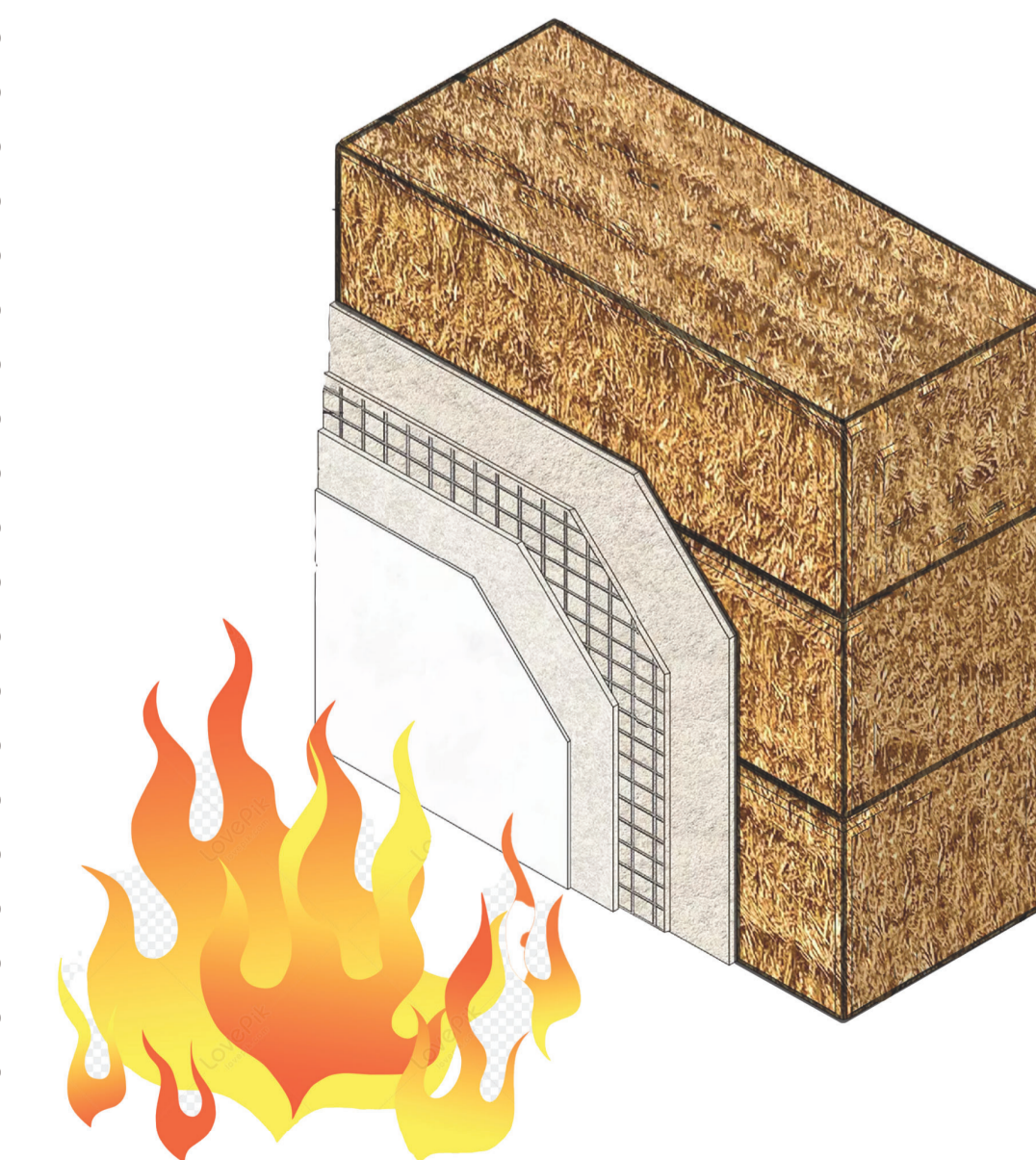
30 reported moisture damage in walls due to wind driven rain

43 reported moisture damage due to poorly designed doors/windows



## Fire Properties

of lime rendered strawbale wall



**EcoCocon Reaction to Fire:**  
B-s1 , d0.  
Very limited contribution to fire  
Complies with European Standard EN-13501-1, Testing carried out by BM TRADA, 2014

**EcoCocon Resistance to Fire:**  
121 minutes exposed to fire internally & externally without failure.  
Complies with European Standard EN 1365-1, Testing carried out by FIRES, 2016



# Case Study - Moyola Court

Churchtown Dublin 14

## Project Overview

Location: Moyola Court, Churchtown, Dublin 14  
 Architects: DLRCOCO, A2 Architects  
 Proposed: The development of 12 social and affordable housing units split between two terraces

## Why Moyola Court?

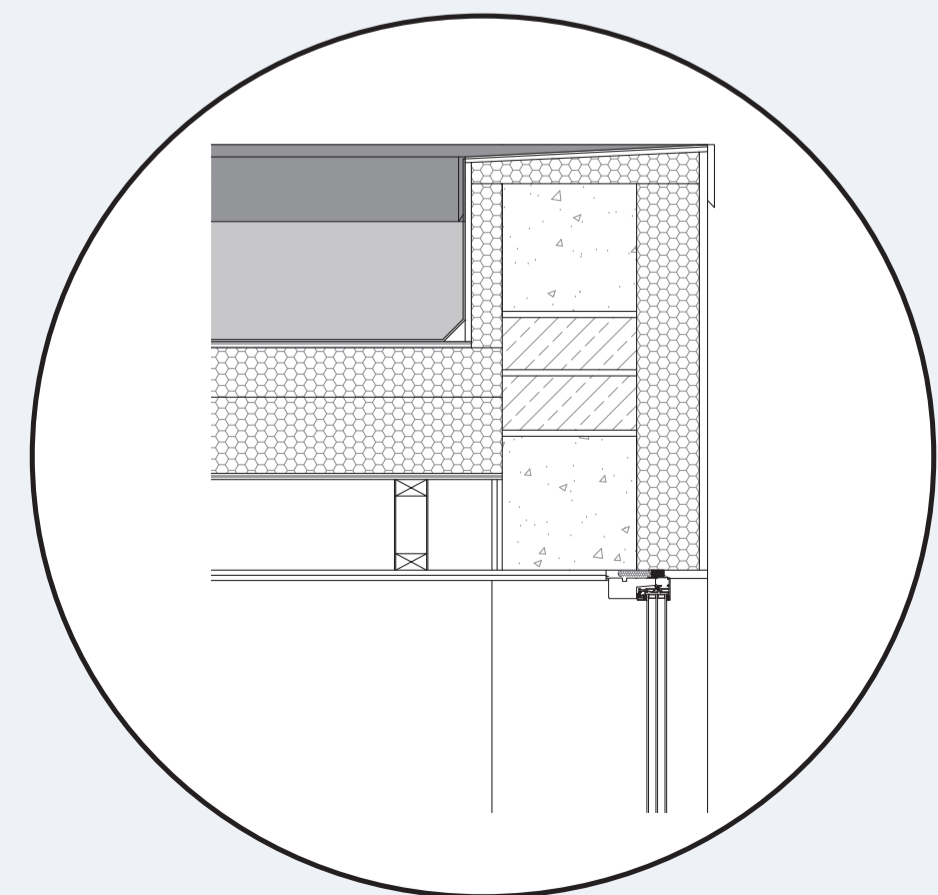
Moyola Court is an example of newly built energy efficient social housing built by a local authority within an urban location. The proposal of 30,000 BER B3 houses to be constructed each year will be similar to what is found on this site. Social housing sites such as this can be built all across Ireland.

## Why Terrace over Detached?

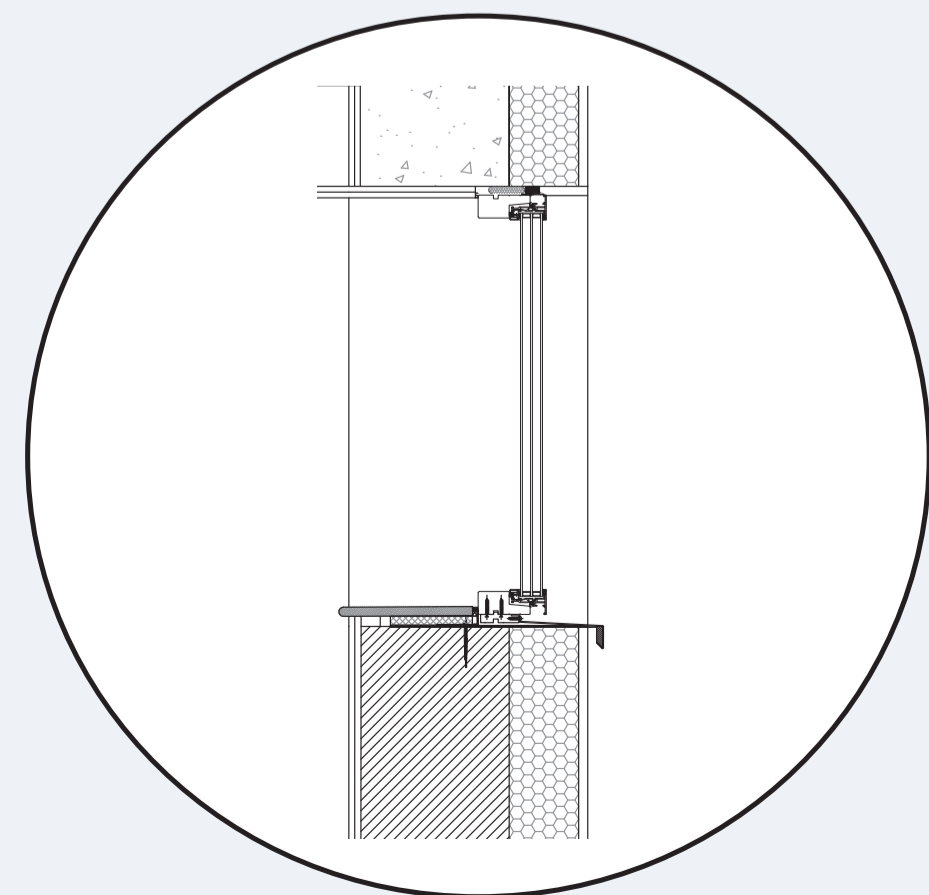
A terrace of housing was chosen instead of detached housing due to the popularity of this method when building social housing. Due to the housing for all initiative being introduced by local authorities an emphasis has been placed on delivering more social housing in Ireland. Choosing terrace housing allows for a simplified design and construction process by mirroring the same house type across the site.

## External Wall Build Up

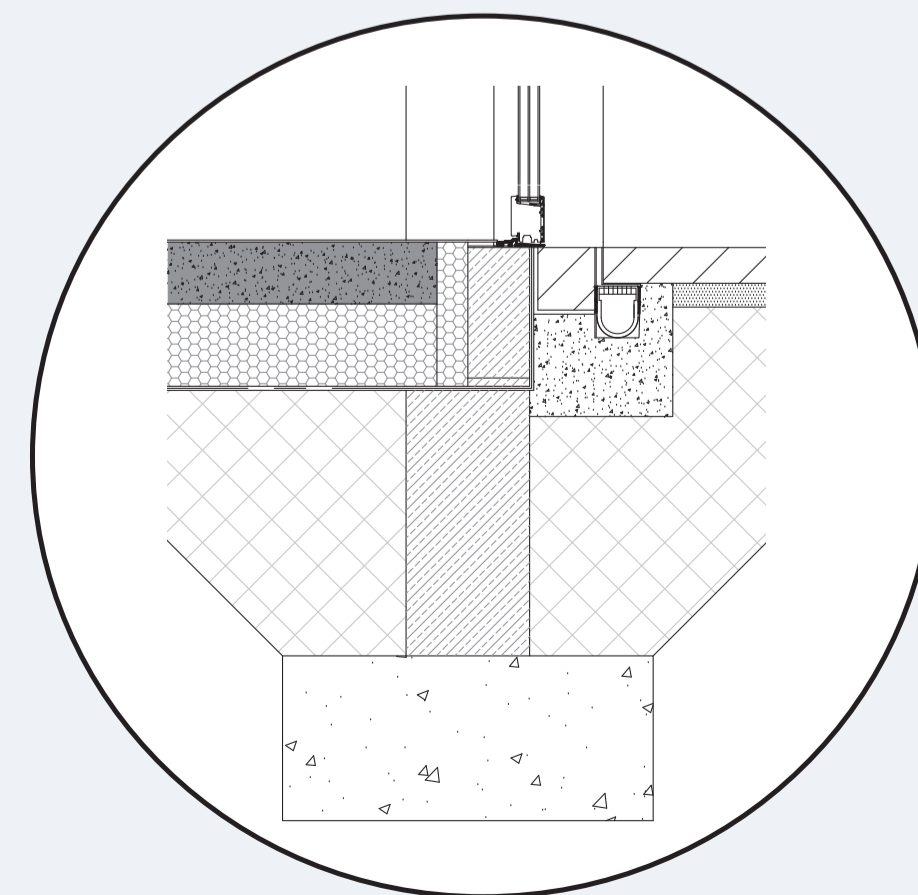
15mm stucco render, 150 external eps insulation, 215 concrete block, 2x 12.5 plasterboard, 3mm skim finish.



Parapet Detail



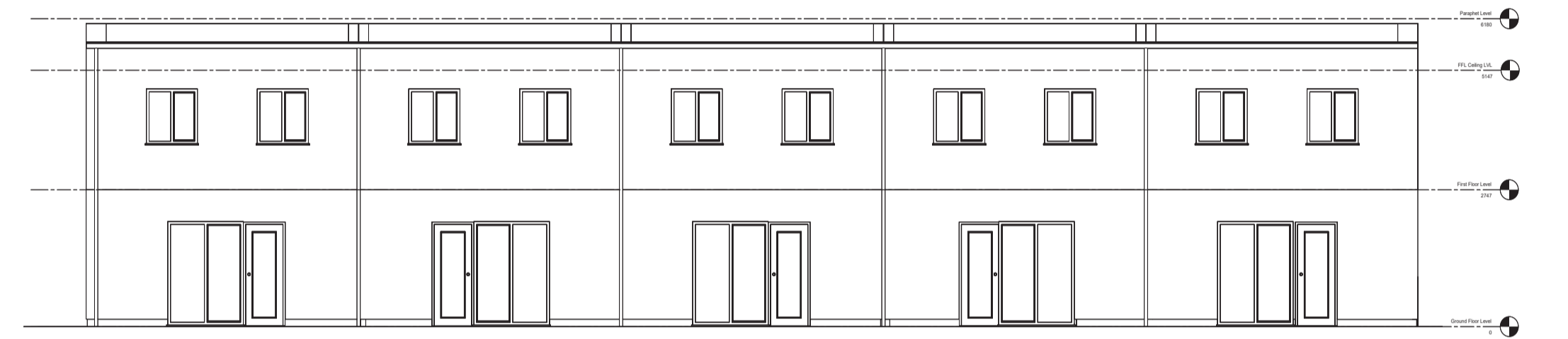
Window Head/Cill Detail



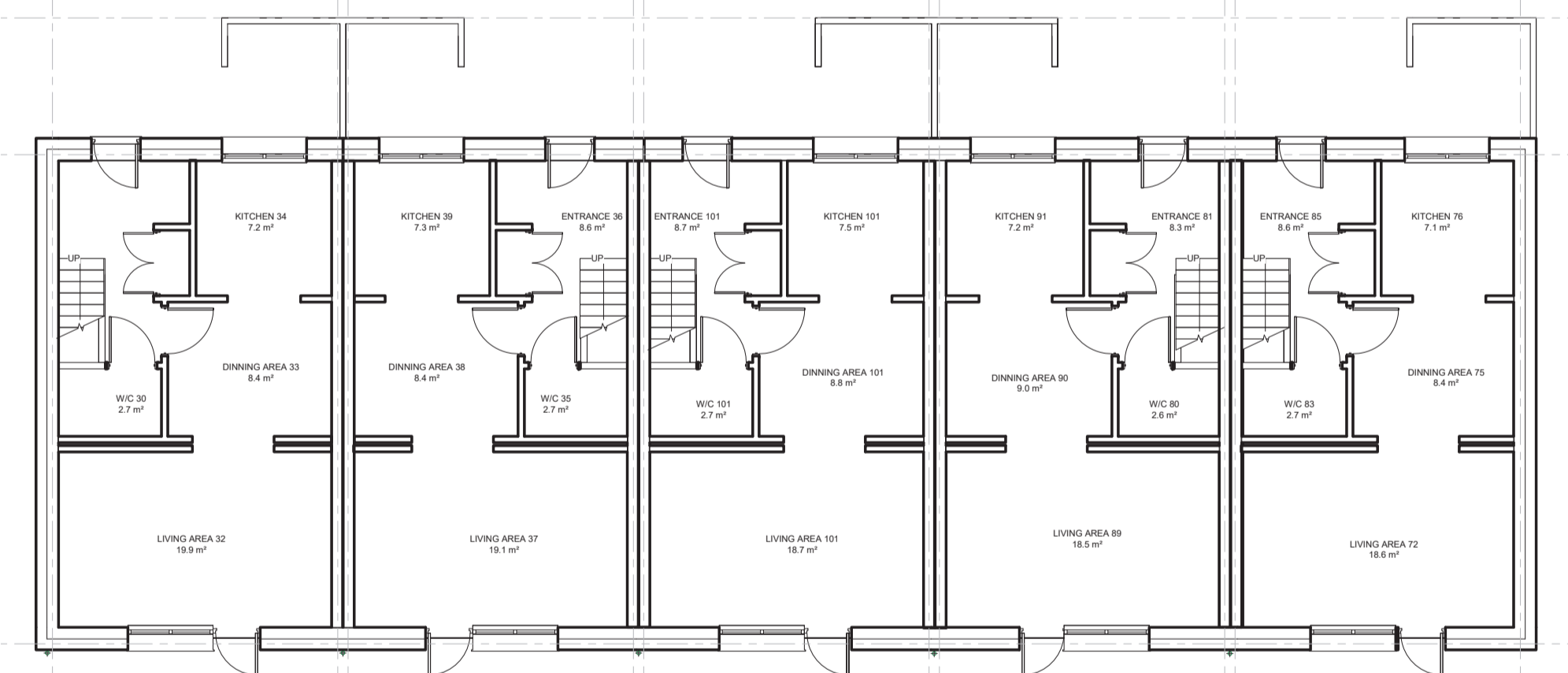
Door Threshold Detail



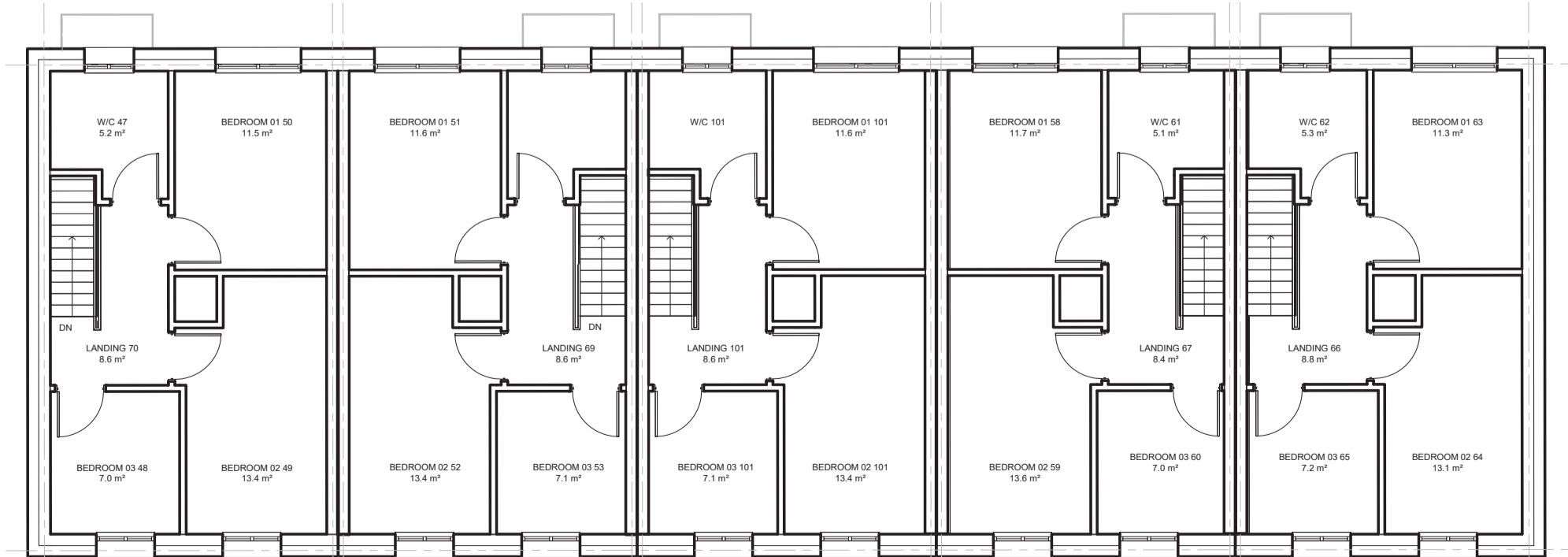
Front Elevation



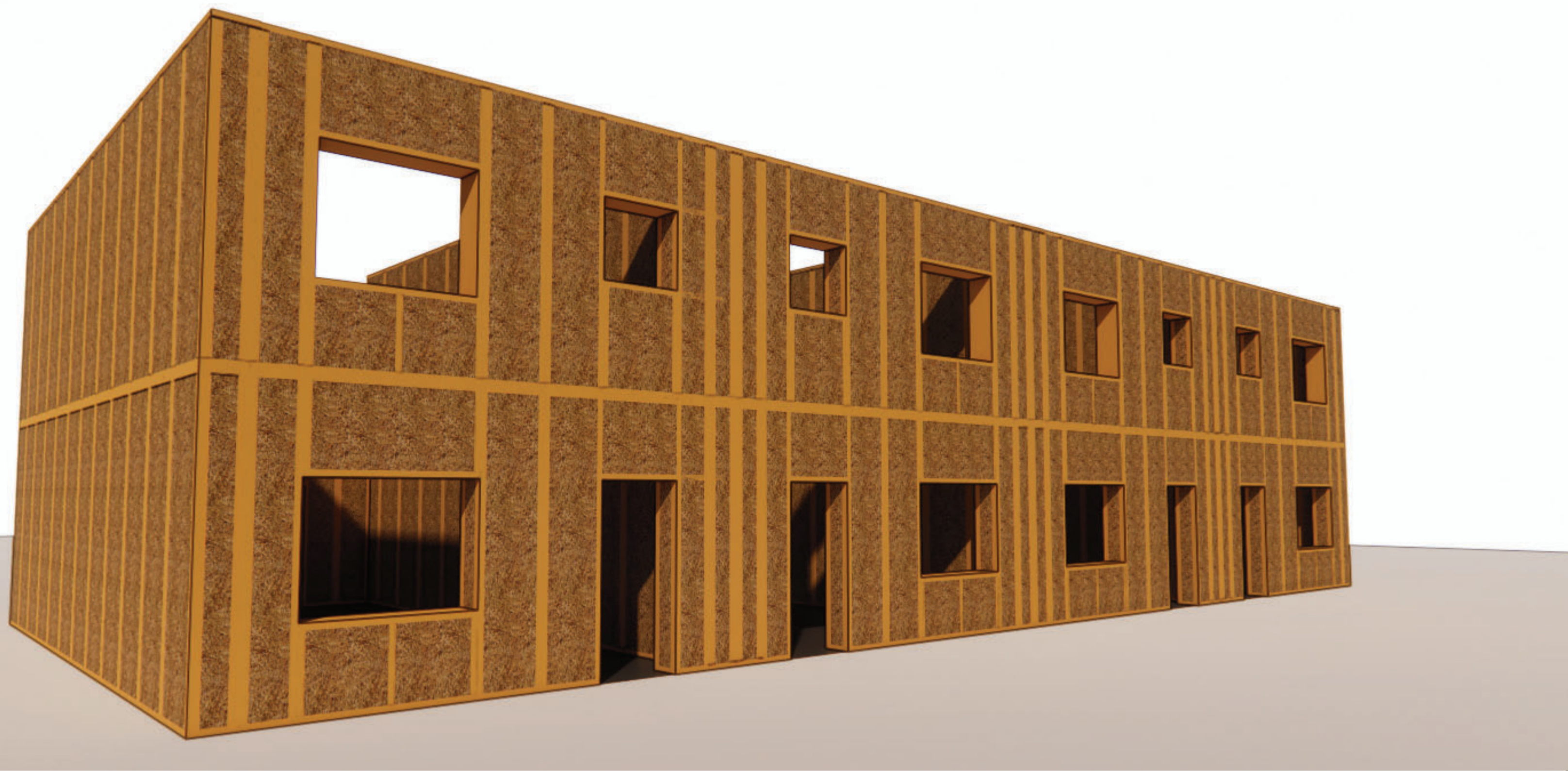
Rear Elevation



Ground Floor Plan



First Floor Plan



# Straw Proposal

## Prefabricated straw panel 'EcoCocon'

### Project Overview

Location: Moyola Court, Churchtown, Dublin 14  
 Architects: DLRCOCO, A2 Architects  
 Proposed: The development of 12 social and affordable housing units split between two terraces

### Why Prefabricated Straw Panels

The product 'EcoCocon' was used for this proposal due to their low embodied carbon coupled with high thermal performance. EcoCocon acts as both the structure and insulation for a building allowing a rapid construction process to take place. The product is considered the future for straw construction by many professionals.

### What are the challenges to prefabricated straw

The biggest risk to any straw based material is moisture exposure. However another difficulty that needs to be addressed before being used is the increased wall thickness. Each EcoCocon panel is 400mm thick with an extra 200mm needed for woodfibre and cladding in an Irish context. This drastically increases wall thickness when compared to traditional construction methods. In the redesigned model the wall thickness was increased by 150mm. This expanded the buildings footprint by **4.3%**

### External Wall Build Up

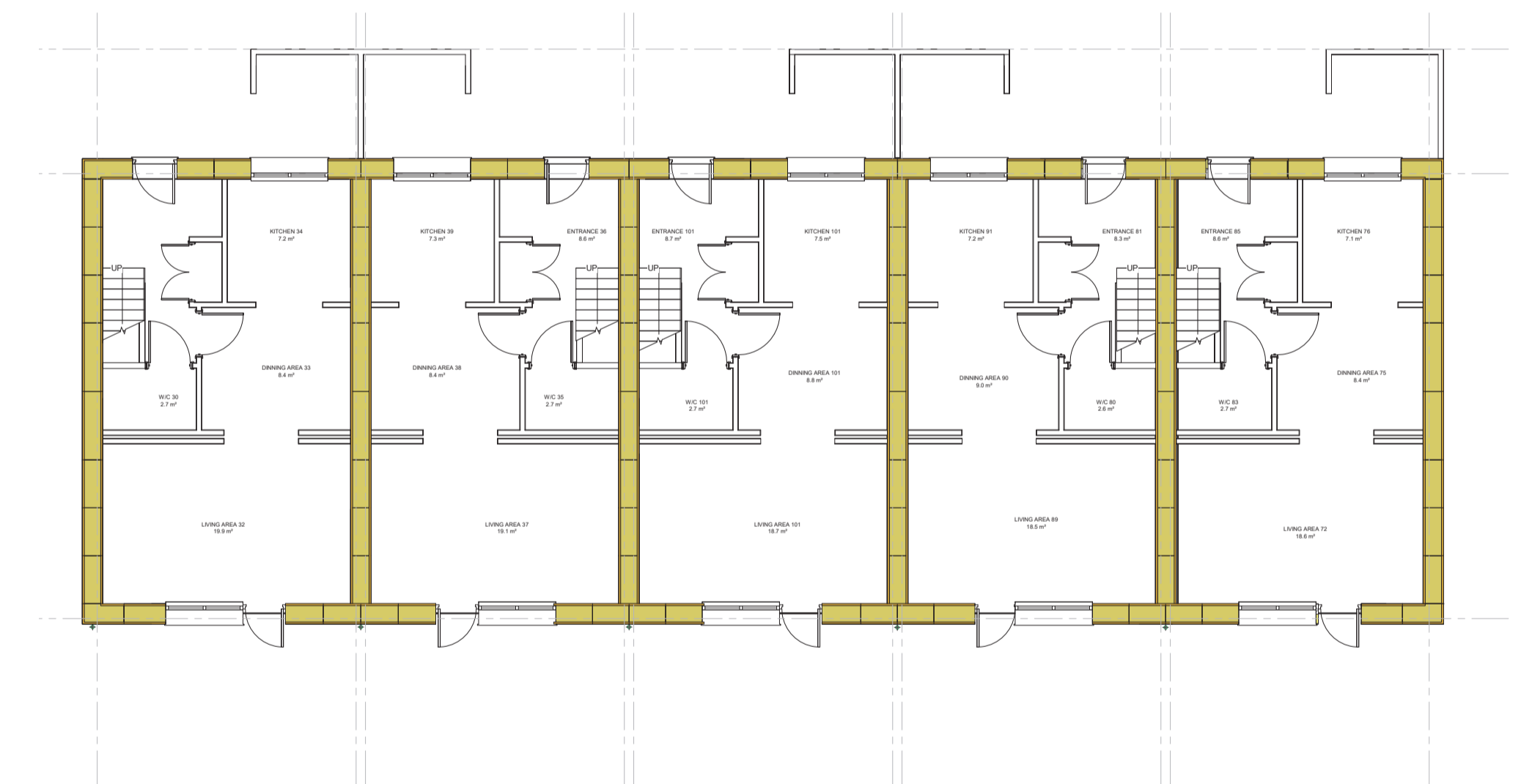
15mm lime render, 200mm woodfibre insulation  
 400mm timber & straw EcoCocon panel 12.5 plasterboard,



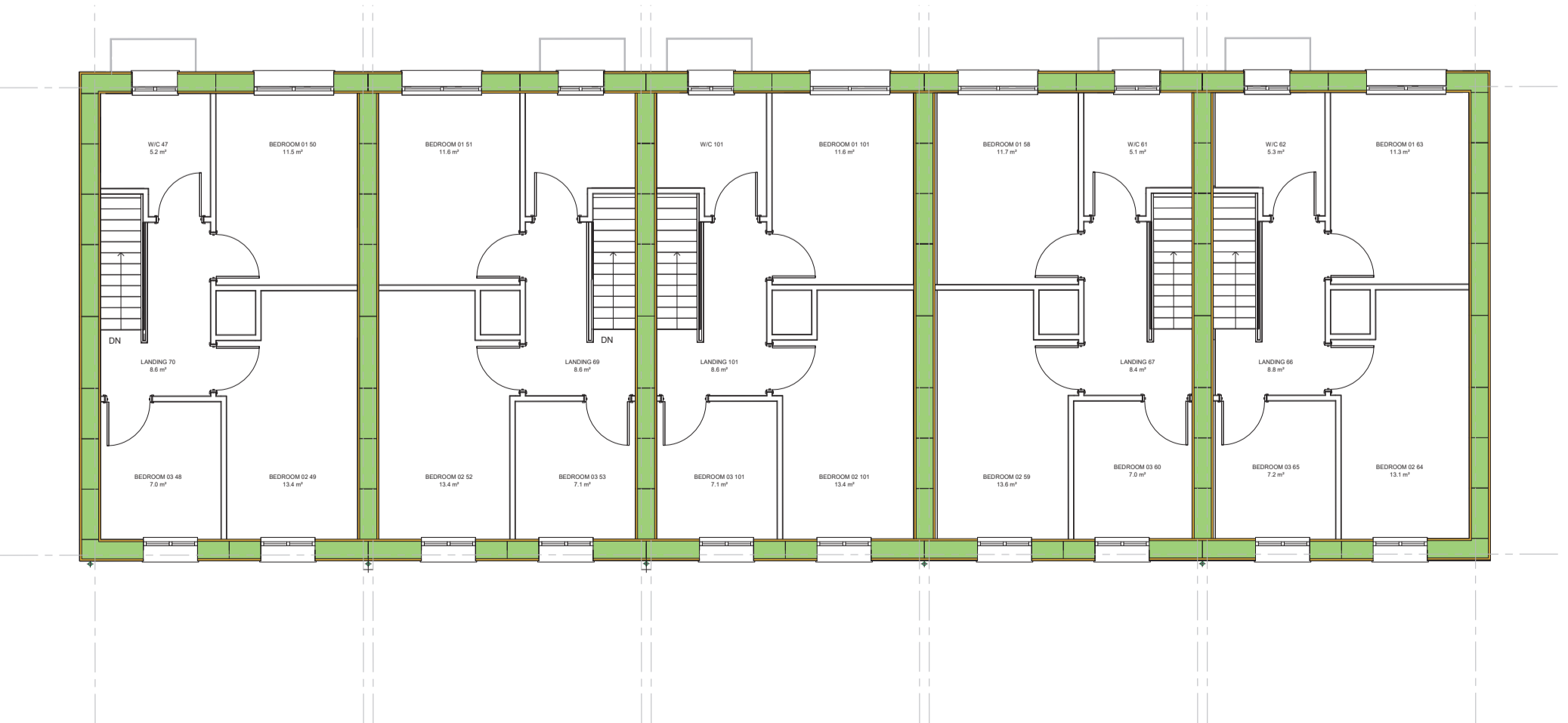
Front Elevation



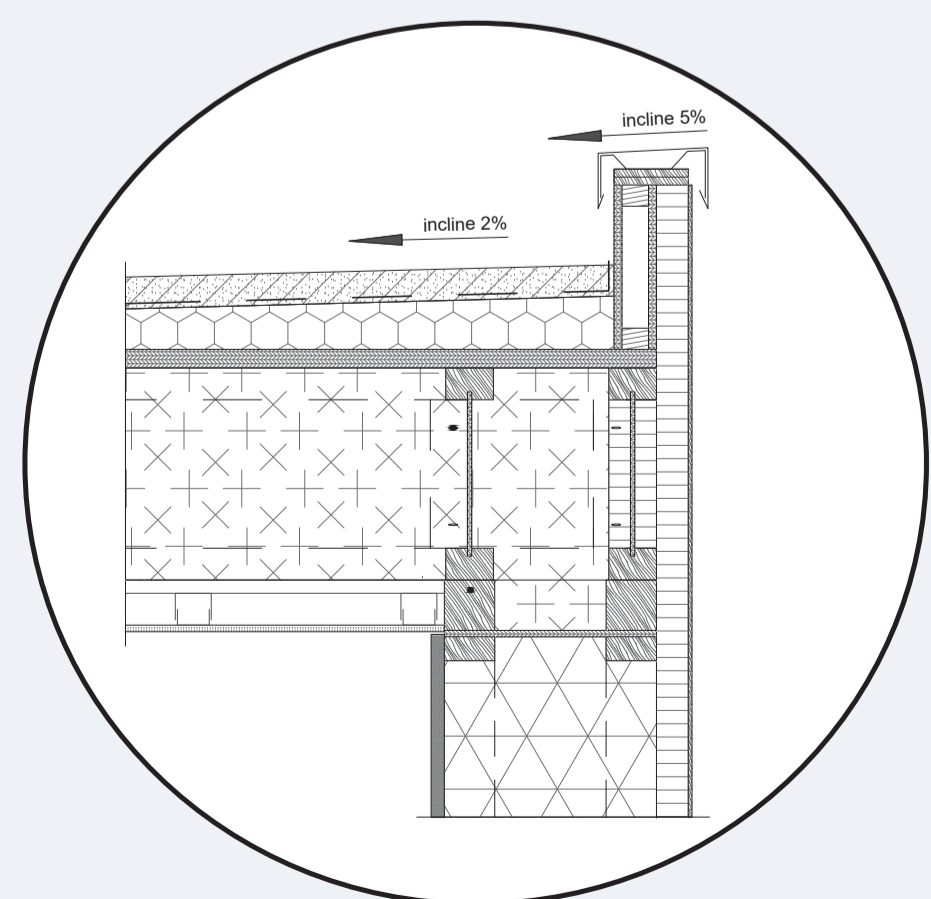
Rear Elevation



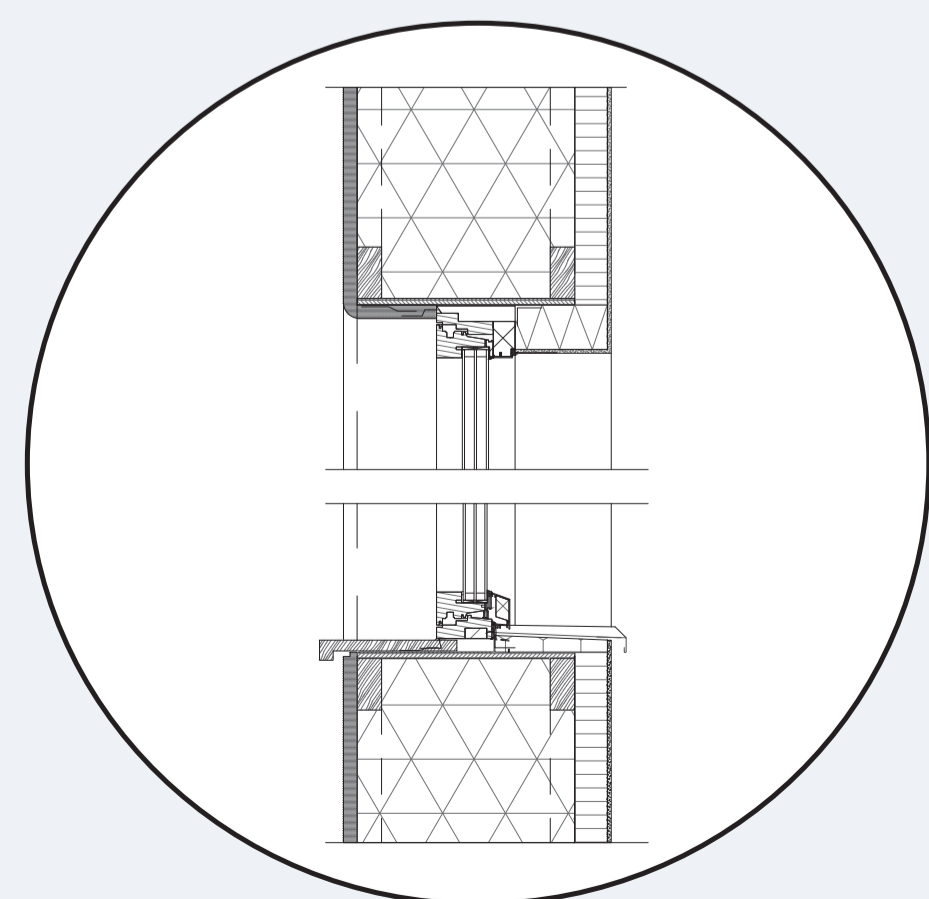
Ground Floor Plan



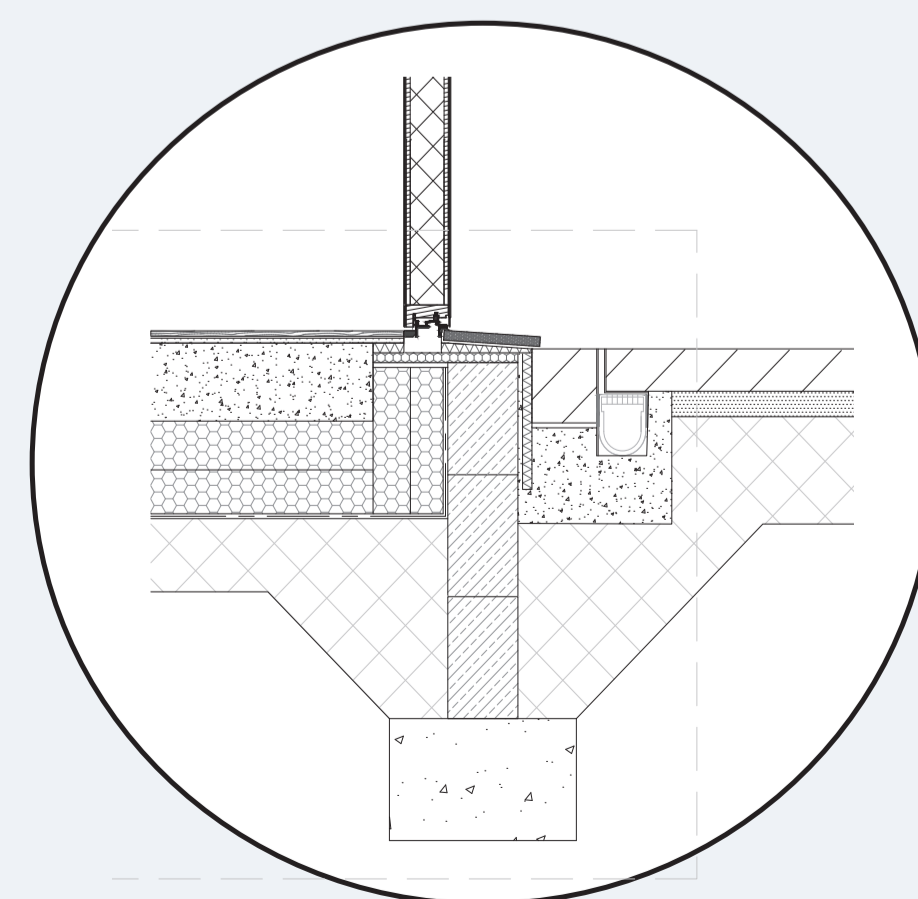
First Floor Plan



Parapet Detail



Window Head/Cill Detail



Door Threshold Detail

# Thermal Testing

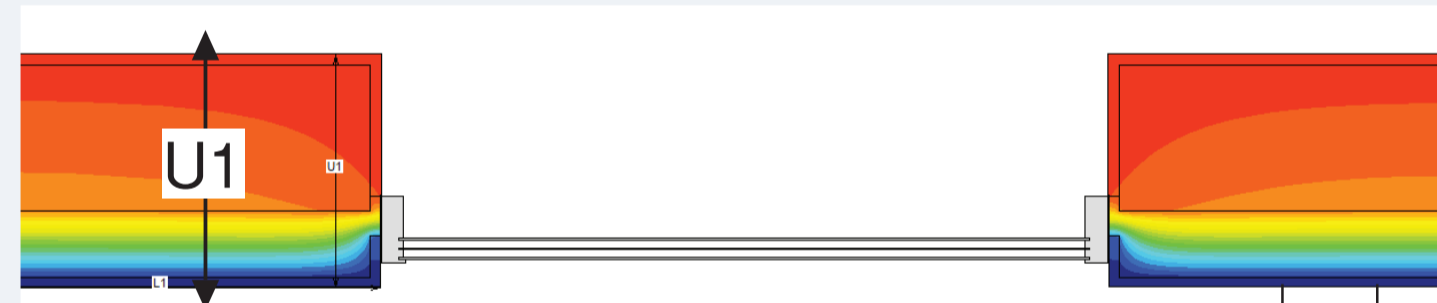
## Conventional

### Build Desk U Results

Element	Thickness (mm)	R-Value (W/m <sup>2</sup> K)
Rse		0.04
Render. Cement & Sand	15	0.015
Kingspan Aerowall	200	6.451
Concrete Block	215	0.177
Gypsum Plasterboard	12	0.048
Rsi		0.13
Total		6.86m <sup>2</sup> K/W
U-Value		<b>0.15 W/(m<sup>2</sup>K)</b>



Conventional window jamb



### TRISCO Results

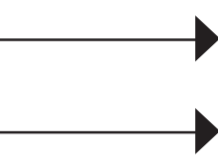
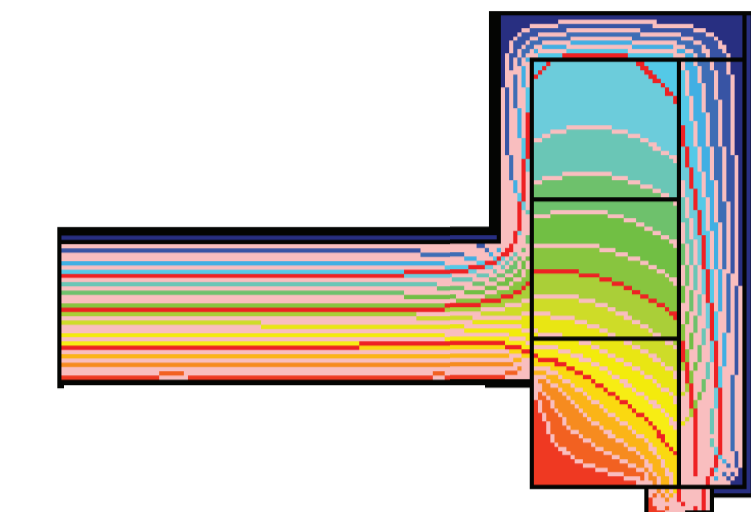
Length	0.997 m
Width	523.5mm
U Value	0.15 W/(m <sup>2</sup> K)
Psi-Value	0.08 W/(m.K)
fRsi-Value	0.952

### Regulation Compliance

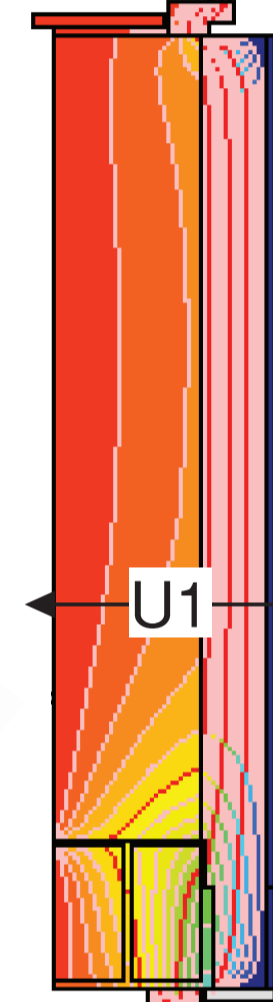


Mould growth and surface condensation: fRsi greater than or equal to **0.75**

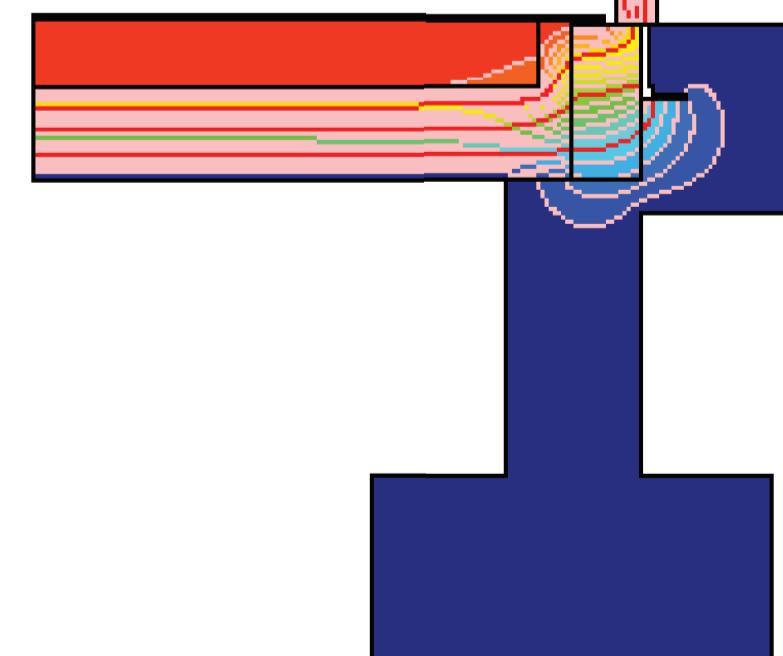
PSI value requirement to comply with TGD Part L External Insulation Jamb **0.088 W/(m.K)**



20°C



0°C

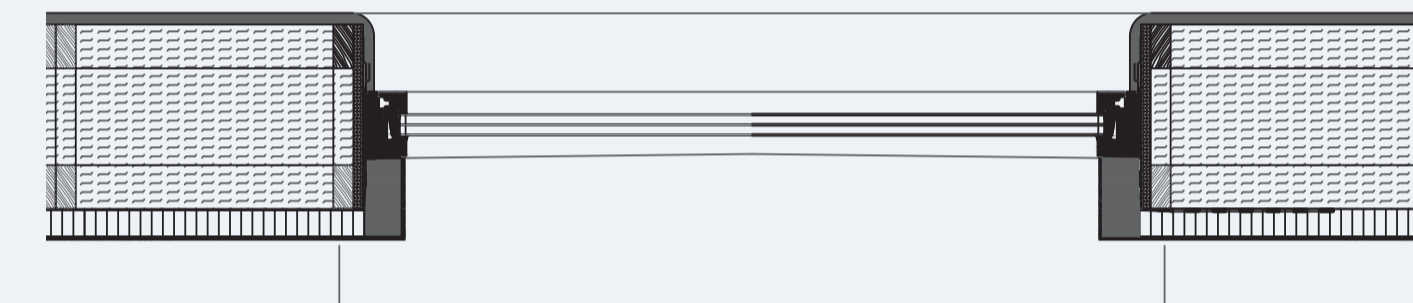


1:20 Section

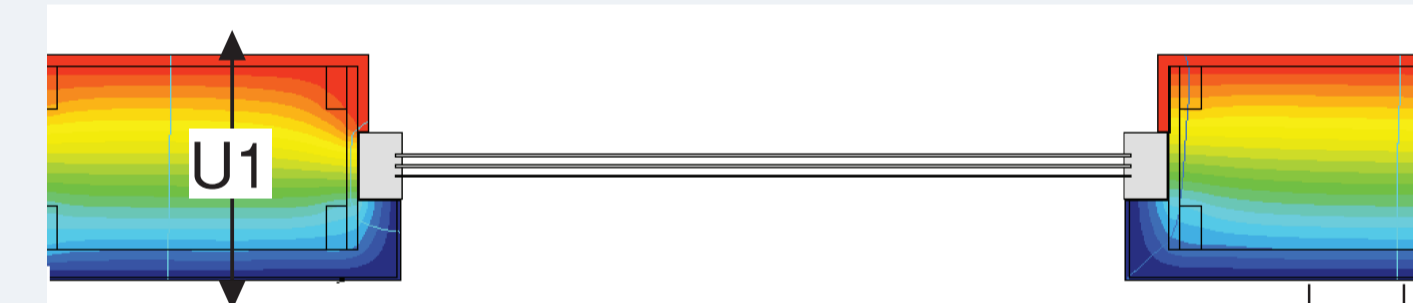
## Straw Panel

### Build Desk U Results

Element	Thickness (mm)	R-Value (W/m <sup>2</sup> K)
Rse		0.04
Render. Cement & Sand	15	0.015
Wood Fibreboard	100	1
Straw Panel	400	0.064
Gypsum Plasterboard	12	0.048
Rsi		0.13
Total		7.51m <sup>2</sup> K/W
U-Value		<b>0.13 W/(m<sup>2</sup>K)</b>



Straw window jamb



### TRISCO Results

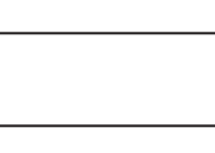
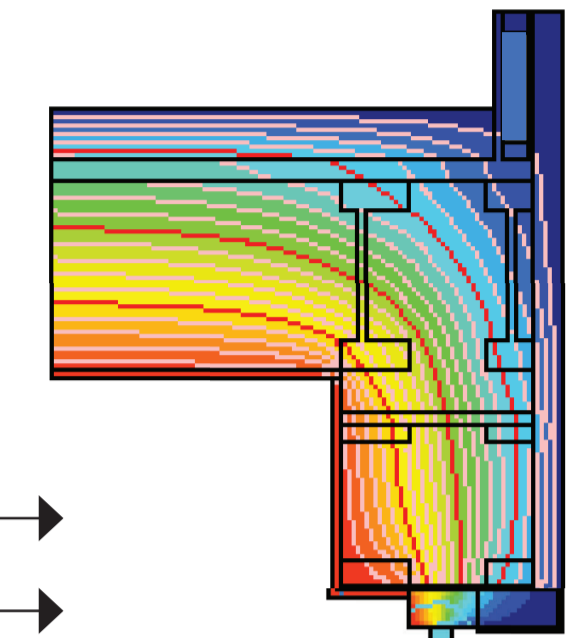
Length	1.289 m
Width	450mm
U Value	0.13 W/(m <sup>2</sup> K)
Psi-Value	0.072 W/(m.K)
fRsi-Value	0.963

### Regulations

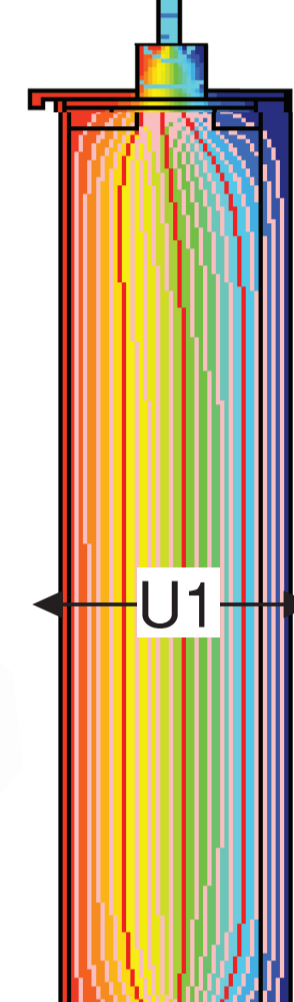


Mould growth and surface condensation: fRsi greater than or equal to **0.75**

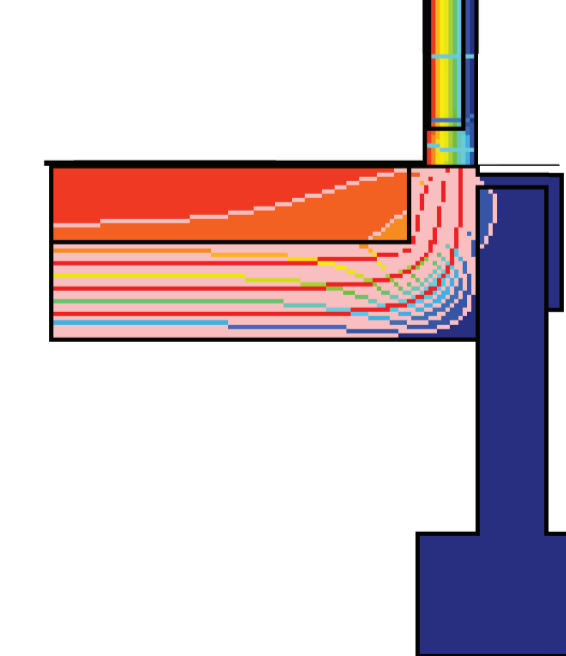
PSI value requirement to comply with TGD Part L Timber frame jamb ope **0.080 W/(m.K)**



20°C



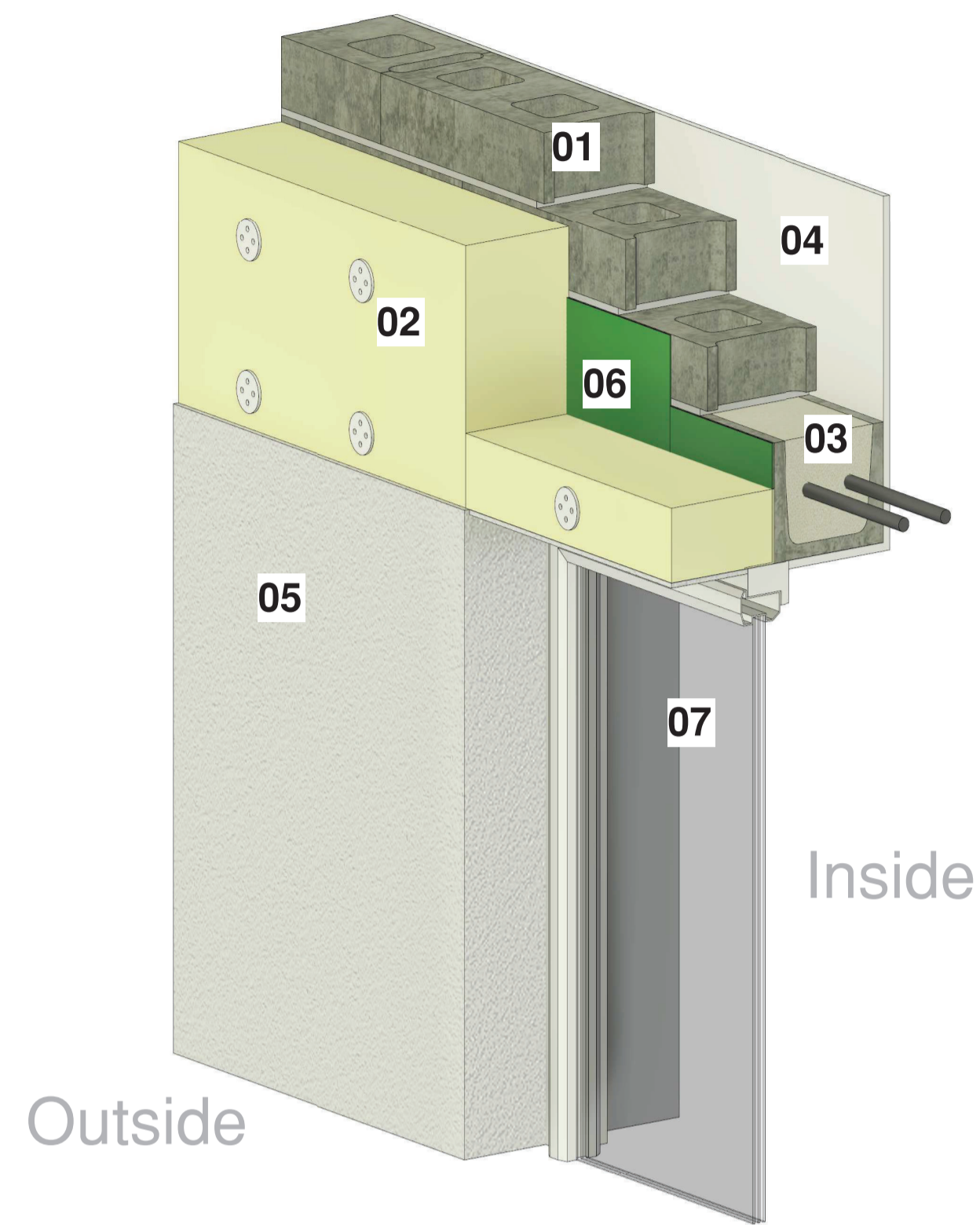
0°C



1:20 Section

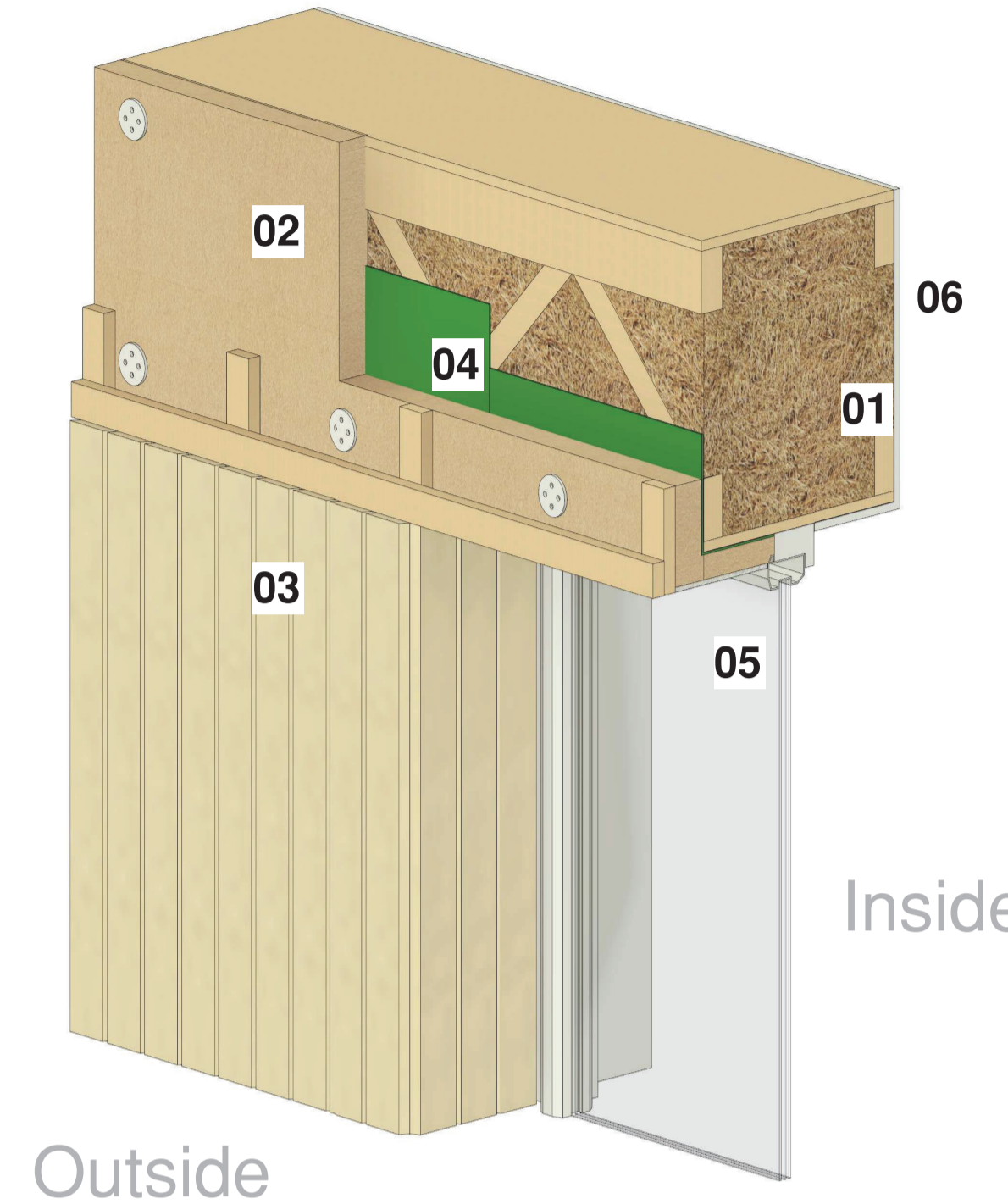
# Hygrothermal Testing

## Conventional



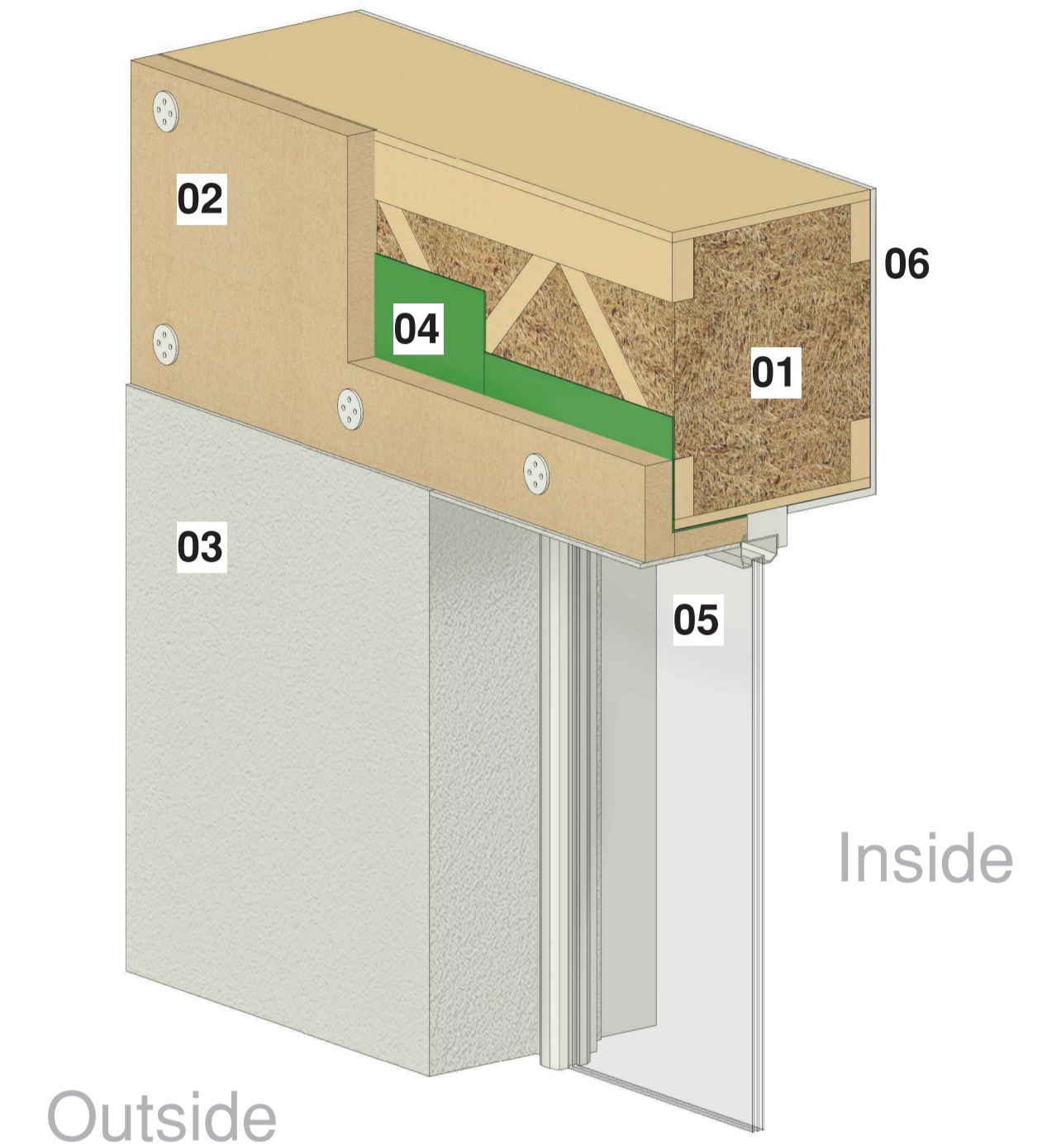
- 01 - Concrete Block
- 02 - EPS Insulation
- 03 - Concrete Lintel
- 04 - Plaster Board
- 05 - Render
- 06 - DPC
- 07 - Window

## Straw Panel Cladding



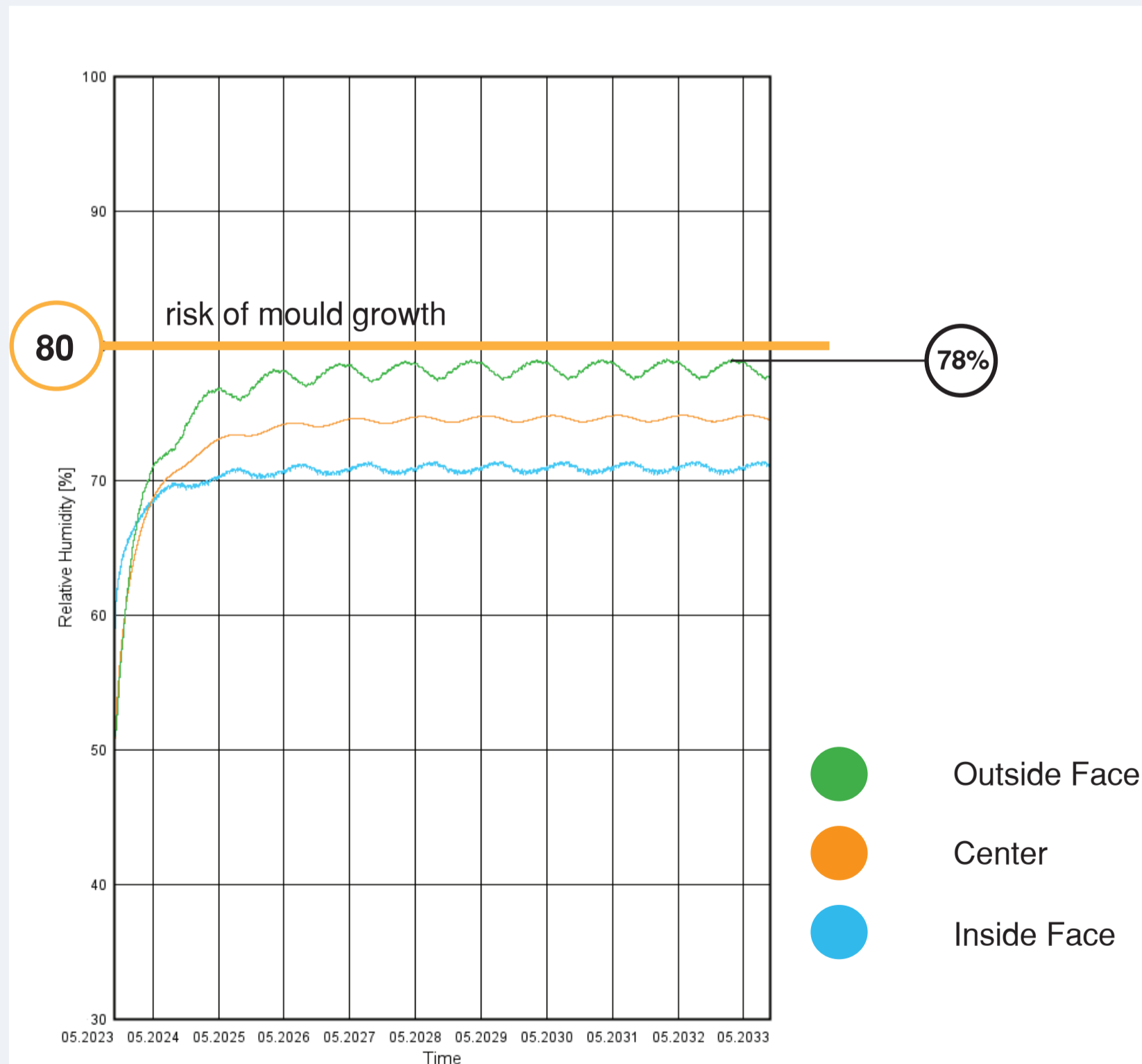
- 01 - EcoCocon Panel
- 02 - Wood Fibre Board
- 03 - Timber Cladding
- 04 - Breather Membrane
- 05 - Window
- 06 - Plasterboard
- 07 - Window

## Straw Panel Render



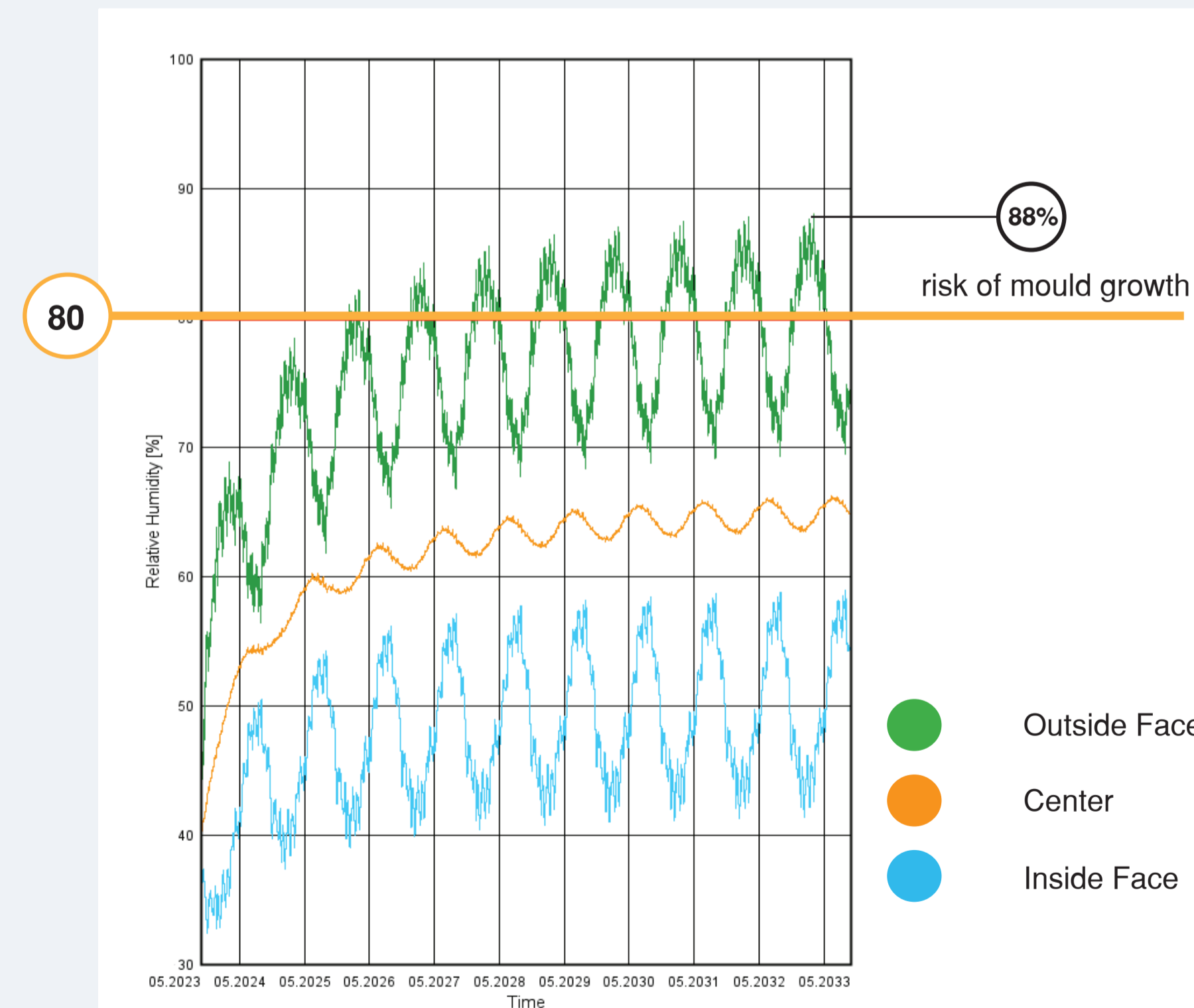
- 01 - Concrete Block
- 02 - EPS Insulation
- 03 - Concrete Lintel
- 04 - Plaster Board
- 05 - Render
- 06 - DPC
- 07 - Window

### Relative Humidity of Concrete



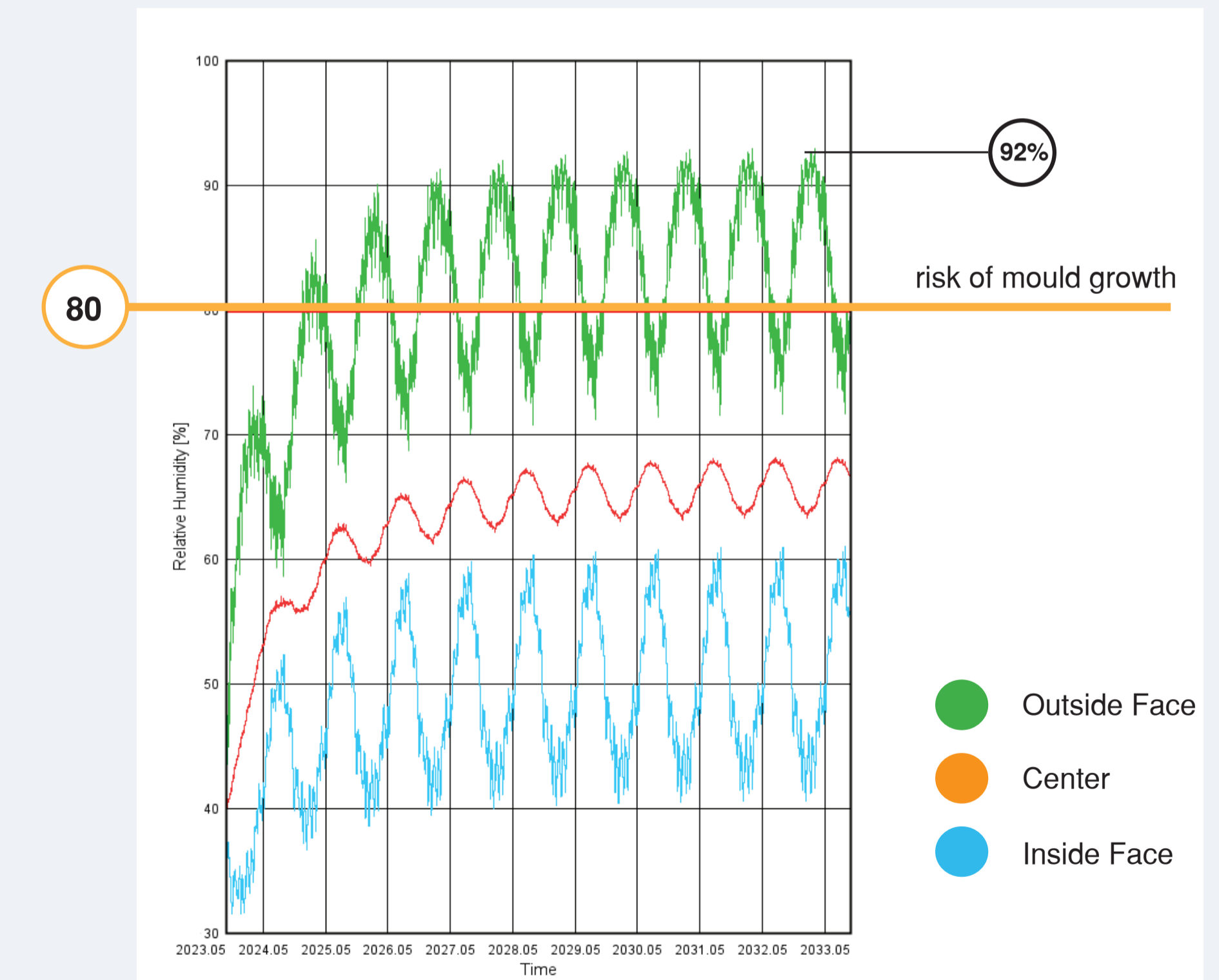
- The concrete structure reaches a maximum relative humidity of **78%** in its outer face.
- This is **2%** less than the threshold for the risk of mould growth. No significant drying process takes place

### Relative Humidity of Straw with cladding



- The concrete structure reaches a maximum relative humidity of **88%** in its outer face.
- Within 6 months this material dries by **18%** being reduced to **70%** RH which causes no risk of mold

### Relative Humidity of straw with render



- The concrete structure reaches a maximum relative humidity of **92%** in its outer face.
- Within 6 months this material dries by **12%** being reduced to **78%** RH which causes no risk of mold

# Life Cycle Assessment

## Straw Panel Construction



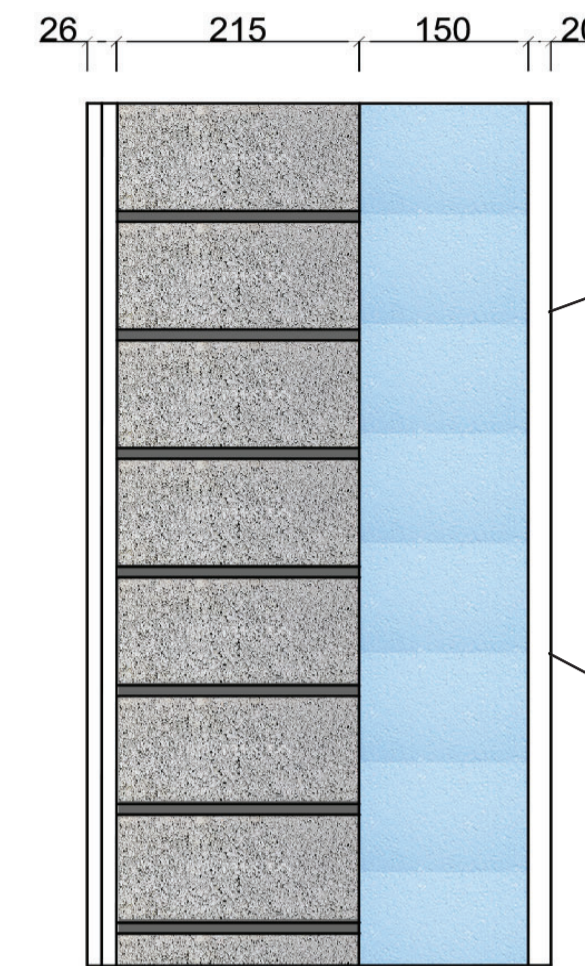
U-Value = 0.13 W/m²K

BER A2



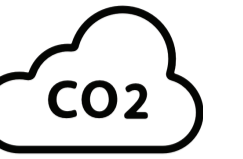
The Eco Cocon Straw Panel is a straw insulated wall panel, which always has a depth of 40cm. The exact dimensions of the EcoCocon panels vary. This EPD is based on the background LCA for panel types Standard and Braced. The panel types Inclined, Sill, Lintel and Column are not included. The product consists of a wooden frame with strawfilling. The wall panels serve as constructive and insulating elements.

## Conventional Construction



U-Value = 0.15 W/m²K

BER A3



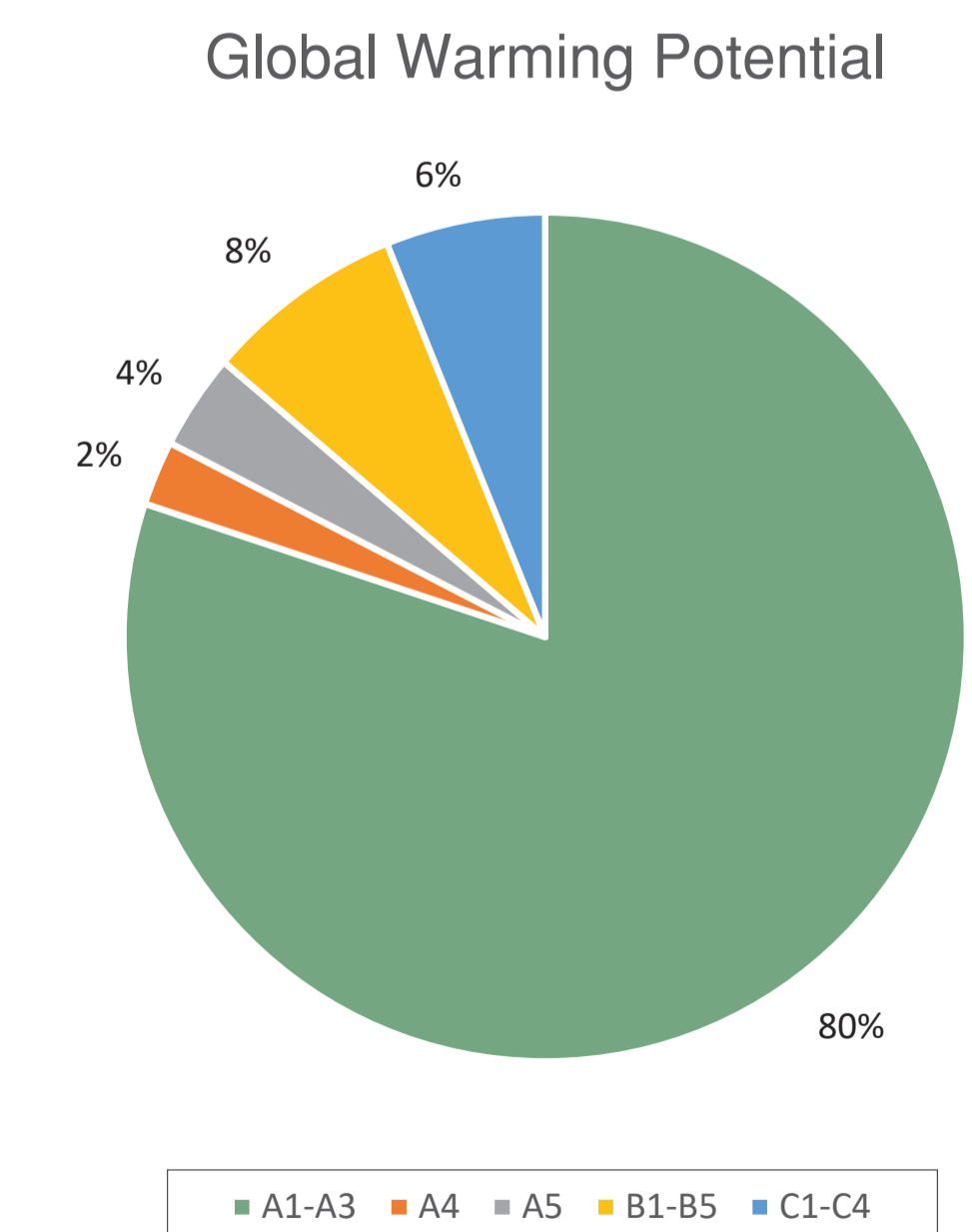
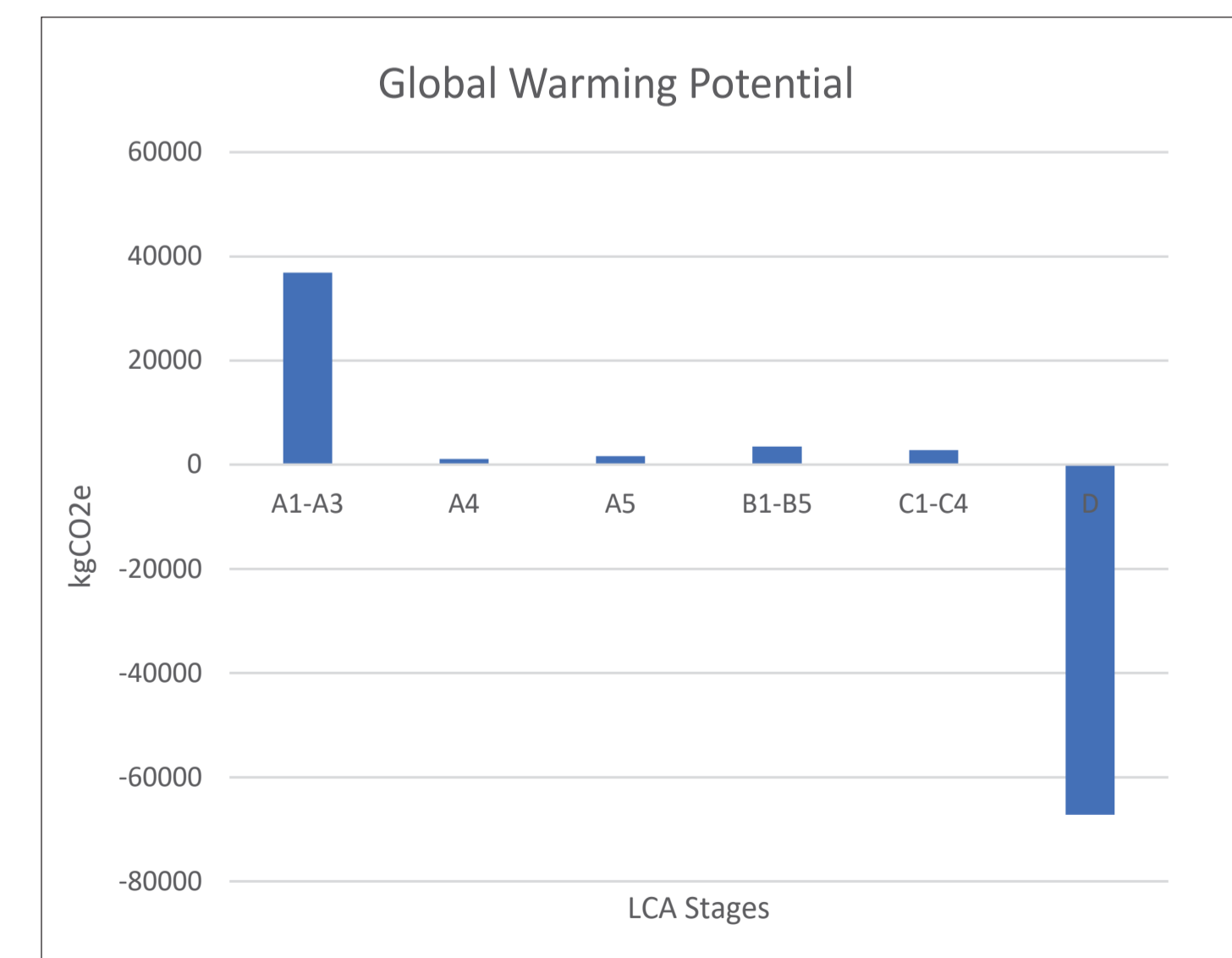
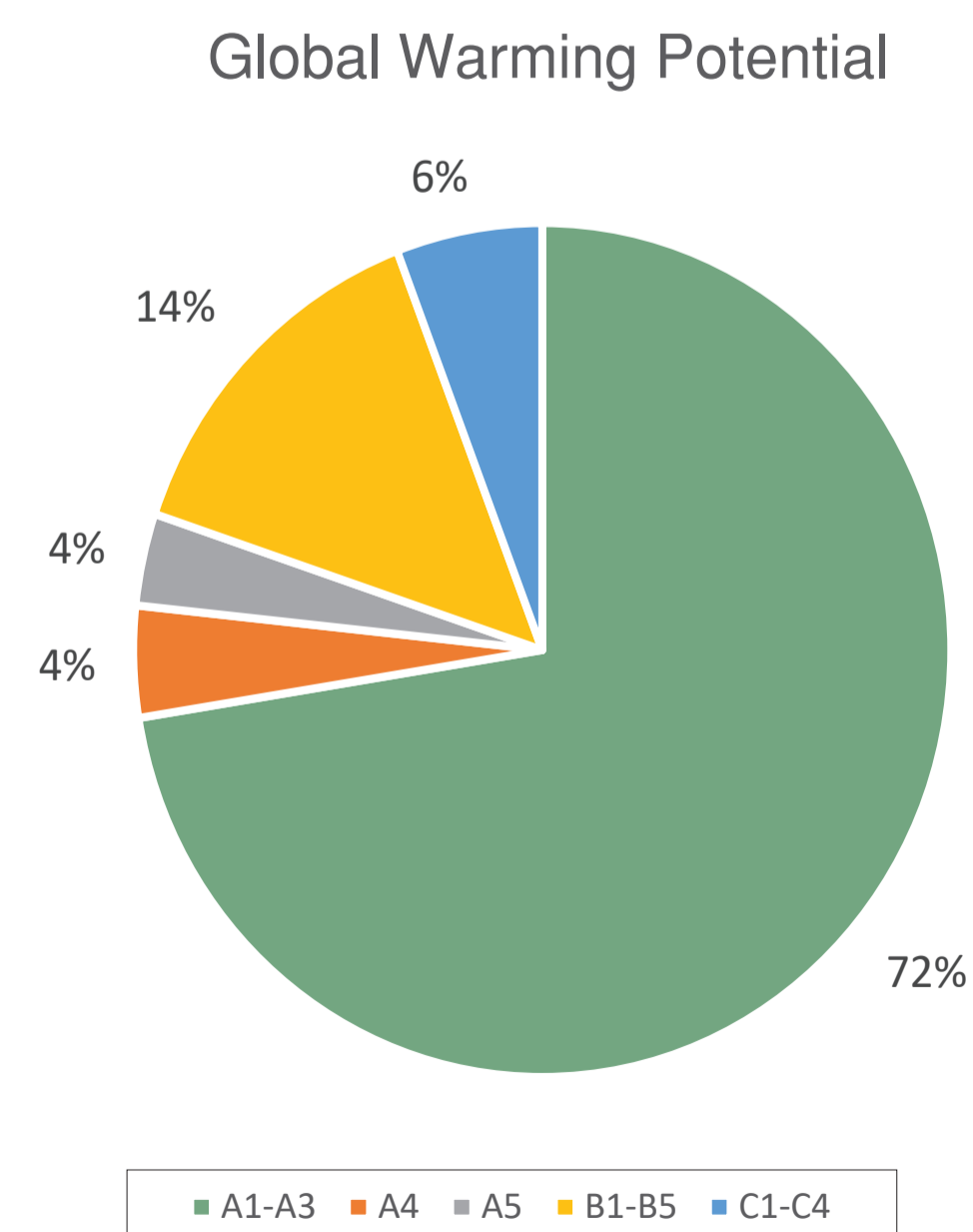
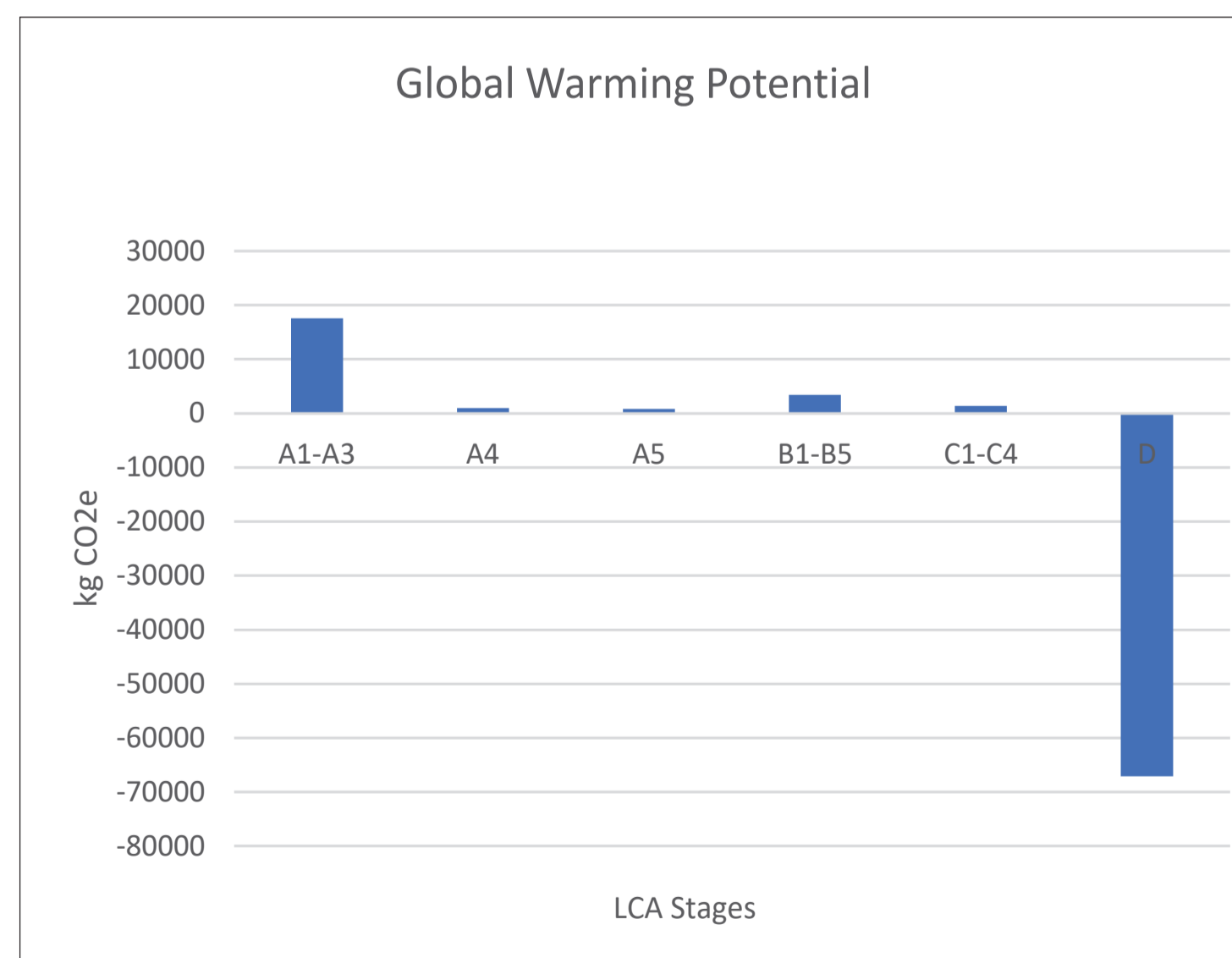
Kingspan Kooltherm K5 is a rigid thermoset cellular insulation material faced on both sides with a glass tissue based facing. The product is available in variable thicknesses from 20mm up to 200mm. This LCA covers one of the most commonly sold thickness of 150mm with an RD-value of 4,75 m²K/W. Due to its high insulating value the Kooltherm K5 is suitable for use as external thermal insulation.

### Embodied Carbon Results: Cradle to Gate (Without B6)

LCA	Product Stage	Construction Stage		Usage Stage	End of Life Stage	Repurpose Stage
	A1 - A3	A4	A5	B1 - B5	C1 - C4	D
<b>GWP</b>	<b>17566.06</b>	<b>511.34</b>	<b>847.26</b>	<b>847.26</b>	<b>3408.75</b>	<b>-67049.30</b>
<b>Total</b>	23,180 kgCO <sub>2</sub> e		Note: Does not include sequestered carbon			

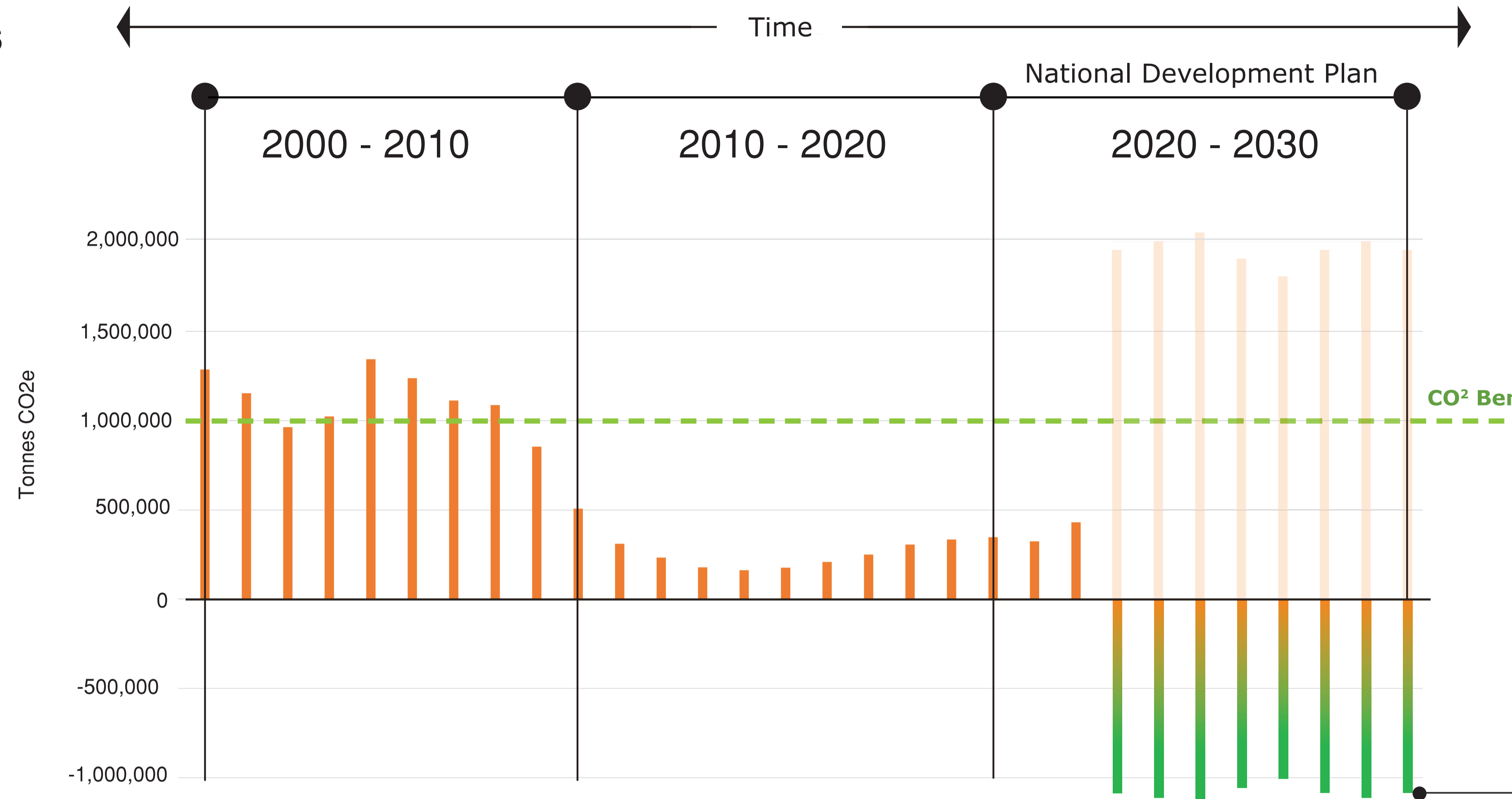
### Embodied Carbon Results: Cradle to Gate (Without B6)

LCA	Product Stage	Construction Stage		Usage Stage	End of Life Stage	Repurpose Stage
	A1 - A3	A4	A5	B1 - B5	C1 - C4	D
<b>GWP</b>	<b>36855.23</b>	<b>1136.50</b>	<b>1683.47</b>	<b>3527.81</b>	<b>5635.96</b>	<b>-2455.52</b>
<b>Total</b>	48,838.97 kgCO <sub>2</sub> e		Note: Does not include sequestered carbon			



# Future Emissions

## Using Straw Panels

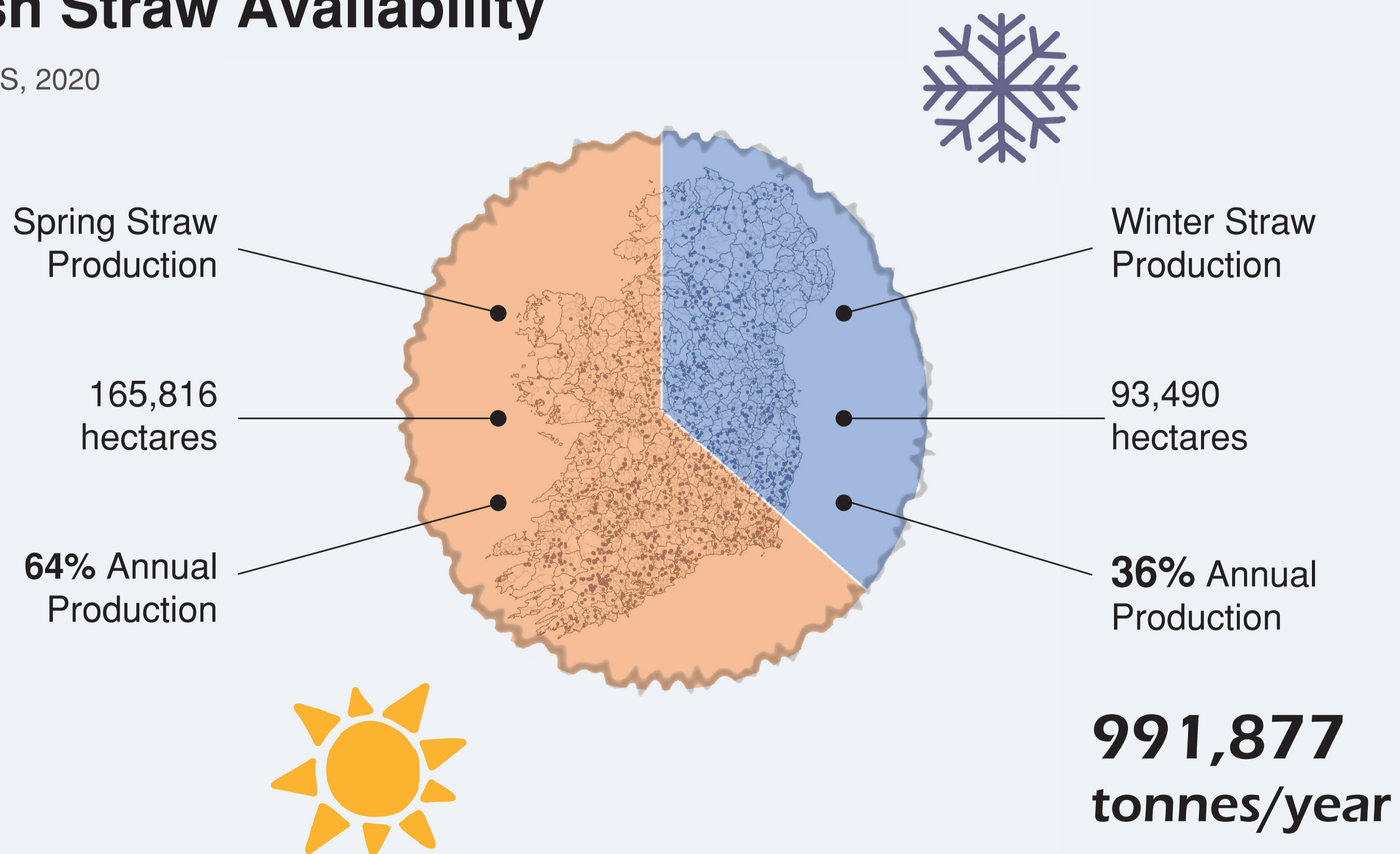


Reduction of  
**1,000,000 tonnes**  
of CO<sub>2</sub> emissions per annum

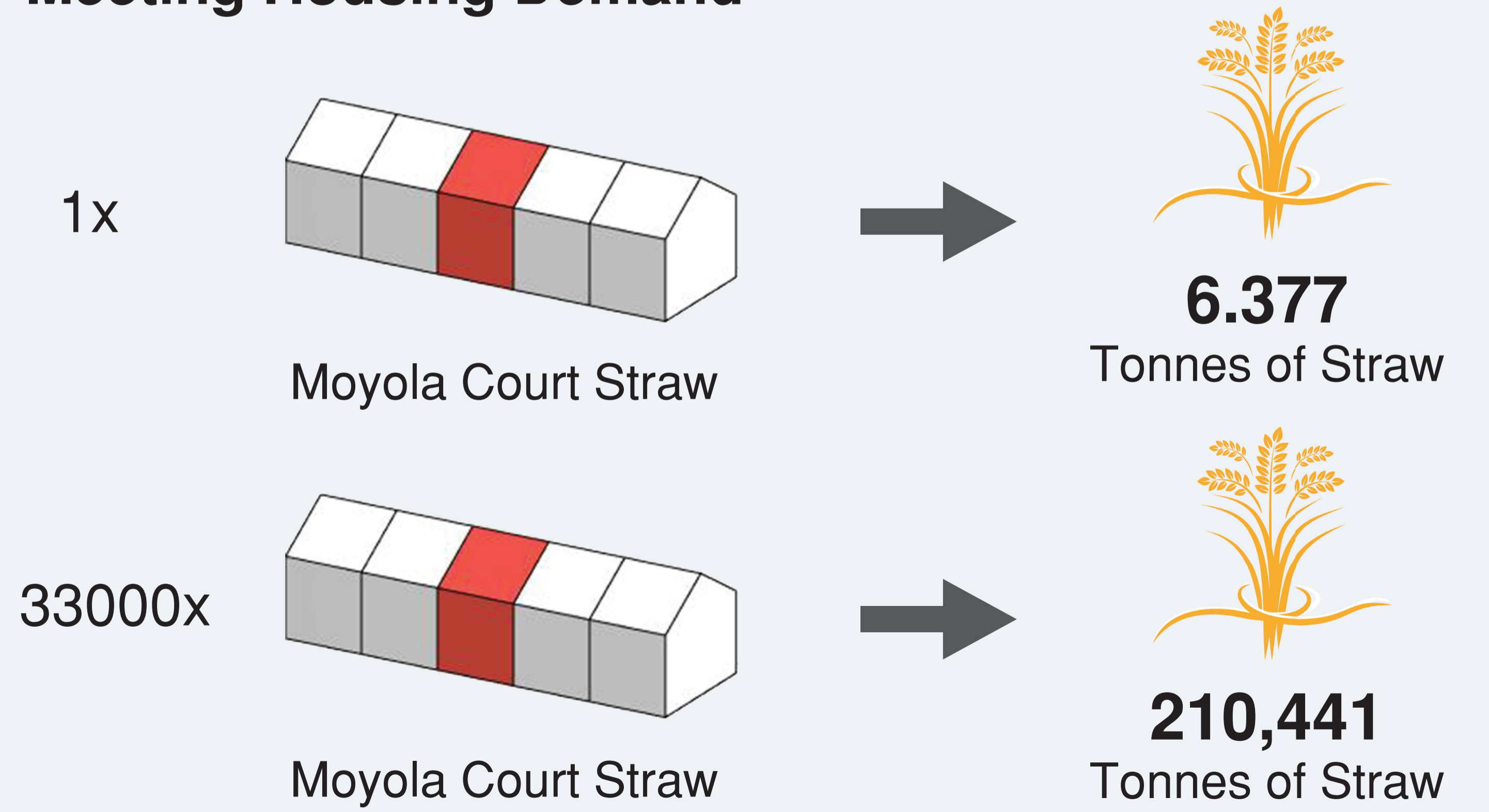
Equals the CO<sub>2</sub> produced by  
**217,000 Cars**  
per annum

## Irish Straw Availability

TEGAS, 2020



## Meeting Housing Demand

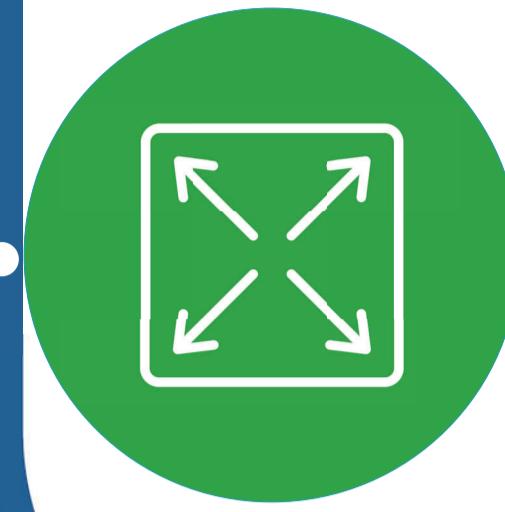




# Key Findings

## Investigation of Straw Panel

4.2% Increase in building footprint from conventional construction to straw proposal



Use a case study building of social housing

The proposed pre-fabricated straw panel construction has a U-value of **0.13W/m2K** PSI of **0.072 W/(m.K)** a fRsi value of **0.963**



Test both proposals for their thermal properties

The existing construction has a U-value of **0.15W/m2K** PSI of **0.164 W/(m.K)** a fRsi value of **0.95**

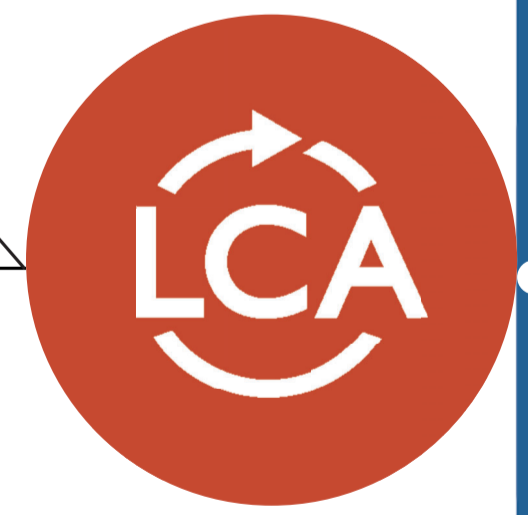


Test both proposals for their hygro-thermal properties

The relative humidity of the straw panel with render finish was consistently at **92%**. The cladded proposal reached **88%** but would dry to **70%** in 6 months



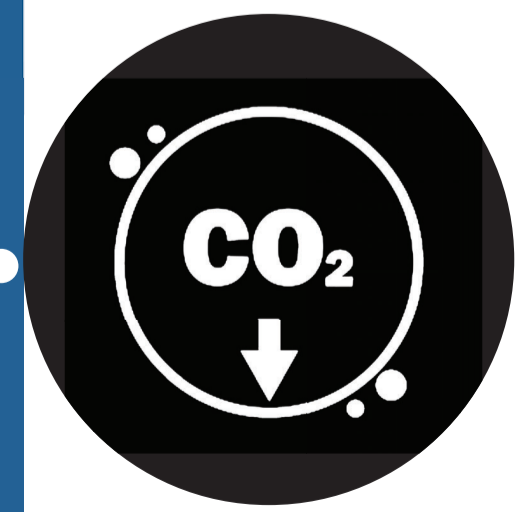
The embodied carbon of the straw proposal was **23,180 kgCO<sub>2</sub>e** which is half the conventional EC of **48,838.97 kgCO<sub>2</sub>e**



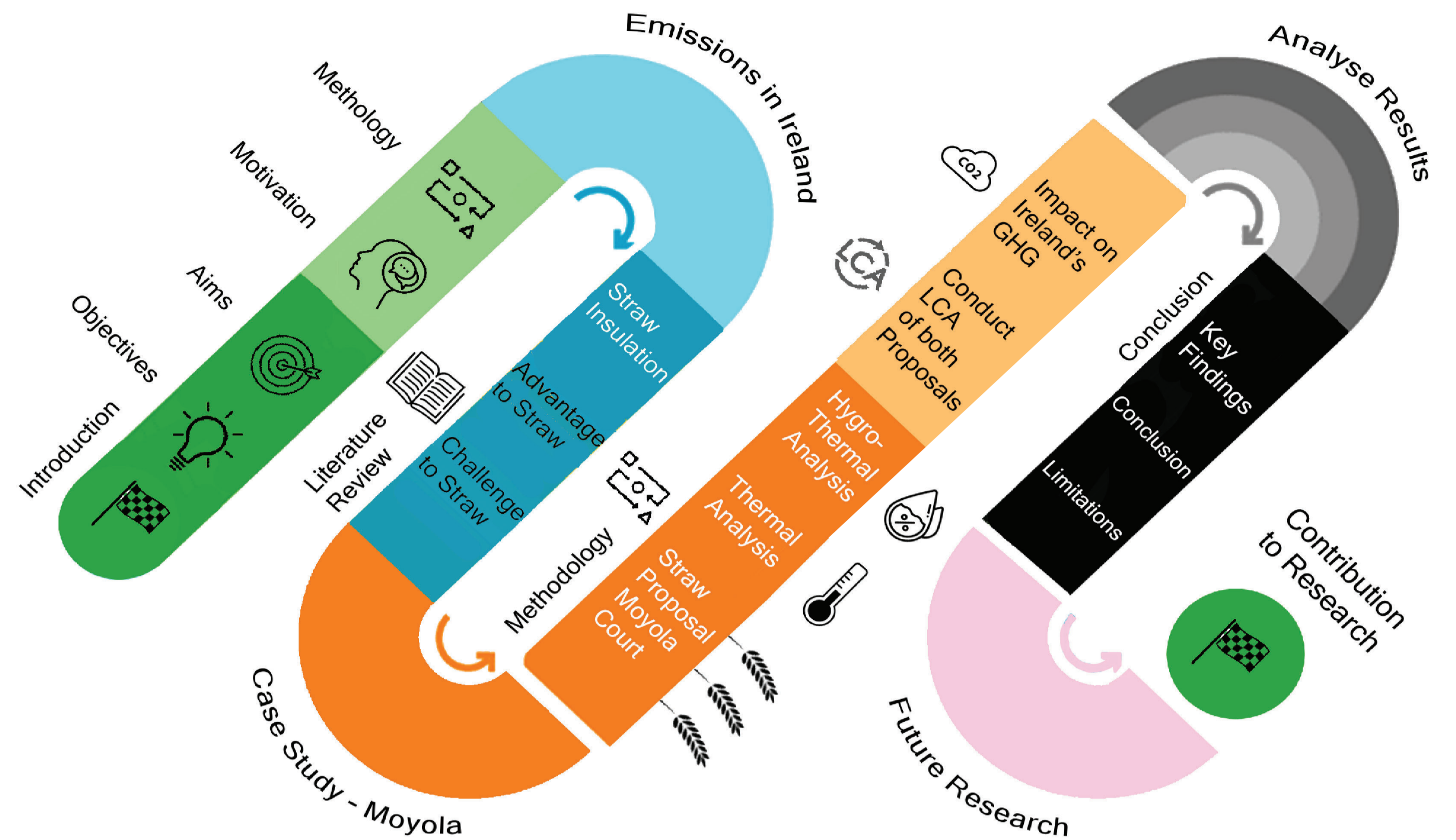
Test environmental impact of proposals

When all that is proposed in the national development plan is built with Straw construction, the year 2030 will produce **-1mtCO<sub>2</sub>e** which is a difference of **3mtCO<sub>2</sub>e** from the predicted 2030 target

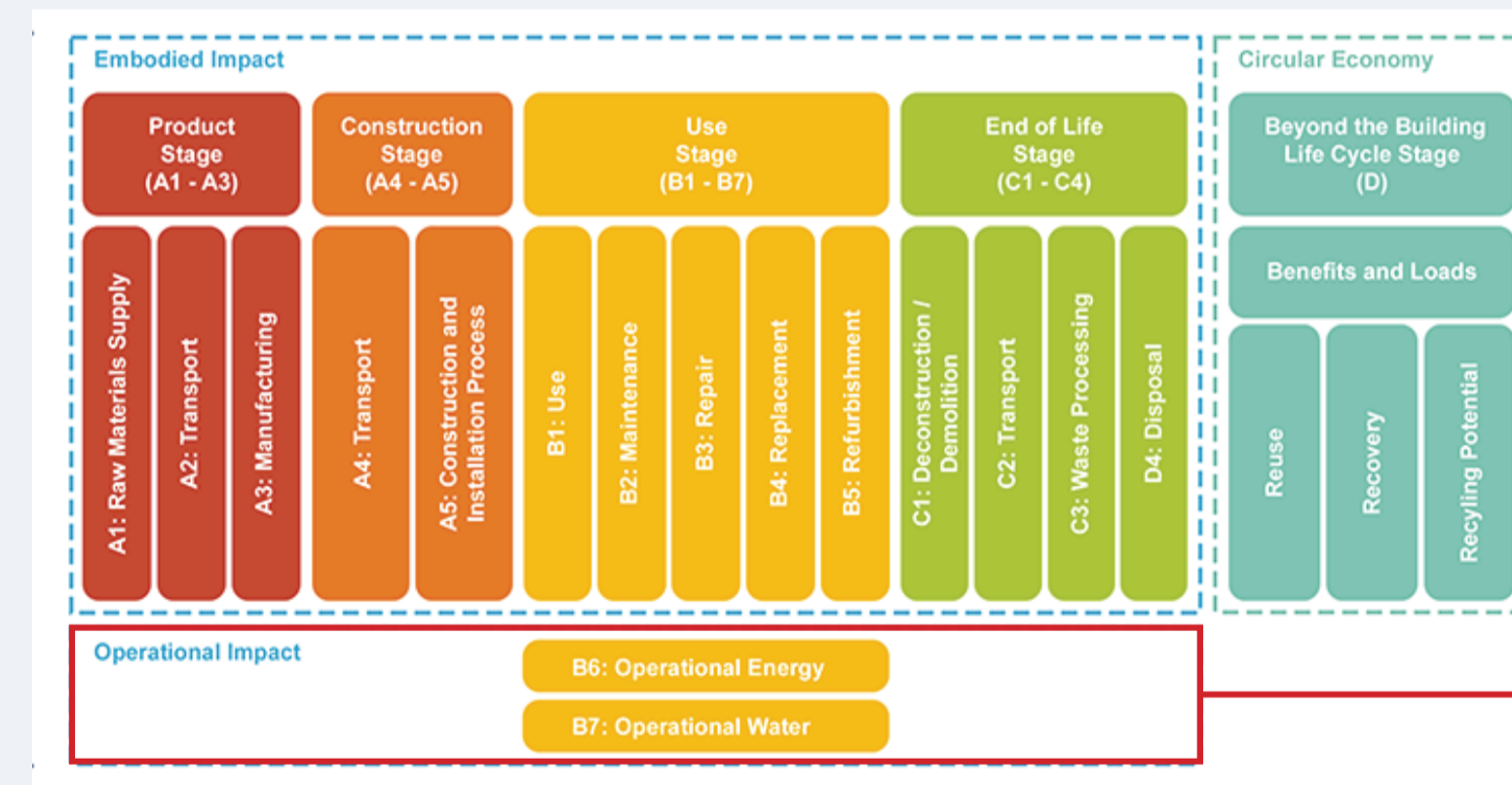
determine potential reduction in annual carbon emissions



# Conclusion



## Limitations and Future Study



### Operational Carbon

Phases B6 & B7 regarding operational energy and water were excluded from the LCA carried out in this research. Therefore operational carbon was not considered a factor and a whole carbon assessment was not conducted. Future research should be carried out to determine if using prefabricated straw panels has the potential to reduce operational carbon. This would also give further clarity regarding the impact on Ireland's annual emissions by considering both carbon emissions.

### Housing Typologies

The following research was conducted using one case study of a mid terrace residential building. To provide more strength to the results regarding prefabricated straw's ability to surpass regulations multiple housing typologies should be assessed. This is also true for the impact prefabricated straw could have on Ireland's annual emissions as the emissions for all 33,000 straw houses were assumed to be identical.



Detached  
49%



Semi-Detached  
32%

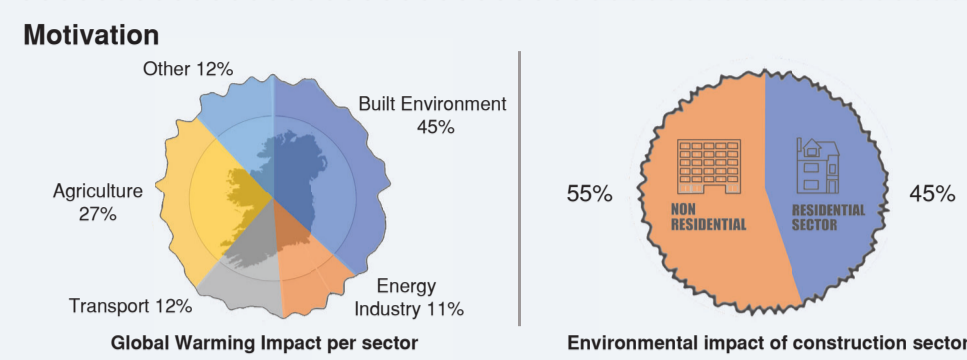


Terraced  
19%

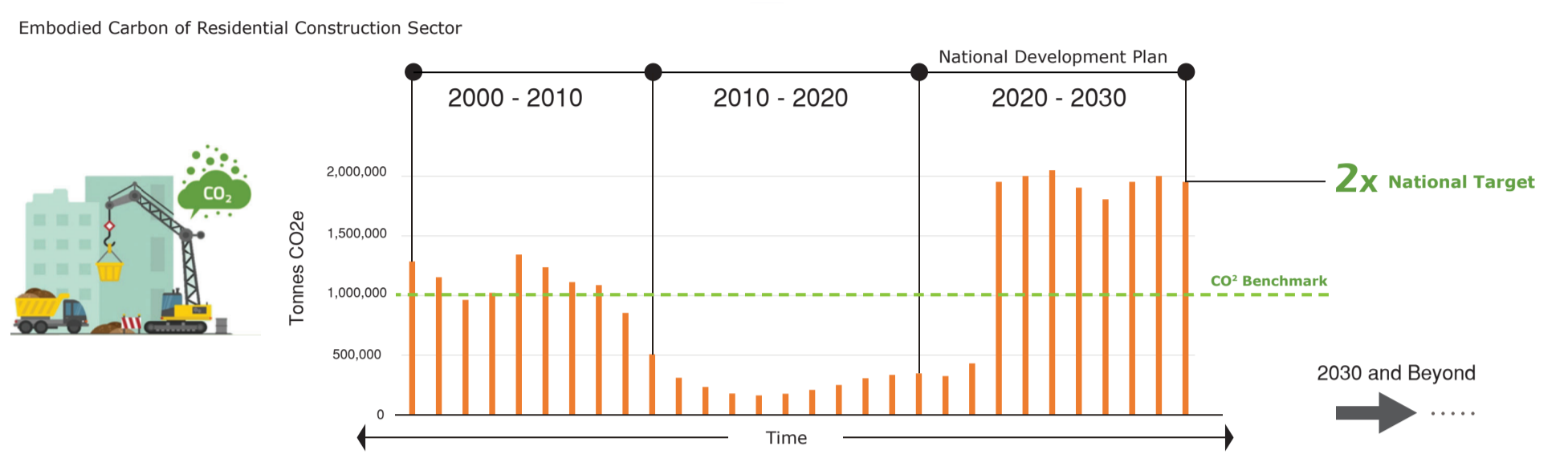
# Exploring the Feasibility of Prefabricated Straw Panels in Ireland's Construction Industry

- ### Objectives
- 1 Research and conduct literature reviews to determine the advantages and challenges to straw.
  - 2 Use a case study building of social housing and redesign with prefabricated straw panels.
  - 3 Test and compare construction details of both proposals for their thermal and hydrothermal properties.
  - 4 Test and compare environmental impact of proposals to determine potential reduction in annual carbon emissions.

- ### Aims
- 1 The aim of this research is to determine the reduction in carbon emissions if all that was proposed in Ireland's national development plan were construction with this method.
  - 2 to quantify the potential reduction on annual carbon emissions if all that was proposed in Ireland's national development plan were construction with this method.



## Built Environment & National Context



## Hygrothermal Testing

### Conventional

Relative Humidity of Concrete

### Straw Panel Cladding

Relative Humidity of Straw with cladding

### Straw Panel Render

Relative Humidity of straw with render

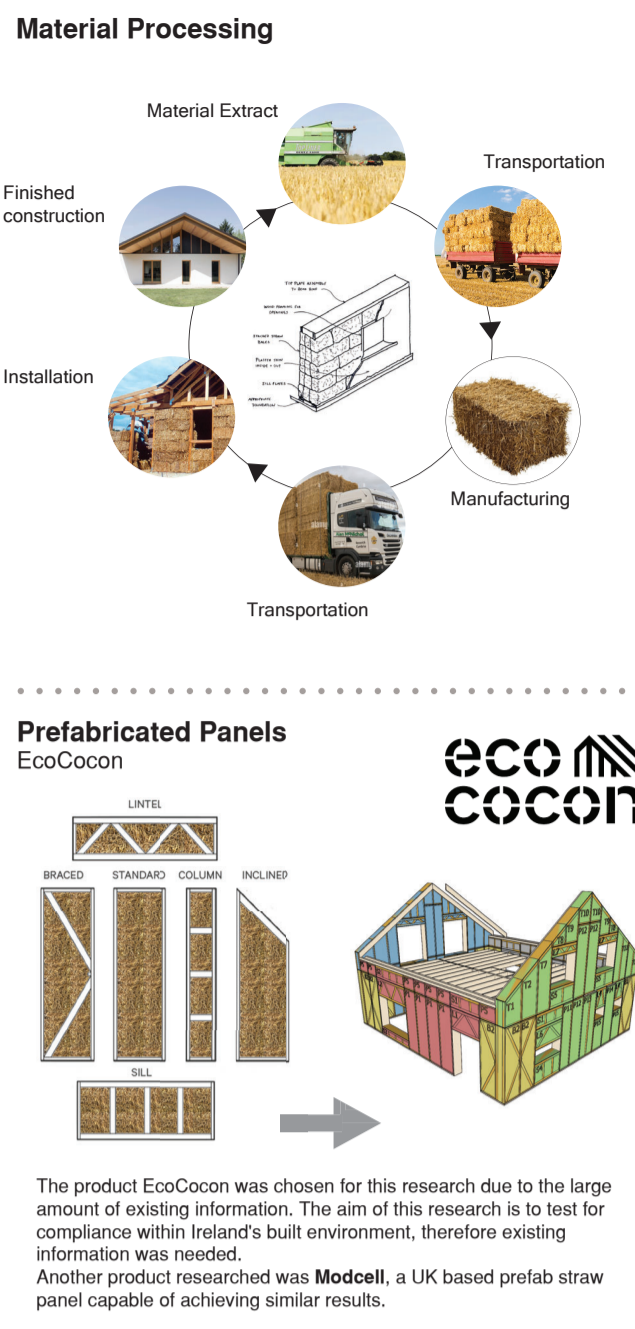
## Life Cycle Assessment

### Straw Panel Construction

### Conventional Construction

Product Stage	Construction Stage	Usage Stage	End of Life Stage	Repurpose Stage
A1 - A3	A4	A5	B1 - B5	C1 - C4
D				
<b>GWP</b>	<b>17566.06</b>	<b>511.34</b>	<b>847.26</b>	<b>3408.75</b>
<b>Total</b>	<b>23,180 kgCO<sub>2</sub>e</b>			

## Straw Insulation



## Advantages to Straw

### Embodied Carbon

### Operational Carbon

### Thermal Properties

Thermal Conductivity: Mean A value: 0.065 W/mK Meeting ISO 10456 requirements. Test carried out by John Butler, 2022.

### Fire Properties

EcoCocon Reaction to Fire: B-s1, d0. Very limited contribution to fire. Complies with European Standard EN-13501-1. Testing carried out by BM TRADA, 2014.

EcoCocon Resistance to Fire: 121 minutes exposed to fire internally & externally without failure. Complies with European Standard EN 1365-1. Testing carried out by FIRES, 2018.

## Challenges to Straw

### Hydrothermal Properties

Out of a report for 174 straw bale buildings:

- 102 Building owners reported moisture damage
- 29 reported moisture damage due to leaky roof
- 30 reported moisture damage in walls due to wind driven rain
- 43 reported moisture damage due to poorly designed doors/windows



## Case Study - Moyola Court

### Project Overview

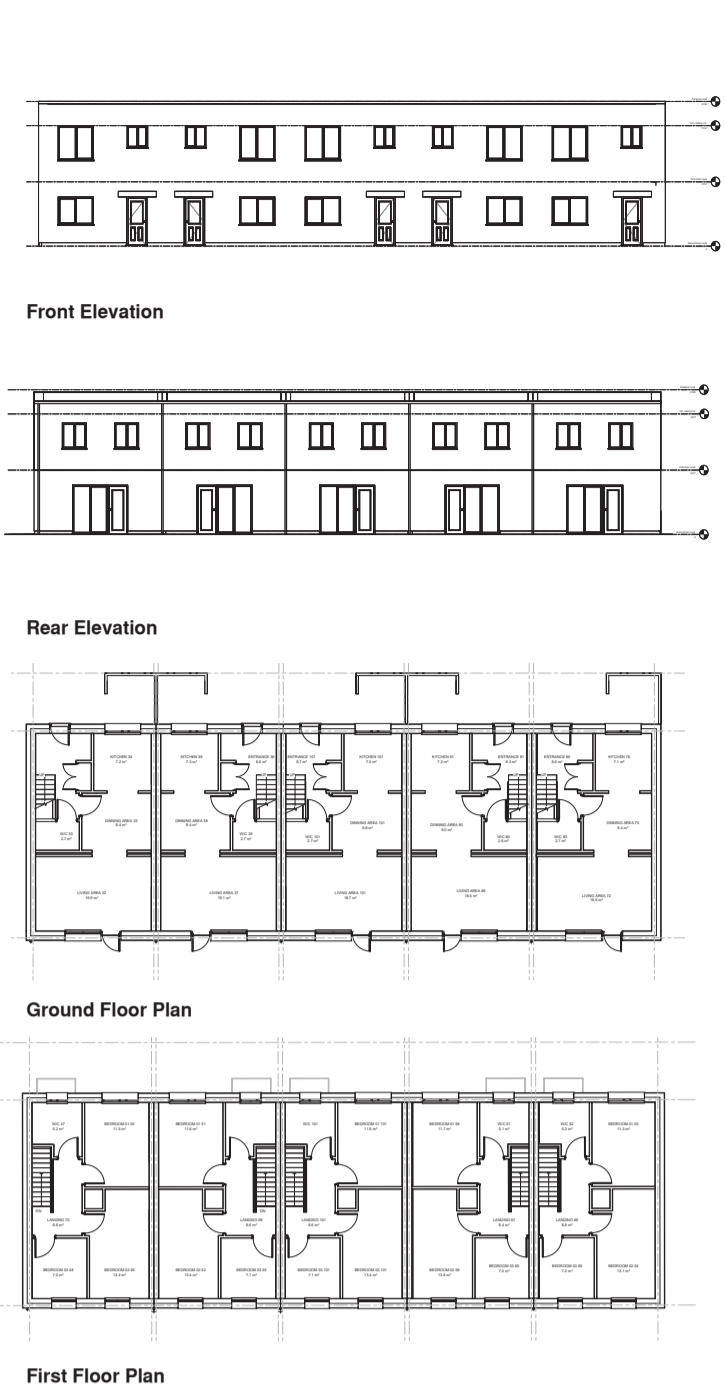
Location: Moyola Court, Churchtown, Dublin 14  
Architects: DLRCOCO, A2 Architects  
Proposed: The development of 12 social and affordable housing units split between two terraces.

### Why Terrace over Detached?

A terrace of housing was chosen instead of detached housing due to the popularity of this method when building social housing. Due to the housing for all initiative being introduced by local authorities an emphasis has been placed on delivering more social housing in Ireland. Choosing terrace housing allows for a simplified design and construction process by mirroring the same house type across the site.

### External Wall Build Up

15mm stucco render, 150 external eps insulation, 215 concrete block, 2x 12.5 plasterboard, 3mm skim finish.



## Thermal Testing

### Conventional

Element	Thickness (mm)	R-Value (W/m²K)
Plaster	15	0.015
Render, Cement & Sand	200	6.451
Concrete Block	215	0.177
Extruded Polystyrene (XPS)	12	0.048
DPC		0.13
Total		6.8662/W
U-Value		0.15 W/(m²K)

TRISCO Results

Length	0.997 m
Width	523.5mm
U Value	0.15 W/(m²K)
Psi-Value	0.08 W/(m.K)
fRsi-Value	0.952

Regulation Compliance

Mould growth and surface condensation: fRsi greater than or equal to **0.75**

PSI value requirement to comply with TGD Part L External Insulation Jamb ope **0.088 W/(m.K)**

### Straw Panel

Element	Thickness (mm)	R-Value (W/m²K)
Plaster	15	0.015
Render, Cement & Sand	100	0.015
Wood Fibreboard	1	0.001
Straw Panel	400	0.064
Extruded Polystyrene (XPS)	12	0.048
DPC		0.13
Total		0.3332/W
U-Value		0.13 W/(m²K)

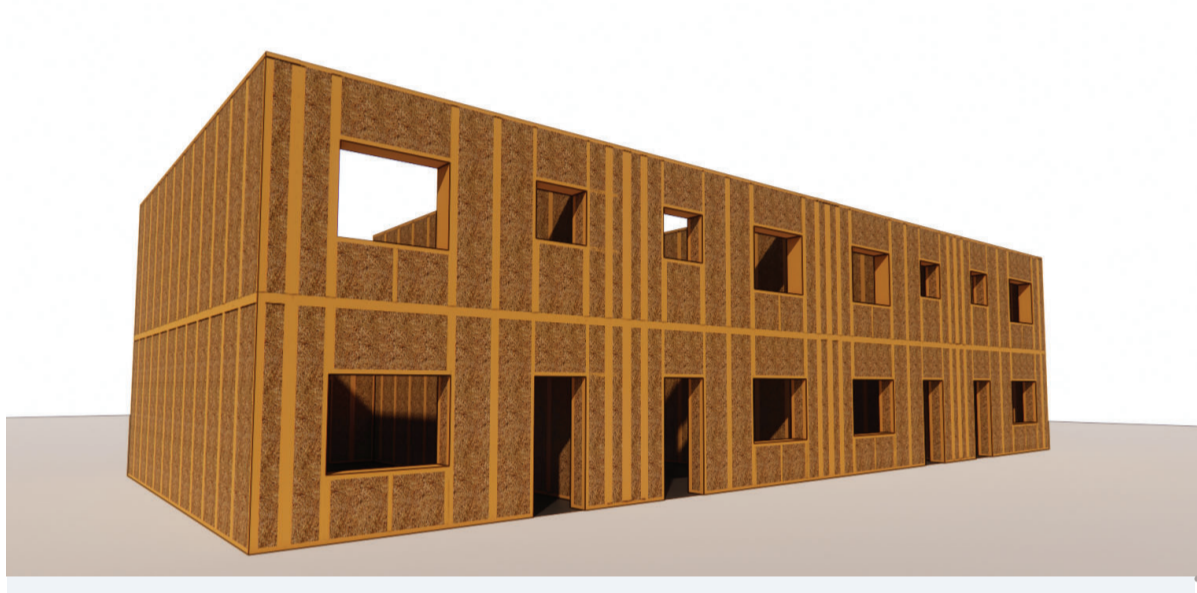
TRISCO Results

Length	1.289 m
Width	450mm
U Value	0.13 W/(m²K)
Psi-Value	0.072 W/(m.K)
fRsi-Value	0.963

Regulations

Mould growth and surface condensation: fRsi greater than or equal to **0.75**

PSI value requirement to comply with TGD Part L Timber frame jamb ope **0.080 W/(m.K)**



## Straw Proposal

### Prefabricated straw panel 'EcoCocon'

### Project Overview

Location: Moyola Court, Churchtown, Dublin 14  
Architects: DLRCOCO, A2 Architects  
Proposed: The development of 12 social and affordable housing units split between two terraces.

### Why Prefabricated Straw Panels

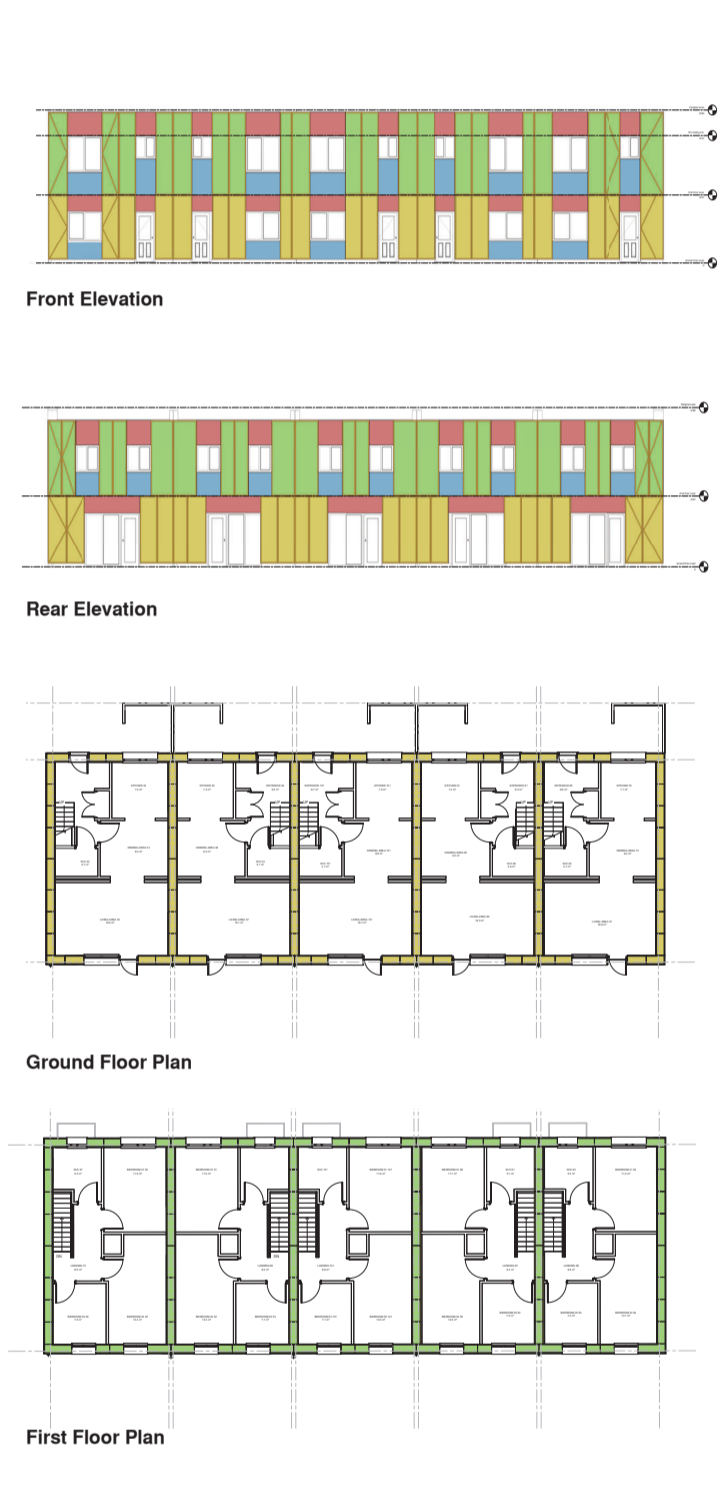
The product 'EcoCocon' was used for this proposal due to their low embodied carbon coupled with high thermal performance. EcoCocon acts as both the structure and insulation for a building allowing a rapid construction process to take place. The product is considered the future for straw construction by many professionals.

### What are the challenges to prefabricated straw

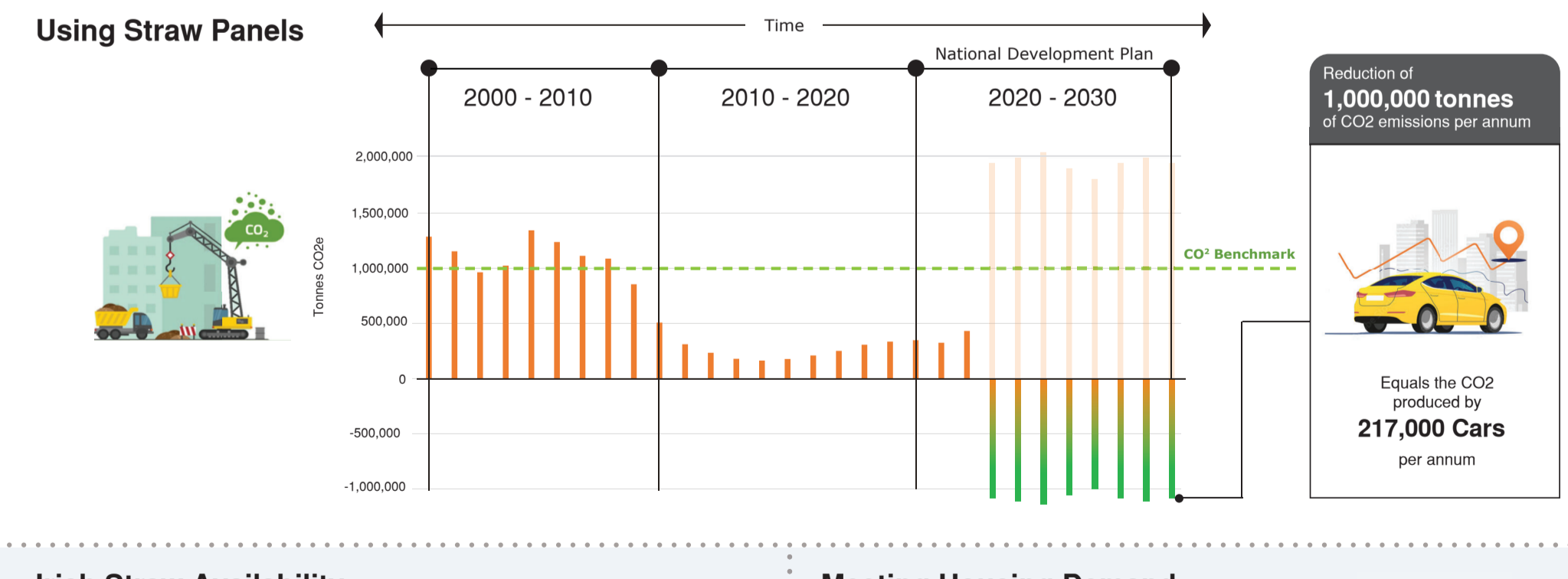
The biggest risk to any straw based material is moisture exposure. However another difficulty that needs to be addressed before being used is the increased wall thickness. Each EcoCocon panel is 400mm thick with an extra 200mm needed for woodfibre and cladding in an Irish context. This drastically increases wall thickness when compared to traditional construction methods. In the redesigned model the wall thickness was increased by 4.3%.

### External Wall Build Up

150mm lime render, 200mm woodfibre insulation, 400mm timber & straw EcoCocon panel 12.5 plasterboard.



## Future Emissions

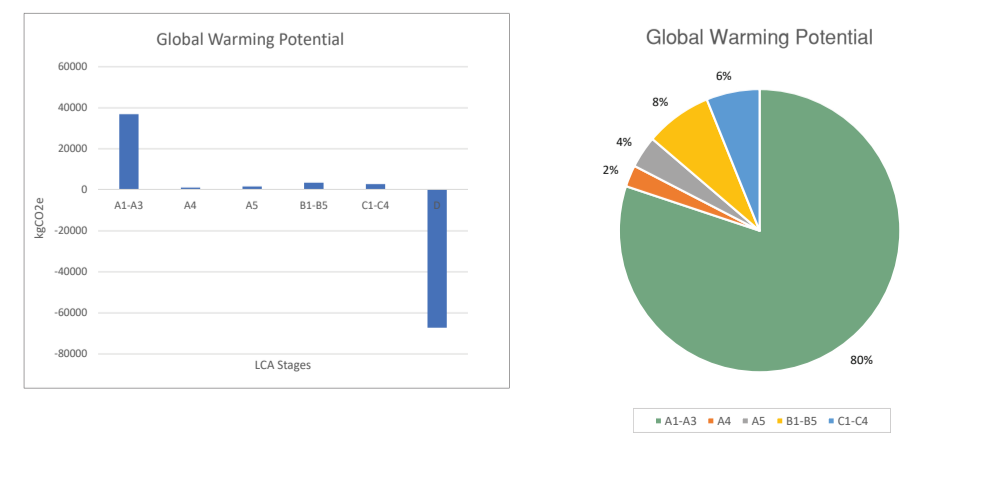
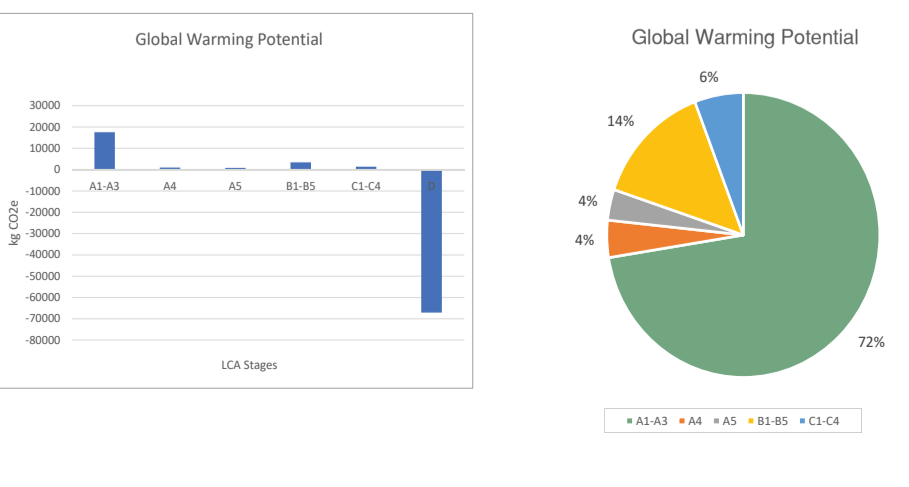
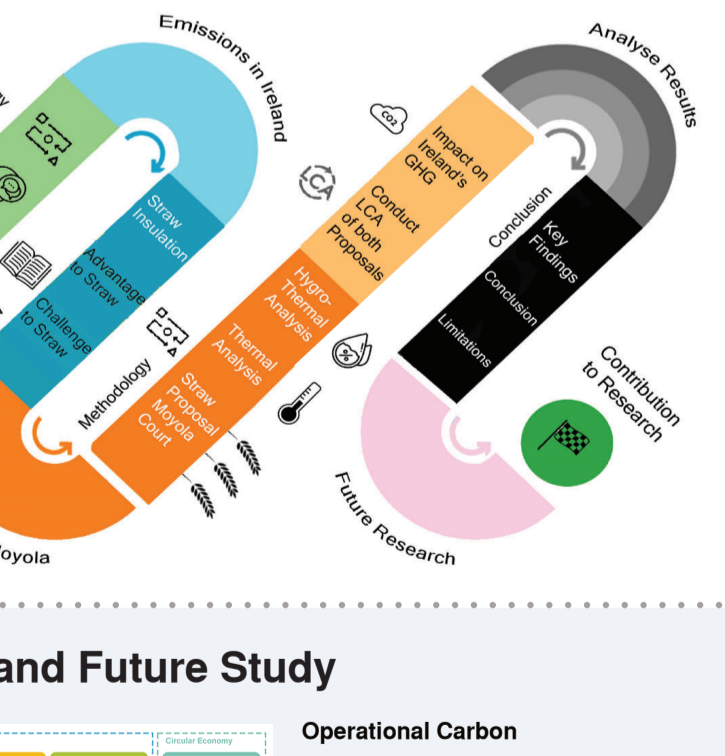


## Key Findings

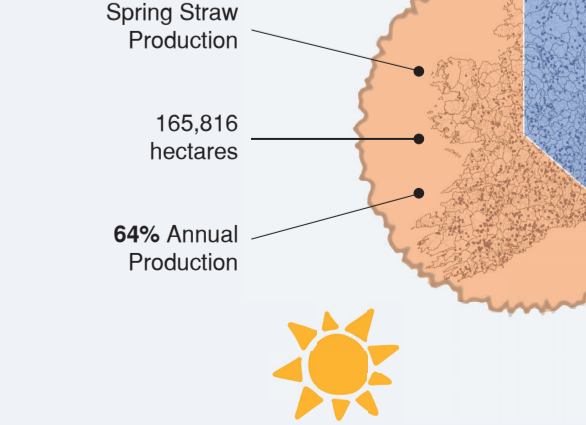
### Investigation of Straw Panel

- 4.2% Increase in building footprint from conventional construction to straw proposal
- Use a case study building of social housing
- The proposed pre-fabricated straw panel construction has a U-value of 0.13W/m²K, PSI of 0.072 W/(m.K) and a fRsi value of 0.963
- Test both proposals for their thermal properties
- The existing construction has a U-value of 0.15W/m²K, PSI of 0.08 W/(m.K) and a fRsi value of 0.95
- Test both proposals for their hydro-thermal properties
- The relative humidity of the straw panel with render finish was consistently at 92%. The cladded proposal reaches 88% but would dry to 70% in 6 months
- Test environmental impact of proposals
- When all that is proposed in the national development plan is built with Straw construction, the year 2030 will produce **-1mCO<sub>2</sub>e** which is a difference of **3mCO<sub>2</sub>e** from the predicted 2030 target
- determine potential reduction in annual carbon emissions

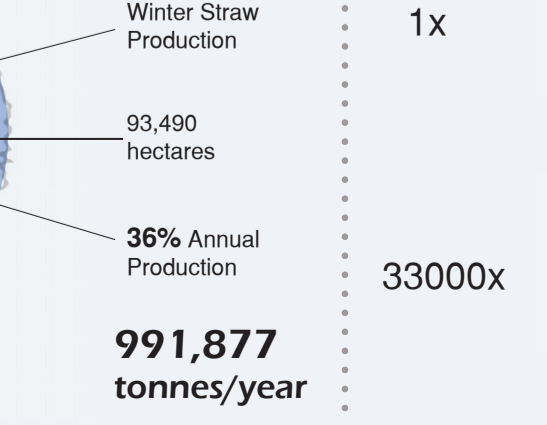
## Conclusion



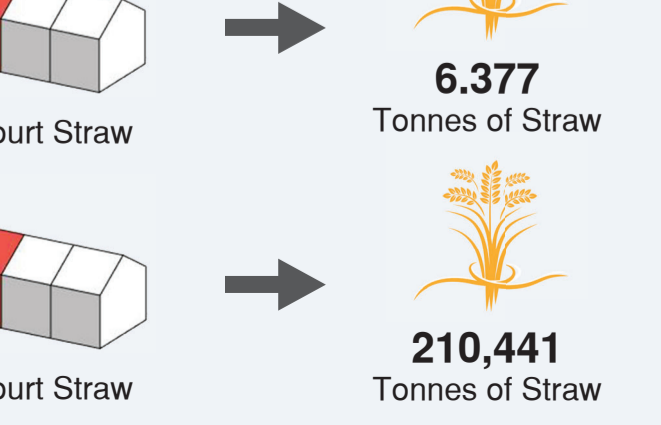
## Irish Straw Availability



## Meeting Housing Demand



## Operational Carbon



## Limitations and Future Study

Phases B6 & B7 regarding operational energy and water were excluded from the LCA carried out in this research. Therefore operational carbon was not considered a factor and a whole carbon assessment was not conducted. Future research should be carried out to determine if using prefabricated straw panels has the potential to reduce operational carbon. This would also give further clarity regarding the impact on Ireland's annual emissions by considering both carbon emissions.

### Housing Typologies

The following research was conducted using one case study of a mid terrace residential building. To provide more insight to the results regarding prefabricated straw's ability to surpass regulations multiple housing typologies should be assessed. This is also true for the impact prefabricated straw could have on Ireland's annual emissions as the emissions for all 33,000 straw houses were assumed to be identical.