AN INVESTIGATION INTO THE FEASIBILITY OF A BESPOKE PREFABICATED PANEL'S POTENTIAL TO UPGRADE THE EXISTING IRISH HOUSING STOCK

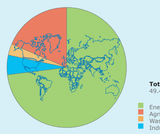
By Conor Heffernan

Objectives

1. Analyse the existing irish housing stock to identify an underperforming age bracket and an area at risk of energy poverty
2. Develope Specifications through detail analysis of the bespoke prefricated retrofit panel and contact Irish manufacturer to investigate feasibility of panel.
3. Construct a BIM model to aid in the completion of 2D and 3D drawings representing the selected case study
4. To perform a DEAP calculation using the SEAI software to determine whether the panels can assist reaching a B2 building energy rating
5. Perfome U-Value Analysis on existing and proposed Critical junctions using both the new-build and retrofit panel
6. Carry out a thermal analysis of critical junctions within selected case study to evaluate the panels potential to reduce heat loss
7. To Conduct a Life Cycle Analysis comparing the bespoke panels to traditional retrofit practices

Motivation

Global Greenhouse Gas Emissions By Sector



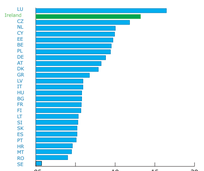
Total GHG Emissions
49.4 Billion Tonnes

- Energy = 73.2%
- Agriculture= 18.4%
- Waste = 3.2%
- Industry = 5.2%

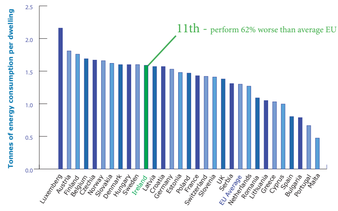
Global Greenhouse Gas Emissions Energy Sector

Emissions
- Transport = 22%
- Built enviroment = 39%
- Industry = 30%
- Other = 9%

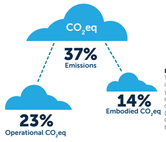
Europe GHG Emissions



Average European Residential Housing Stock Energy consumption

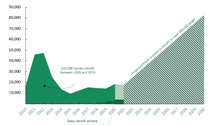


Built Enviroment Emmisions



Built Enviroment
The report indicates that in Ireland 23MtCO2e per year are linked to the construction and operation of our built environment (BE). This equates to 37% of all national emissions, the same as agriculture.

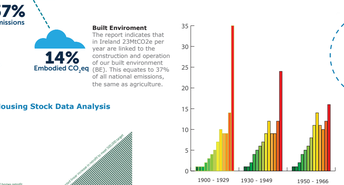
Proposed Irish Housing Stock Data Analysis



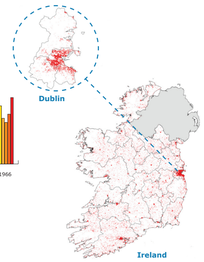
Considerable retrofit of the residential sector is proposed over the coming years to 2030 with the aim of improving the energy efficiency of the worst of the housing stock. The National Retrofit Policy proposes a total of 500,000 homes to be retrofit by 2030. Many of these will be deep retrofit. The national press has reported budgets of 28 billion to be dedicated to retrofit, or 56,000 per home. Under the Deep Retrofit SEAI Scheme.

Irelands Existing Housing Stock Data Analysis 1900 to 1966

Average BER from 1900 to 1966



Dwelling which recieved a G rating

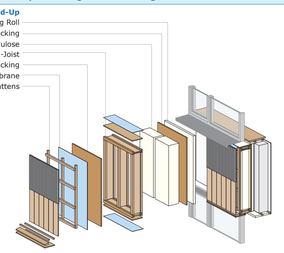


Time Period	Total Dwellings
1900 - 1929	57,299
1930 - 1949	48,372
1950 - 1966	75,404

Average C02 Emissions
1900 - 1929 = 96 KgCO2/m2/year
1930 - 1949 = 84 KgCO2/m2/year
1950 - 1966 = 74 KgCO2/m2/year

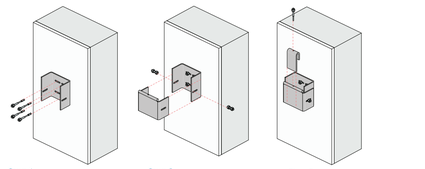
Methodology - Case Study - Existing Cabra Housing Scheme

3D Material Build-Up
60mm Rockwool Cladding Roll
18mm FR OSB3 Anti-Racking
200mm Recycled Cellulose
200 x 60 mm I-Joist
18mm FR OSB3 Anti-Racking
Protect TF200 Breather Membrane
Sw Battens & Counter Battens



3D-Exploded Prefabricated Retrofit Panel 1 to 20

Retrofit Panel Fixing Sequence

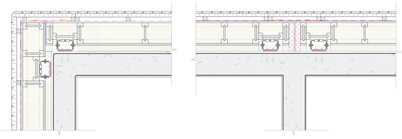


Step 1
- Fix Aluminium Bracket to existing wall
- Fixings = Stainless Steel M12 Bolts
- Tolerance = Horizontal tollerance along wall

Step 2
- Fix Aluminium Bracket to Wall bracket
- Fixings = Stainless Steel M12 Bolts
- Tolerance = Horizontal tollerance away from wall

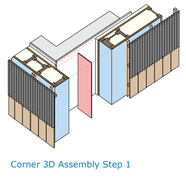
Step 2
- Aluminium Hook fixing slotted onto aluminium bracket
- Fixings = Stainless Steel M12 Bolts
- Tolerance = Vertcle tollerance

Proposed Bespoke Prefabricated Retrofit Panel Detail and Assembly Analysis

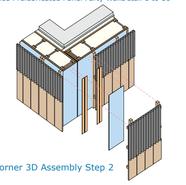


Proposed Prefabricated Panel Corner Detail 1 to 10

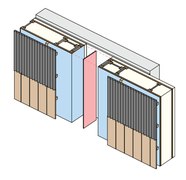
Proposed Prefabricated Panel Party WallDetail 1 to 10



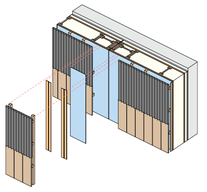
Corner 3D Assembly Step 1



Corner 3D Assembly Step 2



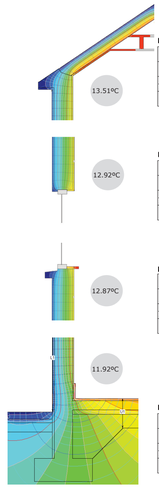
Standard Panel 3D Assembly Step 1



Standard Panel 3D Assembly Step 2

Existing Key Junctions Thermal Analysis

- Potential for Mould Growth If FRSI Is Below 0.75
- Does Not Comply With Current Part L Regulations



Existing Eaves

FRSI	0.676
PSI	0.142
TGD Part L	0.074
U-Value	1.230

Existing Window Head

FRSI	0.646
PSI	0.080
TGD Part L	0.097
U-Value	2.730

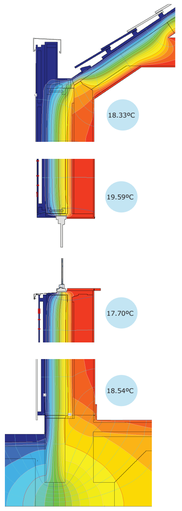
Existing Window Cill

FRSI	0.644
PSI	0.035
TGD Part L	0.149
U-Value	2.730

Existing Footing

FRSI	0.596
PSI	2.388
TGD Part L	
U-Value	0.98

Proposed Key Junctions Thermal Analysis



Proposed Eaves

FRSI	0.916
PSI	0.066
TGD Part L	0.074
U-Value	0.12

Proposed Window Head

FRSI	0.979
PSI	0.021
TGD Part L	0.097
U-Value	0.13

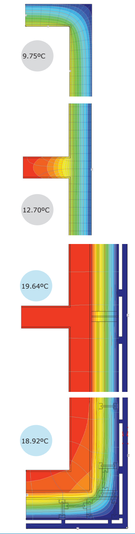
Proposed Window Head

FRSI	0.885
PSI	0.017
TGD Part L	0.149
U-Value	0.13

Proposed Window Head

FRSI	0.927
PSI	0.372
TGD Part L	
U-Value	0.98

Proposed & Existing Key Junctions Thermal Analysis



Existing Corner

FRSI	0.487
PSI	0.226
TGD Part L	0.070
U-Value	2.746

Existing Party Wall

FRSI	0.635
PSI	0.037
TGD Part L	0.033
U-Value	2.813

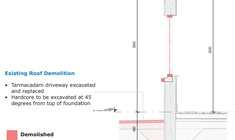
Proposed Party Wall

FRSI	0.982
PSI	0.015
TGD Part L	0.033
U-Value	0.13

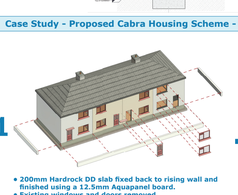
Proposed Corner

FRSI	0.946
PSI	-0.047
TGD Part L	0.070
U-Value	0.13

Existing & Proposed Cabra Housing Scheme



Ground Floor Plans



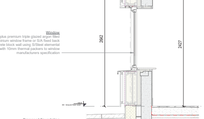
First Floor Plans

Front Elevations

Rear Elevations

Existing Building Energy Analysis

Existing Mid Terrace Building Energy Rating



Annual Final Energy Consumption

Main space heating	13,657 Kwh/yr
Secondary space heating	3,155 Kwh/yr
Water heating	11,956 Kwh/yr
495.16 Kwh/m²/yr	BER G
125.57 Kg/m²/yr	

Existing End Terrace Building Energy Rating

Annual Final Energy Consumption

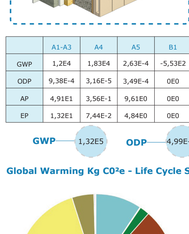
Main space heating	13,657 Kwh/yr
Secondary space heating	3,155 Kwh/yr
Water heating	11,956 Kwh/yr
594.68 Kwh/m²/yr	BER G
136.04 Kg/m²/yr	

Existing Cabra Housing Scheme Heat Loss Analysis

U-Value Analysis Case Study Baseline Results

	TGD-Part L W/m²k	After Renovation W/m²k
Existing Roof	0.16	1.23
Existing Wall	0.16	2.6
Existing Ground Foor	0.18	0.54
Existing Windows	1.4	5.4
Existing Doors	1.4	3.84

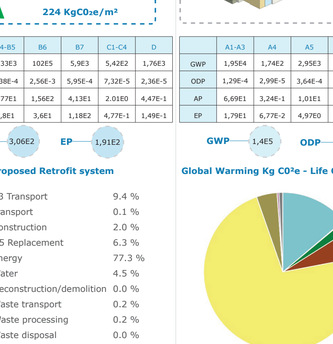
New Build Panel Rear Elevation 1 to 10



Eaves to New Build Panel Detail 1 to 10

Intermittent floor to New Build Panel Detail 1 to 10

New Build Detail Analysis and Assemble Investigation

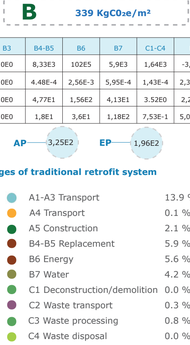


3D Assembly Investigation - New Build Panel to Footing Analysis

- Step1 - Swelling Motar poured
- Step 2 - Soleplate placed on top of swelling motar
- Step 3 - panel placed on top of soleplate and fixed using stainless steel M12 anchor bolt

Step 4 - Once fixed 500mm of recycled cellulose is blown into the bottom of the panel
Step 5 - Prefabricated internal partition is fixed to prefabricated panel I-joists

Sequence Of Construction - New Build Panel



1
- Identify Ground Floor Opening to be demolished
- Remove existing windows and doors.
- Foundations poured and rising wall added
- 120mm Kore EPS placed on 150mm concrete slab with additional 75mm insulated floor screed plus selected finish

2
- New Build corner & party wall panel fixed to Ground floor
- Ground floor back elevation panel fixed to Ground floor & corner panels
- Proposed first floor fixed on top of ground floor panels and fixed back to existing house

3
- Flat roof placed on top of first floor utilising the floor joists which act as the structure
- First floor new build panels fixed to first floor
- Proposed sloped roof fixed to existing roof and first floor panels

New Build Panel Rear Elevation 1 to 10 Material Analysis

New Build Panel Rear Elevation 1 to 10 Thermal Analysis Through Critical Junctions

Proposed Eaves

FRSI	0.946
PSI	-0.061
TGD Part L	0.031
U-Value	0.133

Proposed Intermittent

FRSI	0.957
PSI	0.027
TGD Part L	0.080
U-Value	0.133

Proposed Footing

FRSI	0.941
PSI	0.016
TGD Part L	0.021
U-Value	0.114

Proposed Corner

FRSI	0.957
PSI	0.029
TGD Part L	0.079
U-Value	0.112

Proposed Window

FRSI	0.946
PSI	0.055
TGD Part L	0.064
U-Value	0.114

Proposed Corner

FRSI	0.957
PSI	0.029
TGD Part L	0.079
U-Value	0.114

Existing 1 to 20 Section Front Elevation Demolition

Proposed 1 to 20 Section Front Elevation

Proposed Cabra Housing Scheme 3D Section Heat Loss Analysis

Case Study - Proposed Cabra Housing Scheme - Sequence Of Construction Using Retrofit Panel

1
- 200mm Hardrock DD slab fixed back to rising wall and finished using a 12.5mm Aquapanel board.
- Existing windows and doors removed
- Existing overhang and services removed

2
- Firstly the end Terrace side elevation wall panels are fixed back to the existing dwelling
- Next the front elevation panels will be fixed to existing walls and sealed to both the side elevation panel and the next panel to follow

3
- Existing roof tiles and battens removed
- Roof to be fitted with new roofing felt, battens, counter battens and clay tiles
- Lasity insulation will be placed accross the first floor ceiling

Results Of life Cycle Analysis Proposed Retrofit System

Proposed Prefabricated Panel retrofit system

- C0² 0.762 Tonnes C0₂e
- C0² 132 Tonnes C0₂e
- C0² 25.09 Tonnes C0₂e/m²/yr

Carbon Benchmark Rating
A 224 KgC0₂e/m²

	A1-A3	A4	A5	B1	B3	B4-B5	B6	B7	C1-C4	D
GWP	1,2E4	1,83E4	2,63E-4	-5,53E2	0E0	8,33E3	102E5	5,9E3	5,42E2	1,76E3
ODP	9,38E-4	3,16E-5	3,49E-4	0E0	0E0	4.38E-4	2,56E-3	5,95E-4	7,32E-5	2,36E-5
AP	4,91E1	3,56E-1	9,61E0	0E0	0E0	4,77E1	1,56E2	4,13E1	2.01E0	4,47E-1
EP	1,32E1	7,44E-2	4,84E0	0E0	0E0	1,8E1	3,6E1	1,18E2	4,77E-1	1,49E-1

GWP 1,32E5 ODP 4,99E-3 AP 3,06E2 EP 1,91E2

Results Of life Cycle Analysis And Traditonal Retrofit System

Traditional retrofit system -Kore EPS70 Silver

- C0² 2.11 Tonnes C0₂e
- C0² 140 Tonnes C0₂e
- C0² 26.72 Tonnes C0₂e/m²/yr

Carbon Benchmark Rating
B 339 KgC0₂e/m²

	A1-A3	A4	A5	B1	B3	B4-B5	B6	B7	C1-C4	D
GWP	1,95E4	1,74E2	2,95E3	-5,53E2	0E0	8,33E3	102E5	5,9E3	1,64E3	-3,4E3
ODP	1,29E-4	2,99E-5	3,64E-4	0E0	0E0	4.48E-4	2,56E-3	5,95E-4	1,43E-4	2,36E-5
AP	6,69E1	3,24E-1	1,01E1	0E0	0E0	4,77E1	1,56E2	4,13E1	3.52E0	2,24E0
EP	1,79E1	6,7E-2	4,97E0	0E0	0E0	1,8E1	3,6E1	1,18E2	7,53E-1	5,06E-1

GWP 1,4E5 ODP 5,43E-3 AP 3,25E2 EP 1,96E2

Global Warming Kg C0²e - Life Cycle Stages of Proposed Retrofit system

A1-A3 Transport	9,4 %
A4 Transport	0,1 %
A5 Construction	2,0 %
B4-B5 Replacement	6,3 %
B6 Energy	77,3 %
B7 Water	4,5 %
C1 Deconstruction/demolition	0,0 %
C2 Waste transport	0,2 %
C3 Waste processing	0,2 %
C4 Waste disposal	0,0 %

Global Warming Kg C0²e - Life Cycle Stages of traditional retrofit system

A1-A3 Transport	13,9 %
A4 Transport	0,1 %
A5 Construction	2,1 %
B4-B5 Replacement	5,9 %
B6 Energy	5,6 %
B7 Water	4,2 %
C1 Deconstruction/demolition	0,0 %
C2 Waste transport	0,3 %
C3 Waste processing	0,8 %
C4 Waste disposal	0,0 %

Proposed End Terrace Building Energy Rating

76 %

Annual Final Energy Consumption

Main space heating	2166 Kwh/yr
Secondary space heating	233 Kwh/yr
Water heating	5005 Kwh/yr
88.53 Kwh/m2/yr	BER B1
15.37 Kg/m²/yr	

Prefabricated Panels + Renewables

Energy Consumption
Proposed - 8,017 Kwh/yr
Existing - 33,325 Kwh/yr

Carbon Consumption
Proposed - 15.73 Kg/m²/yr
Existing - 136.04 Kg/m²/yr

SEAI Target - 500,000

Proposed Mid Terrace Building Energy Rating

75 %

Annual Final Energy Consumption

Main space heating	1473 Kwh/yr
Secondary space heating	158 Kwh/yr
Water heating	5005 Kwh/yr
80.17 Kwh/m2/yr	BER B1
13.96 Kg/m²/yr	

Prefabricated Panels + Renewables

Energy Consumption
Proposed - 7,229 Kwh/yr
Existing - 29,356 Kwh/yr

Carbon Consumption
Proposed - 13.96 Kg/m²/yr
Existing - 125.57 Kg/m²/yr

SEAI Target - 500,000

Building Performance Conclusion

Prefabricated Panels Facade Conclusion and Key Findings

Life Cycle Analysis Conclusion

U-Value Analysis Case Study Results

	TGD-Part L W/m²k	After Renovation W/m²k
Retrofit Panel	0.16	0.13
New Build Panel	0.16	0.12
Pitched Roof	0.16	0.12
New Build Sloped Roof	0.16	0.13
New Build Flat Roof	0.18	0.13
Existing Ground Floor	0.18	0.54
New Build Ground Floor	0.18	0.11
Windows	1.4	0.78
Doors	1.4	0.79