Fergal Lane K00260886
Mechanical Engineering (Facilities)
4th Year Dissertation

A Detailed Review of the Level of Renovation needed in a Derelict Dwelling for the Efficient Operation of a Heat Pump.

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Aim of the Project

The aim of the dissertation is to gain an understanding of the level of renovation needed in a derelict dwelling for a heat pump to run efficiently. Each stage is to be broken down by cost of renovation and cost of energy to heat the dwelling. The dissertation will be focused on gaining an understanding of the benefits from each stage of renovation of a derelict dwelling.

Objectives

- Research existing building regulations, CIBSE guidelines and SEAI documentation.
- Model existing dwelling in Revit.
- Integrate a heat pump into the Revit model, make incremental changes to perform a cost benefit analysis.
- Analyse the findings and determine are the guidelines leading to over engineered structures.

Background

This dissertation looks at a dwelling that has been derelict for over 20 years and aims to investigate the standard that the dwelling would need to be renovated to, for a heat pump to provide all heating efficiently. The dwelling is currently of typical late 1800s construction with thick stone walls and no insulation throughout the fabric of the house. There are two open chimneys that would have been the main heat source for the dwelling when it was habitable.

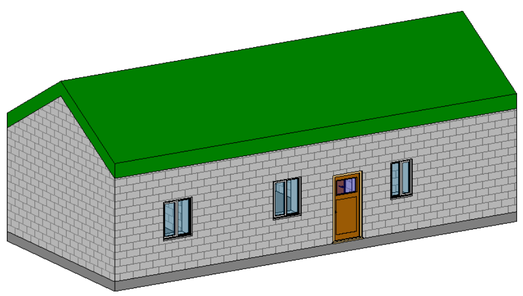
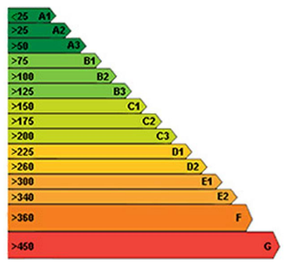


Figure 1: Existing dwelling in Revit.

Literature Review

The literature review comprised of various avenues of research. These ranged from the benefits and uses of BIM in the renovation process of derelict dwellings. The history of, and current building regulations in Ireland. BER ratings and the fundamentals of heat pump operation.



BER Energy Chart

Figure 2: BER Energy Chart.

Methodology

The methodology of this project involved determining an effective way of calculating the energy requirement of the heating of the dwelling, at each stage of renovation. Initially the house was modelled in Revit and an energy analysis was carried out. As the results did not have enough detail to calculate the energy usage throughout the course of a full year, DEAP software was used to calculate the energy usage in kW/m^2/yr.

Calculations

The u-values of the building elements firstly needed to be calculated to be input into the software.

First level of Renovation			
Exterior Wall - 1			
U-Value			
Item	**Thickness (m)**	**k**	**R**
Outisde			0.13
Exterior Wall	0.6	1.45	0.413793
Insulation	0.05	0.025	2
Skim	0.013	0.43	0.030233
Interior			0.04
		R Total	2.614026
		U-Value	0.382552

Table 1: U-value calculation of exterior wall.

Floor			
U-Value			
Item	**Thickness (m)**	**k**	**R**
Outside	0		0.5
Concrete Slab	0.12	2.25	0.053333
Interior	0		0.04
		R Total	0.593333
		U-Value	1.685393

Figure 28 Existing Floor u-value data.

Roof			
U-Value			
Item	**Thickness (m)**	**k**	**R**
Outside			0.13
Structure	0.125	0.6	0.208333
Plaster Board	0.015	0.25	0.06
Inside			0.04
		R Total	0.438333
		U-Value	2.281369

Figure 29 Existing Roof u-value data.

Windows	
U-Value	5.7 W/m2/yr

Door	
U-Value	3 W/m2/yr

Figure 30 Existing Window and Door u-value data.

Table 2: U-value calculations of floor, roof, windows, and doors.

The calculations are the main driving factor in determining the energy performance of the building, it was important to keep all stages of the renovation improvements consistent.

A cost breakdown was completed on the building materials that would be needed at each stage of renovation. A comparison of the cost to benefit could then be carried out.

Reno Stage	Wall Insualtion	€/m^2	Area	Total Cost
1	50mm Internal	15.71	121.27	€ 1,905.15
2	100mm Internal	28.01	121.27	€ 3,396.77
3	100mm External	17.69	121.27	€ 2,145.27
4	100mm external + 50mm internal	33.4	121.27	€ 4,050.42
Reno Stage	**Wall Plaster**	**€/m^2**	**Area**	**Total Cost**
1	Internal Skim	2.34	121.27	€ 283.77
2	Internal Skim	2.34	121.27	€ 283.77
3	External Plaster	2.76	121.27	€ 335.00
4	Internal Skim + External Render	5.10	121.27	€ 618.77

Figure 3: Cost breakdown of wall insulation and wall plaster throughout renovation.

Results

The results show the energy performance of the dwelling at each stage of the renovation. The cost of materials at each stage is also found.

Renovation Stage		Total Cost
1	Total cost of materials	€ 11,461.73
2	Total cost of materials	€ 13,274.88
3	Total cost of materials	€ 13,029.58
4	Total cost of materials	€ 15,488.12
1	Total cost of energy	€ 3,199.45
2	Total cost of energy	€ 1,828.21
3	Total cost of energy	€ 1,761.28
4	Total cost of energy	€ 1,576.61

Table 3: Cost of energy and materials at each stage of renovation.

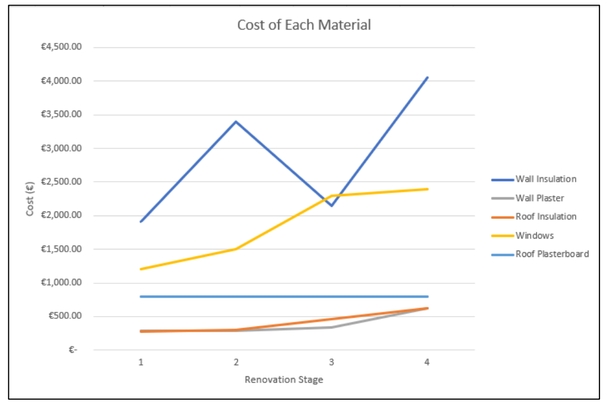


Figure 4: Comparison of the cost of materials for each stage of renovation.

Conclusion

It was found that the second stage of renovation was the first level of renovation that could justify a heat pump as the sole space heating source. There is big cost savings made across all stage of renovation in terms of energy cost per annum.

Acknowledgements

I would like to thank my dissertation supervisor, Dr Alan O'Donovan, he's support and encouragement throughout this project proved invaluable for the successful completion of this dissertation. Alans expertise and knowledge in this area of study provided invaluable insight and feedback for me along the way.