The Costs, Benefits and Stakeholder Analysis of an Irish Social Housing Deep Energy Retrofit Case Study

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Abstract. This paper analyses the results of a pilot deep energy retrofit (DER) implementation including the financial perspectives of the stakeholders with the aim of assisting DER policy development. The Multiple Beneficiary Analysis (MBA) provides technical and energetic details for a recent 12-unit DER social housing project and quantifies the multiple direct and indirect benefits – e.g. financial, economic and societal to enable a stakeholder (beneficiary) analysis. The analysis is apposite given the urgent need for effective policy development in order to enable the achievement of the low-energy retrofit mandated by the EU. The MBA finds that the stakeholder who benefits most (the tenant) makes no financial contribution to the higher standards and while the Central Exchequer also benefits significantly, the stakeholder who makes the upgrade decision (landlord) is financially dis-incentivised. Given the significant benefits which accrue to the Central Exchequer, there is an opportunity for strategic investment by the government to unlock the benefits of low energy dwellings. This would simultaneously realise ongoing financial benefits, "seed" the capability within industry and crucially increase the knowledge and understanding of low energy dwellings which is necessary to enable widespread adoption. The key finding is that despite potential returns of approximately twice the investment, and the urgent need to retrofit existing buildings, the required DER uptake is unlikely as the decision-makers require financial support to unleash the multiple benefits of energy efficient dwellings. A self-financing support is suggested for the case study for consideration.

1. Introduction

1.1 Overview & Objectives

The Energy Performance of Buildings Directive (EPBD) requires that a clear vision for a decarbonised building stock by 2050 be set out in national roadmaps across the EU for renovation with concrete milestones and measures [1]. In June 2019 the Irish government committed to retrofitting 500,000 homes to higher energy efficiency standards by 2030 [2], a significant target given that currently 23,000 units pa are upgraded, mainly to shallow retrofit standard, rather than the required Building Energy Rating (BER) [3] of B2 (or higher). In 2017, the Sustainable Energy Authority of Ireland (SEAI) launched the Deep Energy Retrofit (DER) Pilot Programme[4] to inform the approach towards a large scale deep retrofit of the housing stock, and by the end of 2019, 325 homes were upgraded, 12 of which have undergone a Post-Occupancy Evaluation (POE) and are considered here. The case study follows a typical 'fabric first' approach of reducing heating energy consumption via upgrades to insulation and airtightness etc., with the residual heating demand being met with a Heat Pump (HP).

The POE has detailed significant reductions in energy consumption from the worst Building Energy Rating (BER) of (F&G) to the best (A) along with high internal temperatures and high occupant satisfaction rates.
This analysis quantifies costs and estimates the multiple financial benefits (both direct and indirect) for the tenant, landlord and government in order to determine the financial attractiveness of the approach. Through the case study, it is hoped to gain insights into stakeholder motivations and make a contribution to understanding how best to progress the ambitious Irish governments home retrofit objectives.

1.2 Description of Deep Energy Retrofit Project and Costs
The scheme of 12 x 1 bed 30.77 m² social house dwellings (Fig 1.1), located in the south-east of Ireland underwent a DER in 2018, which resulted in an average BER of A2, similar to that typically achieved by a new nZEB building. The dwellings provide housing for Wexford County Council (WCC) Local Authority (LA) tenants, typically pensioners.

Figure 1.1 College View, Wexford town, County Wexford, Ireland

Table 1.1 gives an overview of the energy paramaters for the dwellings both before and after the energy upgrade, along with the associated upgrade costs - €300,000 ex VAT, or €339,000 incl VAT. €146,000 was paid by WCC with the remainder paid by the SEAI DER Pilot Project. Each of the direct and indirect benefits are quantified below for the scheme of 12 dwellings over 15 years. The benefits are assigned to the beneficiaries of tenant, Central Exchequer or Housing Association/Local Authority (HA/LA). In this specific case study, WCC are responsible for providing the social housing, but HAs also provide social housing, and play the same stakeholder role.

Measure	Before	After	Cost {€ '000)
External insulation	1.8 W/m^{2}K	0.2 W/m^{2}K	60
Attic Insulation	0.16 W/m^{2}K	0.12 W/m^{2}K	10
Windows and Doors	2.8-3.1 W/m^{2}K	0.8 W/m^{2}K	60
Heating	OFCH / BB	4 kW HP	84
Renewable energy	None	6 x 285W PV	60
Ventilation	Natural	Demand Controlled	24
BER / Overall	4 x "F", 8 x "G"	1 x A1, 10 x A2, 1 x A3	298 + VAT **Total €339**

Table 1.1 Energy Efficiency Upgrade Measures

2. Quantification and assignment of Direct Benefits

2.1 Overview

The DER direct financial benefits were quantified by using the before and after BER calculations. This gives the regulated load energy consumption[5], and provides an estimate for the energy savings and the associated financial benefits of the reduced expenditure on energy and lower carbon taxes based on the financial parameters in Table 2.1 Other direct benefits such as reduced property maintenance costs and cost reductions due to avoidance of chimney fires were also calculated based on WCC expenditure records. It is noted that the time value of money was not incorporated given prevailing marginal inflation and low interest rates.

NZEB Multiple Benefits Analysis -1 Bed Retrofit Dwelling Ireland	
Timeframe Analysed {years}	15
House size {m2}	30.77
Value of Mid Terraced House {Euro}	110,000
Value of End of Terrace House {Euro}	120,000
Cost per kWh (Electricity) {Euro}	0.1617
Cost per kWh (bag of std coal) {Euro}	0.0591
Cost per kWh (Oil) {Euro}	0.0807
HP Efficiency - COP	2.5
Oil Boiler Efficiency	0.90
Primary energy conversion factor for Electricity	2.6
Primary energy conversion factor for Oil	1.1
Primary energy conversion factor for coal	1.1
Carbon emissions for 1000 kWh (oil) {Tons}	0.32
Carbon emissions for 1000 kWh (electricity) {Tons}	0.498
Cost of Carbon Emissions {Euro/Ton}	70
Euro - US Dollar conversion rate (25 June 2019)	0.875
GDP per household (Euro)	147,292

Table 1.1 Key Financial parameters used in Multi Beneficiary Analysis of Irish 1 Bed Dwelling

Quantified values are given for each of the four direct benefits identified (fig 2.1);

- energy consumption reduction,
- reduction in GHG emissions (carbon tax),
- reduced public expenditure on maintenance costs
- reduced public expenditure due to the elimination of chimney fire costs

The direct costs and benefits accrued over the 15 year period amount to €320k while total costs amount to €339k (fig 2.1). The details for the direct benefits are given below. The analysis is carried out at the level of the scheme of 12 dwellings, as this most closely matches the perspective of the (landlord) decision-maker i.e. the HA/LA.

2.2 Energy consumption reduction – Tenant benefit

Based on the BER data, the saving per dwelling ranged from €0.4k per annum to €2.0k pa with savings predominantly related to heating bills. It is noted that the saving of €2.0k pa, based on the BER calculations is unlikely to be achieved in practice, as the more likely scenario is that the tenant would not have heated the building to the BER - expected 21°C in the living room and 18°C elsewhere for the daily eight-hour periods assumed by the software. The more likely scenario is that the tenant would have suffered from temperatures in the dwelling being below those required for healthy living. The total energy-related cost reduction in the regulated load amounts to €214.9k for the 12 dwellings over the 15 year period.

2.3 CO2 savings – Tenant benefit
The carbon tax savings amount to €74.4k for the 12 dwellings over the 15 year period.

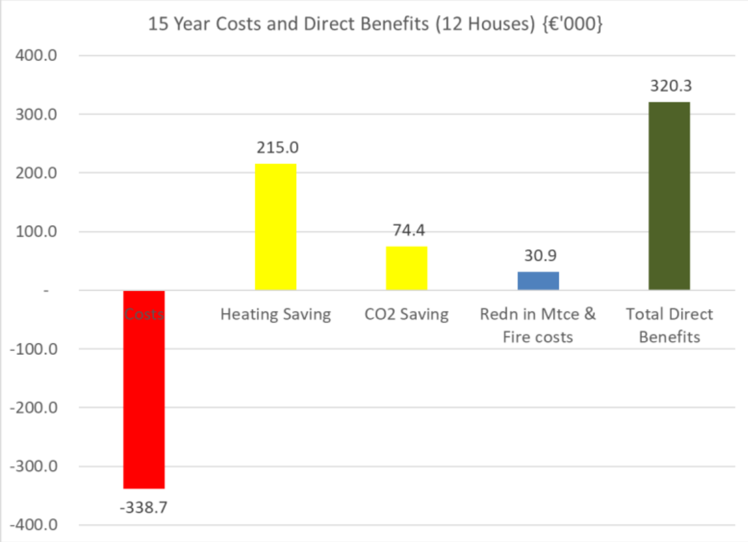


Figure 2.1 Costs and 15-year Direct benefits for scheme of 12 dwellings

2.4 Reduction in Maintenance and fire Costs – LA/HA Benefit
All the dwellings had problems with damp and poor thermal bridge performance before the upgrade. Due to the "fabric first" approach of upgrading the building fabric and eliminating thermal bridges, direct savings in maintenance in addition to energy consumption will continue to accrue.
The annual OFCH maintenance cost amounts to €250 per dwelling for the 7 dwellings with OFCH and €40 for the six dwellings with back boilers. The annual cost for carbon monoxide sensors (€11) is avoided given HPs were installed, as the annual mould remediation cost of €17.22.
Post retrofit, costs of €65pa are incurred in the maintenance of the HP's.
Taking the above costs into account, the annual saving per dwelling amounts to €213 for houses with OFCH, €3 for houses with back boilers, and €253 for houses with dual central heating with a total maintenance cost reduction across the 12 properties for the 15 year period amounting to €23.2k.
As a direct result of the removal of chimneys, the costs associated with chimney fires can be eliminated amounting to a saving of €7.7k.

3. Quantification and Assignment of Indirect Benefits

3.1 Overview
The Multiple Benefits (MB) Energy Efficiency (EE) and have been reported on by a number of organisations including the International Energy Agency [6] and academic publications e.g. [7], [8], [9] and [10]. The significant and far reaching Multiple Benefits [14] of EE range from the elimination of fuel poverty, improved comfort and better health outcomes, to knock-on benefits to the local economy etc. The following indirect co-benefits have been quantified for the DER scheme:

- improvements in the economy
- improved health outcomes
- increase in the value of the property

Given the imprecise nature of quantifying the indirect / co-benefits, in this analysis, they are given an estimated range of values, quantifying both a lower bound and upper bound (based on varying methods identified through a literature review. Figure 2.1 gives the lower and upper estimates for each of the indirect benefits for the energy upgrade project. The calculations method is given below.

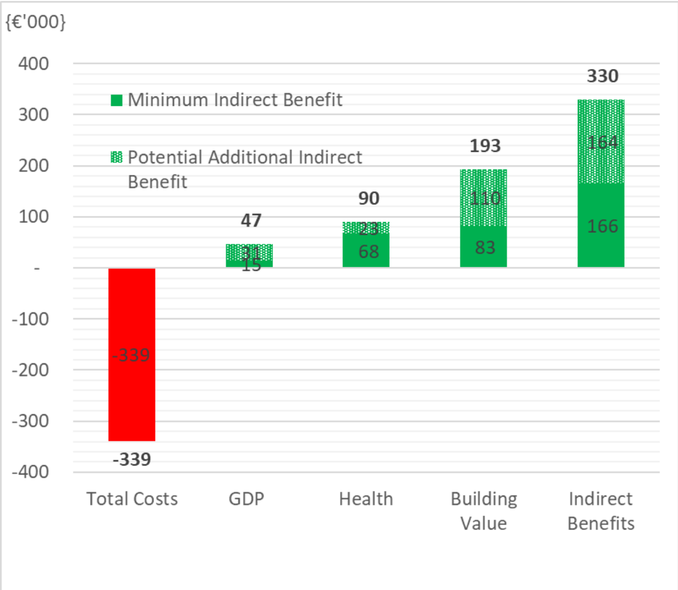


Fig 3.1 Upper and Lower estimated 15-year Indirect benefits for scheme of 12 dwellings

3.2 Economic benefits - Central Exchequer Benefit

Based on Turner et al [11], a 5% decrease in energy consumption could lead to a 0.1% improvement in GDP. The GDP of Ireland [12] is reported by the IMF to be $331.6 (€295bn), equating to £147,292 per household per annum, (based on 2.003m households[13]). Therefore the project could lead to a contribution to the economy of €15.4k over the 15 year period analysed. Based on the Cambridge Econometrics report, the contribution to the local economy would be €46.8k [6] (scaling over the 15 years required).

3.3 Health benefits - Central Exchequer Benefits financially

Based on the Kirklee 0.2:1 cost benefit ratio [14] and the total DER project cost of €339k, the lower estimate for the health benefit is €67.7k. Based on the UK CMO calculation method[15], the total benefit for the Collegeview project amounts to €90.3k. These financial benefits accrue to the Central Exchequer given that the tenants qualify for medical cards.

3.4 Energy Efficiency-based Increase in Value of Property – LA/HA Benefit

Fuerst [16] noted that A rated dwellings sold at a premium of 5% compared to D rated dwellings, and F rated dwellings sold for 1% less than D rated dwellings. The price premium between F and A dwellings is assumed to be 6%. Based on the value of each Collegeview property, this equates to an increase of €83k for the 12 properties. The EE improvements equate to an increase of 13 BER points (13%) for some dwellings and 14 BER points (14%) for others. These percentages improvements indicate an increase in the property values of €193k based on the Lyons study [17].

4. Summary and Analysis – Systemic/Societal Level

Figure 4.1 gives the overall costs (€339k) and the direct (€320k) and indirect benefits (€166k to €330k) over the 15 year period analysed. Considering only direct benefits, 94% of the investment is recouped over 15 years. Considering also indirect benefit, the benefits range between 143% and 192% of the €339k invested. These (undiscounted) figures reveal that the project is viable and the direct benefits almost ensure full payback within the 15 years, and overall (direct and indirect) benefits provide a payback of almost twice the invested amount. However a stakeholder analysis is pertinent.

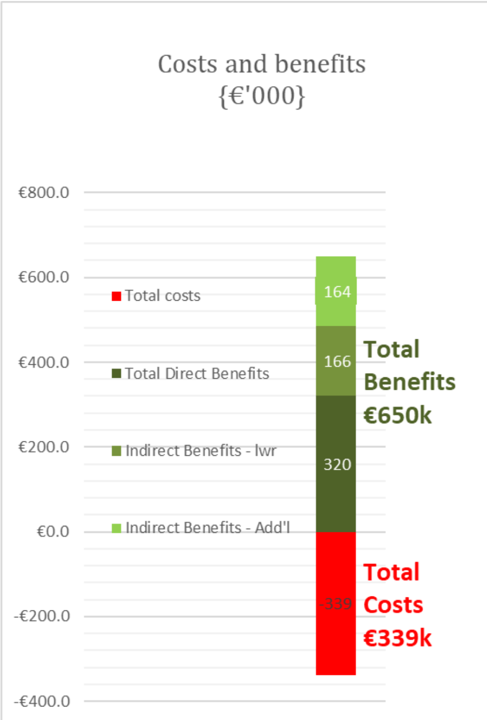


Figure 4.1 Costs and Benefits (15-year) for Case Study Scheme

5. Stakeholder perspectives

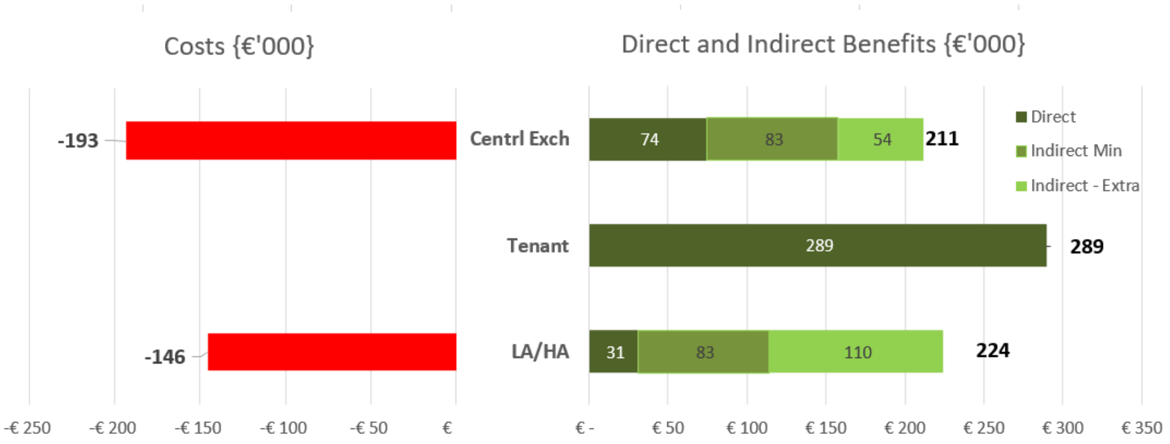
Figure 5.1 gives an overview of the costs and the direct and indirect benefits per stakeholder or beneficiary. The LA/HA invests €146k, with the remaining €193k being met by central government. Direct benefits are realised by the tenant (€289k), the LA/HA (€31k), and the Central Exchequer (€74k). Indirect benefits of €83k to €137k are enjoyed by the Central Exchequer, and the HA/LA also accrue indirect benefits of between €83k and €193k due to the increase in the property value.

The financial perspective of the LA/HA: Direct benefits (reduced maintenance costs and reduced costs associated with chimney fires) total €30.9k. If this is the only benefit considered, the 15 year return is 21% based on the investment made by the LA/HA.

When the additional indirect benefit of increased capital values of the property is also considered, it is seen that the total potential return could amount to between €113k (60%) to €224.1k (116%), indicating that the LA/HA have a potentially financially attractive project over the 15 year period. While the increased capital value is considered primarily a "book value", (as the properties will typically not be sold), the additional value could assist a HA in raising funding for other projects as its overall market capitalisation will be increased, reducing loan to value ratios for the lender.

The financial perspective of central government: for a total cost of €193k, the indirect benefits include lower healthcare costs and increased economic activity and total between €83k and €137k. There are direct benefits of €74k carbon taxes collected from the tenant (on the basis that the polluter pays). The Central Exchequer will bear the cost of international carbon emissions penalties. However, carbon taxes are not currently ring fenced by the central exchequer for payment of the international fines. If these €74k benefits are considered as general income, the Central Exchequer could benefit by in excess of €200k, indicating that returns will exceed investment over the 15 year period. If the €74k carbon tax is assumed to be paid directly in International fines, the net central exchequer 15 year benefit will be 71% of the investment (via the benefits of decreased health costs and increase in GDP).

The financial perspective of the tenant: He/She has no role to play in the decision-making process, makes no investment and yet will accrue direct benefits in excess of €289k due to reduced energy and carbon tax costs. The DER project is very attractive to the tenant given the increased comfort, reduced running costs and improved health outcomes associated with the project.



5.1 Costs, and Direct and Indirect Benefits per Stakeholder/Beneficiary

6. Discussion & Conclusion

An evaluation tool has been developed to understand stakeholder motivations for upgrades to much needed Energy Efficient (EE) standards which can be applied across jurisdictions & scenarios.
The "Multi-Beneficiary Analysis" is used here to quantify direct & indirect EE financial benefits for an Irish DER project and assign them to the beneficiaries. It is shown that at a societal level the direct financial benefits cover the investment, and when indirect benefits are included, the 15 year return can accrue to almost twice the investment. For the individual stakeholders, the investment and return vary significantly. While tenants enjoy significant financial benefits and the Central Exchequer benefits financially, the key decision-maker (Local Authority or Housing Association) incurs significant financial risks/losses. The provider of Social Housing (e.g. HA or LA) is seen to bear significant increased capital costs whilst only benefiting directly in reduced maintenance costs, and indirectly through increased capital values of the asset, (a performance metric on which they are not assessed).
A clear picture is emerging of the need for the Central Exchequer to support providers of Social Housing in delivering low-energy dwellings, not only for the benefit to the local economy and the avoidance of excessive future upgrade costs, but also for the immediate benefit of the tenants including the associated health and comfort benefits and the elimination of fuel poverty.
This may be through an augmentation of schemes such as the DER grants or through the provision of appropriate sources of finance and funding or through other incentives.
In addition, the analysis suggests that it would be beneficial for all stakeholders if a mechanism could be constructed whereby the tenant would have the ability/empowerment to initiate/drive the upgrade project thereby avoiding the potential current stalemate where the HA does not have the means to do DER at scale, yet the tenant would benefit physically and financially and yet does not have an ability to influence the upgrade decision. Consideration could perhaps be given to investigating mechanisms whereby the HA could finance their portion of the investment if the tenant agreed to contribute a fraction of the savings enabled by the ongoing reduced energy bill. Looking at the specific case study, heating costs have been reduced by an average of €1,189 pa. If qualifying tenants were to forgo their fuel allowance, a contribution of €840 pa could be used to assist the HA finance the DER. This could be sufficient to enable the HA (for example) to make a business case and raise the required capital, thereby unlocking the multiple benefits of the DER, whilst also giving the tenant a financial surplus.
The POE analysis indicates that the DER resulted in very high occupant satisfaction, excellent indoor environmental quality (IEQ) and very low cost of heating. Furthermore an holistic financial analysis demonstrates that the DER is self financing, even without considering the considerable indirect financial benefits. However, the stakeholder analysis demonstrates that the government's DER targets are unlikely to be achieved in the social housing arena without enabling mechanisms such as the heating allowance reallocation suggested. In this case study, the simple act of allocating the tenants

fuel allowance to the housing association could save the tenant money and simultaneously enable all the multiple benefits of DER to be achieved by all stakeholders.

7. References

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