NO-FINES HOMES – THE MAKE OR BREAK QUESTION?

James Sommerville, Nigel Craig[1] and Antoinette Charles

School of the Built and Natural Environment, Glasgow Caledonian University, UK.

No-fines concrete (NFC) homes comprise about 1% of the housing stock, in Scotland, which equates to around 33,000 homes. Most of these homes are located within the social housing providers' domain and given the 2050 target to reduce Scotland's carbon emissions by 80%, then it becomes apparent there may be significant challenges for these homes to achieve a u-value close to 0.3 W/m²K. In the 1970's, NFC was identified as a material which could save cement and energy. However, as practices changed, technology developed, and climate change became a real force, then the right of these housing units to exist became questionable. This research aims to evaluate the future value of existing NFC homes through detailed cost-benefit analysis. The cost-benefit analysis compares the cost of refurbishing existing NFC homes and the cost of building new homes. It is suggested that the cost analysis comparison will help social housing providers and construction managers to better understand the feasibility of refurbishing these homes. Data for this analysis was collected through fieldwork and case studies where a mixed methodology approach was adopted to derive answers to questions through both quantitative and qualitative methods. The sample for this research focuses on existing NFC homes in Irvine, Glasgow and West Dunbartonshire. The findings of this research will help social housing providers and construction managers make decisions about the future of their NFC stock. The cost of a new build is £205/m² higher than refurbishment and the minimum payback period for the refurbishment activity of a single bedroom property, generally, has a 16 year period. The findings from this paper show the need for further research on evaluating the assessment criteria used when considering to either 'make or break' existing NFC properties. The current emphasis on cost versus quality of life of the tenants within these existing properties may be questionable.

Keywords: cost, eco-homes, energy efficiency, fuel poverty, no-fines homes.

INTRODUCTION

NFC housing was adopted as a 'quick and cheap' alternative to traditional forms of house construction by the UK building industry from the 1950's onwards. This paper evaluates the cost of refurbishing NFC properties against the cost of new build homes. Data analysed is obtained from field work and case studies with the results from the analysis helping social housing providers and construction managers make decisions relating to the future of NFC housing in Scotland.

NO-FINES CONCRETE IN SOCIAL HOUSING

NFC construction is a non-traditional (NT) form of construction adopted in the UK to meet part of the housing demand after the Second World War. In England, NFC construction was chosen over other NT forms of construction as a result of shortages of skilled labour, essential building materials, industrial capacity and, manpower. NFC

[1] ncr@gcu.ac.uk

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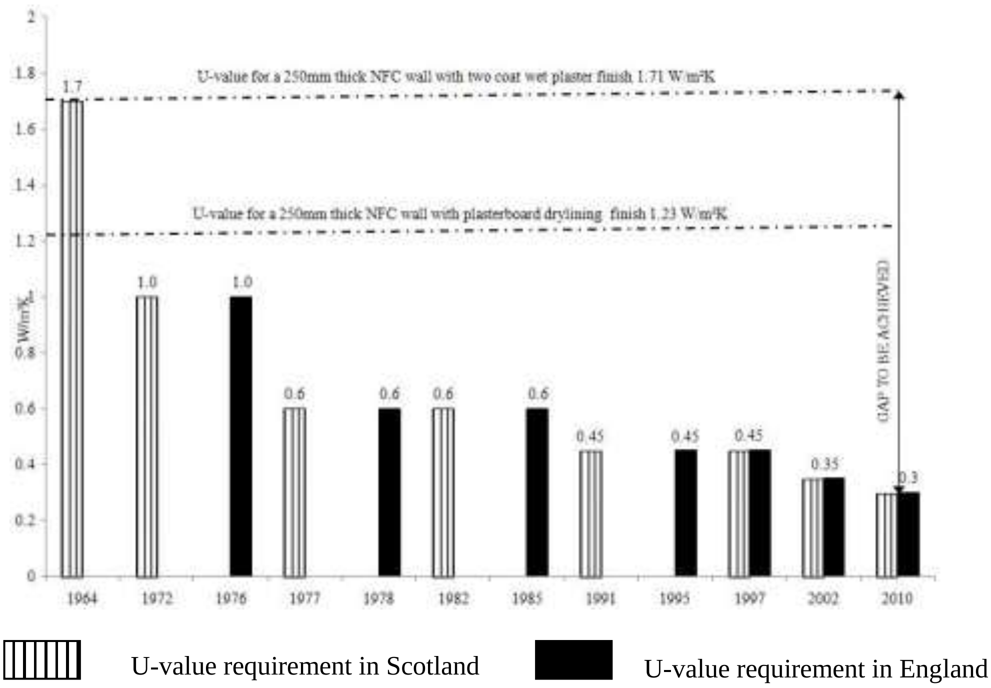
forms of construction emerged in Scotland due to the shortage of good quality bricks and bricklayers, and the rising cost of traditional building stones and slates (William and Ward, 1991; Ross, 2002). These drivers led to the construction of approximately 300,000 NFC homes throughout the UK (William and Ward, 1991). These NFC homes were built over a 30 year period from the 1950s through to the 1980s with most of these properties being built in ‘special or distressed areas’ where the demand for housing was high (Ross, 2002). In Scotland, the Scottish Special Housing Association (SSHA), now embraced within the umbrella of Communities Scotland, was formed in 1937 to assist Local Authorities (LAs) in special or distressed areas with their housing programmes. The pressure on LAs to provide quick and cheap housing for people combined with the lack of skilled labour in the construction of NFC properties, and the absence of standard construction approaches affected the overall quality of the constructed NFC homes.

Of the 33,000 NFC homes in Scotland, the majority have lasted for circa 60 years: Edwards (2010), estimated the effective life span of a building to be 50 years and builds on William and Wards (1991) observation that NFC properties, in general had no significant structural problems. However, owing to the nature of the actual construction techniques adopted when building the NFC homes, which typically had outdated interior layouts and the absence of precise building standards, it may be argued that the homes now suffer from fuel poverty and are classified as ‘hard to treat’. Figure 1 identifies the gap that existing NFC properties must bridge to reach a level of thermal performance that matches current building standards. To bridge the thermal performance gap and to reduce green house gas emissions, the UK government focuses on two major approaches:

1. Increasing the energy efficiency of housing stock; and,
2. Advising consumers about low carbon alternatives for space and water heating.

Figure 1: U-Value requirement of NFC walls (Sommerville et al., 2010)



Some two-thirds of existing dwellings will struggle to meet the targets set to achieve a 34% reduction in green house gas emissions by 2020 and an 80% reduction by 2050 (Boardman *et al.*, 2005; Climate Change Act, 2008). The Scottish Government aims to reduce green house gas emissions by at least 42% by 2020, a target that is more ambitious than the target set for rest of the UK. Considering the performance of existing NFC homes (outlined in Figure 1), social housing providers in Scotland have adopted different refurbishment approaches aimed at bringing the property up to standard (see Table 2) to improve the performance of the NFC homes. In the 1970s, NFC was identified as a means to reduce energy and cement costs (Moss, 1979). However, with growing concern surrounding climate change, the performance of NFC has, rightly, been called into question. Fabric performance is vital in the context of energy efficiency: for example, when energy demand in a property is reduced by 10% a subsequent reduction on space heating by 1ºC is effected (DECC, 2009). Similarly, lowering the U-value of an external NFC wall will result in a significant reduction in space heating demand.

Table 1 highlights the cost associated with different approaches that can be adopted to reduce the energy consumption of a property; such reductions can help reduce overall greenhouse gas emissions. Some of the common approaches adopted by different social housing providers are presented with the data labels in Table 1 highlighting the annual energy saving for a two bedroom flat. By adopting a standard refurbishment package of external and internal wall insulation, loft and floor insulation, double glazing, draught proofing and controlled ventilation for a two bedroom terraced property. The energy saving for this property would be, in theory, 82% for a total cost of £10,550. However, considering the physical environment of this terraced property, the construction details and the lifestyle of the occupants; 82% energy saving requires to be quantified. For evaluating the actual performance of NFC properties, in terms of energy saving and cost, data has been collected from NFC properties through case studies and field work.

Table 1: Cost of refurbishment activity and annual energy savings % (adapted from Good practice guide 81, 1994)

Refurbishment approach	Cost/ unit (£)	Energy saving (annually) %
External wall insulation – low rise	4800	20
External wall insulation – high rise	11000	20
Internal wall insulation	2200	20
Pitched roof insulation	200	20
Flat roof insulation	1700	20
Ground floor insulation - suspended	200	10
Ground floor insulation - solid	750	10
Balcony insulation	300	15
Double glazing	2000	12
Draught proofing	100	Improvements to thermal comfort standards
Controlled ventilation	500	Improvements to thermal comfort standards

METHODOLOGY

To determine the future of existing NFC homes through cost analysis; a mixed methodology approach was adopted: this will help to overcome the shortcomings of adopting either purely qualitative or quantitative approaches. In other words, the complexity of this research will be analysed utilising the strengths of both qualitative and quantitative approaches (Creswell, 2009). Data was collected from secondary (desk study) and primary sources (fieldwork and case studies). To identify the refurbishment practices adopted within the literature, various research articles, working group papers and government publications were reviewed. According to Punch (2005), secondary data explores previous research and articulates knowledge. The findings from the secondary data collection provide a background for primary data collection.

As an initial scoping exercise, 32 unitary councils within Scotland were contacted by email to identify the number of existing NFC properties within their housing stock. Most of the local councils mentioned their NT housing stock; including NFC properties had been transferred to housing associations. As a few NFC properties were still retained within the local authorities, this research identifies both the local authorities and housing associations as social housing providers. Only 15 social housing providers were able to identify NFC properties amongst all NT construction. As a second stage of data collection; the 15 social housing providers were contacted for information on their refurbishment package adopted for the existing NFC properties. A questionnaire, comprised of four questions, was sent by email:

1. The type of approach adopted in refurbishing NFC homes
2. The total cost of adopting this approach
3. From a social housing provider's perspective is the approach adopted cost effective and
4. Has the approach adopted improved the thermal performance of the existing NFC homes?

For confidentiality, each social housing provider has been identified as Area A, B to F. To evaluate the performance of the NFC homes, fieldwork and case studies were conducted; Biggam (2008), suggests case studies are useful for observing the characteristics of an individual unit of analysis. Moreover, Denzin and Lincoln (1994) suggested that case studies are useful for studying phenomena in their natural settings and for attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them. For the direct case studies, all 15 social housing providers were contacted. Only three social housing providers were able to provide vacant or occupied properties for the research. The data collected from the field is tabulated in Tables 2 and 3 with relevant images illustrated in Figure 2.

A total of four properties were studied in detail to identify the thermal performance of the NFC external wall. External and internal temperature sensors were installed for each property. Internal heat flux meters were also placed within each property to monitor the heat loss through the external fabric. The monitoring was conducted over a two week period during the winter months, from December 2010 to March 2011. The data logged in the sensors were analysed using Microsoft excel spreadsheets to determine the U-value of the external wall. The energy consumption within these properties was also collected to identify the annual heating cost. Floor areas for each property were calculated to compare the heating bills of each property (refer to Figure 3). To determine the economic feasibility of refurbishing existing NFC properties to new build homes a two step financial calculation was adopted including: Simple Payback Period = Initial cost of efficiency measure/ annual value of energy saving.

Finally, data from Building Cost Information Services (BCIS, 2010) provides the cost/m2 of new build and refurbishment (refer to Figure 4). This data will help visualise the gap between the refurbishment cost of existing NFC homes and the cost of new build homes.

DATA ANALYSIS AND RESULTS DISCUSSION

This section is divided into 4 sub sections. The initial sub-section discusses the building features of the properties studied. Table 2 highlights the existing condition of the four NFC properties: the four properties were a terraced unit, four in a block, and multi-storied. The data from Table 2 also displays some upgrading activities that have been carried out in these properties.

Table 2: Building features of each property.

Property	A	B	C	D
Type	1br. (top)	1br. (top)	2br. (mid)	2br. (bottom)
Orientation	East	North	South	West
Floor area	43	45	63	70
Ventilation type	Controlled in bathroom and kitchen	Controlled in bathroom and kitchen	Controlled in bathroom and kitchen	Controlled in bathroom and kitchen
Glazing	Single	Single	Double	Single
Type of heating	Electric storage heaters	Electric storage heaters	Electric storage heaters	Electric storage heaters
Heating bills	840£/yr	600£/yr	750£/yr	746£/yr
Wall insulation	none	none	none	none
Floor insulation	none	None	none	none
Loft insulation	150mm mineral wool	150mm mineral wool	none	none
U-value of the wall	1.21 W/m2K	1.03 W/m2K	1.09 W/m2K	1.19 W/m2K

Figure 2 visually identifies the physical environment of the properties using infra-red images to illustrate the performance of the external fabric. Figure 3 illustrates that as the U-value increases; so too does the cost of heating bills. The relationship between the floor area and the heating bills however is not consistent. For example, in terms of property A, a single bedroom top floor flat with a floor area (FA) 43 sq.m costs £840 annually on heating bills. Though the property is a mid terraced house it has its East and West façade and its roof and floor exposed to the external environment. The walls and the floor of this property are un-insulated and the loft has 150mm insulation. Property A and B are located in the same neighbourhood, with the same floor area. Both properties are located on the top floor. The exposed floor of property A partly explains the high energy consumption in this property.

When considering a refurbishment package, most social housing providers are forced to take decisions based on available budgets. The Good Practice Guide 179 (1995) points out that it is not always possible to install a full package of measures over a whole estate during a single refurbishment programme. With phased refurbishment programmes the choice of the measure adopted is important, as it could justify the spending cost on that measure by reducing fuel bills and improving comfort for the occupants. Alternatively if an appropriate measure is not properly chosen; such as insulating the walls internally without upgrading the loft insulation, the refurbishment activity might fail resulting in mould growth and condensation risks near the ceiling and the wall corners of the property.

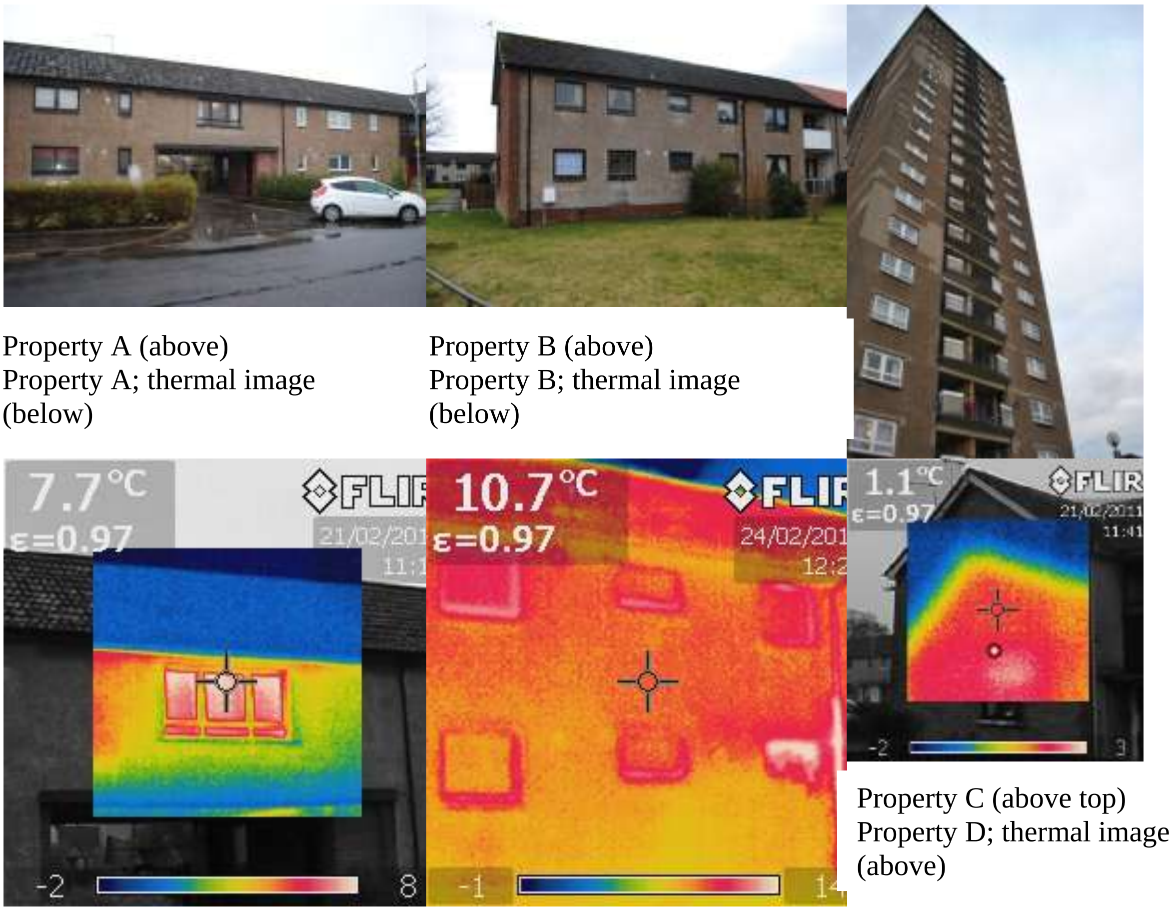


Figure 2: Images of the four properties.

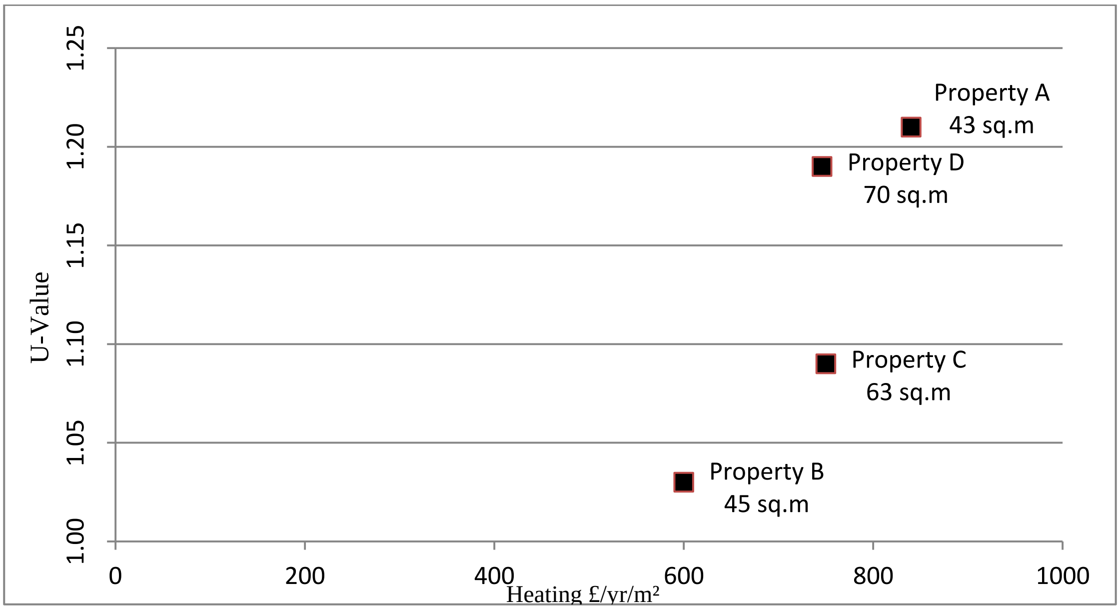


Figure 3: The relationship between the thermal performance of the external wall and the cost of heating existing NFC property.

Table 3:Refurbishment approaches adopted by social housing providers

Approaches adopted by social housing providers						
Approaches	Area A	Area B	Area C	Area D	Area E	Area F
External Insulation	✓ over cladding	over cladding (awaiting budget approval)	✓ ext. insulation with polymer render	✓	✓	✓ over cladding
Internal Insulation	✓	✓ dry lined (existing)		✓ Space-therm	✓	✓ Space-therm
Loft Insulation	✓	✓ 250-300 mm			✓	✓
Double glazing/ Draught proofing	existing	✓ Double glazing with rubber seals	existing	existing	✓	existing
Trickle vents	✓					
Storage heaters	✓				✓	
Gas-fired district heating/ hot water						
Gas-fired central heating					✓	
Cylinder insulation, off-peak meter		✓ Grade A boiler				
Extractor fans	✓					

Table 3, provides information on all the refurbishment approaches adopted by different social housing providers. The most common approach adopted is insulating the walls externally and internally. However, the social housing providers identified that their challenge in adopting external insulation depended on the type of tenure of the properties. External insulation is only feasible to adopt when all properties in the block are owned by the social housing provider. Internal insulation is considered an alternative when private owners are unwilling to insulate their homes externally (Area D).The social housing provider that oversees Area B are awaiting budget approval before externally insulating the walls. Therefore, current refurbishment activity has seen boilers replaced and upgraded to Grade A boilers. In terms of Area D, however, boiler replacement is a separate programme as the budget allocated is ring fenced and intended only for insulating homes. Different areas within Scotland adopt different packages to suit available budgets.

The data presented in Table 4 shows the refurbishment costs incurred for each house type in comparison with the improvement in the U-value of the external NFC wall. The Standard Assessment Procedure (SAP) value for Area A properties fall within a band of 70 to 80. However, in terms of Area C and D the Nation Home Energy Rating (NHER) scales from 5.2 to 10. The difference between SAP and NHER is that the latter gives a more accurate estimate in terms of energy used, CO_2 emissions and running costs. SAP, on the other hand uses standard occupancy and standard heating patterns (National Energy Services, 2011). To identify the projected energy bills and payback period for the properties case studied under the scenario of area A, refer to Table 5.

Table 4: The cost of refurbishment of each property type (Area A)

House type	Property type	U-value (before refurbishment) W/m²K	U-value (after refurbishment) W/m²K	Cost of refurbishment
Tenements		1.358	0.328	£13,000/-unit
4 in a block	B, D	1.6	0.341	£10,000/-unit
Terraced	A	1.6	0.341	£10,000/-unit
Multi-storied	C	1.208	0.31	£1.5 million/-block

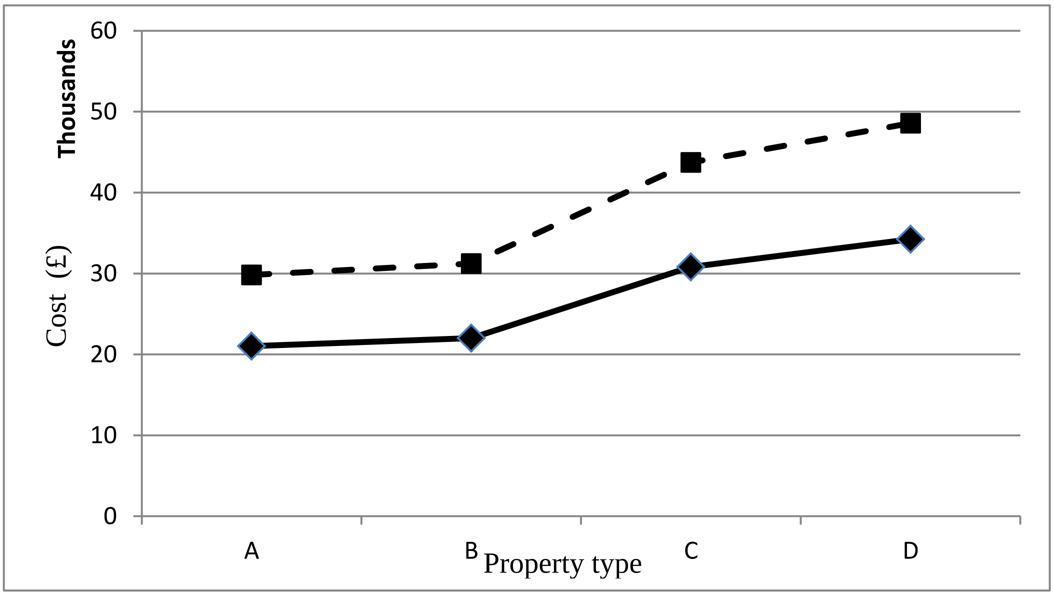
** Note unit includes each property*

Table 5: Projected energy bills after refurbishment and payback period of the initial investment.

Property type	U-value W/m²K	Energy bills £/yr	Targeted U-value W/m²K*	Projected energy bills £/yr	Payback period yrs.
A	1.21	840	0.341	236.72	16.5
B	1.03	600	0.341	198.64	25
C	1.09	750	0.31	213.30	Less than 18 (depends on no. of flats/ block)
D	1.19	746	0.341	213.76	18

**column taken from Table 4 U-value after refurbishment*

Figure 4: The cost of refurbishment and the cost of new build for each property type.



In Table 5; the projected energy bills is calculated logically using “if – then” relationship. For this calculation the inflation rate of 4.5% is not taken into account. This will have an effect on both the projected energy bills and the payback periods. An ideal situation is assumed for both the projected energy bills and the payback period. However, in reality this is not possible. Future research will consider the cost benefit analysis on existing NFC homes and the discounted cash flow. Edwards (2010) identified the ideal payback period to be seven years for any property type but with a minimum of 16.5 years for the payback of the initial investment. The practicality of refurbishing NFC properties is questionable. With reference to Table 4; property A (which performs poorly compared to property B) reaches the payback point quicker than property B. The difference between the two payback periods for property A and B is almost nine years. This has a significant impact on lowering carbon emissions and reducing the fuel poverty in property A. The issue is however, the future of the NFC properties. It is not clear if the social housing providers are prepared to wait for 16 yrs for a return on investment from these properties.

Considering the increased cost of new build in relation to NFC properties including the cost of relocating the tenants, the option of refurbishment is a considerably more attractive proposition as can be seen in Figure 4 which calculates the cost of refurbishment (least expensive, solid line) against the cost of a total new build (most expensive, dashed line). However, taking into account the outdated interior layouts, energy performance and indoor air quality of the NFC properties, and the quality of life of the tenants in these properties, it is worth considering the future of NFC homes.

CONCLUSIONS

This research focuses on NFC houses in Irvine, Glasgow and West Dunbartonshire. It evaluates the cost of refurbishing existing NFC properties based on different approaches adopted by social housing providers within Scotland. This data was then related to the case studies conducted. Literature was reviewed to collect information relating to the cost of constructing new homes to current building standards. The cost of a new build is £694/m^2 and the cost of refurbishment is £489/m^2. Though the cost of refurbishment is lower than the cost of new build, the payback period of existing NFC properties is almost 16 years, when a payback period of 7years is considered ideal. A payback of 16 to 25 years for the return on investment on a refurbishing activity is a long period for homes classified as ‘hard to treat’ as a result of insufficient interior spaces. NFC as an approach, was in its day, an approach that offered solutions to the problems posed at that time; however, the facts suggest, that in the contemporary built environment, the NFC homes may not be 'fit for purpose'. This paper calls for further research on evaluating the assessment criteria to either make or break existing NFC properties on cost, quality of life of the tenants within these existing properties and the indoor air quality within these properties. Future research should focus on the evaluation of refurbishment procedures adopted in refurbishing NFC properties. It would also be of value to carry out a cost benefit analysis on the future of NFC properties in relation to discounted cash flows.

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