The Sustainable Refurbishment of High Rise Housing

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ABSTRACT: The consequences of global warming and the UK's commitments to achieving targets for the reduction of greenhouse gas emissions is increasing the urgency for the UK to move towards a more sustainable future. One aspect of this is to improve the sustainability of the existing housing stock. Our housing stock as a whole is ageing because current demolition and new-build rates cannot meet ever-increasing demand. It is estimated that 800,000 people reside in 4000 high-rise tower blocks. Refurbishment of these existing buildings needs to be a high priority.

PBA have been commissioned to provide Structural, Mechanical and Electrical consultancy services in support of Sandwell Metropolitan Borough Council, West Midlands in their refurbishment of 44 tower blocks to 'Decent Homes Standard'. This paper will aim to examine the sustainable value of refurbishment by assessing a 'typical' case study and reviewing the environmental and economic impact when compared to new-build.

1 INTRODUCTION

There is international acceptance that global warming is perhaps the biggest challenge at the start of the 21st century and a major threat to our future. The Stern Review published on 30th October 2006 on the economics of climate change has identified that unless urgent change is carried out across all sectors, it could cost the world up to fifth of its entire wealth with major implications for human welfare.

In the UK the housing stock is of particular importance as it is responsible for approximately one quarter of all carbon dioxide emissions (CO_2), two thirds of which result from domestic energy use. We have a considerable legacy of old energy inefficient homes. Conservatively it is estimated that 75% of the housing stock that will be inhabited in 2050 already exists, therefore reducing domestic emissions requires significant improvements to the current housing stock.

There is a strong argument for improving the resource efficiency of these existing homes, rather than seeing widespread new build as the more appropriate option. Regulation and cost of landfill associated with demolition is a key positive factor for retention and improvement instead of demolition and rebuild. If the existing stock can be made more efficient at a reasonable cost we can realise many environmental and social gains.

The aim of this paper is to consider the benefits of the investment associated with the Government's Decent Homes initiative with particular respect to the Sandwell high rise programme and the benefits of refurbishment over demolition and rebuild.

Figure 1: Meadow Avenue, Sandwell
Existing

Photograph: BM3 Architecture

Figure 2: Meadow Avenue, Sandwell
Proposed Refurbishment

Graphic: BM3 Architecture

To fulfil this aim the following assessments have been made:

– Reduction in % CO_2 emissions after refurbishment.
– Wider economic, social and environmental benefits of refurbishment of existing properties over constructing new properties.

To facilitate this assessment we will draw on our experience as a partner in the Sandwell high rise refurbishment programme. This programme involves the refurbishment of the external fabric and internal communal areas of 44 number 1960's residential tower blocks ranging from 6 to 17 storeys in height in Sandwell, West Midlands without decanting residents. The initiative involves working in partnership with Sandwell Homes, an 'Arms Length Management Organisation' (ALMO), and Sandwell Metropolitan Borough Council to upgrade to the Government's Decent Homes Standards by December 2013. (See Figures 1 & 2)

Each block will have undergone a different range of repairs and refurbishment in its 40-year life so the characteristics of a 'typical' block considered here combines the salient features characterising the blocks.

2 POLICY CONTEXT

The UK's housing provision and its response to climate change are two important policy areas.

Currently it is estimated that 4 million of the 21 million homes in England are categorized as social housing. The Decent Homes programme is a government initiative which aims to ensure that all social housing meets standards of decency by 2013. A decent home should;

– meet the current statutory minimum design standards for housing e.g. Building Regulations Part L 2006,
– be in a reasonable state of repair,
– have reasonable modern facilities and services, and
– provide a reasonable degree of thermal comfort, i.e. it has effective insulation and efficient heating. (Essentially meet current Building Regulation standards.)

It is estimated that by 2012, around 3.6 million existing homes will be upgraded to this standard involving an estimated investment of over £40bn.

The Government's response to climate change has largely centred around achieving targets set in the Kyoto Protocol and then aiming for successive targets from that basis. Under the Kyoto Protocol the UK is committed to reducing CO_2 emissions, believed to be the main cause of climate change, by 12% from 1990 levels by 2010. The Government has also set its own target of a 20% reduction in CO_2 emissions by 2010, however it is widely recognised that achieving this target is unlikely.

The 2003 Energy White Paper included the target to reduce CO_2 emissions by 60% by 2050, with "real progress by 2020". The White Paper also documented the target for 50% of the reduction in CO_2 emissions by 2020 to result from energy efficiency.

Housing has a key role to play in meeting the UK's challenging carbon targets for 2010 and 2050. Buildings contribute around half of the UK's carbon dioxide (CO_2) emissions. Currently UK homes contribute about 27% of UK carbon dioxide emissions (HMG 2004) and energy consumption is rising.

The Government's new 'Code for Sustainable Homes' aims to draw together housing standards and the effect on climate change. It also aims to provide a single national standard for sustainable homes and form the basis for the next wave of change to the Building Regulations.

Overall, the state of the UK housing stock and our response to climate change creates key challenges that the Government is only beginning to address in a coordinated manner.

3 DEMOLISH OR REFURBISH?

Is it more sustainable to refurbish buildings or to demolish and replace with new build?

There appears to be a general perception that new homes will be built to a much higher standard of environmental efficiency than old ones, so the older less attractive properties should be demolished to make way for the new. But is this necessarily so?

This perception will be examined using economic, environmental and social indicators which can be measured in terms of:

- How much more fuel efficient are new/ refurbished dwellings compared with old and the consequent reduction in CO_2 emissions?
- What are the economic and environmental savings of refurbishment? For example, waste minimization.
- Social benefit of maintaining existing communities, though difficult to quantify.

4 METHODOLOGY

The assessment is based on a ‘typical’ high rise residential building built in Sandwell and most parts of the UK in the 1960s. The following basic assumptions have been made:

- The building is a 20-storey RC framed tower block built circa 1965
- Typical apartment size is $50m^2$ (Plus $10m^2$ allowance for communal space)
- 100 number apartments per block i.e. 5 number apartments per floor
- Total building floor area = $6000m^2$

The following situations were considered for the study:

- Existing tower block – in its current unmodified state;
- Existing block refurbished to Decent Homes Standards;
- Demolition and an equivalent new build residential scheme.

The following assessments were carried out to compare the economic and environmental impact of each approach:

- SAP 2005 – Standard Assessment Procedure: A review of the U-Values and energy requirements before and after refurbishment.
- A review of the typical costs for demolition and rebuild with comparison to the cost of refurbishment. This would include an assessment of CO_2.

The following lists items relevant to the SAP values of a typical building:

4.1 *Existing:*

- Frame - insitu RC
- Elevations – cavity brick and block with no insulation
- Flat Roof - concrete with no insulation
- Windows - timber framed
- Balconies - exposed with no thermal break
- Light fittings - standard
- Heating - electrical convectors
- Hot water - electric immersion heater

4.2 *Refurbished:*

- Existing masonry walls insulated and overclad
- New double glazed timber/aluminium windows
- Balconies enclosed with full height rainscreen cladding
- New pitched insulated aluminium standing seam roof
- Heating and Hot water - gas fired combination boiler of the condensing type.
- Heating - radiators to have thermostatic radiator control valves
- Low energy lighting

4.3 *New Build:*

Decent Homes requires that all existing buildings are to be upgraded to achieve the current minimum statutory requirements. However, for a new build there is an incentive, due to planning issues, government funding etc. to exceed these minimum requirements and achieve the Ecohomes 2006 ‘Very Good’ criterion.

Ecohomes 2006 has 7 primary categories all of which offer credits for various ‘sustainable’ initiatives/ additions incorporated into the design, which when aggregated provide the Ecohomes rating. These categories are (number in brackets are maximum credits available; Total 107): Energy (24), Transport (8), Pollution (11), Materials (31), Water (6), Land Use and Ecology (9), Health and Well Being (8), and Management (10). These categories are then further sub-divided: For example Energy has 6 sub-categories (Energy 1 to 6.)

Energy 1 (‘Dwelling Emission Rate’) accounts for 15 of the 107 total credits available. The dwelling emission rate is measured in terms of average CO_2 kg/m^2/year. At first glance it would appear that this measure will need to be significantly better than the minimum needed for Decent Homes standard to achieve the 'Very good' criterion. However further analysis of the breakdown of the Ecohomes credits system suggests otherwise.

Currently 58 credits are required to achieve a 'Very Good' rating. There are sections within Ecohomes 2006 such as 'Materials' and 'Management' which in an economic sense offer easier credits than further lowering the 'dwelling emission rate'. For example the provision of a 'Home User Guide' to enable home owners/occupiers to understand and operate their home efficiently, in line with current good practice, provides 3 credits. In terms of the 'dwelling emission rate' 3 credits would typically mean a reduction in CO_2 by 6kg/m^2/yr which would require a significant expense.

Based on this and from previous experience of carrying out Ecohomes pre-assessments, a 'dwelling emission rate' which achieves 7 credits i.e. <24kg/m^2/yr is typically sufficient for attaining the 'very good' criterion.

5 ASSESSMENT RESULTS

5.1 *Environment*

5.1.1 *Operational:*

SAP assessments for the 'typical' block are shown in Table 1 with the calculated (estimated) annual energy use and equivalent CO_2 emissions per apartment, using current technologies for generating electricity.

Table 1: SAP Assessments/ apartment

Apartment	Existing		Refurbished/ New Build	
	Energy (Kwh/m^2)	CO_2 (kg)	Energy (Kwh/m^2)	CO_2 (kg)
Ground Floor	318	2600	130	1300
Typical Floor	249	2100	111	1100
Top Floor	350	2900	126	1200
Average	258	2200	113	1100

From Table 1 it can be seen that for a typical unit within the 'existing' block the CO_2 emissions would be 44kg/m^2/yr assuming an apartment size of 50m^2 (i.e. 2200/50 = 44). This would get zero credits if assessed to Ecohomes 2006. After refurbishment to current Part L regulations, an emission rate of 22kg/m^2/yr (i.e. 1100/50 = 22) would apply, getting 8 of the 15 credits available. Hence, it is therefore a reasonable assumption that the CO_2 emissions rate required for a new build structure to achieve 'Very Good' Ecohomes will be similar to that needed for a refurbished block to achieve Decent Homes Standard. Thus, both refurbished and new build figures have been grouped in Table 1.

The summary in Table 1 shows that there is a 50% saving on operational CO_2 emissions if the existing block is refurbished or rebuilt.

5.1.2 *Construction and Demolition:*

An analysis of the amount of construction material required to build a new 20-storey residential block for 100 apartments has been done quantifying only the substructure, frame and walls. Based on the replacement cycles provided in Table 4 it can be seen that other building components required for new build construction will at the very least be replaced twice during the typical 60-year design life of a building. Hence, regardless of whether an existing building is retained or replaced there is no difference in cost or CO_2 for these components.

The quantities of material required for the substructure, frame and walls have been measured and are listed in Table 2a below:

Table 2a: New Build Construction Materials

Material	Quantity (tonnes)	Embodied CO2 - (tonnes) 1
Concrete	4000	570
Masonry	3000	1050
Steel	300	360

1. Table D.1, SCI Publication 182

The embodied CO_2 levels shown in Table 2a allow for both transport to the site and manufacture.

A similar quantity of demolition arisings would be generated prior to a new build 'replacement' building. The embedded energy within the demolished structure i.e. energy consumed primarily for the production and transportation of these materials will be moved and further energy will be required during the demolition process i.e. recycling, disposal and transportation etc. This is difficult to quantify as distances to landfill, recycling plants and new sites will vary from site to site. An estimation of CO_2 levels dependent on the haulage of demolition materials is presented below. The distance to landfill/recycling plants is a conservative estimate for Birmingham.

Table 2b: Demolition Materials

Material	Tonnage	Haulage: No. of trucks [2]	Distance to plant [3]	Total km [4]	Litre fuel/km	kg CO_2 /km [5]	Total CO_2 (tonnes)	Demolition, Excavation & Disposal [6]: kg CO_2/tonne	Total CO_2 (tonnes)
Concrete	4000	200	20	8000	0.4	1	8	9.5	38
Masonry	3000	150	20	6000	0.4	1	6	7	21
Rebar	300	15	20	600	0.4	1	0.6	27	8.1
						Total	15		67

2. Assuming rigid heavy truck with 20 tonne capacity
3. Conservative distance to landfill/recycling plant (GHG Protocol - Mobile Guide (03/21/05)
4. Includes unloaded return journey
5. Guidelines for Company Reporting on Greenhouse Gas Emissions, DEFRA. Continuing Survey of road Goods Transport 2001.
6. Table D.1, SCI Publication 182

There is also the issue of increased waste which should be considered. The construction and demolition industry produces approximately 33% of all the waste from industry in the UK each year. An astounding 19% of this waste is a consequence of over-ordering for new build construction. A programme of housing stock replacement would exacerbate the problem unless waste management practices are also improved. The re-use of the demolished building materials, close to source, would mitigate the apparent significant carbon cost of demolition. However, the vast bulk of the high rise blocks are reinforced concrete and material re-use is not always possible. Some energy for processing during the recycling i.e. crushing, screening, sorting, transporting will be needed. Reinforced concrete elements are easily used in a down-graded form e.g. hardcore beneath roads. In this case, the maximum potential from the initial resource is lost and as such further energy is expended in manufacturing new to replace old.

From Tables 2a and 2b the total sum of estimated CO_2 emissions arising from demolition and new build construction (frame, walls and substructure only) is approximately 2060 tonnes. Over a typical 60-year design life this equates to an annual CO_2 consumption of 0.35 tonnes per unit (Assuming 100 units) or 7kg/m^2/yr (i.e. 350/50 = 7.)

5.2 *Economy*

5.2.1 *Operational*

The following is an assessment of the lighting, heating and hot water bills for a ‘typical’ block as existing and refurbished. The rates are based on information published by DTI in 2006 i.e.2.5p/kWh for gas and 8p/kWh for electricity, assuming a 40:60 gas:electricity ratio. Note the bills for the new build are considered similar to that of refurbished. Renewable or centralised energy sources have been omitted. Depending on the payback period, this would yield some further saving on the new bills.

Table 3: Energy Bills[7]

Flat	Existing Bills (£)pa	New Build/ Refurbished Bills (£)pa
Ground Floor	922	377
Typical Floor	722	322
Top Floor	1015	365
Average	748	328

7. Annex 2C.Energy – Its Impact on the environment and Society 2006. DTI

From the summary in Table 3 it can be seen that a programme of refurbishment can result in 56% savings on energy bills. New build would achieve comparable saving over the existing, unmodified blocks but with the carbon penalty shown in 5.1.

5.2.2 *Construction and Demolition*

Table 4: Typical replacement cycles and % cost for building components within a new build multi-storey apartment block.

Building Component	Replacement Cycle	Cost
Decorations	5 years	2%
Floor Finishes	10 years	2.5%
Kitchen and Bathroom Fittings	15 years	7.5%
Mechanical and Electrical Systems	30 years	24.5%
Envelope: External walls, Windows and Roof	60 years	17.5%
Substructure, Frame and Floors	60+ years	46%

From Table 4 it can be seen that approximately half of the total cost of a new building can be saved by retaining the more durable elements beyond the typical 60-year design life of a building. This represents a significant saving in terms of initial capital expenditure.

Refurbishment avoids the cost of demolition and disposal. It should be noted that satisfying current planning procedures has become slower and more expensive. This further supports a policy of refurbishment over new build.

6 DISCUSSION

Everything we do has an environmental impact, but from this assessment it appears that the refurbishment option comes out best value on whatever measure is used.

Operational CO_2 levels in refurbished blocks are comparable to new-build, if upgraded to current building regulations. It is acknowledged that newer sustainable technologies e.g. renewable energy sources, combined heat and power (CHP) plants; can be relatively easily integrated into the design process for a new-build but these benefits must be broadly equivalent to the loss of embedded energy through demolition of an existing building and the embodied energy required for new construction. All this assumes that the new buildings achieve their design lives.

In cost terms the energy bills are again comparable to new-build as thermal efficiency meets current regulations. The primary economic benefit results from the large initial cost saving of retaining the 'structural' elements of the building which have a value beyond their original design life. Other factors which need to be considered are the costs of demolition and rising costs associated with landfill.

The assessment ignores changes in public and government policy to housing densities and assumes that new will directly replace old. The reality is that housing densities have reduced greatly since the 1960's and new build projects outside major cities will generally be low-rise and as such will have greater demands which are difficult to quantify. For example: new infrastructure, new roads, shops, and car parks. These developments require even more journeys and therefore require transport enhancements. Even if built on brownfield sites there may be economic costs associated with remediation and environmental costs with the loss of biodiversity, vegetation etc. Retaining tower blocks as a high density form of housing where social structures are stable permits housing needs to be met whilst keeping land use to a minimum. Green space, which would otherwise be required for low density housing development, is thus safeguarded. It is also worth noting that tower blocks have the potential to leave a smaller 'ecological footprint' than traditional low rise homes. They can be made much more energy-efficient by capitalising on their characteristic low surface area to volume ratio.

There are also long-term concerns with some new houses. Development pressure to make homes more affordable is leading to more prefabrication. Whilst this has many advantages, it results in homes that are less easy to adapt. Future refurbishment on site of a factory produced product poses some challenges. In essence these homes are likely to have a shorter life span requiring replacement sooner than traditional building construction.

Social implications need to be addressed for example there are 20.9 million households in England (2003 figure.) In March 2006, the government published projections that this number will increase to 25.7 million by 2026, implying a theoretical shortfall of 4.8m. Increasing housing supply does not necessarily mean building new houses. In fact, if the supply was to be built new then there can be significant social implications relating to the abandonment of existing stock in less popular areas. Today, there are 680,000 empty homes in England. These homes could be refurbished along with the estimated 400,000 empty commercial spaces in England which in turn could resolve the supply problem. This process can help regenerate areas, and have significant economic and environmental benefits.

The retention of communities is a significant benefit, difficult to measure and beyond the scope of this paper. Discussions with local residents can give an important steer in consideration of retention or demolition. A defining feature of a tower block is that its size, typically around 100 households is similar to a small village. Unlike a typical street, a tower block with its shared facilities and services forms a distinct and self-contained unit within which residents can interact with each other. From this follow opportunities for a sense of collective responsibility for the communal areas and for each other.

We must be careful however not to paint this picture of 'gold paved streets in the sky' providing an improved close-knit quality of life for the residents. Tower blocks in some of the most deprived areas have been plagued with decline due to fabric neglect, poor maintenance and ultimately a break-down in community leading to a lack of respect for each other. In such instances demolition may be necessary or where the block has such deep social problems that the best hope lies in giving the residents a new start in new homes.

Tower blocks are in desperate need of an image 'make-over.' Different types of housing carry various associations in people's minds that relate to their own housing aspirations. In many places tower blocks have a very negative image and are seen as one of the least desirable forms of housing. Image is important because it affects whether people will choose to live in high rise accommodation. With a reasonable image, tower blocks stand a better chance of attracting a good social mix. Otherwise they may develop as concentrations of people suffering from disadvantaged conditions, unable to assert their own housing preferences. This failure unfortunately sets back for decades residential tower living.

Problems experienced on some local authority estates relate to the physical condition of buildings. In some cases serious structural deficiencies have promoted negative attitudes to tower blocks. For example, when in 1968 a tower block in Newham, Ronan Point, collapsed following a gas explosion. The force of the explosion caused the failure of a load bearing precast concrete panel that formed the side of the building and caused a subsequent progressive collapse of part of the structure, resulting in four deaths. Following this major failure, the rate of construction of system-built concrete tower blocks decreased abruptly and design codes were revised and updated.

The decision for refurbishment should typically focus on localised problems, such as:

– carbonation
– chloride content
– de-lamination of panels or brick slips due to inadequate movement joints on blocks built with traditional frames.

These structural issues are relatively minor in nature and the longevity of the structure can often relatively easily be enhanced by localised remedial works or more expensively over-cladding/over-roofing. The advantages of re-cladding can help improve the image of tower blocks locally and nationally.

7 CAN THE DECENT HOMES STANDARDS BE FURTHER IMPROVED?

To achieve the challenging targets set for 2050, i.e. 60% reduction it would appear that though refurbishment to Decent Homes Standards can reduce operational CO_2 by 50% this would need to be offset by CO_2 produced throughout the maintenance of the extended life. Further improvements could assist in improving efficiency and lower CO_2 levels. Consideration should be given amongst others to the following enhancements:

– Use of new technologies – encourage renewable energy sources and/or centralised plant. Towers are well suited to the application of group heating and combined heat and power (CHP) schemes.
– Encourage more recycling – segregated refuse chutes, grey-water recycling. Within a single building the systems for waste management and other services can be made more efficient. It has been acknowledged that the water demand from WC flushing can be met by grey water availability in tower blocks. Total water use can be reduced by 30% by utilising rain water in the uppermost flats of a tower block and a floor by floor system using grey water in the lower flats (Sustaining Towers 2005).
– Improved Communal Facilities – This can have social, economic and environmental benefits. For example laundries can reduce the number of separate appliances required and used by people for their own homes, thereby saving money, reduce resource use and encouraging congregation.
– Heat recovery ventilation - Guertler & Smith (2006) state that ventilation is important to ensure that air changes take place inside a building in order to avoid air stagnation that encourages mould growth. The heat energy potentially lost as air changes take place through venting can be recovered by the use of a heat exchanger that transfers heat from the outgoing air to the incoming air, without combining the two streams. In tower blocks, this is especially effective in kitchen areas. The Sustaining Towers website (2005) describes that depending on the type of heat exchanger configuration, an efficiency of 70–90 % heat transference can be achieved.
– Landscaping - A tower by its very nature has a small footprint and costly green roofs are no substitute for ground level green areas. These are available for leisure that comes at no cost when towers are retained.

8 CONCLUSION

It can be seen that there is a complex interaction between social, economic and environmental factors which influences the demolition *v* retention debate.

The general perception is that the environmental and economic costs of new-build housing will be balanced out over a few years because of efficient energy consumption. This is true when comparing a new-build block to an un-refurbished old one, however as shown in the assessments comparing a refurbished dwelling to Decent Homes Standards with a new build is less favorable.

We have shown that by improving the efficiency of existing homes a 50% saving in CO_2 can be achieved over the un-refurbished building and an approximately 50% saving in economic terms over new-build. It seems obvious that by encouraging re-use, the most sustainable method of waste minimization; we are by inference 'sustainably' refurbishing existing high rise housing.

From this perspective, at a time of housing expansion, existing tower blocks are an asset. Tower blocks are a great space-saving housing resource that the country cannot afford to lose. Programmes such as 'Decent Homes' are key to developing urban regeneration initiatives ensuring the maintenance of such assets. However, as with all 'sustainable' initiatives, more can always be done.

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