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Lawani, Kenneth; Callaghan, Nicola; Hare, Billy; Cameron, Iain

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Sustainable Development and the Scottish New Build Scheme – A Case Study

Kenneth Lawani,
Glasgow Caledonian University
(email: kenneth.lawani@gcu.ac.uk)
Nicola Callaghan,
Glasgow Caledonian University
(email: nicola.callaghan@gcu.ac.uk)
Billy Hare,
Glasgow Caledonian University
(email: B.Hare@gcu.ac.uk)
Iain Cameron,
Glasgow Caledonian University
(email: i.cameron@gcu.ac.uk)

Abstract

The agreement set out in The Climate Change Act 2008 to reduce the UK's greenhouse gas emissions by at least 80% by 2050 places pressure on the construction industry across the UK. This study focuses on the Scottish New Build Housing Scheme and how the construction sector is reducing CO_2 production through sustainable developments. A systematic literature review examined strategic elements of a sustainable development; social, economic and environmental sustainability to understand the criteria used to measure sustainability. An ethnographic approach based on observations, discussions and documentary evidence was adopted during the course of data gathering.

Ongoing developments within the West of Scotland identified as being built for sustainability in the 21st century was used as the case study. Significant changes in construction design, materials and techniques were identified; the principal one being the change from traditional brick and block, to timber frame crane erect construction. The study identified other construction design elements such as affordability, community facilities, public transport, and waste reduction as imperative in a sustainable development. While the choice of external finishes could reduce the impact of the development on local environment and wildlife; internal material selection and specification could potentially increase the long-term energy efficiency of these new build. New technologies such as solar panels, high-speed broadband, electric car charging points were also identified as important elements within these sustainable developments.

Keywords: Sustainability; Energy efficiency; Scottish New Build Housing Scheme

1. Introduction

The requirement for sustainable development stems from the need to significantly reduce the amount of CO_2 emissions which the construction industry currently produces. Therefore, in 2008 the UK government established the world's first legally binding climate change target. The Climate Change Act 2008 aims to reduce the UK's greenhouse gas emissions by at least 80% by 2050 (HM Government, 2008). Research from the Department for Business Innovation and Skills indicates that the construction industry produces 47% of the UK's total CO_2 emissions (BIS, 2010). A key aspect of reducing carbon emissions is consequently related to developing sustainability within the construction industry as a typical house in the UK takes between 50 and 80 tonnes of CO_2 to build (Cabinet Office, 2011).

Sustainable development is one that is designed, built, operated, and disposed of in a resource-efficient manner using ecologically sound approaches and with both human and ecosystem health as goals (Kilbert, 2016). This theory works on the concept of closed loop life-cycle assessment, where materials should be reused or recycled rather than being sent to landfill. Moreover, it focuses on a balanced consideration for environmental, social and economic impacts (Elkington, 1998); thus fulfilling basic human obligation morally and legally. Hence, a sustainable development must fulfil the needs of the current generation, whilst also setting aside enough resources to ensure future generations can fulfil their needs.

The Brundtland Report outlines four primary areas which must be fulfilled by a sustainable development which are: safeguarding long-term ecological sustainability, satisfying basic human needs, and promoting intra-generational and intergenerational equity (WCED, 1987). Ecological sustainability involves the capacity of ecosystems to maintain their essential functions and processes, and retain their biodiversity in full measure over the long-term (Kilbert, 2016). With regards to sustainable development, this means developers have to consider the impact a development has on the environment over a prolonged period with consideration for existing ecosystems such as plant and animal habitats.

The environmental sustainability is where human actions have no impact on the planet to a level where the ecosystem cannot recover to previous levels and won't deprive future generations from having the same opportunities as the current generation (Vezzoli & Manzini, 2008). Social sustainability within the construction industry involves the ability to create new communities whilst improving existing communities (Almahmoud & Doloi, 2015) which is what the case study development is all about. This include areas such as the industry's community (those who work on the construction project), user's community (those who will use the building) and the neighborhoods' community (those with an interest in services in or around the construction development). Economic sustainability is the most traditional aspect of sustainability related to the ability for a business to remain profitable over time (Vlachvei, et al., 2016). For the developers, economic sustainability is the ability to successfully implement environmental and social sustainability whilst maintaining profitability over time. However, economic sustainability is often the main challenge faced by sustainable construction and this is largely due to high costs associated with the materials, construction techniques and technologies used in sustainable developments.

1.1 Criteria for Sustainable Homes

The Sustainable Development Strategy set out in 2005 offers the criteria that the UK government expects a sustainable development to meet across all three elements of sustainability. The report emphasizes that a sustainable build should ensure a better quality of life for everyone now and for the future generations through the pursuit of the five objectives - living within environmental limits; a strong, healthy and just society; achieving sustainable economy; using sound science responsibly and promoting good governance (DEFRA, 2005). Living within the environmental limits where a balance needs to be made between production and consumption (Ding, 2008) involves effectively maximizing the land, energy and materials used for the development, design and position of each house towards maximizing daylight, sunlight and solar potential and reducing the impact on existing wildlife and plants.

For the developers, the economic success starts by carrying out a full land appraisal, which identifies the maximum land purchase price for the development to reach the sustainable profit margins. This assessment includes site investigation to analyze the current landscape for features such as watercourses and animal habitats; invasive weeds or ground gases (Opoku & Ahmed, 2015). More importantly, multi-level communication during pre-construction and the design stages (HSE, 2015) will also improve the economic success of the development, as costly design changes could be minimized (Appleby, 2011).

Sustainable homes within the Scottish context involves partnership with the developer, planners and the public to allow for accountability during making and implementing decisions that affects the project. This include taking into consideration views from all parties during public consultations from the initial conceptual planning through to the approved development layout. The development is normally designed and built to cater for the needs of the widest range of demographics possible. This often consists of houses and apartments made available at an affordable price and qualifying for schemes such as the Scottish Government 'help to buy' and part exchange (Scottish Government, 2018).

2. Aim & Objectives

This study evaluates the implementation of sustainability in the Scottish housebuilding industry towards achieving sustainable developments in the West of Scotland. This was achieved through reviewing developments within the UK that were identified as being built for sustainability in the 21st century; evaluating the advantages and disadvantages of sustainable timber frame construction compared to traditional brick and block; assessing new technologies being utilized to help build more sustainable homes; evaluating the materials, construction techniques and technologies being used; and evaluating how the case study development compares to traditional developments.

2.1 Method & Design

Ethnographic research which was used for this study involve gathering data that does not necessarily precedes formulating a hypothesis or revision and focuses on descriptive investigation and analysis. Ethnography could be qualitative method, interpretative research, case study or participant observation (Hammersley, 2016). This qualitative method was adopted by gathering documented evidence, people's behaviour, approach to data collection, focusing on a case study (multipurpose development) to establish criteria for sustainable homes and existing sustainable housing developments. The Ethnographic technique was implemented through observations and interviews with the project team to establish the details of the chosen design aspects, materials and technology within the case study development, (LeCompte & Schensul, 2010). Open-ended interviews were conducted with members of the project team involved in the case study development. These interviews were important in identifying several sustainable themes which the case study development was benchmarked against. From the observations and interviews, the acquired information was analyzed to refine the details of each sustainable category. The relationships between these categories helped to develop a better understanding of how sustainability is being incorporated by the house builders. Aside the discussions, observations were recorded monthly to establish if including sustainable elements had an impact at site level. This was further discussed with the project manager towards establishing lessons learned and any improvements that could have been incorporated during the physical build of the development.

3. Findings, Analysis & Discussions

The observations and interviews with project site managers indicated that the guidelines used for these projects emanated from three fundamental sources; the Eco town Planning Policy Statement (PPS) (HM Government, 2015), principles of One Planet Living (Bio Regional, 2016) and the Building Research Establishment Environmental Assessment Method (BREEAM, 2018), see Table 1. The rationale for adopting this was because the PPS is a government initiative which advises the criteria that developments must meet to be legally considered as an Eco Town. However, principles of One Planet Living further developed these by detailing how developments could achieve the criteria set out by the government. Due to Bio Regionals vast experience in supporting sustainable developments, it was logical that future developments use the principles of one planet living as a guideline or the Building Research Establishment Environmental Assessment Method in achieving these sustainable developments.

Table 1: The five key assessment areas implemented for the sustainable developments

Planning Policy Statement	**One Planet Living**	**BREEAM**
High speed broadband	7% affordable homes	Sustainably managed timber
30% affordable homes	Public art work	100mm wall insulation & 120m roof insulation
10-minute walk of public transport	Bird/ bat boxes	Cycle paths
Schools located within 800m	Porous paving	Less than 13.3m^3 of waste per 100m^2
Electric car charging points	Essential goods and services located within a 5-minute walk for all residents	Segregated storage

The decision by the project team to adopt the eco town Planning Policy Statement which supports the national policies for spatial planning throughout the UK promotes sustainable developments as it exceeds the current legal requirements of new homes (Communities and Local Government, 2009). The goal of Bio Regionals One Planet Living scheme is to have all buildings energy efficient. This means meeting 100% of every buildings needs with electricity which is produced by a renewable energy source. Buildings within the development were designed to incorporate a renewable energy technology; such as solar panels, wind turbines or rain water harvesting, and innovative heating and lighting controls such as ‘Hive and Nest’ active heating kit to maximize heating and lighting efficiency. Unlike the Planning Policy Statement and One Planet Living principles, the Building Research Establishment Environmental Assessment Method (BREEAM) was implemented as the independent assessment of the developments sustainability performance which consists of energy, health and wellbeing, materials, management, land use and ecology, pollution, transport, waste and water use.

The developments were designed to minimize energy consumption during the operational use of the homes through reducing the primary energy consumption as well as the amount of CO_2 emissions. The consumption of energy would be monitored through the installation of smart meters while energy efficient products, both during construction and use, were installed to minimize electricity consumption. External drying areas were incorporated in the design for each plot and energy efficient transportation also provided. The thermal properties of the timber frame developments were far greater than those of a traditionally built house because of the insulation which is contained within the structure of the timber. Although the total thickness of the walls are reduced, the amount of insulation was increased meaning a wall that is almost 100mm thinner could produce a U-value that is 10% lower (Pullen, 2016). Reducing the U-value indicates the house will lose less heat through its walls, therefore making it more efficient to heat. The focus on reducing the thermal values of these new developments is largely driven by the Standard Assessment Procedure (SAP) which is a legal requirement for building regulations (Ponting, 2016). One main disadvantage regarding the timber frame houses is the reduced acoustic properties in the party walls. The thinner lightweight properties of the timber houses compared to block means more noise transfer between shared partition walls such as the semi-detached and terraced houses. This issue was however, further mitigated through the installation of acoustic matting which absorbs noise. The researchers identified that although studies have shown that these necessary steps could reduce the level of noise transmission between dwellings, timber framed houses tend to have poorer acoustic properties due to their light weight and density compared to traditional blocks (Caniato, et al., 2017).

Further reduction in energy consumption in the development was through the installation of energy efficient combi boilers which only produces hot water when required as opposed to the conventional boilers which will typically fully fill a hot water tank twice a day. For a house with three bedrooms and one bathroom, this could averagely save about 1,200 kg of CO_2 each year which also equates to an annual financial savings. As well as reducing the amount of energy consumed from traditional energy sources, two renewable energy sources were made available on this site i.e. wind and solar energy. Because this was a residential development, the developers considered solar powered energy as the most suitable. The concentrated photovoltaic (PV) cells or solar panels on rooftops with a very high performance and efficiency rating was the preferred choice although this would require solar tracker and cooling system to achieve optimum efficiency rate. The decision to install solar panels on the houses was made early in the conceptual phase to ensure houses were designed with as much roof surfaces facing South as possible. The utility provider was also involved from the conceptual stages (pre-construction) that a two-way electricity feed would be required. The researchers reflected on the decision regarding the solar powered energy as an inexhaustible sustainable fuel source that is pollution and often noise-free but however, these technologies are also very expensive. Therefore, these homes would be able to feed off the national grid and feed excess power back into the system which could compensate the home owner for the associated cost of installations. The electricity provider will be responsible for crediting the home owners' bills but this amount would be dependent on the feed-in tariff.

A component of the health and wellbeing assessment considered the amount of natural daylight that enters the homes, as well as the artificial lighting installed and how the resident would be able to control the amount of each of these light sources. The indoor air quality of the homes was also assessed by measuring air tightness, ensuring suitable ventilation and filters were installed to remove pollutants. Upon reflection on issues of health and wellbeing, this research identified that good indoor air quality could help support a good night's sleep and help to protect against the development of sleep-related breathing conditions such as sleep apnea, asthmatic respiratory issues and mould growths. This is significant for residents with breathing and other health related issues. Therefore, appropriate thermostatic controls were installed to ensure that the residents would be able to keep their homes at a comfortable temperature.

The materials used in the sustainable developments were considered to have a low environmental impact and this includes timber that was sustainably sourced and managed. To reduce the in-use carbon consumption of the building, the thermal insulation of 100mm wall thickness and 120mm roof and floor thickness were used although a major disadvantage is the acoustic properties of the timber. It is important to state that the procurement decisions were not solely focused on the cheapest options, the management considered the whole life-cycle cost of each product to promote economic sustainability. One of the significant differences between the traditional housing development and this particular development was the choice of timber frame construction over traditional masonry construction. The main rationale for adopting this construction technique was the significant reduction of 51% less embodied carbon and 35% less energy consumption equating to around 4 tons of CO_2 per house (Monahan, 2011). Based on observation and interviews with the Project Manager; it became apparent that the new build scheme had a quicker build duration of approximately one week to get the structure wind and water tight compared to approximately three weeks for traditional builds. This was due to the offsite prefabrication of wall panels, floor cassettes and the quick assembly by experienced joiners on site. Once the kits were assembled, the internal trades immediately commenced their task which further reduced the build period (Brinkley, 2017). With a significantly shorter build duration, timber frame kit erect offers substantial savings on site prelims; for example, this 60 house development using timber kits would take just over 18 months to complete, while a traditional site would take over two and a half years. This study also identified other factors that were associated to decisions made by the project team such as savings on labour cost, material wastage and storage due to just-in-time deliveries and ultimately, a reduction in workforce related health and safety incidences.

An evaluation based on the average monthly prelim cost savings show that the timber frame kit-erect offered significant financial savings. Considering the west of Scotland climate, the timber frame kit erect is not as prone to extreme weather delays compared to traditional block construction, where the build could potentially become difficult to construct when temperature falls below -2.0 degrees centigrade (NHBC, 2011). Other advantages of using the timber frame kit erect by the developer included greater precision as they are built using automated machinery, which tends to reduce issues on site with fitted components such as the stairways. These parts often have issues with traditional build if the walls are not built to the right specification, place or standards (Brinkley, 2017). To achieve this level of accuracy, a full structural drawing pack which is designed, checked, and approved by a structural engineer is required. These structural drawings play a vital role for the manufacturer to create their manufacturing drawings, which are then checked and approved by the engineers to minimize delays on site.

The importance of selecting the correct materials to minimize the impact these developments have on the environment was considered essential for e.g. external cladding and porous paving could potentially reduce the ecological effect on the natural water runoffs. The use of non-permeable material such as asphalt would preclude the natural runoff of water due to the changes in the ground levels and these could result to 'ponding' in some areas. Although roads and paths are inevitable elements of any development, choosing the porous paving for these developments has the ability to reduce the effect on the water runoff. The selection of materials such as porous block paving over traditional tarmac roads would allow water to penetrate through to the soil and disperse naturally. This is not only advantageous to the environment but also reduces the amount of drains within the development which in turn helps to keep costs to a minimum. The selection of appropriate ground finishes could potentially reduce the environmental impact of the development e.g. by ensuring that as much green landscaping is included in the design, but also selecting the correct surface finishes for areas of hard landscaping, as well as roads and paths.

The developments were also designed to reduce the amount of rainfall discharged into the public sewers and watercourses towards minimizing the risk of localized flooding and watercourse pollution. Light pollution was also considered and minimized by ensuring that there was no unnecessary external lighting that could impact the ecosystem and wildlife. Similarly, noise pollution was controlled both during construction and from fixed installations within the development. The use of mobile cranes for heavy lifting of materials reduced the number of forklifts used during construction which also reduced pollution, noise, traffic and other workplace safety related hazards. These sustainable developments located within areas with good public transport links are geared towards encouraging residents to reduce their dependency on private cars which will reduce pollution and congestion in the local area. Local amenities that are readily accessible without the need for transportation was a fundamental part of the development and these further reduces local congestion, pollution and increased safety for children within the development by minimizing the number of cars.

During the construction phase of the developments, construction waste was kept to a minimum through the effective use of a site waste management plan that diverted as much waste as possible away from landfill, mainly re-using of materials. This was achieved through the reduction of the amount of material that was damaged on site by providing segregated storage areas for each trade. Although waste minimization during construction reduced the short term environmental impact of the development, it was equally important to consider how waste would be reduced post construction and during use. The developments were installed with products that consume less energy and produce less waste e.g. installing dual flush toilets and eco shower heads which use less water.

The provision of high speed broadband infrastructure was identified as an important requirement for the sustainable developments for the house buyers similar to the provision of gas, electricity and water. High-speed broadband was considered as an important cost to future-proof the development and ensure they are sustainable in the long term. With the development of internet-controlled heating, lighting and security, the demand on these infrastructures is ever increasing in these new builds. The benefits of the high-speed fiber-optic broadband include faster download and upload speeds compared to traditional copper wires and this increased speed could allow multiple users to access the internet which could further enable residents to work from home. Therefore, the fibre-optic broadband was included in the services design package and the additional ducts required were included in the groundwork package. Similarly, the location of the fibre-optic input was considered for each house type, taking into account the location of the lounge and the orientation of the house to the services.

Affordable housing within the Scottish Planning Policy is a housing of a reasonable quality that is affordable to people on modest incomes (Scottish Government, 2014). Based on the Planning Policy Statement and One Planet Living assessment methods, the developments highlighted the need to ensure that between 7% and 30% of the homes were deemed ‘affordable’. Although sustainability has a large focus on the environmental cost of resources, it was also important to ensure that the final product was financially sustainable for prospective homeowners of the development. Therefore, these developments ensured that there was a good mix of different sizes and styles of houses to suit all budgets, ranging from two and three-bed apartments, four and five-bed detached houses, including both terraces and semi-detached house styles. Within Scotland, affordable homes up to the price of £200,000 are eligible for the Help to Buy Scheme (Scotland) Affordable New Build Scheme. This is a government initiative that supports both first-time buyers and existing home owners by taking a 15% equity stake in the house, meaning buyers only need a combined deposit and mortgage of 85% of the house price. To align with the above policy, the case study development with 60 plots had between 6 and 18 plots classified as ‘affordable’ homes.

The impact of the development on wildlife (e.g. bird nesting) based on its location on a Greenfield site was considered as important. Where reasonably practicable; existing trees and hedges were included in the overall design although some that had to be removed were included in the landscaping. These could potentially take some years to mature in size to allow nesting to take place. However, to compensate for this loss of natural nesting areas, bird boxes were designed and incorporated into the gable (the triangular upper part of a wall at the end of a ridged roof) of each plot to provide an interim safe nesting place. In addition to these sustainable homes being built, community facilities and public transport was incorporated into the masterplan identified through all three assessment methods. This case study development contains within its final package a primary school that is already built with a capacity for 400 children and this is located 300m from the development thus discouraging the residents from driving and improving environmental awareness. The existing public transport points are located within 200m of the developments with a direct link to the city centre every 30 minutes. Other fully functional community facilities include football pitches, large areas of public open space and some local shops which are about 5-minute walk from the new developments to also minimize car use.

The Public Planning Policy Statement recommends that developers should make provisions that will accommodate future use such as electric car charging points in light of the sales ban of petrol and diesel cars by 2040 (HM Government, 2018). The decision to include car charging points throughout the development by the developers was made in the latter phase of the planning compared to the other technologies. This was due to the developer awaiting approval from the utility (electricity) provider that there was capacity within the grid to accommodate the additional demand from the charging points. Therefore, each plot with its own drive had their individual charging points while communal charging points were installed for the apartments and a further 2 communal charging points for the 2 sets of terraced plots. Each plot was fitted with a 13amp external socket as standard and these sockets would provide 3kW of power and an hour's charge with an average electric car range of 12 miles. However, homeowners would have the opportunity to upgrade the external socket to a 7kW charger designed specifically for electric cars with a car range of 30 miles per hour charge. However, an alternative and more expensive AC rapid charger was proposed with a charging capability of 22kW which gives an average electric car a range of 80 miles in an hour's charge. Although these chargers require a 3-phase power supply, they can be taken from the same feed as the electric supply to the plots.

Conclusion

This study identifies a number of new technologies which are beneficial to a sustainable development within the West of Scotland. The primary ones identified include timber frame kit erect, solar panels, car charging points and fibre-optic broadband. Although timber frame is common practice in the house building industry in Scotland, the thicker frames with 50mm insulation is something new to the business unit. The rationale for making such a change to the thicker kit was due to the requirement to improve the thermal properties of the houses which thus reduces the U value, i.e. the ability to transmit heat from a warm space to a cold space in a building, and vice versa. The lower the U-value, the better the insulation properties.

The benefit of the timber frame kit erect was the completion of the houses within three days to be fully air and water tight and with the roofs tiled. However, minor issues such as incompatibility of the nail guns used by the joiners with the fixings of the timber frame on site were identified and quickly resolved. The speed of the construction enabled internal trades (joiners, electricians, plumbers etc.) to start work while the bricklayers built the external brick skin. It took the bricklayers averagely six to seven weeks to fully compete the brickwork of a house compared to the traditional 10-12 weeks. As part of the post installation process, thermal images were taken of each plot to ensure there were no gaps in the insulation and it identified that the panels were correctly and successfully installed from the tests.

The solar panels and car charging points are products which have not been widely used by the developers, but they however ensured that industry best practice was used for product specification and selection which was jointly coordinated between the technical, commercial and production departments with guidance from reputable industry experts. There were different house types within this development with a price range of between £137,000 - £271,000. Comparatively, the developments average price was £10,000 less than the average price of a house in the local area which makes it more affordable. All the two-bed plots and three-bed end terraced houses qualified for the 'Help to Buy (Scotland) Affordable New Build scheme', for first time buyers.

The roads were constructed from porous paving with soft landscaping in the service strips and small areas of low level shrubs to soften the aesthetics of the development. Although porous paving is more time-consuming, this final surfacing technique was preferred over the standard asphalt surface finish. Regular review of this case study development is planned to help the developer identify and resolve any issues at an early stage. Any issues identified and the solutions proffered would be implemented on other sustainable developments which are currently under review with the local planning authorities.

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