Sustainable Built Asset Management Performance Indicators and Attributes: A UK Social Housing Case Study Example

Abstract: This paper aims to identify key performance indicators (KPI), and their corresponding attributes, required to successfully manage asset management sustainably in a built environment context. Improving the sustainability of existing housing stock is a major challenge facing the UK social housing sector. There is a lack of support to navigate the growing and often incongruent information relating to sustainable development and how to operationalise it. The problem is twofold; firstly, the current (single criterion) condition-based approach to maintenance planning constrains Asset Managers and does not fully address the social, environmental and economic aspects of sustainability. Secondly, the toolkits available for assessing the sustainability of housing are often generic and are time consuming and expensive to implement. This paper reports the findings of a participatory research project with a leading London based housing association, using a series of landlord and tenant workshops to derive a set of attributes associated with key performance indicators (KPIs) to fully reflect the local requirements of the landlord and their interpretation of the sustainability agenda. Five KPIs considered to be measurable, directly affected by maintenance work and independent of each other were identified by this landlord (comfort, running costs, adaptability, maintenance costs and community).The resulting outputs, in a policy context, will provide a clear route-map to social housing landlords of how to improve the sustainability of their housing stock with the additional benefits of addressing fuel poverty, carbon emissions targets whilst at the same time help create and maintain housing in which people want to live. The proposed approach is flexible enough to incorporate the individual requirements of landlords, be able to adapt to changes in government policy (local and central) in a timely, robust, transparent and inclusive format.

Keywords: *Key Performance Indicator (KPI); Performance Attributes; Sustainability; Building Asset Management; Housing*

Introduction

It has long been recognised that assets are a principal concern for improved management within the built environment context for organisations (Brown et al., 2014; Too, 2010), governing the required service level in the most cost-effective manner over their entire lifecycle: including the design, construction, commissioning, operating, maintaining, repairing, modifying, replacing and decommissioning/ disposal of physical and infrastructure assets. However, Brown et al., (2014) posited that concerns have emanated to an inherent need for organisations to foster a strategic view of their assets. These concerns relate to increasing resource scarcity, degrading environment and climate change (Brown et al., 2014). As such, a shift towards a more integrated asset management practice which allows performance improvement and future investment planning is much needed (Too, 2010). Asset management has been viewed as an integrated approach that allows the optimal balance of performance and investment (TheIAM, 2012). Lin et al (2006) defines asset management as a structured program of optimising the lifecycle of asset through cost minimisation and service level improvement and requires addressing both planning and information requirements. Achieving this requires the assimilation of management, engineering and information disciplines, which Brown et al., (2014) considers as the three main pillars of asset management. The assimilation of these pillars enables organisations to access additional knowledge, expertise and resources to create collaborative advantage (Brown et al., 2014). However, a significant challenge lies in determining the key performance indicators (KPIs) in a manner that appeases all stakeholders. KPIs which are defined by attributes which can assist in increasing asset productivity (Brown et al., 2014).

As noted by Lin et al., (2006) asset management requires substantial information for its planning processes, and a thorough understanding by all stakeholders of the attributes that constitute the KPI is essential for providing quality and timely data for decision-making. Additionally, asset owners and

stakeholders are constantly struggling with a shared understanding of sustainability to make crucial decisions. In order to resolve this, there is an imperative to understand the attributes needed to successfully manage improve the sustainable performance of assets as there are no standard, and only generic guidance of what is required in the literature (Lin et al., 2006; Too, 2008).

This paper aims to determine the attributes associated with key performance indicators (KPIs) within the context of sustainable asset management activities in the social housing sector in the UK. The attributes associated with KPIs within this context are examined in this paper and subsequently, describes the process of identification for future application.

Performance Based Sustainable Social Housing Assessment

Our built environment has a negative impact on the planet's natural resources (United Nations, 2015) as well as the health and wellbeing of its occupants (Pevalin et al, 2017). It is estimated that 87% of buildings in the UK will likely be standing in 2050 (UK GBC, 2016), ensuing refurbishment (of which maintenance plays a key role (European Commission. 1998)) will be a large proportion of future construction projects. The CIOB (2011) reported that the UK has around 30 million domestic and non-domestic buildings, whereby 28 million of these are needed to meet the Government's carbon targets. The importance of low carbon refurbishments, maintainence and improvements of buildings are also reported by Ferreira *et al.* (2013), de Larriva *et al.* (2014), Juan (2009) and Killip (2013) among others. Refurbishments provide an opportunity to improve poor energy performing buildings by replacing old items with new energy efficient materials and technologies. Ali et al (2018) also acknowledge the importance of refurbishment in preserving and improving a building's useful life. Thus, refurbishment has the opportunity to contribute towards Sustainable Development Goal 11 targets of improved resource efficiency and the mitigation and adaption to climate change (United Nations, 2015) however, Ali et al (2018) goes on to state that due to the complexity, uncertainty and risks associated with such projects, the decision to refurbish must be carefully considered.

The UK has multiple guidelines, regulatory frameworks and incentive schemes that are designed to improve the standard of maintenance and refurbishment projects. Within the housing sector, initiatives such as Decent Homes and Warm Front have each provided guidance and funding avenues for construction work (DCLG, 2006). Whilst in the private sector, greater autonomy is given to allow stakeholders to determine the best options of individual projects. The BREEAM Refurbishment (BRE, 2014), Considerate Constructors (CCS, 2015) and SKA rating (RICS, 2019) schemes are examples of benchmarking methods that aim at improving the environmental performance of construction and the resulting buildings. Despite the various schemes, the success of regulation and guidance for refurbishment has been widely criticised (CIOB, 2011; Killip, 2013; Rawlinson and Wilkes, 2014) and the uncertainties, risks and the bespoke nature of refurbishment projects makes them inherently unsuitable for generic assessment schemes (Juan, 2009). The refurbishment sector in the UK is poorly regulated, suffers from lack of skills and knowlegde, the industry at large is unwilling to change and there is a lack of government funding (CIOB, 2011; Killip, 2013; Rowlinsons and Wilkes, 2008). In addition, refurbishment projects carry higher risks than new builds due to its uncertainty of the existing building, shortage of information and unknown job scope (Juan, 2009). Therefore, as sustainable construction standards and regulations become increasingly available for new build, this is not the case for sustainable maintenance (Olanrewaiu et al, 2015), more guidance is needed to support the refurbishment projects.

Buildings are amongst the UKs most valuable assets and yet until recently, building maintenance was based on subjective criteria from a reactive perspective (Falorca, 2019). Concerns regarding the quality of social housing were raised in the 1980s when a combination of low management and maintenance allowances resulted in large repair backlogs (DCLG, 2000). By 1996, the repairs backlog had reached £19 billion for England alone (DCLG, 2008) which prompted New Labour to commit to making housing decent by 2010 via The Decent Home Standard (DHS), which established a common definition of

decency but was conceived as a minimum standard which triggered action if a range of decency standards were not met. A property was considered decent if it: satisfied the Housing Health and Safety Rating System (HHSRS) as fit for purpose; was in a reasonable state of repair; had reasonably modern and appropriately located facilities; and had a reasonable degree of thermal comfort (SAP 2005 rating of 35 or more) (DCLG, 2006a). As such, the DHS was not designed to, nor did it address the sustainability agenda however, it did raise the profile of maintenance amongst senior executives, enabled a more planned approach to maintenance to be undertaken and provided funds. More recently, the increasing role maintenance plays over the entire lifespan of buildings has been recognised (Mydin, 2017) The DHS remains a key standard against which dwellings are measured and whilst it did not eradicate non-decent housing by 2010, the last decade has witnessed a significant decline in the number of non-decent homes in England with 13% non-decent social homes (down from 29% in 2007 (DCLG, 2009)) recorded in 2017, although the rate of improvement has since stalled. Energy efficiency has undergone a similar pattern of improvement with the average SAP rating increasing from 45 in 1996 to 62 in 2017 (MHCLG, 2019).

Managing, maintaining and improving sustainable performance in social housing is complex. Social housing maintenance need is largely determined upon a single attribute condition model (Cooper and Jones, 2008). To accommodate the broader physical and in-use performance attributes of the sustainability agenda, a multi-attribute approach is needed. This research seeks to adopt a performance approach based upon the performance of a house in-use rather than on its condition, that provides a transparent and robust system for prioritising maintenance and refurbishment works which integrates social, environmental and economic criteria to improve the overall sustainability of existing housing stock through planned maintenance.

There are a number of building assessment models available to rate individual buildings through to community-based developments with the objective of encouraging continuous improvement in sustainability, all be they flawed. The models measure the sustainability of a building in its current state, but little work had been carried out to demonstrate how these toolkits could be integrated to inform the improvements needed through routine maintenance and refurbishment to improve the sustainability of existing buildings. The National Housing Federation encourages members to measure the performance of their stock in-use, suggest national policy should be combined with local need, provide examples of the tools and data that may be required and conclude that single criteria measures will not provide the depth of knowledge required. However, they do not provide landlords with an approach to assimilating performance data in order to inform their asset management strategy.

Performance indicators and attributes

Wang et al., (1996) noted that in order to ensure attainment of KPIs, an understanding of the construct (or attribute) from an information consumer perspective is important. Literature suggests that there is lack of confidence in the quality of the data upon which decisions are being made (Cai & Zhu, 2015; Koronios et al, 2005; Lin et al., 2007). Chaffey and Wood, (2005) argued that for an organisation to gain value from information, many management issues will be raised which are not limited to technology alone. This requires information that is comprehensive, accurate and immediately accessible which enables decisions to be made faster and more precisely (Jylhä & Suvanto, 2015). Koronios et al., (2005) stated that personnel management, organisational factors and effective technological mechanisms affect the ability to assess KPIs. Wang et al. (1993) acknowledged that people operating within an organisation have individual opinions about KPIs and thus different quality definitions and attributes exist across users.

Thus, according to Wang et al. (1995) in order to assess and manage KPIs effectively, a clear understanding of the characteristics making up the KPI is needed. They define attributes as a single

aspect or construct of an indicator. Whereas Sebastian-Coleman (2013) defines attributes as those aspects of data that can be measured and through which its quality can be quantified. To determine the performance attribute, a contextual view must be established. This view should consider the type of operations or activities performed by the information consumer. By so doing, a vivid and explainable construct of attributes can be determined.

Despite its faults the DHS raised the profile of maintenance amongst senior executives, enabled a more planned approach to maintenance to be taken, provided funding and focussed attention on the quality of existing properties for the first time since the 1960s (Cooper, 2015). However, it did not provide guidance on the identification of appropriate sustainable performance attributes, nor the assimilation of multiple attributes. Cooper (2015) identified a wide range of sustainable performance attributes were needed (beyond that of the DHS), but more importantly, the final selection would be unique to individual landlords based upon their specific organisational needs. Attribute selection would depend on; stock portfolio (age, size, condition, distribution, location), tenant profile (need), interpretation of the sustainability agenda, landlord strategic objectives, financial position (availability of funds).

Thus, a sustainable social housing asset management model is required that is generic in form to provide guidance for all social landlords yet flexible enough to incorporate the local requirements and policy/agenda interpretations of individual organisations.

Methodology

The aim of the research was to develop an approach to maintenance (and refurbishment) that systematically improved the sustainability of existing social housing. The main limiting factor of the current approach to social housing maintenance is that maintenance is determined upon a single attribute condition model in which physical condition has become a proxy for performance and prevents the systemic sustainable improvement of a dwelling from taking place. To overcome this problem, broader physical and in-use performance attributes of the sustainability agenda must be taken account of via the development of a multi attribute maintenance model capable of incorporating the objective and subjective attributes associated with the sustainability agenda.

The wider research project (summarised in Table 1) sought to answer the question 'Can performance-based decision making be used to integrate sustainability into the Built Asset Management (BAM) process?' and as such dealt with research within building management and social contexts from the perspective of professionals and (non-professional) housing occupants. The toolkits required by the sustainable performance based social housing maintenance model adapted from Jones and Sharp 2007 included subjective and objective measures, themselves consisting of a mix of qualitative and quantitative data and analysis. Therefore, the methods used to determine the content of such toolkits and their indicators should include both quantitative and qualitative data collection. The pragmatic approach to research was utilised.

Table 1 Research Design Summary

Phase 1 – Social Housing Landlord, Extensive Questionnaire	Phase 2 – (25No.) Social Housing Landlord Interviews (from the Questionnaire group)	Phase 3 – Participatory Research
Aims • Identify gaps in current practice • Suggest improvement that could result in routine	Research Questions • What is the range of criteria that social housing maintenance managers need to address when	Aims • Identify appropriate KPIs for Company O • Populate the 'Performance based sustainable social

maintenance being used to plan improvements in the sustainability of existing social housing	assessing the sustainability of their existing social housing?	housing maintenance model (including the identification of KPIs and corresponding attributes) • Develop AHP model to support sustainable built asset management
Key Findings • The sustainability agenda had started to impact the way asset managers perceived the performance of their housing stock • The current approach did not fully address all aspects of sustainability	Key Findings • Landlords wished to consider a wider range of criteria • Landlords wished to choose criteria which best reflected national and local requirements	Key Findings • 5 KPIs identified with associated attributes

A case study (one element of the participatory research identified in Table 1), comprising of 3 workshops, was used to establish the KPIs and corresponding attributes for Company O; each workshop was carefully planned with varying stakeholders to gain differing perspectives, and in a sequential manner, to determine and validate performance measures. Company O was selected, having a property portfolio of over 5000 properties and was deemed suitably large with a wide range of housing stock for thorough investigation. Company O is a not-for-profit organisation that provides affordable homes in inner London. Due to resource constraints, and the complexity and breadth of Company O, one case study was deemed satisfactory.

The case study adopted the following approach:

- Workshop 1: With 12 staff representing Asset Management teams (split into 2 groups), the workshop aimed to establish Company O's starting position by a) Determining their key strategic drivers and b) Analysing the highest-ranking drivers.
- Workshop 2: consisted of two parallel sessions with 6 staff (representing resident's liaison and Asset Management teams) and 6 tenants, aimed at developing a methodology for rating the sustainability of Company O's existing housing stock by a) Establishing issues that effect residents' quality of life and b) Building upon Company O's sustainable performance maintenance model established during workshop 1
- Workshop 3: with the senior management team responsible for new build and existing housing stock. The workshop was developed in response to the perception that Company O's current asset management strategy was too operationally focused and did not provide the strategic vision needed to develop long term asset management plans. The workshop addressed this perception by exploring the perceived requirements of Company O's asset management strategy and identifying the practical steps needed to compile the strategy. The outcome from the workshop was an action plan for the development of a more strategically focused asset management strategy.

Thus, the workshops sought to answer three key questions:

1. Is the current approach to built asset management right, or is a change in direction needed?
2. What type of assets do we want in the future?

3. What do we need to know about our stock in order to make informed built asset management decisions?

By addressing these questions, the workshops aimed to:

1. Raise awareness of strategic built asset management amongst Company O's senior management team; and
2. Provide those responsible for developing the asset management strategy clear guidance on Octavia's priorities and future vision.

Results

Company O Staff Workshop (Workshop 1)

The first workshop identified Reduce Cost/ Energy, Government Policy, Reduce Waste, Efficient Programming and Fuel Poverty as Company O's top 5 key strategic drivers as shown in Figure 1.

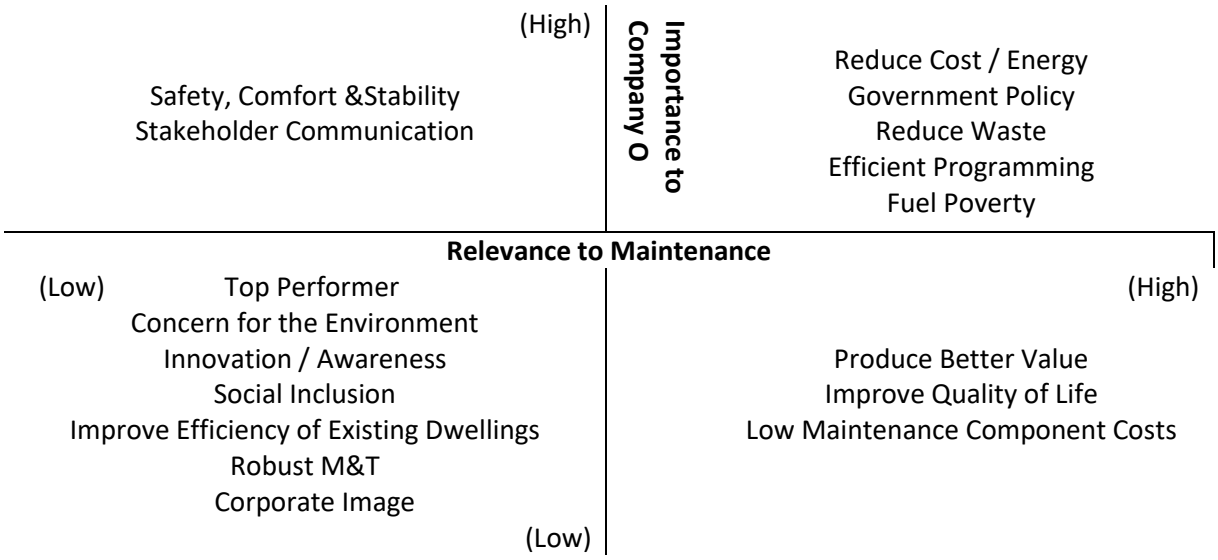

Figure 1. Company O Housing's Strategic Drivers

The meaning of the strategic drivers in terms of their importance to Company O and their relevance to maintenance was further explored, Table 2.

The workshop group reviewed the strategic drivers (Figure 1) and corresponding driver analysis (Table 1) to ensure criteria (and weighting) of most importance/relevance to Company O had been captured. It was then brought to their attention that customer satisfaction did not feature explicitly in their drivers. The ensuing discussion could not determine if this was because participants felt customer satisfaction was intrinsic to their work as maintenance providers and was therefore built in or because they did not rank it highly as part of their work.

The workshop group agreed that had board members been involved, they would have cited client satisfaction as a top driver but that, the issues would be similar.

Just-In-Time was the favoured mode of building maintenance. Responsive maintenance was considered more expensive than planned maintenance, however, implementing a JIT approach to maintenance was viewed as a move towards responsive maintenance albeit in a very planned way accurate building performance data would be required to enable maintenance managers to plan replacements just before they fail.

Table 2 Analysis of Company O's Strategic Drivers

Group 1	Group 2
Reduce Cost / Energy • Low maintenance components • More standardisation in components • Reduce energy consumption (boilers / insulation, etc.) • MMC • Better supply chain management • Better integration within the organisation • Pilot studies (trials) to measure performance	**Reduce Cost / Energy** • What are the initial costs (starting point)? • Bulk cost, supply chain management • Efficient programming • Efficient use of product to reduce energy • Capital vs. revenue cost to reduce cost (links to efficient programming) • Starting point for energy data (D. E. Assessment) • Educate stakeholders (domestic energy) • Monitoring of carbon footprint – use info to reduce energy
Government Policy • Meet targets • Innovation to actual needs • More "joined up thinking" at local level	**Government Policy** • Corporate plan linked to government policy • Company O + policy • Can we influence policy / challenge? • Awareness – consult with stakeholders • Join relevant groups to use 'shared knowledge' • Resources to comply if required • Right schemes (IT) to manage • Training i.e. DES and HHSRS • Development of policy and procedures (robust)

Reduce Waste
• Recycling of surplus building materials
• Better distribution of resources (plant/labour)
• Reduction of water – dry forms of construction
• More greywater use – rainwater etc.
• Awareness – education
	Reduce Waste
	• Clear policy and procedure
	• Define waste – work with stakeholders, contractors, LA etc.
	• Manage through efficient programming and contractual control
	• Recycling policy
	  ○ Reduction of use of water
	  ○ Use rainwater
	  ○ Greywater

Efficient Programme • Better use of resources • JIT approach – based on accurate stock data • Improved processes	**Efficient Programme** • Supply chain management • Procurement strategy • Use of relevant data, asset management tools • Resource planning • Combine programmes where possible to gain efficiencies • VFM (economies) • SMART KPIs • Training • Consultancy

Company O Housing Staff and Tenant Workshops (Workshop 2)

The KPIs identified by the staff and residents are presented in Table 3. As can be seen the resident group selected a broader set of KPIs than the landlord group, who suggested very specific environmental/ economic performance measures. As expected, the tenant group identified a range of social KPIs associated with issues they were facing within their homes and communities. They also sought a more planned approach to maintenance which improved overall performance of the home over time, not dissimilar to the landlord aspirations. Both groups identified Energy as an important KPI, this was not unexpected as fuel poverty is a serious issue within the social housing sector.

Table 3 KPIs Identified during Tenant and Staff Workshop

Tenant KPIs	Landlord KPIs
• Building Security • ASB • Energy Consumption (£) • Community Cohesion • Planned Maintenance • Number of Difficult to Treat Homes • DHS +	• Water • Energy

The landlord representatives considered water and energy consumption the overriding KPIs with the acknowledgement that currently they were unable to monitor (in-use consumption of) either. In addition, the landlord group also identified the following as important issues for future consideration within their built asset management;

- Benchmarks/ Tenant profile – asset management needs to better understand the maintenance demands of different tenant profiles and how best to accommodate changing tenant profiles (e.g. more single parent families) to avoid overcrowding and incorporate adaptability. *Supported by Olubodun, 2001.*
- Tenant Expectations – align the asset management strategy with tenant expectations. Clear links need to be established between decision making and expectations, e.g. do not offer fuel poverty improvements that cannot be delivered by direct action.
- Well Being
    - 'Feel Good Factor' needs to be understood and monitored, for instance, are residents concerned about their carbon footprint and the green credentials of Company O?
    - Security (perception of)
    - Climate change
    - Comfort – Are residents affected by noise, overheating, location issues?
- Payback
    - Wellbeing discounts must be included
    - Life Cycle Costs should also be integrated to maintenance decision making.

The KPIs of relevance to the tenant group focused on running costs, which was more limited than anticipated following interviews with landlords (Cooper and Jones, 2008). A desire to reduce energy consumption was driven by economics rather than environmental protection and a desire to limit emissions.

The participating tenants recognised the implications of maintenance process, policy (DHS), tenant behaviour and landlord expenditure on housing quality, rents and service charges. As a result, they desired;

- A planned approach to maintenance (greater cost efficiency should be reflected in service charges and greater programme efficiency should reduce maintenance completion period and the number of household visits),
- The maintenance standard to go beyond the requirements of the DHS so that performance / quality of the home was improved and not just its cosmetics,
- Tenants to take greater responsibility for their actions.
- A system to reward good (tenant and landlord) behaviour and penalise poor (tenant and landlord) behaviour to improve social housing performance (the physical asset, quality of life and economic performance).

In conclusion, Company O were not giving residents what they wanted, and a matrix approach to prioritisation which integrates tenant and stock profiling should be developed.

Company O Housing Workshop (Workshop 3)

Company O perceive their current asset management strategy as more of an action plan than a strategic document. Whilst it served a purpose, it does not provide the basis for structured forward planning against Company O's strategic organisational goals. It is also ineffective at integrating new build with ongoing maintenance and refurbishment of the existing stock. Company O wish to review their housing stock considering changing business and market drivers. Drivers include but were not limited to: the condition of the stock; the stock profile against changing tenant demographics; the location of the stock; the balance between stock acquisition and disposal; and the impact of sustainable technologies. In addition to reviewing their stock profile, Company O also wanted to review its management approach to built asset management over time. However, any future asset management strategy must recognise;

- Company O is committed to providing affordable housing in London and will not sell inner London properties to fund building projects outside London.
- The Company O Housing Standard must be achieved
- Company O aspires to achieve a SAP rating of 75 across the entire stock.

Breakout Session 1: identify the business drivers that should inform Company O's asset management strategy and the attributes a Company O home should exhibit are reported below in table 4 and 4 respectively.

Table 4 Potential Drivers

Drivers	**Ranking score**
Sustainability	30
Tenant satisfaction/expectations	20
Demographics (e.g. an aging society)	10
Legacy/Brand/Image	10
Location	6
Legislation (including tenure)	3
	79 votes

The expected mean number of votes (assuming all votes were equally distributed) per driver category was 13.2 (total number of votes (79)/number of potential drivers (6)=13.2). As such, Sustainability and Tenant Satisfaction/ Expectations both scored above the expected mean. All the other drivers scored below the expected mean. This does not imply that these drivers are unimportant but suggests they were perceived as less important than Sustainability and Tenant satisfaction by Company O's management team.

Upon closer examination, it could be argued that Location should have been included alongside Legacy/Brand/Image which may have raised the relative importance of the category above the expected mean threshold.

Table 5 Potential Attributes

Attributes	Ranking score
Comfort (visual, thermal, noise, ventilation)	19
Running Costs (from the tenant's perspective)	16
Adaptability/Longevity/Space Standard	15
Maintenance costs	12
Location	8
Maintainability	5
Community	3
Security	2
	80 votes

The expected mean number of votes (assuming all votes were equally distributed) per category was 10 (total number of votes/number of attributes). As such, Comfort, Running Costs, Adaptability and Maintenance costs all scored above the expected mean. All the other attributes scored below the expected mean. Again, this does not imply that these attributes are unimportant but suggests they were perceived to be less important by Company O's management team. Note: location was identified as both a driver and an attribute.

The final activity during breakout session 1 was for workshop members to map drivers (KPIs) against attributes, shown in table 6.

Table 6 Mapping (Business) Drivers and Potential Attributes

Drivers	Attribute
Sustainability	Community, Location, Comfort, Low running costs
Tenant satisfaction/expectations	Comfort, Adaptability/Longevity/Space Standard,
Demographics (e.g. an aging society)	Adaptability/ Longevity/Space Standard
Legacy/Brand/Image	Running costs, Maintenance costs, Location,
Location	Location
Legislation (including tenure)	Tenure*

*Identified by one group but not included in the generic list of attributes

Exploring the relationships between the drivers and attributes and expressing these as a series of performance metrics was the next stage in developing the housing asset management strategy (Breakout Session 2), table 7.

Table 7 Attributes and Associated Indicators

Attribute	Indicator
Comfort (visual, thermal, noise, ventilation)	Heating, Space/Overcrowding, Noise, Layout, Fixtures & Fittings, Security
Running Costs (from the tenant's perspective)	Fuel Bills, Water Bills, Service Charges, Council Tax Bands
Adaptability/Longevity/Space Standard	Age of Property, Refurbishment History, Layout, Floor Area, Value, Potential for Conversion/Adaptation, Repairs History, Cost in Use, Location, Accessibility,

Maintenance costs	Major components, Minor Components, Obsolescence/Life Cycle Analysis, New Technologies, Changes to Legislation, Day-to-Day Repairs, Voids
Location	Distance/Travel Times, Borough Spread
Maintainability	Number of Breakdowns, Ease of Repair, Cost of Repair,
Community	Satisfaction with Neighbourhood, Length of Tenancy
Security	Covered under comfort

The indicators identified are complex and inter-related, and workshop delegates found it difficult to separate out performance indicators from the factors that affect the indicators. This is not a problem (any benchmarking process must eventually drill down to underlying causes), but it does complicate the picture at the strategic level. Table 8 identifies indicators that directly measure the performance of a home in-use; that directly relate back to the strategic drivers identified in Table 5; and can be changed through an intervention by Company O.

Assessing the existing stock against the 23 indicators given in Table 7 will allow the current level of performance to be assessed. Furthermore, these indicators will also allow the potential impact of future interventions on the overall performance of a home to be assessed. This in turn will inform priority setting to ensure that those interventions that are implemented address Company O's key strategic goals.

The performance criteria established throughout the participatory research phase have been combined to produce 'Company O's Performance Based Social Housing Maintenance Key Performance Indicators'. Only KPIs have been considered that can be directly affected by maintenance work and which are measurable, linked to a process and independent of each other. The next stage would be to develop short and long-term targets for each of the headline KPIs which would measure how well the landlord was performing in terms of sustainable social housing maintenance, however this is beyond the scope of this current research.

Table 8 Quantitative Measures for Attributes and Indicators

Attribute	**Indicator**	**Possible quantitative measures**
Comfort	Heating	Tenant Satisfaction, Temperature
	Space	Tenant Satisfaction, m^2/occupant
	Noise	Tenant Satisfaction
	Fixtures & Fittings	Tenant Satisfaction
	Security	Tenant Perception, Crime Statistics
Running Costs	Fuel Bills	Tenant Bills
	Water Bills	Tenant Bills
	Service Charges	£, £/m^2
	Council Tax Bands	£
Adaptability	Layout	To be advised
	Floor Area	m^2, m^2/occupant
	Potential for Conversion/Adaptation	To be advised
	Cost in Use	£, £/occupant
	Life Time Homes	To be advised
	Accessibility	To be advised
Maintenance Costs	Major Components	£
	Minor Components	£
	Obsolescence/Life Cycle Analysis	% remaining life, Time to next action
	New Technologies	£ (futures scenarios)
	Day-to-Day Repairs	£

	Voids	£
Community	Satisfaction with Neighbourhood	Tenant Satisfaction
	Length of Tenancy	Years

Discussion and Conclusion

The starting position of this research was that sustainability cannot be addressed through a single condition-based assessment, that in order to address the sustainability agenda systemically within social housing maintenance, multiple criteria need to be assessed and therefore a multiple criteria approach needed developing that addressed the environmental, social and economic performance of the dwelling. At the outset of the research, it was unclear exactly what measures should be included under those headings but it was possible to speculate, for instance, environmental measures would need to include those that addressed the building as well as the maintenance process; social measures would need to address fuel poverty, living costs, wellbeing; and economic measures would need to cover tenant and landlord perspectives. Some of these criteria may overlap but ultimately need to be analysed and a way of completing that analysis needs to be determined.

A key issue facing organisations involved with asset management is the inability to assess effectively the impact of the quality of information being generated (Lin et al., 2006; Sebastian-Coleman, 2013). It has been noted that improving the quality of information in businesses can yield significant benefits to a company's overall efficiency, competitiveness and responsiveness (Chaffey & Wood, 2005; Jylhä & Suvanto, 2015). Company O used the traditional condition-based approach to social housing maintenance but struggled with several issues including maintenance prioritisation (having no formal approach in place) and lack of confidence in the SCS meant budgets and maintenance plans were hard to justify at board level. They had clear sustainable development aspirations (SHIFT and their Environmental Strategy) but social and environmental metrics were excluded from their maintenance planning approach.

The participatory research sought to introduce Company O to the performance-based approach to social housing maintenance. Specifically, workshop 1 and 3 showed the evolution of Company O's key strategic goals whilst workshops 2 and 3 identified the criteria against which they would measure the in-use performance of their properties (breaking down the problem of sustainable social housing maintenance into a hierarchy for AHP) and started to identify the toolkits they would need as a result. As expected, Company O identified a far wider range of criteria than they were currently using. It is however doubtful that the KPIs established as a result the workshops will be the final set and may change as other stakeholders are included in the process. The process of identifying appropriate performance, analysis, modelling and impact toolkits was started during the participatory process but as maintenance planning is conducted over a long period of time, how these models can be integrated and which will be the most appropriate (other models were suggested by the research that Company O had not considered) should form part of future research. The final stage of the participatory project was to populate the 'performance based sustainable social housing maintenance model (Table 1) and build Company O's AHP model to benchmark the sustainable performance of their existing housing stock and prioritise maintenance action going forward. The results of which are reported separately.

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