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Investigating Drivers Stimulating Demand for Green Renovation of Existing Buildings and Systems

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Abstract

The main purpose of the research is to investigate drivers that motivate homeowners, investors, government institutions etc., to undertake green renovation. Sustainable upgrade actions have been slow although new smart technologies such as solar panels, e-glazing, insulation systems, cogeneration etc., are developed or upgraded every year. At such a slow pace, the existing building stock presents a challenge as drivers are not rigorously identified and applied. A survey questionnaire was designed to examine all the drivers that encourage energy renovation. Extensive review of the literature provided a theoretical framework that supported the study. The survey was administered to energy consultants, architects, quantity surveyors, facility managers and engineers with sufficient professional experience. The data was analysed using means, T-test analysis and Mann–Whitney U test. The results establish a relationship between drivers and upgrade of existing buildings and systems. The findings identified a strong level of agreement among the respondents on the drivers of green renovation. Incentive and support systems, penalties for noncompliance, high energy bills, energy conservation and policy and regulations, awareness etc., are some of the motivating factors that drive energy management retrofit.

Keywords: carbon dioxide, drivers, energy saving, existing buildings and systems, green renovation

1. Introduction

Energy management studies keep painting a gloomy picture of the effects of human activities on the environment. Reports indicate rising temperature including the identification of glaciers in Asia and Europe. Indeed, parts of the world are likely to lose more than 80% of the available ice mass in a couple of decades (Van der Geest & Van den Berg, 2021). Estimates show human activities have contributed to the 1.1ºc of global warming and effects of rising sea levels. Unfortunately, other projections point to a sharp increase from 1.1 to 1.5 in the near future. The Intergovernmental Panel on Climate Change (IPCC) states that the effects of high emissions such as loss of endangered species and aquatic life, predicted shortage of global water etc., may continue until corrective strategies are adopted (IPCC, 2021). Notwithstanding, environmental challenges associated with buildings and systems are on the rise. The existing building stock is associated with heat losses because of defective envelopes, poor insulation, corrosive components, undocumented high level of air infiltration, leakages and defective roof systems (Douglas & Ransom, 2013; Uotila et al., 2021). For example, estimates indicate high infiltration concerns, low level of sustainable practices and to some extent adoption of smart meters has also been slow (Giest, 2020; Ndlovu et al., 2020). Energy consumption of buildings is on the rise with figures between 15-19% and 23% of carbon dioxide (CO_2) emissions (Movahed et al., 2021; Sandanayake et al., 2019). Similarly, actions from various countries that tie to energy management have been slow (IPCC, 2021). However, there are reports of some gains through energy retrofit. Green renovation or sustainable upgrade has proved to contribute positively to emission reductions (Dunn et al., 2021). The concept of green renovation presents opportunities in energy saving and sustainable development (Desideri & Asdrubali, 2018; Dadzie et al., 2020).

Mawed et al. (2020) suggest that awareness of the benefits of green retrofit amongst owners and decision-makers drives actions and decisions to improve energy performance of existing buildings. Dunn et al. (2021) determined the amount of savings in cost, carbon reduction and kilowatt usage and confirmed that repayment for energy used and cost savings drive LED retrofit projects. Ebekozien et al. (2022) through a systematic review highlighted drivers of green building practices. Hrovatin and Zorić (2016) demonstrated that drivers of energy efficiency upgrade include subsidy interventions, supports and information systems. Rispoli & Organ (2019) revealed that climate change and heritage preservations drive energy retrofit of houses in the UK. Fasna and Gunatilake (2020) studied stakeholder's involvement as a driver of a hotel energy retrofit. Principal interest and communication, project and energy management, technical and research skills deliver building retrofit projects (Bevan et al., 2020). There are findings on methods used to implement green refurbishment. Methods and strategies are important to the drive towards energy upgrade of buildings and equipment. Hamida and Hassanain (2021) developed an AEC/FM knowledge in adaptive reuse projects. Alwan (2016) developed and proposed a BIM framework for the maintenance and refurbishment of housing stock. The BIM approach largely used in the analysis can be applied to achieve effective modern asset management. Mauro et al. (2015) presented a new methodology for energy retrofit based on cost-optimality, energy design and survey strategies for auditing of indoor environment. The use of records from building key cards has proved to be an effective way of keeping track of activities in a building, thereby contributing to energy gains (Rohdin et al., 2016). However, majority of the studies are not tied to the practical implications of drivers of green retrofit. Also, not many studies attempt to compare decisions from different professionals to encourage energy management renovations. Given the level of emissions, it is clear attention must shift to drivers that influence policy decision or formulation. Thus, the study seeks to investigate drivers of green renovation of existing buildings and systems.

2. Literature Review

2.1 Sustainable Upgrade of Existing Buildings and Systems

Sustainable upgrade of existing buildings presents an opportunity to drive energy savings and improve the environment. The environment is life, hence actions to preserve nature are in tandem with the aim of the study. The demand-side approach of energy retrofit has been widely discussed in the literature as it presents a shift from the conventional model to a more energy management system. Karunaratne & De Silva (2019) considered the demand-side energy retrofit (DSER) potential in existing office buildings in Sri Lanka. The authors underlined a methodology that addresses energy demand from HVAC and lighting systems. Detailed analysis shows the method proposed can be used to control electricity demand. Gultekin-Bier et al. (2018) presented a cross-case analysis of an integrated system for advanced energy retrofit projects. The research argued for a case study approach to understand the integrated system design process and related effects on energy efficiency. Toachieve the objectives, the authors adopted three retrofit projects with varying processes and rates of energy consumption. Accordingly, a collaborative energy benchmarking and performance goal setting provided a transparent decision-making condition that supports iterative energy modelling of an integrated building system. Deep renovation of historic buildings for lowest possible energy demand and CO_2 emissions was studied by Herrera-Avellanosa et al. (2019). The analysis highlighted the importance of improving energy performance of historic buildings as there is the potential to reduce carbon emissions while protecting built heritage. Dissemination of best-practices and guidelines are presented as critical in addressing barriers and ultimately to achieve the lowest possible energy demand for historic buildings.

Evaluation of post occupancy performance of a typical conventional building was undertaken by Atkins & Emmanuel (2014). The research used a single case to explore gaps and overlaps and their role in improving energy and carbon emission performance of traditional buildings. The results show that green renovation of the case study could halve the energy use in traditional buildings with comparable savings in CO_2 emission. Pazouki et al. (2021) applied a robust possibilistic programming method to deal with uncertainties and mathematical modelling to find the best decarbonisation strategy. The multi-objective optimization model considers economic variables such as profit, initial cost and payback period. Others include energy-saving and the use of clean and renewable energy technologies. Detailed analysis of the data indicates that the presented model can find the best possible strategy to improve energy efficiency and significantly improve a buildings' energy saving. Energy efficiency approaches should consider building portfolios, given that deep decarbonisation of existing stocks would bring significant environmental and economic benefits (Gabrielli & Ruggeri, 2019). The study presented a decision support model for planning and managing energy retrofit operations in wide building portfolios. The purpose was to use a single-building perspective and identify the level of energy retrofit that leads to the greatest possible benefit. The results consider extreme flexibility in comparing countless design scenarios, limited number of building characteristics required and straightforwardness of the model developed as important contributions to ensure decarbonisation of the built environment.

2.2 Drivers of Green Renovation of Existing Buildings and Systems

Table 1 presents details of the drivers in the literature that relate to sustainable upgrade of existing buildings and systems. In relation to the research questions, variables that present demand for green renovation were identified and discussed. Details of the variables include socio-economic conditions, incentive and support systems, energy efficiency advice, energy savings, increasing cost of energy, energy savings after upgrade among many others.

Table 1. Drivers of green renovation

No	Drivers of Sustainable Upgrade	Source
1	Socio-economic conditions	Hrovatin & Zorić (2016), Azar & Al Ansari (2017), Wang et al. (2018), Jia et al. (2018)
2	Incentives/support systems	Wang et al. (2018); Geng & Cui (2020), Bergman & Foxon (2020); Liang et al. (2019), Guo et al. (2019), Häkkinen et al. (2019)
3	Level of awareness	Azar & Al Ansari (2017), Trianni et al. (2016), Wang et al. (2017), Spyridaki et al. (2020), Haraldsson & Johansson (2019), Sa et al. (2017), Andersson & Thollander (2019)
4	Government policy & regulations	Martiskainen & Kivimaa (2019), Wang et al. (2018), Liang et al. (2019), Andersson & Thollander (2019), Polzin et al. (2018), Alam et al. (2019)
5	Management support	Wang et al. (2016), Sola et al. (2020), Bertone et al. (2018), Johansson & Thollander (2018), Haraldsson & Johansson (2019)
6	Energy savings	Cooremans & Schönenberger (2019), Liu et al. (2020), Geng & Cui (2020), Polzin et al. (2018), Beccali et al. (2019), Hamilton et al. (2016), Johansson & Thollander (2018), Ahmed et al. (2021)
7	End user expectations	Wang et al. (2016), Thøgersen (2018), Antonietti & Fontini (2019), Trianni et al. (2016), Collins & Curtis (2018), Bevan et al. (2020), Häkkinen et al. (2019)
8	Eco-friendly environment	Rispoli & Organ (2018), Salim et al. (2019), Persson & Grönkvist (2015), Thøgersen (2018), Miller et al. (2018), Berg et al. (2017), Damette et al. (2018)
9	Increasing cost of energy	Rispoli & Organ (2019), Hrovatin et al. (2016), Del Río et al. (2018), Du et al. (2016), Hasan et al. (2019), Andersson & Thollander (2019)
10	Availability of a sustainable technology	Jia et al. (2018), Seth et al. (2018), Sáez-Martínez et al. (2016), Wang et al. (2017), Qi et al. (2020), Miller et al. (2018), Beccali et al. (2019), Nižetić et al. (2019), Spyridaki et al. (2020), Guo et al. (2019)
11	Penalties for non-compliance	Martiskainen & Kivimaa (2019), Cagno et al. (2015), Chmutina et al. (2014)
12	Indoor thermal comfort	Hrovatin & Zorić (2018), Klöckner & Nayum (2016), Nair et al. (2010)
13	Emissions tax	Tesema & Worrell (2015), Lu et al. (2019), Qi et al. (2020), Hoicka et al. (2014), Chmutina et al. (2014)
14	Owner involvement	Trianni et al. (2016), Miller et al. (2018), Gliedt & Hoicka (2015), Thollander & Palm (2015), Wilson et al. (2018)
15	Payback time on investment	Bergman & Foxon (2020), Bertone et al. (2018), Damette et al. (2018), Polzin et al. (2018)

Demand driven drivers vary from county-to-country and scope depending on the level of policy formulation and implementation. Policy drives many energy renovations all over the world. Alam et al. (2019) studied Government championed strategies to overcome barriers to public building energy efficiency retrofit projects, whereas government policy, regulation and potential to improve demand for green renovation were discussed by Martiskainen & Kivimaa (2019). Alam et al. (2019) added that government decisions to support energy efficiency upgrades are likely to drive reductions in CO2 emissions. Actions in the form policies and regulations should be aligned to the overall goal of improving energy savings particularly of existing buildings and equipment. Incentives and support systems derived from policies have the potential to stimulate demand and actions relevant to energy saving upgrades (Geng & Cui, 2020). Incentive and support systems cause demand for sustainable upgrade (Wang et al. 2016). Economic conditions vary, however that has no correlation with energy wasted as indicated in an earlier study by Wang et al. (2018). Socio-economic level influences the type and size of building and installation of sustainable technologies (Wang et al., 2018). As the cost of technologies and systems that drive low energy consumption rise, low-income earners or countries may not be able to adopt and install. Building type and size could attract different incentive and support systems (Salim et al. 2019; Lu et al. 2019). Large buildings consume more energy, likely to attract support compared to small buildings. Azar & Al Ansari (2017) discussed quest to conserve energy as a driver of emissions savings consistent with similar studies by Hasan et al. (2019). Hasan et al. (2019) highlighted energy saving concerns as a driver of energy retrofit actions. Overall, a large percentage of the studies are aligned to the theory of clean technology transfer and sustainable construction as indicated in Fig. 1.

*H*1: There is no agreement between management group and the non-management group on drivers of energy renovation projects.

3. Research Conceptual Framework and Context

The main aim of the study is to investigate drivers of sustainable upgrade of structures and systems. Given the established aim, Fig. 1. argues that investigating drivers of sustainable upgrade of existing buildings is consistent with benefits of improved environmental performance. Improved environmental outlook which includes energy savings and reduced emissions is consistent with the concept of sustainability. The framework serves as a guide that tie all the variables for the study.

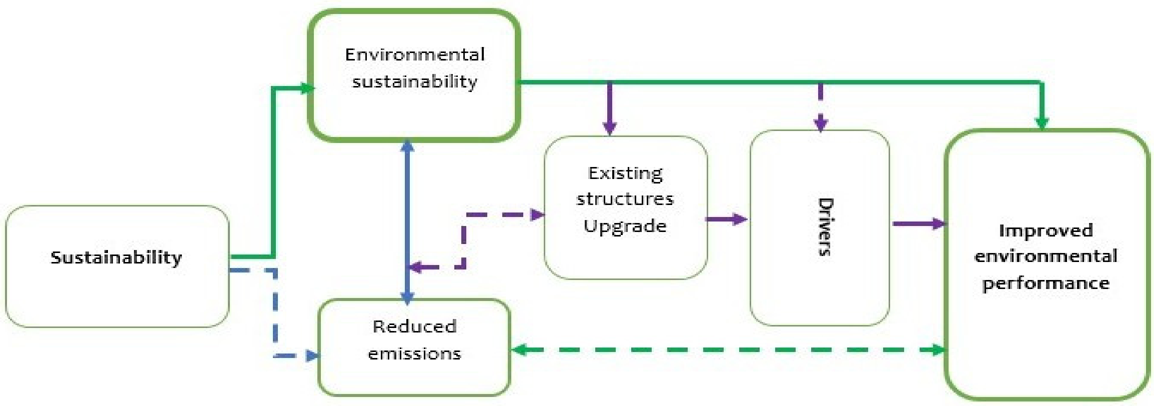

Figure 1. Framework and research context

Economic and social gains as in the theory of sustainability may not be achieved without a critical look at the environmental parameters. In this vein, the research links the ultimate goals of addressing environmental effects to the benefits associated with sustainable upgrade. Therefore, by identifying weaknesses in the present building stock and designing appropriate systems to save energy leads to improved emissions and ensure environmental sustainability. The concept of sustainable upgrade (SU) ties the actions of environmental performance to drivers that influence actions or decisions. The drivers influence decisions in a positive way, they are in actual sense acting opposite inactions. It is based on this assumption that the investigation connects the variables to improve environmental performance. The framework is a guide for the selection of relevant variables for the study.

4. Research Methodology

The investigation adopts a quantitative approach consistent with the theory established by O'Dwyer & Bernauer (2013). O'Dwyer & Bernauer (2013) argue that the structure of research questions directs the paradigm of a scientific examination. For example, questions that are "what" in nature dictate a quantitative approach. Although it is common to find a mix of quantitative and qualitative methods, this research ties to the quantitative paradigm as highlighted in the research questions, methodology and analysis of findings. Adoption and application of a single research method has been hindered by certain deficiencies (Creswell & Clark, 2017). Mwageni & Kassenga (2022) used a quantitative paradigm and argued the use of a survey questionnaire to understand cost-benefit analysis of green space investment in residential areas. Sackey et al. (2020) used survey questionnaire to investigate factors of solar panel investment. The responses were analysed using a quantitative tool and approach such as one sample t-test to assess the significance of the main variables. Similarly, Agyeman et al. (2012) used a quantitative approach for a study on commercial charcoal production and sustainable community development of the upper west region, Ghana. Leyian et al. (2021) adopted a pragmatism paradigm as well as a correlational research design and a sample of 251 respondents. Data was collected using semi-structured questionnaires, interview guides, and observation. Quantitative data was analysed for means and standard deviation as well as inferential techniques for correlation and regression while hypothesis was tested using ANOVA.

4.1 Data Collection

The research adopts a survey questionnaire to collect quantitative data on the drivers of green renovation. An initial detailed literature review was conducted to identify the nature and types of existing buildings, sustainable technologies, energy and environmental performance, barriers and drivers. Drivers of sustainable upgrade were extracted from the literature and expanded after an extensive review by industry professionals. The first part of the survey questionnaire covered the working experience of respondents, projects undertaken in the past and the total value of renovations undertaken by the respondents in Australia. The second part focused on sustainable technologies, barriers and drivers that drive green renovation. Testing of the viability of the variables was to ensure that irrelevant drivers inconsistent with industry practices were eliminated. Sections of the survey were improved and incorporated into the main structure before distribution through SurveyMonkey. The websites of professional's bodies were the main tools used to establish contact with respondents. Others were contacted through referrals although that sample was not large. Architects, project managers, facility managers, building services engineers and quantity surveyors who formed the core of respondents were randomly selected from professionals registered with various professional bodies. These professionals work with different clients and buildings: residential, educational, commercial, heritage, retail facilities and religious buildings. Table 2 illustrates the professionals contacted and details of the qualifications. In relation to the hypothesis, the sample was grouped under management team (facility managers and services engineers) and non-management team (architects, project managers and quantity surveyors) were randomly selected. The data obtained was analysed using SPSS.

4.2 Data Analysis

Given the research questions, a Cronbach's alpha coefficient was used consistent with similar studies by Leyian, Rambo & Mulwa (2021). According to Tavakol & Dennick (2011) a Cronbach's alpha coefficient should range between 0 to 1. Statistically, a value greater than 70% is required to reach acceptability level. By applying the steps provided by Gliem & Gliem (2003) the estimated Cronbach's alpha coefficient value of 0.788 for all the drivers was established, indicating consistency in the data set to allow for further statistical analysis. The most common formular is the use of means to determine the main drivers likely to trigger reductions in emissions. Calculated means provide the descriptive analysis of the data for detailed and further analysis, based on the maximum and minimum values. The means of each group are then assessed to produce the overall ranking for discussions and conclusions. Similar means are differentiated using the standard deviations. This is where standard deviation estimates become relevant as that forms the basis for ranking of similar means.

$$\text{Mean} = \frac{\sum_{i-1}^{5} W_i . X_i}{\sum_{i-1}^{5} X_i}$$

where: i – responses category of a Likert scale – 1,2, 3, 4, 5. W_i – is the weight assigned to i^{th} response – (5 is Strongly agree, 4 for agree, 3 for neutral, 2 is disagree, 1 for strongly disagree); and X_i – frequency of the i^{th} response.

$$\alpha = \frac{Qa}{(Var + (Q - 1)a)}$$

Where α—Cronbach's coefficient alpha

Q = the number of components

a= mean of covariances between the components

Var= variance of each component

Statistical means and standard deviations have been used in studies related to the environment and energy efficiency. Babatunde et al. (2018) used means and standard deviations to understand drivers and benefits of BIM incorporation into quantity surveying profession. In line with the objectives, a p-value of 95% confidence interval was tested against statistical t test. The next phase of the analysis adopts the Kendall's coefficient of concordance to explain the level of agreement of the drivers. The Kendall's coefficient of concordance (W) measures the agreement of the various respondents based on mean values within a particular sample or population (Field, 2005). The range of the value of W is from 0 to 1; a higher value of W, indicates consensus among the sample. Similar tools have been used in previous studies around sustainability and energy management. The Mann–Whitney U test provides basis to accept or reject a null hypothesis. For this study, the U test suggests two different groups from the same sample and that they are autonomous, homogeneous and have the same distribution. The U test works on the assumption that as calculated p-value is less than the allowable significance level (95%), the null hypothesis (H0), stating no significant differences in the median values of the same item between the two survey groups, should be rejected.

5. Results and Discussion

5.1 Background of Respondents

All 350 sets of survey questionnaires were distributed, 86 responses were received of which 81 were complete and used for further analysis. Table 2 presents details of the respondents. Almost 50% of the respondents have a postgraduate degree with another 40% with first degree. Also, 80% of the respondents have over 10 years of professional experience in renovation and sustainable construction. The level of education and experience of the respondents correlates with the quality of the data obtained and analysed.

Table 2. Background of respondents

Profession	%	Qualification	%	Working Experience	%
Architects	28	Postgraduate	45	<5years	20
Project Managers	15	Degree	40	> 10 years	80
Service Engineers	35	Diploma/others	15		
Facility Managers	11				
Quantity Surveyors	11				

5.2 Drivers of Green Renovation for Energy and CO_2 Savings

Table 3 indicates the results of the drivers of SU of existing structures and systems. In all, 23 drivers were identified as main variables influencing upgrade. The analysis is in two sections: the first section focuses on analysing the means of the two teams as the other section concentrates on the overall results. For the analysis of the management group, main drivers include incentive and support systems (1st, 4.81), energy conservation (2nd, 4.72), penalties for non-compliances (3rd, 4.66), policy & regulations (4th, 4.60), high energy bills (5th, 4.53), decision to sell (6th, 4.48), public awareness (7th, 4.44), Heritage purpose (8th, 4.40), household income (9th, 4.32) and acquire green certification (10th, 4.30).

Table 3. Drivers of green renovation of existing structures and systems for CO_2 savings

No	Drivers of Sustainable Upgrade	Management Group		Non- management Group		Overall Response		
		Mean	Rank	Mean	Rank	Mean	Rank	Sig.
1	Household income	4.32	9th	4.27	9th	4.30	7th	0.000
2	Household population	3.25	21st	3.14	23rd	3.20	23rd	0.000
3	Improve average property value	4.17	12th	3.24	21st	3.71	18th	0.000
4	Heritage purposes	4.40	8th	3.42	19th	3.91	13th	0.000
5	Change Use or function of building	4.00	13th	4.11	10th	4.06	11th	0.000
6	Acquire Green certification	4.30	10th	4.07	11th	4.19	8th	0.000
7	Professional / Technical advice	4.19	11th	3.78	15th	3.99	12th	0.000
8	Available data on energy saving potential of SU	3.89	14th	3.55	16th	3.72	17th	0.000
9	Decision to sell	4.48	6th	3.8	14th	4.14	9th	0.000
10	Availability of low interest loans	3.40	19th	3.46	18th	3.43	19th	0.011
11	Government policy & regulations	4.60	4th	4.55	5th	4.58	5th	0.000
12	sustainable upgrade energy audit	3.67	16th	4.57	4th	4.12	10th	0.000
13	Incentive and support systems	4.81	1st	4.75	3rd	4.78	1st	0.002
14	Penalties for noncompliance	4.66	3rd	4.8	2nd	4.73	2nd	0.000
15	Ensured public awareness	4.44	7th	4.51	6th	4.48	6th	0.001
16	Climate change effects	3.50	18th	4.00	13th	3.75	16th	0.000
17	Indoor thermal discomfort	3.70	15th	3.16	22nd	3.43	19th	0.010
18	Affordable energy efficient technologies	3.61	17th	4.01	12th	3.81	14th	0.000
19	Size of building	3.15	23rd	4.42	8th	3.79	15th	0.000
20	Age of building	3.30	20th	3.33	20th	3.32	22nd	0.002
21	Existing energy savings systems in building	3.20	22nd	3.50	17th	3.35	21st	0.000
22	High energy bills	4.53	5th	4.82	1st	4.68	3rd	0.000
23	Energy conservation	4.72	2nd	4.50	7th	4.61	4th	0.000

Many studies tend to separate policy and regulations as a driver, however, the analysis attempted to merge the two to understand the position of professionals. The results show there is no significant difference as they do not function independently. Addressing policy directives in the form of regulations contribute to fines or penalties drive sustainable upgrade. On the other hand, in relation to non-management team, the results indicate to some extent consistency in the data. The analysis indicates significant drivers as high energy bills (1^{st}, 4.82), penalties for non-compliance (2^{nd}, 4.80); incentive support systems (3^{rd}, 4.75); SU upgrade energy audit (4^{th}, 4.57); policy and regulations (5^{th}, 4.55); public awareness (6^{th}, 4.51) energy conservation (7^{th}, 4.50), size of building (8^{th}, 4.42), household income (9^{th}, 4.27), change use /function of building (10^{th}, 4.11). The results indicate consistent as indicated in Table 3, for instance, as government policy was ranked 4^{th} by management team, it was ranked 5^{th} by the non-management team. Incentive and support systems was ranked 1^{st} by the management team whereas the non-management ranked that 3^{rd} with a mean of 4.81 and 4.75 respectively.

The second part of the analysis shows incentive and support systems, penalties for noncompliance, high energy bills, energy conservation, policy and regulations were ranked 1^{st} (4.78, p=0.002), 2^{nd} (4.73, p=0.000), 3^{rd} (4.68, p=0.00), 4^{th} (4.61, p=0.000) and 5^{th} (4.58, p=0.000) respectively. In the same vein, ranked 6^{th}, (4.48, p=0.001), 7^{th} (4.30, p=0.000), 8^{th} (4.19, p=0.000), 9^{th} (4.14, p=0.000) and 10^{th} (4.12, p=0.000) are public awareness, household income, acquire green certificate, decision to sell and SU upgrade energy audit in that order. At the bottom of the order are indoor thermal comfort (3.43, p=0.010), availability of low interest loans (3.43, p=0.011), existing energy saving systems (3.35, p=0.000), age of building (3.32, p=0.002) and household population (3.20, p=0.000). The overall position is that the respondents acknowledge age of building, household income etc. as drivers.

5.3 Hypothesis Testing

The values of W for each group show that the null hypothesis should be rejected as the p-value at a significance level less than 0.005 ($p \leq 0.005$). This implies that there is agreement between the management group and the non-management group of the sample on the rankings regarding the drivers of SU of existing structures and systems. The values of W, 0.158 and 0.125 for the management group and non-management group respectively. As the variables are 23, Chi-square analysis conducted indicates values between 62 and 65. In the case of the management group (65.83; df=8) and non-management group (62.44; df=8). The results indicate agreement between the two groups, inconsistent with the null hypothesis.

Table 4. U test analysis

No	Drivers	Mann Whitey U	Z-value	p-value
1	Household income	91	1.405	0.432
2	Household population	67.88	2.452	0.105
3	Improve average property value	77	2.253	0.229
4	Heritage purposes	68	2.549	0.182
5	Change use or function of building	89	1.598	0.44
6	Acquire Green certification	90	1.522	0.448
7	Professional / Technical advice	49	3.762	0.000
8	Available data on energy saving potential of SU	88	1.601	0.436
9	Decision to sell	84	1.675	0.376
10	Availability of low interest loans	82	1.698	0.311
11	Government policies and regulations	107	0.456	0.672
12	Sustainable upgrade energy audit	101	0.509	0.627
13	Incentive systems	104	0.486	0.589
14	Penalties for noncompliance	100	0.529	0.651
15	Ensured public awareness	96	1.344	0.482
16	Climate change effects	50	3.187	0.300
17	Indoor thermal discomfort	75	2.373	1.835
18	Affordable energy efficient technologies	48	3.246	0.000
19	Size of building	55	3.159	0.000
20	Age of building	70	2.347	0.137
21	Existing energy savings systems in building	70.85	2.361	0.126
22	High energy bills	96	1.344	0.483
23	Energy conservation	100.63	0.511	0.662

The Mann–Whitney U test is used to determine any significant differences or divergences in the median values of the same item between any two selected respondent groups. There is only one pair in this research, that is management and non-management group of professionals. Table 4 shows calculated the Z values, U values and p-values. For example, household income (U= 91, Z=1.405, p-value= 0.432), household population (U=67.880, Z=2.452, 0.105) and improve average property value (U=77, Z=2.253, p value=0.229). Professional and technical advice, affordable energy efficient technologies and size of building with p-value inconsistent with that of 0.05. The implication is that the drivers are outlining variables as p-values ($p<0.05$) indicate a shift. However, the remaining 20 drivers, the U test show ($p>0.05$). This implies that for a conventional renovation project, the initial consultation between a client and a group of professionals to formulate a contract constitute a professional advice. Technically, a professional advice is embedded in any formal contract as explained by the p-value. In the case of affordable energy efficient technologies, the respondents anticipate improved high energy saving technologies such as the solar panel systems, smart envelopes etc.

6. Discussion of Results

The discussion is based on the results of the study as indicated in Table 2 and Table 3. The main drivers are incentive and support systems, penalties for noncompliance, high energy bills, energy conservation, policy and regulations etc. Incentive systems drive energy retrofit of existing structures and systems. Supportive systems can be of different forms including subsides, full cost recovery, free installations, discounts, and tax reductions (Geng and Cui, 2020). For example, providing financial assistance or subsidy for solar panel systems or the battery program can improve decisions to renovate or upgrade. Some countries have such programs whereas others do not have at all. In some countries the level of implementation is slow; often not targeting the many households and industries. Households, small businesses and community groups can be encouraged with incentive systems such as certificate of installation to drive upgrades (Kontokosta, 2016; Häkkinen et al., 2019). Also, commercial solar rebates, loans and grants are likely incentives systems for large scale companies with the desire to renovate. Financial institutions can focus on providing support to industries willing to adopt sustainable upgrade. Such financial support can attract low interest rates to encourage many homeowners to renovate. Liang et al. (2019) mentioned the importance of enforcing support systems to promote energy renovations. The focus of the results is that although there are many incentives programs, majority are ignored or not enforced. Acting to implement such directives could trigger demand for sustainable upgrade of existing buildings and systems. Liang's et al. (2019) position is consistent with the position of the respondents. It implies that as support systems are introduced or enforced, actions to upgrade also improve.

A global lack of investment in sustainable technologies to reduce energy consumption has forced many high-demanding nations to continually rely heavily on fossil fuel; the effects on the climate and global warming are severe. The result of the study is critical as it points out the need to understand energy saving through retrofitting. Similar concerns in line with the results were expressed by Johansson & Thollander (2018). Energy conservation or management is the process of ensuring that energy is consumed or used for the desired purpose. Similarly, it means adopting ways to minimise or eliminate unnecessary energy wastage. It involves installation of energy efficient systems, or use of materials with low U-Values, behavioural actions etc., that contribute to low energy consumption (Polzin et al., 2018). There is the need to establish achievable benchmarks that can be measured, monitored and improved. The implication is that clients, institutions, investors and professionals in the field are encouraged to act. A mere suggestion that people should conserve energy without actions to back such proposals may not deliver positive results. Proper financial regulations to strengthen weak structures are relevant to CO_2 savings. Simple technologies that promote energy management are needed to reinforce retrofit actions. For example, government's investment actions can target investors and developers willing to venture into green renovation. Also, manufacturers, clients, institutions and investors are to some extent aware of this concept, but unable to act due to inadequate support or leadership. Clients are increasingly becoming aware of the need to conserve energy to the level of retrofitting lighting systems and introducing insulators in old buildings (Gabrielli & Ruggeri, 2019). The results indicate penalties for non-compliance as a driver of actions towards CO_2 savings. It is the position of the respondents that by addressing compliance and providing fines or penalties that go with non-compliance, actions to retrofit are ultimately activated. The current regulations are to some extent not strictly enforced. With such a condition, many potential clients may not take actions to renovate. The building codes provide actions that should be adopted and applied including inspections to ensure compliance at all the stages of renovation. For example, inspections of simple technologies such as insulation, room heights, quality of materials fall within the building code. Expanding the building codes to address areas such as expected level of upgrade and technologies drives upgrade. Thus, regulations can be aligned to the codes by specifying penalties for non-compliance to promote green renovation.

Globally, high energy bills drive actions to upgrade existing structures and systems. Energy companies are required to investigate sustainable ways of production that do not harm the environment and future generations. Continuing with the unsustainable ways contributes to high cost of energy, which is usually passed on to the consumer. However, consumers are aware that a simple life cycle cost analysis of a sustainable upgrade over a period can pay for a high energy cost (del Río et al., 2018; Hasan et al., 2019). Also, consumers understand the impact of data indicating short-term recovery of investment for green renovation. Given such a background, potential clients or investors are increasingly seeking approaches that can cause energy savings and conservation (Du et al., 2016; Hasan et al., 2019). The results of the study on policy and regulations as drivers of sustainable upgrade are consistent with findings of studies by Martiskainen & Kivimaa (2019). Martiskainen and Kivimaa (2019) discussed the impact of policy on energy management renovations. Polzin et al. (2019) and Alam et al. (2019) argued for stronger policies and regulations. Policies and regulations are to some extent not enforceable, negatively impacting expected gains in energy savings. Wang et al. (2018) also stated that policies backed by regulations positively impact energy conservation. Wang et al. (2017) highlighted awareness creation as important as economic regulations that stimulate demand for improved of energy efficiency.

6.1 Implications for Practice

The findings are relevant as that indicate extent to which the concept of sustainability triggers employment through research. The drivers of sustainable upgrade highlight areas for practice. The level to which the findings are applied relies on the adoption and implementation of the drivers identified. The results seek to create and enhance understanding of the main parameters that are needed to improve emissions. As the drivers are enforced through policy and regulations; investment, research and development, jobs etc. are created. For example, penalties for noncompliance can drive adoption of sustainable systems and trigger demand and supply thereby creating jobs in the sustainability industry. Incentive and support systems should drive potential clients to undertake SU thereby promoting energy savings. Studies show desire to adopt green renovation due to related energy and CO_2 savings, however this requires actions as indicated by the results of the study.

7. Conclusions

Energy management through green renovation of buildings and systems is consistent with the aim of this research. Decarbonisation of the existing building stock through sustainable upgrade has been identified as a major step towards energy efficiency. As drivers are identified and applied, energy renovations activities are encouraged to save energy and the environment. This requires that buildings and equipment are upgraded to ensure improved energy efficiency. However, there are studies that indicate a slow pace at which these actions are undertaken. The consequence is high CO_2 emissions that tend to affect the environment and sometimes human life. The main objective of the study is to investigate drivers of green renovation. This involved extensive review of the literature to establish a theoretical foundation to understand and develop a framework to guide the investigation. Detailed data collection approach and analysis delivered basis to argue in relation with the established framework. The results identified two main levels or groups of drivers as indicate in the conceptual framework of study. The main drivers identified include incentive and support systems, penalties for noncompliance, high energy bills, energy conservation and policy and regulations. Others are public awareness, household income, acquire green certificate, decision to sell and SU upgrade energy audit in that order are regarded as highly ranked drivers. Indoor thermal comfort, availability of low interest loans, energy saving systems, age of building and household population are considered least ranked drivers. The second objective is to test the hypotheses of any relationship between the respondents on the drivers. In this section significant statistical agreement between the two groups of professionals was established. Thus, the research provides a policy tool for governments, institutions, the construction industry etc. Also, it presents literature to aid decision making regarding sustainable upgrade of existing buildings and equipment. The practical and policy implications of the study are presented as part of actions required to improve the environment.

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