Stakeholder Decision Making in Passivhaus Design

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ABSTRACT
The design and construction of a building is inherently complex and a myriad of decisions must be made during the design and planning process. No single stakeholder (architect, client, building physicist) has complete knowledge and visibility of the consequences of each decision and each stakeholder group is driven by different objectives.

Those aspiring to construct low-energy buildings, and Passivhaus in particular, are subject to numerous constraints, relating to building performance, site restrictions and planning policy (amongst others) and seemingly innocuous small changes to the design can divert decision- makers from their aims.

Multi-criteria decision making provides a method of attempting to satisfy numerous, often conflicting objectives, in order to reach the 'optimum' solution, and therefore provides a means to combine these varied goals. Existing research in the sphere of building performance simulation often focuses on its application to quantitative criteria.

This paper proposes incorporating stakeholder preference modelling in multi-criteria decision making by first analysing stakeholder goals, to gain a greater understanding of their motivation and decision paths, within the context of Passivhaus construction in the UK.

Author Keywords
MCDM; Decision Support; Passivhaus

1 INTRODUCTION
Under the terms of the Climate Change Act 2008, the UK has a legal obligation to reduce CO_2 emissions by 80% by 2050 [7]. Improved building performance is crucial to achieving this target, given that the construction and operation of buildings is responsible for half of the UK's CO_2 emissions [20]. This sits within the wider European context of 40% of emissions originating in the construction sector [5]. In response to this issue, the Energy Performance of Buildings Directive requires all EU member states to ensure that all new buildings achieve "nearly-zero energy" status by 2020, with a deadline of 2018 for publicly-owned buildings [4].

As the de facto standard for energy efficient building, Passivhaus offers a potential solution, since standards are independently set by the Passivhaus Institute and hence not subject to international differences in building standards or the vagaries of changing government policy [10]. It has clearly-defined constraints for successful certification, covering targets for peak heating/cooling load, annual heating demand, primary energy consumption and frequency of over-heating [10]. Buildings constructed to the Passivhaus standard are of particular focus in this study.

The tools and methods offered by Multi-Criteria Decision Making (MCDM) have a clear application in this context. Building design is a complex process, involving multiple stakeholder groups, all of whom make key decisions which impact on the building performance. The design and construction of buildings is subject to multiple objectives, ranging from energy efficiency and indoor air quality requirements, through to more subjective aspects, such as architectural aesthetics. Often the pursuit of one criterion can be to the detriment of another, for instance, designing to minimise heating demand may compromise aesthetics, particularly when retrofitting heritage properties [19]. Hence, there are trade-offs between competing criteria.

2 METHODOLOGY
A literature review of stakeholder decision-making in the design process was conducted and used to inform the development of a stakeholder goals matrix. This research is in the very early stages and will ultimately form part of wider consultations, by using a case study to examine the preferences of stakeholder groups relating to a specific building design.

3 LITERATURE REVIEW
Two elements are reviewed in relation to stakeholder preference modelling and its role in MCDM: the use of subjective measures in MCDM and the role of different stakeholders in the design process.

3.1 Applying MCDM to Subjective Measures in BPS
Much work has been done on the application of MCDM methods to the quantitative aspects of building performance [9, 10, 17, 22]. However, little research has been completed on how subjective aspects, such as aesthetics, can be incorporated alongside technical measures in MCDM [8].

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RIBA Design Stage	0 **Strategic Definition**	1 **Preparation and Brief**	2 **Concept Design**	3 **Developed Design**	4 **Technical Design**	5 **Construction**	6 **Handover and Close Out**	7 **In Use**
Stakeholders	Client Architect Planner	Client Architect Planner	Client Architect Planner Engineer Builder Financer	Client Architect Planner Engineer Builder Financer	Client Architect Planner Engineer Builder Financer	Client Architect Builder	Client Architect Builder	Client Occupant

Table 1: Design Stage Stakeholders (derived from RIBA 2013)

Furthermore, BPS is often used to verify compliance to regulations [12], rather than to inform decision making. Hence, the purpose of BPS is not to offer design 'solutions', but to aid understanding by providing users with outcomes of potential design choices. It is hypothesised that, users need a more developed, easy-to-use, tool to aid multi-variate decision-making in a timely manner, with clearly-defined levels of accuracy. The wide-ranging criteria for performance and ubiquitous issue of uncertainty both serve to add to the complexity [3].

3.2 Design Process and Stakeholders

In the UK, the Royal Institute of British Architecture (RIBA) defines the design lifecycle using their Plan of Work. Although it is designed with the UK in mind, it is indicative of the construction process in other countries. Within this structure, there is scope for flexibility; pre-application discussions with planners may take place during stages 0 and 1 and a planning application may be submitted as part of stages 2, 3 or 4. Similarly, finance may be sought at any point during these stages. The key stakeholders at each stage are illustrated in Table 1.

<u>Architect:</u> Clearly, the role of architects is apparent at every stage in the design process, hence, they have a key role in ensuring effective continuity of communication [18].

<u>Client:</u> A client may be a social housing provider, such as a housing association, a private individual or a property developer, each of whom will have differing priorities and levels of experience. Understandably, inexperienced clients can find the design life-cycle a source of concern, due to the lack of familiarity, as well as socio-technical reasons. Architects might be well-advised to use visual approaches to aid comprehension and help fill the void in client understanding [14].

<u>Building Physicist:</u> In the context of Passivhaus, the specialist role of the building physicist focuses on ensuring that the design satisfies energy efficiency criteria. Amongst other aspects, the building physicist is concerned with the magnitude of passive solar gains, which have an impact on the heating demand. Hence, building density will be a concern, given the potential for over-shadowing from neighbouring properties [23].

<u>Planner:</u> Planning decisions in England are governed by the National Planning Policy Framework, which covers a wide range of criteria, including aesthetic and heritage concerns. Specialist technical knowledge is not part of their remit; that lies in the domain of building regulations [2]. In a survey of the adoption of the CASBEE sustainable building standard in Japan, it was found that the majority of local authorities employed no accredited professionals [21]. Hence, they were unable to make an independent assessment and were influenced by elected officials, rather than industry professionals. This situation may cause a "vicious circle", whereby an absence of knowledge in the local authority, leads to a lack of public awareness and without wider knowledge of low-energy building, demand will stagnate [21].

<u>Builder:</u> Knowledge shortages have been identified as a barrier to builders delivering improved standards in the construction of low-energy building [6]. Achieving the air-tightness target is essential to Passivhaus accreditation, therefore, attention to detail in the implementation of a design is vital [10].

3.3 Research Questions

If the UK is to reduce CO_2 emissions by retrofitting homes, then a more holistic approach is needed, which takes into account the link between CO2 emissions reduction and the importance of incorporating aesthetic and heritage aspects [19]. Furthermore, despite its potential to tune building performance, BPS is rarely used as a decision support tool, due to usability issues [12].

The research so far raises some pertinent questions:

- To what extent are the goals of client synonymous with those of the owner or occupant? Whilst a property developer will bear in mind the purchasers' needs, they do not necessarily share their priorities; similarly, the objectives of a buy-to-let investor do not necessarily align with those of a tenant or those of an owner-occupier.
- To what extent does a client's choice of architect dictate success in Passivhaus construction?

- To what extent does the decision-making process differ in Passivhaus compared to conventional construction? Can the Passivhaus paradigm be considered as a microcosm of the construction industry in general?

4 RESULTS & DISCUSSION

Following the initial literature review, a number of themes emerged, which resulted in the development of a stakeholder goals matrix, a subset of which is illustrated in Table 2.

	Architect	Client	Building Physicist	Planner	Builder
Capital Cost		[15][1]			[16, 6]
Aesthetics	[12]	[1, 19][2]		[2]	
Building Density		[1]	[23]	[2]	
Maintenance Cost		[15][1,3] [13][4]			
Energy Efficiency		[6, 15][1]	[12]		[16]
IAQ & Thermal Comfort		[13][4]	[10]		

Table 2: Building Design Stakeholder Goals

There is a semantic difference between a goal, as opposed to an incentive, a driver or a benefit; some benefits of Passivhaus are only fully appreciated upon occupancy, such as improved thermal comfort and indoor air quality [10].

Conversely, capital cost might be perceived as a constraint or indeed a barrier, rather than a goal, particularly in the context of Passivhaus.

4.1 Sectoral Differences

It must be noted that, the priorities differ somewhat between the different sectors (self-build, social housing and commercial developer) and according to whether the project is a new build or a retrofit. Whilst some goals are universal (for instance clients' desire to minimise capital cost) others vary between sectors. For instance, housing associations are motivated by minimising the cost of maintaining a property; whereas builders viewed the increased cost of building low-energy homes as a disincentive [13, 16]. In the UK, there are mixed findings on house-buyers' attitudes to energy efficiency, with the Office of Fair Trading (OFT) report of 2008 stating that 19% of people chose a new build home based on their perception of better energy efficiency, compared to existing buildings, whereas, Heffernan et al note that the criteria of price, size and location dominate the decision process for home-owners [6, 15].

4.2 Roles & Influence

In some instances, there is overlap between the stakeholder groups, for instance the role of the "hybrid practitioner", who has knowledge spanning the domains of architecture and building physics [12]. In most cases, the owner is not a direct stakeholder in the design process; whereas, in the self-build sector, the client will also be the owner and occupant, and in some instances the financer [15].

Some stakeholders have a more central role than others, hence their influence will be more significant; a failure to communicate crucial information to the relevant stakeholder in a timely manner causes poor decision-making; hence an architect's role in co-ordinating project data is central to project success [14].

4.3 Interaction Between Qualitative and Quantitative Variables

Incorporating energy efficiency measures can impact the spatial quality of a building. Focussing on a non-technical benefit provides a different stimulus for motivating a decision-maker; for instance, changes to the percentage of glazing on a building façade impacts the spatial quality and the view, as well as the energy performance. Furthermore, perception, rather than reality often guides decisions, an aspect which is illustrated by building density, where proximity to other buildings, building height and street width impact perception [1].

5 FUTURE WORK

This research aims to address the research gaps highlighted in the literature review by incorporating stakeholders' preferences and including all stakeholder groups.

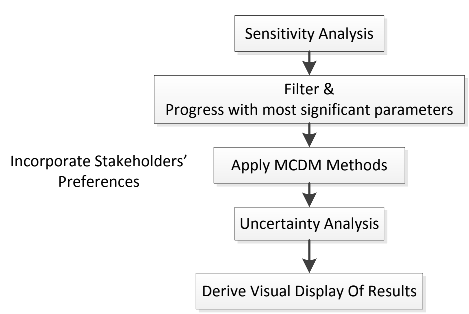

Figure 1: MCDM Prototyping Approach

Both qualitative and quantitative measures will be included in an MCDM model and, eventually, this model will be used to analyse the extent to which a decision support tool might be used to inform better decision making, in the context of Passivhaus.

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[1] Owner-occupier

[2] Retrofit

[3] New homes

[4] Housing Association

The future of this research will incorporate MCDM in the prototyping process as outlined in Figure 1.

The next step will be further refinement of the stakeholder goals matrix to group goals under unifying themes, for instance: property developers' motivations might be largely governed by "financial expediency", which covers capital cost and building densities.

To conclude, subjective aspects are key factors in decision-making in the building design process. Whilst it is difficult to put a value upon them, their impact on building performance can be significant.

Hence, there is a need to incorporate qualitative preferences in MCDM to reflect stakeholders' opinions, if UK construction is to achieve its share of carbon emissions reduction targets [8].

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