Indoor air quality and the suitability of MVHR systems in energy efficient social housing projects; perceptions of UK building professionals

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Abstract

The quality of indoor air in energy efficient buildings is a significantly important yet under-researched area, particularly in a social housing context. This study investigated perceptions of UK building professionals regarding the effect of energy efficient design strategies on indoor air quality. In-depth interviews were conducted with building professionals of four recently completed UK energy efficient social housing projects. The interviews explored perceptions of the importance of indoor air quality consideration during the design process, the impact of energy efficient design strategies on indoor air and the application of Mechanical Ventilation with Heat Recovery systems in a social housing context.

The results suggest a significant lack of attention to indoor air quality in energy efficient social housing projects; attributed by a lack of knowledge, perceived costs associated with indoor air quality strategies, focus on energy efficiency goals and a fundamental lack of motivation. Furthermore, major shortcomings of Mechanical Ventilation with Heat Recovery systems in social housing were emphasised by the building professionals, suggesting an urgent need to re-evaluate the suitability of these systems in a social housing context. The results can be used to aid the development of effective, sustainable social housing schemes that ensure the protection of occupant health and wellbeing.

Keywords: IAQ, perceptions, energy efficiency, social housing, building professionals

1. Introduction

Concern of indoor air quality in energy efficient buildings is growing. In the UK, efforts to meet the legally binding target of an 80% reduction of UK net carbon account by 2050 from the 1990 baseline [1]; have resulted in a number of changes to building regulations promoting energy efficient design practices. The UK domestic sector accounts for approximately 27% of total carbon dioxide emissions, attributed mainly by energy demand from heating, hot water, appliances and lighting [2]. Thus, the decarbonisation of the domestic sector is an important step to meet the targets set out in the climate change act.

Recent studies however have highlighted the potential detrimental impact of energy efficient design strategies on the quality of indoor air [3-8]. For example, studies have found shortcomings of MVHR systems [9-11], high levels of indoor air pollutants [12, 13], inadequate ventilation [14, 15], and issues with overheating [16] in energy efficient dwellings. As explained by Crump et al. [7], there is an "urgent need for research into the performance of highly energy efficient homes with respect to the quality if the internal environment". This is supported by the Innovation and Growth Team [17], who state the lack of skills and knowledge of indoor air quality in energy efficient buildings should be addressed as a priority, in order to "avoid the risk of a new generation of sick buildings".

Building professionals play a fundamental role in the decision making processes of energy efficient schemes, thus have a significant effect on the quality of the indoor environment. Understanding building professionals' perceptions of indoor air quality and MVHR systems in energy efficient housing projects could help improve the success of energy efficient design strategies, while protecting occupant health and wellbeing. However, few

studies have comprehensively investigated attitudes of building professionals on the impact of energy efficient design strategies, particularly regarding the impact on indoor air quality and thermal comfort.

Previous studies have examined indoor air quality perceptions of building occupants of energy efficient buildings [18]. Similarly, occupants and building professionals' perceptions of the importance of various indoor environmental quality criteria have been investigated [19-21]. Furthermore, studies of building professionals' attitudes towards sustainable construction/development [22-26], climate policy [27], and the impact of energy conservation regulations on the achievement of low energy buildings [28] have been conducted. A study by Davis and Harvey [26], for example, found the majority of housebuilders were concerned about high levels of airtightness in energy efficient dwellings and whether they would be constructing a healthy environment. Comparably, a study by Gul and Menzies [29] investigated attitudes and opinions of building professionals on overheating in energy efficient homes; however similar studies exploring indoor air quality perceptions are not available.

Thus, this study explores perceptions of building professionals towards indoor air quality and MVHR systems in energy efficient social housing projects. Firstly, the paper describes the study methodology, followed by findings concerning: 1) the consideration of indoor air quality during the design process, 2) the use of MVHR systems in energy efficient social housing, 3) occupant behaviour and perception of MVHR systems and 4) apprehensions of energy efficient design strategies in social housing. This is followed by a discussion, conclusions and recommendations for future research.

2. Methodology

The purpose of this study is to increase our understanding of current UK building professionals' perceptions towards indoor air quality in energy efficient social housing. Although recent studies have shown the potential impact of energy efficient design strategies on indoor air quality, little attention has been paid to perceptions and opinions among building professionals; particularly in a social housing context. This study aimed to uncover building professionals' perceptions on the effect of energy efficient design strategies on indoor air quality, with particular reference to the use of MVHR systems. Furthermore, consideration of indoor air quality during the design stage was investigated, building on experience from four UK case study projects.

Table 1. Interviewee's and case study details

No.	Job Position	Case study	Building project	Case study location
1	M&E consultant	Case study 1	6x low energy dwellings (no central heating system)	Northern Ireland
2	Housing association			
3	Architect			
4	Architect			
5	Housing charity			
6	Passivhaus consultant	Case study 2	2x Passivhaus, 4x Code 6, 87x Code 3	England
7	Housing association			
8	MVHR supplier			
9	MVHR supplier			
10	Architect			
11	M&E consultant	Case study 3	9x Code 4, 10x Code 3	Northern Ireland
12	Housing association			
13	Architect			
14	M&E consultant	Case study 4	5x Passivhaus	Northern Ireland
15	Housing association			
16	Architect			

Semi-structured, face to face interviews were conducted with a range of UK building professionals involved in four recently completed energy efficient social housing projects; which included architects, housing associations, Mechanical and Electrical (M&E) consultants, MVHR suppliers, a housing charity and a Passivhaus consultant (as illustrated in Table 1). Considering the exploratory nature of the study, this approach was selected as it enabled an in-depth examination of current perspectives; building on previous research conducted within the case studies. This is coupled with the fact that there are a considerably limited number of UK building professionals with experience of energy efficient social housing projects. All building professionals interviewed had extensive experience within their field and were actively involved in the case study projects. Consent forms were signed by building professionals during the interview process.

3. Consideration of indoor air quality during design process

3.1. Lack of indoor air quality strategies

The interviews revealed a number of barriers to the adoption of indoor air quality strategies. Interviewees explained indoor air quality is not really considered (only as required by building regulations) in social housing projects, as there is no real motivation to do so. Focus instead is directed towards energy efficiency and fuel poverty, since these goals are considered more significant in the social housing sector. This problem was evident in all four case studies, where the application of indoor air quality strategies was limited to basic consideration of ventilation, as required by the building regulations.

> *"Air quality isn't really considered. You know- what's the point; it is not on the radar. Things like temperature are more so because of things like complaints that tenants would raise, and because of energy efficiency and fuel poverty and various other goals" (housing association, case study 4).*

> *"In terms for us, the architects; design in terms of indoor air quality is basically as per the building regulations, that we must have 1/20th of the floor area openable, so that's all we do" (architect, case study 3).*

However as highlighted by recent studies, the centralisation of energy efficiency may lead to significant indoor air quality issues through neglect of the inherent trade-offs involved. Interview results suggest perceived costs are a significant barrier to the adoption of indoor air quality strategies within the social housing sector. For example, the housing association of case study 4 explained, "There isn't really a big motivating factor for us, there is nothing to drive us to do it because it involves spending a lot more money and we would be challenged as to why we were spending that money". This suggests a need for effective communication of the value of indoor air quality strategies to building professionals, in order to encourage increased consideration in social housing projects.

3.2. Influence of architectural design on indoor air quality

The limited knowledge of indoor air quality among building professionals (particularly architects), was also highlighted. For example, some architects described the lack of expertise to drive indoor air quality strategies;

> *"We as architects are not specialised in this. (...) This probably demonstrates maybe how little we would know about indoor air quality" (architect, case study 3).*

> *"We know about the stuff but we do not have the expertise to be able to drive that. But we are kind of interested watchers in a sense of what is going on (...) I mean obviously, we know it is now one of those issues that people are saying, OK, it has to be maybe addressed and then reviewed" (architect, case study 1).*

Architects have a profound effect on the quality of indoor air through control of a number of factors, such as ventilation, materials, building systems, layout, and environmental control mechanisms [30]. However the

interview results suggest mixed opinions among building professionals. For example, a number of interviewees explained the nature of design and build contracts and the tradition of sub-contracting may result in diminished control over indoor air quality determinants;

> *"I am not sure how much we can influence air quality as architects, I mean we can specify certain things- it depends on the nature of the contract because if it is a design and build contract then the contractor tends to specify everything and use the products they want to use, that they have deals on" (architect, case study 2).*

> *"As architects we would not have been driving the air quality, I mean it would have been a question of us going there is the main elements of it and then we would have gone into specialist really sub-contractors in a sense to drive that forward" (architect, case study 1).*

> *"I think, outside of ensuring you have openable windows that can be used in the summer, really they don't have very much I think- because generally it becomes so airtight and you have no trickle vents and it becomes a mechanical engineering issue" (M&E consultant, case study 3).*

The influence of architectural design on ventilation however was emphasised by many interviewees, such as accessibility, control and positioning of windows. Influence on the design and performance of MVHR systems was also evident, with a number of respondents stressing the importance of considering accommodation of ventilation systems during the initial stages of the building design;

> *"As important as light and heat, ventilation is just as important and architects these days should be considering it at the first stage of building design. At the same point of thinking where should I put the windows in the house they should be thinking how am I going to accommodate the ventilation system and what is the ventilation strategy going to be because the ventilation system will help to inform room layout in a dwelling" (Passivhaus consultant, case study 2).*

> *"It is critical to the thing, I mean with windows and ventilation and positioning of the mechanical ventilation with heat recovery unit and ensuring it is not too noisy and stuff like that. So all those implications it is- right at the very beginning needs considered" (architect, case study 4).*

Results from the interviews suggest indoor air quality is considered by most building professions as merely the performance of ventilation. This is alarming, particularly in energy efficient building design where ventilation rates are limited, thus consideration of other indoor air quality determinants (such as material emissions and layout) become more critical.

4. MVHR systems in energy efficient social housing

4.1. Lack of knowledge of MVHR systems

Lack of knowledge of mechanical ventilation with heat recovery (MVHR) systems in the UK construction sector was stressed by many respondents during the interviews. As explained by Taylor and Morgan [31], issues with the implementation of MVHR systems have emerged as a result of insufficient installation skills and the current immaturity of supply chains. The need for training across all sectors to ensure effective implementation of MVHR systems in social housing was emphasised by a number of interviewees, as illustrated by the following quotes;

> *"I think what happened is the DSD- you know our department, just implemented that you must do Code 3; and the people that were doing the SAP calculations that were basically the benchmark for getting Code 3 said- oh well, you have to make it airtight, you have to put heat recovery in; and the engineers were just putting it in without really understanding exactly all the implications of what they were doing" (M&E consultant, case study 3).*

"The only fear is that everybody, everybody needs to get up to that level, you know, so we might have very good consultants and very good contractors now, but it might not be the same across the whole market" (housing association, case study 4).

The lack of knowledge of MVHR systems in the UK construction industry is particularly evident, given recent feedback of deficiencies in the design, installation, commissioning and performance in practice.

4.2. Problems with the design of MVHR systems

In theory, the utilisation of MVHR systems should help ensure the provision of adequate ventilation in airtight, super insulated dwellings. Some building professionals discussed the potential benefits of MVHR on indoor air quality, such as air filtration and the provision of continuous ventilation. For instance, as explained by the architect of case study 4, "With mechanical ventilation with heat recovery unit, there should be that continuous air coming in. You also have filters on the mechanical ventilation heat recovery unit that do need replaced, but the reason they need replaced is they are actually taking particles out of the air".

However during the interviews, several indoor air quality issues relating to the use of MVHR systems were highlighted by the building professionals. For instance, the inadequate design and delivery of MVHR systems in the UK residential construction industry was described by the Passivhaus consultant in case study 2;

"*On the one side is the, what has been a very unregulated, under-skilled, which has been from the domestic building side supported by the mainstream manufacturers; people installing a mixture of, putting it crudely, plastic and flexible ducting with no design. (…) Then on the other side you have the, in some projects, M&E- mechanical and electrical companies from the commercial sector becoming involved in domestic buildings. They tend to be very much better skilled but what they tend to do is apply their experience from commercial onto domestic buildings, and the difference there is, fundamentally that the commercial ventilation rates are very much higher than domestic ventilation rates and sound levels are very much higher than what would be acceptable in a domestic rate".*

This is supported by Sullivan et al. [4], who explain, "not all MVHR systems are currently being designed to a sufficiently high standard, possibly due to the limited availability of appropriately trained, competent individuals". More work therefore may be needed to ensure adequate accreditation and/or regulation on the design of MVHR systems in domestic environments. As explained by the M&E consultant of case study 3, "There is a whole science to designing heat recovery ventilation properly, and I think it is only now people are starting to realise, purely because of the negative feedback". This is clear from a number of design issues reported during the case study projects, for example;

"They made a bit of a mess in the apartments, in that they didn't really leave themselves enough room to get all four ducts off the top of the unit and then distributed around the flat" (M&E consultants, case study 3).

"We had to install an additional extract within the staircases in the houses- they are double height type spaces and it was felt that they were too warm. (…) we felt there wasn't maybe enough air movement" (Architect, case study 4).

Through the increased uptake of MVHR systems in UK energy efficient dwellings, lessons are gradually being learned among building professionals. As explained by the housing association of case study 4, "It is all to do with a learning curve. Even the guidance that is out there says you might have to adapt it; and we had to adapt it to try and, you know, solve a problem". However, the redesigning of MVHR system layouts and/or specification on site may have a significant impact on the overall performance of ventilation.

4.3. Inadequate performance in practice

Experience from the case study projects demonstrated a number of performance issues of MVHR systems in practice. For instance, in case study 3, further inspections revealed that a number of the MVHR systems were not working, possibly as a result of blocked filters and/or occupant interference. Similarly, in case study 4, issues with circuit boards and inadequate air distribution between rooms were reported. Awareness of performance issues experienced in other projects were also reported by the building professionals; for example,

> *"What we have feedback on from various consultants is there is potential for- during the night time for these ventilation systems to actually be reducing the temperature in the house by 3 to 4 degrees, so that may be a problem" (architect, case study 3).*

> *"I have read about issues where people have been using sub-soil heat exchanger where they are passing the air and gaining heat there; and there has been, you know, water has maybe got in there which leads to legionella risks" (architect, case study 4).*

> *"I believe there are cases of some of them- some moisture maybe condensing in them and then them dripping as well" (housing association, case study 1).*

Thus there appears to be increased apprehension of performance issues of MVHR systems, including experience of dealing with these issues during the case study housing projects. Despite this, performance testing (excluding commissioning) is rarely conducted in social housing projects. In case study 4 for example, additional testing was conducted as part of a research grant, which flagged problems with flow rates that would have otherwise gone unnoticed. As explained by the housing association, "It was good in a way because any other scheme where you have MVHR and you don't have an independent person come in afterwards and do that, so people can be getting told anything and you have no way of checking".

4.4. Problems with installation and commissioning

Accurate commissioning of MVHR systems is essential to ensure adequate installation and performance in practice. However, the credibility of commissioning certificates in energy efficient dwellings is a significant issue in the UK construction sector. For instance, the M&E consultant of case study 3 explained, "We have certificates to say they are running as per required rates but sometimes whether you believe them or not, it depends". This is supported by complications in commissioning reported by respondents in case study 4, as illustrated in the following quotes;

> *"The guys on site probably weren't fully aware of the way that they should have been commissioned- there was slight differences in what building control or building regulations might ask for in commissioning" (Architect, case study 4).*

> *"There was commissioning carried out by the contractor at handover and then there was re-commissioning only because we weren't confident with what the commissioning certificate said. It was too generic" (M&E consultant, case study 4).*

> *"One of the issues that we had was the ventilation system wasn't commissioned properly the first time, or the second time, so the third time we seemed to have got it right" (Housing association, case study 4).*

Similarly, the installation of MVHR systems in domestic settings remains fundamentally lacking in comparison to the rest of Europe. This is attributed by the fact that many systems are being installed by untrained tradesmen, such as plumbers and electricians; who are not always familiar with ventilation requirements. As explained by the building professionals;

"This country failed to learn from examples of what was going on in Europe and understand properly what the requirements of delivering MVHR systems in domestic systems are, so there have been a lot of systems that have been delivered extremely badly" (Passivhaus consultant, case study 2).

"I think earlier on when the systems were designed, people who were installing them hadn't a clue. And it was, your ordinary plumber was all of a sudden becoming a ventilation expert and weren't commissioning them properly, the valves weren't set right and noise was a big issue" (M&E consultant, case study 3).

"It's more of a coaching thing more than anything else. Ventilation used to be kind of fit a fan and walk away, and that was it, that was the mind-set of a lot of these people because you get a lot of electrical contractors, plumbing contractors that are not always familiar with ventilation" (Ventilation supplier, Case 2).

The UK BPEC course on domestic ventilation systems is helping to addressing this problem by targeting candidates from plumbing, heating or electrical engineering backgrounds interested in becoming MVHR installers. As emphasised by respondents during the interview, the BPEC course is now typically recommended or required by MVHR installers in energy efficient housing projects.

4.5. Maintenance requirements of the MVHR system

Interview results suggest maintenance requirements of MVHR systems in practice can be quite onerous, particularly in a social housing context where access to the homes can be difficult. This has the potential to cause significant problems, particularly if tenants are unaware of maintenance requirements. This may be exacerbated by suppliers downplaying maintenance requirements of MVHR systems. As stated by building professionals;

"We were having to change the filters or clean the filters more often than we thought, and I think it was initially intended something like every six months we would have to clean them or change them, but it turns out it is more like every sort of four months" (housing association, case study 4).

"Some of the manufacturers are overstating the- or understating the amount of maintenance required" (M&E consultant, case study 1).

In case study 4, the housing association explained maintenance of the MVHR systems in the Passivhaus dwellings will be conducted once a year during boiler servicing due to access problems, since access to boilers is a legal requirement in social housing. This is particularly worrying considering filters reportedly needed cleaned or changed in the homes every four months in practice. If access is an issue, this suggests some homes may not be receiving the necessary maintenance required for these systems.

Furthermore, in the future as MVHR system components deteriorate with time, significantly greater maintenance issues are likely to emerge. There are apprehensions therefore that in a social housing context where occupants may not be concerned and/or aware of the importance of maintenance of the MVHR systems, system failures and/or performance issues may go unnoticed which could lead to significant deterioration of the quality of indoor air.

5. Occupant behaviour and perception of MVHR systems

5.1. Occupant interference with the MVHR system

An emerging issue in UK energy efficient social housing projects is the interference of tenants with the MVHR system. This was evident in the case study projects, where building professionals described problems with tenants turning off the MVHR systems. For example, the M&E consultant of case study 4 stated, "Sometimes we thought the people were switching it off at the fuse boxes- they were doing something to turn it off themselves even though they were told not to". Similarly, building professionals recalled experience from other projects where tenants have turned off the MVHR systems, as illustrated in the following quotes;

> *"In the more airtight homes the problems we have is people turning the damn systems off and interfering with them (…) and I speak as someone who has been involved in at least 150 houses with these systems installed, and very few complaints but I still go into ones that I see they have switched the thing off" (M&E consultant, case study 1).*
>
> *"The single biggest problem is they just switch them off" (M&E consultant, case study 3).*
>
> *"Tenants switch them off, and fiddle with them, and close the vents, and block them up" (housing association, case study 1).*
>
> *"Some people don't like the ventilation system. It is too noisy; they want to switch it off" (M&E consultant, case study 4).*

As a result, some building professionals have devised strategies to inhibit tenants turning off the MVHR systems in social housing contexts. For example;

> *"What we were doing at the fuse board basically is we were giving them their own dedicated circuit and the tenants were just going to the fuse board and just turning them off. So now we are wiring them onto the lighting circuit so they can't do that" (M&E consultant, case study 3).*
>
> *"Now we have a way around that, they run monitors so we know how long it has been turned off, so that is discreet for the housing associations so they know if someone has tampered with it" (ventilation supplier, case study 2).*

Issues with building occupants adjusting vents and tampering with the control settings were also reported during the interviews. This is supported by findings from the HOPE project, where Aizlewood and Dimitroulopoulou [18] found that, "the ventilation system was improperly understood by the occupants, so systems were used ineffectively". For example, the M&E consultant of case study 3 described problems with tenants turning the by-pass mode on during winter and consequently complaining that the system was not working correctly.

However most building professionals attributed tenant interference with the MVHR system to the perception of running costs, as illustrated in the following quotes;

> *"I know that one of them in the apartments in particular (…) is turned off because the tenant thinks it is costing him money" (Architect, case study 3).*
>
> *"They tend to switch off the unit. They honestly do, like some of the people down there have measured the electric of this thing running" (M&E consultant, case study 4).*
>
> *"We do have this perception by the tenants that that is something that is sucking air into our house and it is costing me money" (M&E consultant, case study 1).*

One solution to this problem, as suggested by the Passivhaus consultant of case study 2, is to include the running costs of the MVHR systems are part of the rent of the building, which would remove any financial benefits for the occupant of turning the systems off. However, this may result in higher costs to housing associations, particularly if MVHR systems are utilised incorrectly. Furthermore, there may be underlying issues that need addressed, which could be the cause of tenants feeling the need to switch the systems off. For

example, reports of problems with noise and draughts were discussed by building professionals during the interviews,

> *"The tenants just screw them up because it is draughty or something, you know" (M&E consultant, case study 3).*

> *"One of the tenants in the flats says there is a bit of a hum off it so he turns it off at night and turns it on during the day" (Housing association, case study 3).*

> *"We have been looking at putting attenuation into, retrospectively, because sound levels were an issue for the tenants, so we are just trying to get around that to see if we can help, just to try and get the systems on permanently rather than tenants switching them off" (Housing association, case study 4).*

The results suggest significant issues with the perception of MVHR systems among tenants, including the need for further education of the importance of ventilation in airtight dwellings. It was generally recognised by building professionals that tenants lacked the knowledge to operate and maintain these systems effectively. For instance, respondents explained;

> *"You need a certain level of- what's the right word- not even expertise, but sort of awareness of the systems and how you have to operate them- which I think, so that is part of the issue" (Architect, case study 1).*

> *"If they feel any cold draught or anything at all then they will block it up because they don't understand what they are trying to do" (M&E consultant, case study 1).*

> *"I think it is the education of it; them getting used to it" (Housing association, case study 2).*

This suggests the need for greater training of building occupants in energy efficient social housing. However the housing associations explained extensive training activities were conducted with the tenants during handover, including demonstrations and the provision of tenant packs. Numerous visits were also conducted in a number of case studies after occupancy. Yet in most cases, this did not prevent occupant interference with the MVHR system.

5.2. Occupant control of MVHR

There was mixed opinion among building professionals regarding the degree of control tenants should have over the operation of the MVHR system. In some case studies, occupant control was limited as a result of fears of occupant interference. For example, in case study 3, respondents explained;

> *"We have generally tried to avoid tenants getting involved with the systems in case they go in and- you know think the exhaust is too noisy and turn the speed away down and that affects the whole ventilation within the property, so we have tried to keep it in an area where they don't get access to it" (M&E consultant, case study 3).*

> *"It is alright if you have someone who is willing to control it but giving too many controls to tenant's can have problems as well as advantages depending on how they use them" (Housing association, case study 3).*

Similarly, in case study 2, occupant control of the MVHR system was limited in order to simplify operation for the building tenants. The housing association explained that occupants struggle if systems are made too complicated, thus controls were limited to a simple button or dial. The Passivhaus consultant of case study 2 suggested,

"The most robust MVHR systems are those that effectively the occupants don't normally need to think about them. By that I actually mean they leave it running at one ventilation speed apart from when they start cooking and then they think it is time to press the boost to raise the ventilation for half an hour- that is robust and simple".

In case study 4, tenants had much more control over the running of the MVHR system, including access to a five speed controller to adjust the air flow. However, as explained by the M&E consultant, the settings provided tenants with the ability to run the ventilation system at the minimum level, which is lower than that required by building regulations; "It would be too low, but if they are happy with it, they can set it, they can do whatever they want. After the… when they are in the building- whatever way they want to use it, they can do it".

5.3. Importance of occupant engagement

Ultimately, it comes down to how the occupants engage with the MVHR system. As suggested by building professionals:

"Even if you try and put in something to do with air quality, the occupant will be the occupant and they will do what they want to do in the house, and you know, that's their prerogative, that's their house and that's evident, and we can't- we are not big brother" (Housing association, case study 4).

"The occupant's do what they do. It is one of these one's that clearly, predicting human behaviour is always going to be at the very least problematic" (Passivhaus consultant, case study 2).

Further research and development therefore may be required to advance MVHR systems as devices that effectively engage with occupants and adapt to their changing needs. As described by the architect of case study 1, "you are trying to match the environment with the people, you know, in the end". However, if occupant behaviour is indeed unpredictable, this questions the suitability of controlled environments which are designed to accommodate a limited degree of variability.

6. Apprehensions of energy efficient design strategies in social housing

6.1. Suitability of MVHR in social housing

Apprehensions of the suitability of MVHR systems in energy efficient social housing were highlighted by many building professionals during the interviews. For example, concerns regarding acceptance from building occupants, maintenance requirements and space constraints were all emphasised;

"The houses they are building, they are, but I don't believe that the people within the social housing like them. I think they think they are noisy; I think they think they are- they see their electric being used to run these elements" (M&E consultant, case study 4).

"If you had asked me that a year and a half ago I would have said no, but I think, I think when they are designed and installed properly (…) I think it maybe is suitable. But I would kind of reserve judgement until we get the next round of houses handed over" (M&E consultant, case study 3).

"In the way that they work, yea they are perfectly fine. I think the issue to do with social housing is- the maintenance of them- someone is obviously going to have to keep coming and changing the filters and all the rest, and also where they are going to be located because they take up quite a bit of space" (architect, case study 2).

The obligation to use MVHR systems in airtight buildings however was highlighted by building professionals, despite concerns of their fittingness. For instance, the housing association of case study 1 described MVHR

systems as “a necessary evil”, explaining they do not particularly like the technology, but in airtight homes they need to go in. Similarly, the M&E consultant of case study 4 explained, “They are not suitable (…) but I don’t know the alternative- I think if you build an airtight building you must put it in, but I do believe that it is not a great thing for them to have”.

Building professionals also described a reluctance to use MVHR systems in social housing, explaining some housing associations and/or design teams will no longer implement them in their schemes.

> *“I know that some housing associations are not putting them in and some design teams are not putting them in these smaller houses” (Architect, case study 3).*

> *“One housing association in particular, as a rule now will not put them in. They have just categorically said we are not having these systems because they have had so many problems with them” (M&E consultant, case study 3).*

> *“I don’t know what we would do if we were doing another scheme because the department are sort of anti-mechanical ventilation and various other things” (Housing association, case study 3).*

This is significantly alarming bearing in mind the emphasis on energy efficiency and eradication of fuel poverty in social housing. If MVHR systems are not considered suitable, limited alternative ventilation strategies in airtight, super insulated homes exist. For some building professionals, the complexity of the ventilation system is an issue.

> *“There is always a balance between keeping the residents happy with where they are living when they maybe aren’t as used to dealing and managing more technology- they just like things simple” (M&E consultant, case study 3).*

> *“What we find is that our buildings are becoming, for social housing, are becoming less technical than more, so if we can strip everything back, it is preferable” (architect, case study 3).*

> *“They would probably prefer living in a lesser built house without- one that had a bit more natural ventilation or a bit more leakage” (M&E consultant, case study 4).*

Thus the general opinion among building professionals was that MVHR systems are not suitable in a social housing context; but there is no real alternative in airtight homes. Passive ventilation strategies are rarely considered in energy efficient dwellings; despite the fact that they have the ability to address these issues through the provision of low/zero energy, robust and transparent ventilation solutions. A number of barriers to the effective adoption of passive ventilation strategies in energy efficient homes however were discussed by respondents, as illustrated in the following quotes;

> *“The difficulty, as designers, is actually calculating and controlling the air changes; and also, again, the end user, the tenant or home owner; they may feel that they just have a big hole up in their roof space” (architect, case study 3).*

> *“It is the trade off about how do you recover, you know, it is the heat recovery- it is not the mechanical. The only reason you go for mechanical ventilation is because you want to get the heat recovery, otherwise, natural ventilation is the way to go” (architect, case study 4).*

> *“You would need to have the location right. The mechanical ventilation can deal with anywhere but if you were beside a busy road maybe natural ventilation wouldn’t really work too well” (M&E consultant, case study 4).*

Architects and service engineers lack the required skills to specify and design advanced passive ventilation strategies in energy efficient dwellings. As explained by Roaf [32], “Traditional natural ventilation solutions are

largely excluded from the often simplistic and steady-state building and system performance models that are widely used in the industry to design buildings". This needs to be addressed as a priority to provide appropriate alternatives to mechanical ventilation in airtight dwellings.

6.2. Apprehensions of increased airtightness

Analogous to apprehensions expressed by building professionals on MVHR systems; respondents emphasised anxieties towards the achievement of high levels of air-tightness in energy efficient dwellings, as demonstrated in the following quotes;

> *"If I was building my own house, I don't know if I would be wanting to build it to a 0.8 airtightness- I am just not convinced with that. I think it is good- it is good if you are in the right climate- if you were in Sweden or the North Pole or something, but I just don't, I am not convinced whether it is the right thing to do here or not" (M&E consultant, case study 3).*

> *"I think to get down to levels of 3 or 4 is OK, but on the Passivhaus we were considerably less than that, less than one. So, I think that is a bit much, because then everything that you have to do that goes with that- with the extra ventilation and stuff- I am not sure there is a need to go that far. But again that is personal opinion" (architect, case study 2).*

> *"The reason we have sealed these houses up is to reduce energy leakage and loss of heat, and so, it is pretty much fundamental that this issue is dealt with in a way that is appropriate for its users because it is not about suffocating people in plastic bags. I mean, you know, which is really what you have created- a plastic bag" (housing charity, case study 1).*

This is supported by a study by Davis and Harvey [26], who found significant concerns among UK housebuilders on the effect of high levels of airtightness on occupant health. They further describe technical challenges of high levels of airtightness such as; "the complexity of ensuring adequate ventilation to meet building regulations, the lack of suitable technology, the increased potential for buildings to overheat and the heightened requirement that will exist for maintenance of the ventilation system" [26]. These concerns of energy efficient design strategies have largely been ignored by the UK government, since current regulations actively promote high levels of airtightness and the adoption of MVHR systems in domestic environments. Thus, it is suggested that a fundamental step change in sustainability strategies may be required.

Discussion and conclusions

The results from this study suggest indoor air quality is not adequately considered among building professionals in energy efficient social housing projects. A number of barriers to the effective adoption of indoor air quality strategies were identified, including the focus on energy efficiency, lack of knowledge, perceived costs associated with indoor air quality strategies and a fundamental lack of motivation. This is supported by Levin [33], who explains the incorporation of indoor air quality strategies in sustainable buildings suffers from a lack of knowledge integration from indoor sciences to practical guidelines for building professionals.

The lack of knowledge was particularly evident among the architectural profession. Despite the fact that architectural design can have a significant impact on the quality of indoor air, the results suggest architects do not consider themselves responsible and/or influential to indoor air quality. Respondents explained that the nature of design and build contracts and the tradition of sub-contracting diminish the architects control over indoor air quality factors. This may result in negligence of indoor air quality issues during the design process through confusion of responsibilities among building professionals. Similarly, Sorrell [27], found that the limited knowledge of building services among architects; reinforced by the fragmented nature of the industry

further restricts the delivery of sustainable buildings in the UK construction sector. Thus more integrated design teams may be required to ensure the delivery of healthy and sustainable social housing schemes.

One of the most significant findings from the interview process was the emphasis on shortcomings regarding the implementation of MVHR systems in social housing. Problems were stressed at all stages; including the design, installation, commissioning, performance, operation and maintenance of MVHR systems in practice. A fundamental lack of skills and knowledge were identified across all sectors, which suggests an urgent need for training to ensure shortcomings experienced in the case study projects are not repeated in future social housing schemes. This may require legislation ensuring all building professionals responsible for the design, installation and commissioning of MVHR systems have achieved adequate qualification and/or training prior to their involvement in housing schemes.

In addition, the lack of adequate occupant engagement and interferences with the MVHR system reported by building professionals suggest significant issues with operation. These problems were attributed to the lack of understanding, perception of running costs among tenants and performance issues with the MVHR system. As recommended by one respondent during the interview process, the incorporation of running costs of the MVHR system in the rent of the home would help to eliminate the financial benefit to the tenant of turning the MVHR system off.

Furthermore, the onerous maintenance demands of MVHR systems exacerbated by issues with access may result in increased costs to housing associations and/or inadequate upkeep of the ventilation systems. As suggested by the Passivhaus consultant of case study 2, MVHR systems could be designed in a way to provide access to filters for servicing from outside the building in social housing schemes; which would significantly reduce service and administration costs. However, more research is required to ensure fabric and ventilation performance is not affected by such interventions.

The reluctance to use MVHR systems and apprehensions regarding their appropriateness suggest a significant need to re-evaluate energy efficient design strategies in social housing schemes. However, building professionals emphasised the lack of alternative solutions in airtight dwellings. Conversely, concerns were also expressed regarding high levels of airtightness achieved in some energy efficient social housing schemes, which suggests a fundamental step change in sustainability strategies may be required.

The limited number of building professionals interviewed suggest that generalisation of the results is not possible. Furthermore, the focus on social housing schemes suggests findings may not be applicable to private energy efficient housing. However given the exploratory nature of the study, the findings provide a unique insight into an under-researched area, aiding the development of knowledge and understanding of attitudes towards indoor air quality among building professionals. The findings have highlighted a number of issues in energy efficient social housing schemes, which should be addressed as a priority.

Future research needs include a large scale study of UK building professionals perceptions and experiences of energy efficient design strategies to enhance the representativeness and improve the effectiveness of sustainable design strategies. Furthermore, future studies should consider the application of advanced passive ventilation strategies in energy efficient social housing projects, coupled with adaptive, robust and engaging environmental control solutions.

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