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**User and organisational responses to biomass district heating**

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**Abstract**

*Biomass fuelled district heating (BDH) is currently the UK government’s favoured approach to meeting the country's domestic heat demand whilst achieving carbon savings due to its cost-effectiveness, viability and potential to reduce heating and hot water costs for residents. However, there are currently few examples of it within the UK and it therefore remains unfamiliar to both consumers and housing providers raising many possible social and organisational challenges that are not yet fully understood. This paper elucidates these challenges by drawing on two case studies of recent social housing developments heated by BDH. Socio-technical theory and transition theory are used to understand what happens when the technical innovation of BDH meets the rigid social systems within which social housing providers and tenants operate. The paper concludes that both the ability of the organisation and the end user to adapt to and accommodate the innovation will determine the extent to which the intended benefits of BDH are realised.*

**Key words:** biomass; district heating; social housing

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**Introduction**

District heating networks are considered by the UK government to be one of the most favourable approaches to meeting the country's heat demand whilst achieving carbon savings. The National Carbon Delivery Plan (DECC, 2011) states that up to half of all housing has the potential to be supplied by a district heating network and it is estimated that district heating could supply up to 14% of the UK's heat demand (currently 1%) (DECC, 2012a). District heating is attractive due to its cost-effectiveness and viability compared to individual renewable technologies, it’s stability of price and its potential to reduce heating and hot water costs for residents (DECC, 2012a; DECC 2012b; Davies and Woods, 2009; Lund et al, 2010). Biomass is the favoured fuel to power district heating networks and is envisaged to make a key contribution to the achievement of the European Commission's directive to source 15% of energy from renewable sources by 2020 (EU, 2009; DECC, 2012b; DECC 2012c).

This paper aims to shed light on the challenges of BDH by drawing on data from two case studies. In particular, the paper seeks to identify the key social and organisational challenges associated with BDH and in doing so helps to address a significant gap in the literature which has so far focussed largely on technical feasibility, performance, supply chains and comparisons with other forms of renewable energy (see for example Eriksson et al 2007; Vallious et al 2009, Lundgren et al 2009). Socio-technical theory and transition theory are applied as a theoretical framework through which to interpret the case study data and understand what happens when technical innovations (BDH) and social systems (housing providers and residents) meet. The focus of this paper is on understanding the impact of the innovation of BDH in the specific setting of social housing.

Both case study schemes are apartment blocks built to similar specifications in separate areas of London, owned and managed by social landlords. This paper draws on ten in-depth, qualitative interviews (which included a resident-led tour of the home) with residents of the two schemes and five interviews with those responsible for the management and maintenance of the systems. Fuel bill analysis was also conducted. The paper has three main parts. The first sets out the theoretical framework that is later used to interpret the empirical data. The second explores occupants' awareness of and relationship with the BDH system and the third section focuses on its organisational implications.

**Transitions to Biomass District Heating**

The UK government's advocacy of BDH follows an established trend being the favoured option of many European countries pursuing nuclear phase-out policies (World Energy Council, 2012). The experience of Sweden provides a case in point highlighting some of the simultaneous benefits and challenges of transitions to BDH having pursued a shift away from oil and gas and towards biomass to fuel its well-developed district heating networks (DHNs). This shift was motivated by the potential for a safe and decarbonised energy supply and job creation associated with moving to a new mode of generation. Today district heating accounts for over 40 per cent of the heating market, 62 per cent of which is biomass fuelled (EREC, 2009). However, this transition has been slow, taking place over 42 years (EREC, 2009).

In the UK BDH can be understood as a double innovation. Although DHNs have existed in urban social housing schemes in the UK since at least the 1950’s, their development has, in the past, been frustrated by the indifference of mainstream energy providers and central government and their consequent failure to tackle relevant organisational and financial obstacles (Russell 1993). As a result, DH remains relatively rare in the UK compared to many other countries in northern Europe. The recent idea of using biomass fuel is a further innovation within district heating.

Socio technical theory (STT) and its underlying theory of change, transition theory (TT), offer a means of understanding the relationship between technological innovation (in this case BDH) and social systems (housing providers and residents). Developed, in part, to articulate the process of sustainable development, TT assumes that over time, society, life-styles and technology become bound together in a stable and rigid configuration and that changing this configuration is generally slow, with setbacks along the way (Cherns, 1976; Loorbach 2007). The work of Hargadon and Douglas (2001) use a similar approach to highlight the institutional and social upheavals involved in technical innovation, stating that *‘When innovations meet institutions two social forces collide, one accounting for the stability of social systems and the other for change’* (pp.476).

Technology and social practices are embedded with one another with the result that the adoption and diffusion of an innovation changes either the organisation of providers (Hargadon and Douglas, 2001) or the life-styles and aspirations of consumers or both. Adoption of technology is therefore not simply a question of cost, though costs remain important. It is dependent on social practices of all kinds and, in addition, on cultural influences. TT adds that to promote the adoption of innovative sustainable technology, governments have to become involved and work with manufacturers, providers and users in a process of co-evolution that influences but does not determine outcomes (Geels, 2005; Raven 2007).

To relate this theory back to the case of BDH in social housing, it is possible to see how the innovation may be adopted by the housing provider due to a combination of encouragement by funding agencies, regulation and anticipated financial savings for tenants. In turn, tenants' attainment and appreciation of the benefits of the innovation and the ability of staff to cope with its implementation will determine the organisation's decision to persevere with it and adopt it more widely. A successful transition therefore involves an acceptance of new ways of working and living as well as new production and management processes (Goodchild, 2012).

In general, social housing agencies are more likely to undertake innovations than private developers. They provide a protected ‘niche’ (Geels and Schot 2007) where the application of alternative technologies can be protected against the cost and consumer pressures of mainstream provision. The significance of social housing as a niche became apparent in one of the case study schemes- a mixed tenure block- where the private developers refused to participate in the district heating system. However, exactly because niches provide a test bed for new ideas and alternative technologies, they do not necessarily provide a comfortable experience for those involved.

**The user response**

The interviews with residents, which lasted around one hour, explored their perceptions of their apartments, their heating systems and heating and hot water costs. It is important to note that both apartment buildings exhibited additional energy saving features including high standards of insulation, sophisticated heating controls and under floor heating.

## *Moving to the schemes*

The interviews commenced with a discussion of the respondents' previous housing situations and their motivations for moving to their current home in order to contextualise their views of the schemes and how they compared to previous residences.

The majority of respondents were social housing tenants who had obtained their properties through the Choice Based Lettings scheme, a process which enables tenants to 'bid' for available social housing. A smaller number of respondents had purchased a share of their property through shared ownership schemes. Respondents had lived in their properties for between 6 months and 3 years.Common to all respondents' accounts of their motivations for moving to the developments was a clear message that space, location and having a new property were their primary considerations. The eco-credentials or heating system of the properties were not raised independently by anyone in this context. When prompted on this matter, all respondents stated that they viewed the eco status of the building and the associated potential to save money on fuel bills as a 'bonus' rather than something that they expressly looked for.

*"I know it's important to have an energy efficient house but really all I was thinking about was is it a nice place and can I get transport easily. I just have to think if it is a nice place for my family to live with enough rooms."* (Male tenant)

*"They told me it was energy friendly when we looked round but the thing that I loved was the space and how new it looked and smelled….Energy is a big expense for us, our biggest probably so it was a bonus to know the flat would cost less to heat but even if they said it wasn't that way, I would still have loved it."* (Female tenant)

For the majority of respondents, energy saving was a financially motivated activity and several expressed hope that living in a low energy home would help offset escalating energy prices.

*"We need to save money more than ever and the cost of heating bills just keeps going up so really all homes should be eco now."* (Female tenant)

Residents were also asked about their induction to the property and whether it was ever explained to them that it had an alternative fuel supply. All residents reported that their induction was confined to the issuing of a handbook containing detailed information about the apartments, including how to operate the heating and hot water systems and an explanation of billing. Several respondents said that they found the handbook daunting and were unlikely to read it and more likely to *'fiddle around with things until they work'*.

***'Invisible' energy: perceptions of BDH***

Despite being eco-developments, the two schemes do not have many visible eco-features. This is fairly typical of communally powered developments where the majority of the technology is centrally located and not visible to the occupants. To all intents and purposes, the apartments are conventional in appearance and there are no obvious ‘clues’ that they are eco-homes. Respondents' views were canvassed in relation to the main low energy features within the apartments; the communal biomass boiler and the related heating and hot water controls.

The majority of tenants interviewed were unaware that the developments were fuelled by communal biomass boilers. However, when given a brief explanation of this, most liked the idea perceiving financial benefits:

*"It sounds good, like it will save us all money because it has to be cheaper to burn wood rather than gas or coal doesn't it?"* (Female tenant)

One respondent raised an interesting point about its lack of visibility (compared to other forms of renewable energy) and how this may impact on residents' thinking about energy use. The absence of individual boilers in each apartment may also serve to emphasise this sense of 'invisibility'.

*"It's funny though, you can't actually see this biomass thing so it's like your heat comes from an invisible place. You just click a switch and it's there so you don't think about where it's coming from. I think it would be better to have some sort of system that you could see making your power like the windmills or the sun panels because you know when they are making power and when they aren't."* (Female tenant)

Despite the obvious logic of this point, the work of Bahaj and James (2007) has demonstrated that visible energy generation has little impact on attitudes and energy consumption in practice.

Despite a lack of engagement with the handbook, none of the respondents had experienced any difficulties operating their heating systems in the sense that they were able to get heat when they wanted it. However, what was also apparent was that they were all using their heating system manually rather than setting the timer on the basis that the system looks 'daunting' or 'over complicated'.

In one of the schemes individual thermostats have been fitted in each room and although this was generally considered to be a positive feature, several residents thought it was easier to have a more conventional set up whereby one central thermostat controlled the whole apartment. One tenant qualified this comment by explaining that she found it a 'juggling act' remembering which thermostats were set to what temperature:

*"When its night time I want the children's bedroom and mine to be warm so I go round turning them (the thermostats) up. Then the next morning when they have gone to school, it's just me and I might be in the lounge or the kitchen so I have to remember to go to the bedrooms and turn them down in there so I am not wasting it. So I feel like I'm always running up and down that corridor. Before (in previous property) the heating was just on or off."* (Female tenant)

This latter comment about the heating in the respondent's previous property being either on or off, gives an indication that the heating system in her current property is complex by comparison to her previous one. It also alludes to the evolution of district heating systems. This respondent and two others had, in their previous properties, had heat supplied by (fossil fuelled) district heating systems which were either on or off and not within their control. One such respondent commented that she was enjoying having control over the temperature of every room and much preferred this approach to the 'all or nothing' of her old system which made her home either too hot or too cold. On the other hand, the comments of another respondent, quoted above, suggest that they may miss the simplicity of the old system. These findings bear testimony to the ways in which heating arrangements in previous properties can shape respondents' expectations about their current heating systems.

Despite having a modern heating control panel in his previous property, a shared equity occupant was explicit in saying that he was intimidated by the complexity of the system. He found its digital nature and the myriad of options it gave him overwhelming:

*"The way I think is 'I'm cold. I need heat' and I want heat to happen when I want it and not to have to think well what time did I set it to come on in this room and then think, well it's not on for an hour and I'm cold so I'll need to either re-programme the system or keep pushing the boost button. Either way, it's just too much hassle when you come in from work. It's going to take some getting used to."* (Shared equity owner, male)

Discussion about the temperature to which the home was heated revealed that the majority of residents were heating their homes to well in excess of the 17 degrees centigrade recommended in the handbook. This phenomenon appears to be linked in one of the two schemes to the presence of under floor heating and the time it takes to reach temperature. One respondent reported that it took around two hours for her floor to feel warm and the apartment to reach the desired temperature. As a result she always started off with her heating on the maximum setting of 35 degrees in a bid to speed up this process. Another respondent left her heating on a constant (and very high) setting of 28 degrees claiming that it needed to be set at this level for her to 'feel anything' from her under floor heating. The majority of other respondents set their thermostats to between 21 and 24 degrees.

**The organisational implications of biomass district heating systems**

Interviews with those responsible for the management and maintenance of the two schemes focussed on exploring the organisational and operational challenges associated with BDH. Three members of staff were interviewed at each scheme including caretakers, neighbourhood officers and sustainability managers. This section is also informed by interviews with residents.

The two social housing providers responsible for the respective schemes have taken different approaches to the provision of heating to tenants. In one scheme, the provider has sought to maximise savings for tenants and exercise as much control over energy supply as possible. To this end they had set up an ESCo (Energy Services Company) which means that they are the procurer and supplier of the heat used by their tenants (GLA, 2007). Under this model tenants pay their fuel bills to the ESCo thus placing a greater degree of financial risk on the housing provider. By contrast, the other housing provider wishes to avoid responsibility for tenant's energy debts and has therefore installed pre-payment meters in all apartments.

***Paying for heating and hot water***

The experiences of residents in relation to paying for heating and hot water (HHW) differed greatly between the two schemes with the majority of issues arising in relation to the prepayment scheme. When asked how much they were spending on HHW, respondents in the pre-payment scheme raised concerns about the *method* of payment as opposed to the costs. The use of prepayment cards was a new concept to all respondents particularly those who had, in their previous properties, paid for their energy as a flat fee within their rent. However, regardless of their previous situation, all respondents were finding it difficult to adjust to pre-payment and to gauging how long money loaded on to pre-payment cards would last.

*"This is my first place of my own, at my last place the cost of everything was in my rent so I didn’t have to think about how much I need for gas, how much for electric. Now I have to pay three cards, everything is separate so it's really hard for me to budget."* (Female tenant)

*"I used to have all rates included in my rent except electricity and that always cost the same, £20 a fortnight. It takes some getting used to and I don't mind admitting that I was really confused at first."* (Female tenant)

The impending arrival of winter was also a source of anxiety and all mentioned that they were concerned about how long the money they loaded onto their cards would last during cold spells:

*"I normally spend £30 gas every month and this is OK but this has just been for heating water really. What happens when it gets cold? I don't know how this will change. Will I have to spend £60 or even more? I don't know how I will afford that. "* (Male tenant)

Other issues raised included the practicalities of using this system. One resident explained how there were only two shops where she could load money onto her prepayment cards. One of these shops was local but when it was closed or their systems were down, she had to travel several miles to load her card. Another respondent talked about her fear of running out of power late in the evening and having to sleep in the cold until the following morning.

This method was also felt to be impractical for elderly or bed-ridden residents who cannot get out to top up their cards. Elderly residents were particularly anxious about running out of power over the winter and this appeared to be causing some to either under heat their homes or overload their prepayment cards.

Pre-payment also had little discernible impact on energy consumption with only one respondent feeling that it had made them more aware of what they consume. The amount of money tenants using this system spent on energy varied considerably with respondents spending between £10 and £30 per week on heating and hot water. There are many factors which could explain this variation. The size of the household did not appear to have much bearing on energy consumption as the largest household interviewed (5 people) spent more or less the same amount as the smallest (2 people) and it was a family of four that spent most of all. The number and use of electrical appliances, heating preferences, proportion of time spent at home and health are all possible explanations for variations in consumption. Most respondents felt that they were either spending the same or more on their energy bills than they had at previous, much older properties. This is surprising given that one of the most commonly cited benefits of BDH is lower fuel costs. However, this could be explained by the fact that households using pre-payment meters are generally charged a higher tariff for their energy thus negating the benefits of lower fuel costs (Bachelor, 2009).

In stark contrast, residents supplied by the ESCo found payment arrangements straightforward, receiving quarterly bills from the ESCo. Analysis of fuel bill data over the last two years reveals an average cost for heating and hot water of £63 per quarter, almost half the amount paid by the lowest users at the pre-payment scheme.

***Organisational disruption***

Both housing providers reported some degree of organisational disruption resulting from the decision to install BDH. For the housing provider that installed pre-payment meters, this disruption has largely been confined to the appointment of maintenance staff with the appropriate skills whereas the other provider has faced these difficulties in addition to the more onerous task of establishing and operating an ESCo. As one manager pointed out, the main organisational challenges arise from the fact that biomass district heating is still rare both within their portfolio and within the UK. As the following quote reveals, biomass schemes simply do not fit with the established systems and ways of working within these large organisations:

*'I think for a large housing association like us, 35,000 properties, 800 people working for it, established systems and processes, to have this little thing that doesn't fit in gives us enormous problems. I can see why we should be doing it and we should be at the forefront because we're in receipt of public money but the downside is it's very difficult for us to deal with it.'* (Manager, housing association)

***'It's not in my job description: specialist skills***

The key challenge identified by managers at both schemes was finding someone to manage and maintain the system on a daily basis. The management of BDH requires specialist knowledge about how to clean and maintain the system, manage health and safety risks, take delivery of the fuel, monitor fuel supply and deal with breakdowns. These tasks would typically fall to caretakers to resolve but in the event of breakdown heating engineers and plumbers may also be required. As there are estimated to be less than 100 BDH systems in the UK, there are very few people who possess the necessary skills (DECC, 2011). The response of one housing provider has been to recruit and train a caretaker to managing the system yet they remain concerned about who will fulfil this role if he were to move on.

*'We have a dedicated caretaker who knows how to clear the ashes and is happy to do it, trained to do it, but if he left his job tomorrow it would be a real problem, we'd have to find somebody else and I just don't know who that would be.. It's a dirty job and it's a mechanical job'* (Manager, housing association)

This remark was followed up by a comment that whilst other members of staff could be trained up to do this task, no-one within the organisation has the maintenance of a BDH system within their job description.

*'The neighbourhood officer could be trained to do it but it's not her job and it's not my job so somebody has to be recruited just to do this job because it falls through the cracks of all the other jobs'* (Manager, housing association)

Similar problems were also reported in relation to heating engineers and plumbers in so far as the housing association's heating engineers and plumbers do not have the specialist knowledge required to service and fix biomass systems.

*'We’ve got our own heating engineer service and they understand it now so I think they're dealing with it but in the first instance when the heating engineer was being sent down when it had a fault, he'd take one look at it and go 'I don't know anything about this''.* (Manager, housing association)

The absence of a suitably skilled engineer in the local area had come to the attention of residents.

*'When it works it works great, when it doesn't work they take a long time to come and fix it because the engineer who comes lives miles and miles away.'* (Male tenant)

Moreover, the prospect of having to set up a separate, specialised maintenance service is an unattractive one:

*'In Austria probably one in eight plumbers would understand it but here it's one in 2000 plumbers will have seen a biomass boiler, so that's a problem for us. We don't really want to have to run another little specialised maintenance service.'* (Manager, housing association)

What is particularly revealing is that the multiple breakdowns that occurred during the first year that the system was running in one scheme are attributed by management staff not to mechanical problems with the system but to problems with management and maintenance.

*'In the first year it probably broke down at least eight times and all through that the biomass itself went merrily along, it wasn’t the biomass it was all the issues around the management of it.'* (Neighbourhood officer, housing association)

The experience at the other scheme has been different in the sense that they have employed a caretaker through a sub-contractor who supplies their maintenance staff yet once in post it emerged that the skills required are beyond both the skills and the job description of the post holder. Discussions with the care taker revealed that this was the first non-standard communal heating system that he had worked with and he perceived many risks, hazards and technical challenges associated with it’s operation. As such he feels he will need more in-depth training if he is to be able to operate the system safely and competently but feels that the technical knowledge this will equip him with is beyond the scope of a caretaker and will warrant a new job description.

**Conclusions**

This paper has sought to provide case studies of what happens when the technical innovation of BDH meets the practices and expectations of social housing providers and tenants. The decision to install BDH in the two schemes was driven partly by regulation but also by the aim of reducing HHW costs for tenants. The case study data reveals a number of barriers which may prevent residents from taking full advantage of these benefits, some of which relate to decisions made by the housing providers and some to the user.

The decision to install BDH has proved disruptive within both organisations, challenging established ways of working and necessitating the creation of new, specialised roles or the adaptation of existing roles. In relation to management and maintenance skills, the ability of the social landlords to cope is partly dependent on labour market factors outside their control. However, there are also contrasts between these schemes and their landlords. In one scheme the upheaval is ultimately rewarded by the benefits to tenants who make significant savings on their HHW costs. In the other, the housing provider’s decision to avoid financial liability has exposed tenants to higher tariffs which result in them paying almost double for their HHW than their counterparts in the other scheme. The contrast between the two schemes highlights two key lessons. First, decisions taken by organisations can have significant consequences for tenants. Second, the organisations’ ability to adapt to and accommodate the innovation is at the root of the shortcomings of these schemes, not the technology of BDH itself.

In principle, BDH is relatively invisible and can draw on the long established experience of conventional DH schemes. However, a combination of difficulties in the case study schemes- the existence of sophisticated control panels, a reluctance to engage with manuals and overheating- are preventing tenants from taking full advantage of potential savings. Once again these issues are unlikely to be specific to BDH. They suggest, instead, that realising the advantages of alternative heating technology is dependent on the occupants’ ability to adapt to that technology, their ability to challenge their own conceptions of comfort and the support and advice they receive from the social landlord. The difficulties tenants are experiencing support the assertions of Goodchild and Karn (1997) that social sustainability is as important as ecological sustainability and that it is not enough to design and build a low energy scheme and then hope that tenants will cope.

Overall the findings conform to the principles of socio-technical theory and transition theory illustrating how innovations that require changes in the way we live and work in order for their benefits to be realised can be slow to embed and encounter many stumbling blocks (Cherns, 1976; Loorbach 2007). Ultimately, the two case studies bear testimony to the notion that the ability of an innovation to fit into society is critical to its adoption and diffusion (Hadagon and Douglas 2001). Where tenants are accessing the intended benefits, particularly where they are making substantial savings on their fuel costs, it is difficult for the implementing organisation to abandon the innovation in light of organisational disruption. Where the benefits are not manifest then this disruption can feel futile and there is a risk that the transition is not persevered with. As such these schemes may meet very different fates.

In conclusion, the case studies presented in this paper attest the potential benefits of BDH for reducing HHW costs for social housing tenants, a valuable outcome in light of rising energy costs and energy insecurity. The problems that both implementing organisations are facing can be seen as the problems of pioneers that will be overcome if they and other organisations like them continue to roll out BDH across their new schemes. As the contrasts between the two schemes suggest, the exchange of good practice and the evaluation of different implementation strategies will also be critical to the success of BDH on a wider scale. In addition, the use of biomass heating for non-residential properties, for example in schools and commercial buildings, may alleviate the skills shortages. However, the comments of those involved in the case studies are not so favourable as to suggest that either social housing agencies or, even less so, private developers will persist with BDH without encouragement and direction from external agencies, including central government.

**Practical relevance**

It is hoped that this paper will be of relevance to a range of built environment practitioners from housing providers contemplating the installation of BDH to the planners, architects and policy makers advocating it. The overarching message to emerge from this paper is that BDH offers great potential for lower HHW costs but that the approach of the housing provider and the payment arrangements they put in place will determine tenants' access to these benefits. Even those who are successful in securing these benefits for tenants need to be aware of the organisational challenges that they will face, most notably skills shortages. It should also be noted that these challenges are not exclusive to BDH and similar issues are likely to arise in relation to any innovation in this context, including other forms of renewable energy.

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