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Modelling a smart tech user journey to decarbonise tourist accommodation

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ABSTRACT

Smart tech offers much promise for tourism recovery from the COVID-19 crisis and the broader issue of decarbonising tourism. This paper investigates how accommodation managers engaged with smart tech during the crisis, and the journey of learning how to use numerical data output to drive sustainability actions. Interviews with nine accommodation managers/owners at six sites uncovers a 'tech journey' that extends prior to, and beyond, the acquisition and installation of the smart technology itself. The journey is explained by a new framework that recognises the need for users (here, the accommodation managers) of smart tech to 'make it their own', integrating it into their decisions, workflows and finally, identity. This can only happen through a capacity to understand what the data (i.e. numerical outputs) mean, and a process of transforming data into actions. Understanding these processes of 'data domestication' and 'data clotting' addresses key gaps in how to achieve potentially radical changes in resource use. Only one case study site had reached this final stage of the journey. The theoretical framework uses the findings from each case to propose early diagnostic questions/tools that can help identify where smart system may need assistance to move from data to action.

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Smart technology; hospitality; environmental impacts; energy; carbon emissions; COVID-19

Introduction

Buildings contribute up to 40% of the global energy consumption (Harputlugil & de Wilde, 2021), and hotels and other forms of tourist accommodation are particularly energy-hungry with up to 200-300% more energy than a similar-sized office building (Chan et al., 2017). This results in a high carbon footprint that requires urgent reduction (Tsai et al., 2014). Energy is also one of the largest areas of expenditure for tourist accommodation, second only to labour costs, yet a recent study indicates that only 20-30% of hotels actively manage their energy consumption (Filimonau & Magklaropoulou, 2020). Given these numbers, it would seem logical that tourist accommodation providers, many of whom are currently facing financial crises related to COVID-19, would be looking for ways to reduce energy costs. Smart technology is said to offer one solution, widely researched in domestic settings, but less commonly studied in tourism and hospitality buildings (Harputlugil & de Wilde, 2021).

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When conceptualising 'smart', we are reminded that the term comes from the context of computing and the innovation to (self)detect hardware failures through 'self-monitoring, analysis and reporting technology' (S.M.A.R.T.) (Rajashekarappa, 2011), and generally combines some level of automation, programmed through an intuitive interface, often connected to other remote controllable devices (c.f. the Internet of Things). Derzko (2006) argued that technology is considered smart if it undertakes activities an intelligent human carries out. He identified six different intelligence levels for smart technologies: *adapting* behaviour to fit an environment, *sensing* to increase awareness of everyday things, *inferring* conclusions from observations, *learning* from experience to improve performance, *anticipating* by thinking and reasoning about next steps, and the most advanced *self-creating/organising/sustaining* by having the durability to organise, repeat and process.

In tourist accommodation, smart meters can be used to record resource use, sometimes water, but often energy use from air conditioning, lighting and power outlets, and automatically adjust settings to optimise guest comfort and energy use. They are increasingly part of tourist accommodation buildings' environmental management systems (EMS) saving up to 50% of energy (e.g. Chedwal et al., 2015). Yet studies show that support for such EMS, including smart tech, varies greatly in the sector (e.g. Dief & Font, 2012; Filimonau & Magklaropoulou, 2020; Sourvinou & Filimonau, 2018). At its best, smartness in buildings goes beyond the mere use of technology and instead involves users to co-create smart socio-technological systems (Gretzel et al., 2015). Thus, Morozov (2013) and others (e.g. Gram-Hanssen & Darby, 2018; Hargreaves et al., 2013, 2018) call for a rehumanising of smart technologies, confronting the bias towards tech developers and 'black box scripts' with minimal user engagement (Shin & Bull, 2019). Users, be they accommodation managers (in the case of our study), guests or home owners, are under-researched in smart tech studies, with limited research on how smart systems impact energy awareness and behaviour change (e.g. Moezzi & Janda, 2014; McIlvennie et al., 2020).

There is even less understanding of how energy consumers engage specifically with smart data on their journey towards behaviour change and energy awareness. If anything, there is a growing recognition that savings related to smart tech are highly variable, from 55% decrease in energy use to 8% increase in energy use, and are on average lower than we might expect (e.g. McKerracher & Torriti, 2013; Nabeel et al., 2019). We know that smart tech feedback by itself does not lead to behavioural changes in energy consumption (e.g. Aydin et al., 2018), and this variability in outcomes is likely to be related to how people engage with the information, in the form of numerical output, provided – what is referred to as information transformation and exploitation in the absorptive capacity model used in strategic management for competitive advantage (Garay et al., 2017; Zahra & George, 2002). We therefore need a better understanding of how smart energy meters interact with management, and their practices, in commercial residential buildings such as tourist accommodation (Hargreaves et al., 2013, 2018).

The aim of this study is to investigate accommodation managers' (i.e. 'users') engagement with data generated through smart meter systems to make sustainability decisions and take action on the energy-led service provision in accommodation buildings. The COVID-19 crisis provides the backdrop to this study, as it imposed existential financial risks to accommodation operators. Businesses therefore had an added incentive to engage with their smart data to find fiscal savings from resource reductions within their operations. The study contributes to understanding the variability, both in amount and duration (some studies note that savings are rarely sustained) around savings generated from smart tech, as well as addressing three of the gaps identified by Garay et al. (2017) around (i) how information is transformed and exploited for behaviour change, (ii) using field studies combined with actual data to understand how processes are embedded in organisational cultures, and (iii) focussing on the individuals involved in these processes.

By adopting a socio-technological lens combined with social practice theory, we propose a framework of smart tech users' journey through different stages of smart data usage.

Successfully navigating this journey will enable the types of changes required to achieve the level of decarbonisation necessary for tourism, pushing through apparent savings 'ceilings' by providing diagnostic tools that allow decision-makers to understand where they are on their smart tech sustainability journey and what they need to do next to progress towards greater resource savings.

Literature review

Smart tech for commercial residential buildings

Smart meters are fundamental to smart systems designed to manage living spaces (homes, campus residences, health precincts, hotels, etc.). The sensors are capable of transmitting usage data, often energy and/or water, directly to an interface (e.g. Building Management Systems). The key attributes of smart technology are the ability to acquire information in real time and to respond accordingly (Balta-Ozkan et al., 2013; Chan et al., 2008). Importantly, smart systems can be set up to either automate processes with limited human involvement and/or awareness, or alternatively, bring the numerical data to the attention of managers, allowing them to make conscious informed decisions about energy use. It is the latter which interests us here, as part of the movement towards actively engaging tourism users in energy decision-making and 'co-management' practices (Goulden et al., 2014).

Compared to domestic settings, tourist accommodation represents a particular challenge as it blends home-like features and practices with commercial management structures, potentially increasing resource demand through service expectations (Shove, 2018). The connection between energy behaviour and business implications is somewhat broken in that guests staying at a hotel do not normally receive feedback on their usage, nor are they restricted in their use of energy. This disconnect makes socio-technological studies more challenging compared to household studies, and there is a dearth of research on commercial spaces (Foster et al., 2012), including tourist accommodation (Harputlugil & de Wilde, 2021). Given the imperative of climate change mitigation, this represents a major gap. Understanding the drivers of commercial managers engaging in resource conservation and the role smart technology can play is therefore important.

In the domestic sphere, the opportunity offered by smart homes has been heralded as a novel solution to reducing energy (Balta-Ozkan et al., 2013). When smart tech involves users, smart systems can (1) reduce energy usage, (2) provide feedback on consumption, (3) suggest how to use electricity efficiently. Yet, reviews of energy savings based on the application of smart metering have shown mixed results, with reductions in the order of 3-15% in the case of households in the UK, the US and Australia (McKerracher & Torriti, 2013; Nabeel et al., 2019; Shin & Bull, 2019). Savings have not been as significant or lasting as predicted, arguably because of the product-centric focus of smart tech, which underplays the role of the user (Chan et al., 2008). Several researchers express concern that we ignore at our peril how the smart systems interact with user habits and routines (e.g. Hargreaves et al., 2013). A recent review of relevant the literature suggests that in 58% of studies, users are viewed as passive agents (McIlvennie et al., 2020). Ignoring how the user engages with smart tech information and the resulting adaptive behaviours, may explain why we see such significant variability in resource savings, and potentially underperformance of this technology in terms of its contribution to sustainability (McKerracher & Torriti, 2013; Nabeel et al., 2019)

We know that a home is a place of activities, relationships, identity, values and of security. Likewise, in hospitality businesses, guests engage in similar, home-like practices, such as showering, sleeping, watching TV, etc., but bringing with them their own motivations, attitudes and habits which have been found to vary from the home context (Dolnicar, 2020; Dolnicar et al., 2017a, 2017b). Thus, it is important to consider social practices in these spaces. Social practice

theory (Shove et al., 2012) allows for understanding behaviour change as taking place within a set of individual and societal competencies, materials and meanings. Thus, how we use water during our showers will be moderated by societal expectations of cleanliness, the enjoyment of showers as relaxation ('me time'), our perception of an average or acceptable shower length, regulations around shower fittings, how we understand water scarcity, how toiletry manufacturers design their products (e.g. ease of rinsing off products) and so forth. In the case of energy use, the meaning element relates to what Stephenson et al. (2010) refer to as 'energy cultures', and Hargreaves et al. (2013) remind us 'ostensibly have little or nothing to do with energy' (p. 132).

In an accommodation business, there are potentially two or even three energy cultures; (1) the guests' and those of the staff responsible for managing comfort and service delivery, be they (2a) frontline staff and/or back of house staff (such as cleaners), or (2 b) management staff (operations, marketing, etc.). Both staff roles are important if accommodation providers are to achieve greener practices (Sourvinou & Filimonau, 2018). This arguably accounts for why hotels are both one of the most energy-intensive types of commercial building (Filimonau & Magklaropoulou, 2020; Tsai et al., 2014), and face unique challenges related to the practice of being hospitable and providing an indulging environment (Dolnicar & Grün, 2009). Tourist accommodation resource use practices occur within an all-inclusive price, with 'unlimited' resource use, and where guest satisfaction is the primary aim of the service delivery.

These complexities must be recognised, especially in cases of severe disruption to normal practices such as the lockdowns during COVID-19. This study focuses on the suppliers of accommodation who were faced with managing energy use in an extraordinary situation, and examines how they made best use of their smart systems. In particular, we focus on how they engaged with the data from their smart systems to make management decisions about the operations of their buildings and service provision, as well as invited guests to cooperate in energy use reduction behaviours. This extends previous research on smart tech to the under-researched area of users, and specifically how users such as hotel or other accommodation managers actively engage with data to make decisions about energy use in a service context, on behalf of tourists staying in their buildings. This is important as our energy consumption directly impacts sustainability through the carbon footprint via greenhouse gas emissions of our practices.

Users of smart tech: the domestication process

One key component taking action is the users' ability to fully grasp and exploit what smart tech can offer. It is not uncommon for smart data to bypass the user altogether and provide data to the utility provider instead (Moezzi & Janda, 2014). Where users do have access to the information, there is often a lack of 'context in which to situate the data, and the data gathered is either lost after the owner reviews it or saved […] with little to no onward analysis' (Moezzi & Janda, 2014, p.36). There is therefore a need to understand not only energy practices in relation to smart tech data, but also practices in relation to the use of smart systems themselves. This allows energy consumers to become co-managers of energy use through smart data production (Goulden et al., 2014).

A few studies have explored users' engagement with smart tech, to understand how smart data is used to increase our understanding of how to change energy practices. Socio-technological studies have referred to this as the 'domestication' of technology, where technology adapts to users' daily routines and vice versa. Berker (2011) describes a four-stage domestication process of acquisition, objectification (as the technology is redefined in relation to its new owner and context), incorporation and conversion. These four stages require three types of 'work':

1. Cognitive work: what can the technology do
2. Practical work: how to use the technology

3. Symbolic work: incorporating the technology into the users' identity.

In Berker's (2011) words, a successful domestication process involves 'mutual adaptation including practical, symbolic, and cognitive activities' (p. 261). If any of these are missing, then domestication has failed or is incomplete. Hargreaves et al. (2018) consider the domestication of *smart* technology as the 'active work involved in 'taming' 'wild' technologies to bring them into and make them functional within homes' (p. 129). The outcome of domestication is that users construct the meaning of the technologies and incorporate them into self and household identities and/or business practices. Sometimes, however, domestication can lead to a lesser use of smart technology, as users settle for its simpler functions. This 'precarious domestication' (p.134) suggests that more attention is required regarding the types of work required to domesticate smart technologies. Hargreaves et al. (2018) also argue that to facilitate this work, more collaborative approaches need to be created that lessen the burden on users to figure out what the device can offer them, how to use it, and why. In all these scenarios, the users' ability to interpret that information is key to performing the three types of work required and therefore the success of smart technology domestication. In this study, we propose that these different types of work occur as part of a sequential journey towards sustainability actions.

Taking decarbonisation action based on smart data

A key challenge is how the numerical outputs produced by smart meters are turned into usable information for tourism decision-makers to take appropriate decarbonisation actions (Warren et al., 2018). Goulden et al. (2014) note that for the most part smart meters displays are 'opaque in their presentation of information' (p.24) and fail to guide how users should act on these numerical outputs. Providing information on its own has limited use. Instead, information is a participatory process, whereby the information on consumption links to the 'behaviour consequences [of energy-related practices] to generate a spontaneous occurrence for internalisation (i.e. goal-setting)' (Shin & Bull, 2019, p. 4610).

The information that accompanies smart metering can overcome energy's 'double invisibility' and build users' carbon capability, defined as 'the ability to make informed judgments and to take effective decisions regarding the use and management of carbon' (Whitmarsh et al., 2009, p. 2). Research by Coles et al. (2016) on small tourism companies found that carbon knowledge is very limited. Information in the form of smart data may assist to keep energy in users' discursive consciousness. Discursive consciousness means that accommodation managers actively talk about the (social) conditions of their own actions, rather than just focussing on their practical knowledge that enables them to function in the world with little conscious reflection (Giddens, 1984).

Certainly, Hargreaves et al. (2013) note that their energy monitors did have a significant impact on participants' level of energy awareness. Meanwhile, Nafus (2014, p.218) found that for a few of her study participants

> *numbering and measuring served as a heuristic that incrementally glued together a living map of the house. That map might draw one to peer under vents or find the need for another clever sensor deployment which, for a group primarily made of engineers and do-it-yourself enthusiasts, was itself a source of pleasure.*

Yet, as with 'precarious domestication' (Hargreaves et al., 2018), smart tech users often ignore the possibilities and information offered by smart systems. How and why this happens is a key question in this study. During the COVID-19 crisis, several conditions came together, including significant day-to-day uncertainty, lockdowns which presented a completely new set of business circumstances, and an impetus for financial sustainability of commercial residential buildings. Thus, we might expect that smart technology would play a particularly valuable role for tourist accommodation during that time, and yet, as we shall see, this was not always the case. The

following section introduces new socio-technological concepts of stuck and dead data and might provide some clues on what was happening.

Dead data, stuck data and clotted data

In addition to cognitive, practical and symbolic work, labour is also required to identify the implications of new (to the user) data, to bring various elements together to form a picture of the whole to allow decision-making. Nafus (2014) refers to the outcome of this labour as data that start to 'clot'. Although similar to the domestication of smart technology and in particular the symbolic work required to construct the meaning of the technology and incorporate it into identities, clotting extends the former idea somewhat. Where the work is not undertaken, the data become dead, or 'wild' (Hargreaves et al., 2018). Data can also become stuck, similar to the state of 'precarious domestication'. When data are stuck, some of the cognitive and practical work had been undertaken but the symbolic work required to make meaning had failed. The data had not clotted into something useful and cannot be used to make decisions to progress sustainability. This failure to 'clot', leading to dead data, might explain why smart meters have not produced the sustainability outcomes that were initially expected of them.

To represent this process, Nafus (2014) uses the analogy of the presence of smoke pointing to a fire; the smart metering data represent the smoke, but say nothing about the nature of the fire or how to extinguish it. If there is only a vague sense of the context, Nafus (2014) argues that the sensors made users more acutely aware of just how complex the construct 'energy efficiency' is, resulting in stuck data, where there is not enough support to understand how to take action, or where 'frameworks with which users of sensors might negotiate data's possibilities are relatively thin' (p.221). She concludes that 'the production of 'clotted' numbers in digital cultures is far from assured, not just because there are so many data, most of which is machine-generated and never actually looked at, but also because the production process is deeply uncertain' (p. 221).

The process of domesticating and clotting therefore requires informed collating of various data, a focus on user-centred reporting, embedded within a broader understanding of individual and social practices, as well as the engineering and technical systems that shape consumption (Gram-Hanssen, 2014). Understanding how smart metering can support tourist accommodation's sustainability agenda requires appreciating the relevant practices including (i) embodied habits, (ii) institutionalised knowledge, (iii) engagements and (iv) meanings. Embodied habits are routinised and often unconscious practices of energy consumption. Institutionalised knowledge refers to the shared, explicit (as opposed to the embodied habits) knowledge related to specific practices, as well as the training available in this space. Engagement refers to a dialogue between individuals and the meaning allocated to the practices – which, as we noted for the case of tourism is once removed for energy consumption (Gram-Hanssen, 2014).

Framework and methodological approach

Study framework

Our theoretical framework for this study brings together the currently disparate works of Gram-Hanssen (2014), Berker (2011) and Nafus (2014), combining them with social practice theory (Figure 1). To move beyond descriptive evidence of how smart meter existence might associate (or perhaps correlate) with changes in behaviour, we seek to explain why some accommodation managers are able to turn smart metre information into action and why others fail to do so. The model brings together the energy cultures of tourism accommodation providers through a social practice perspective with the tech journey to understand how managers make sense of the data that smart technology is providing.

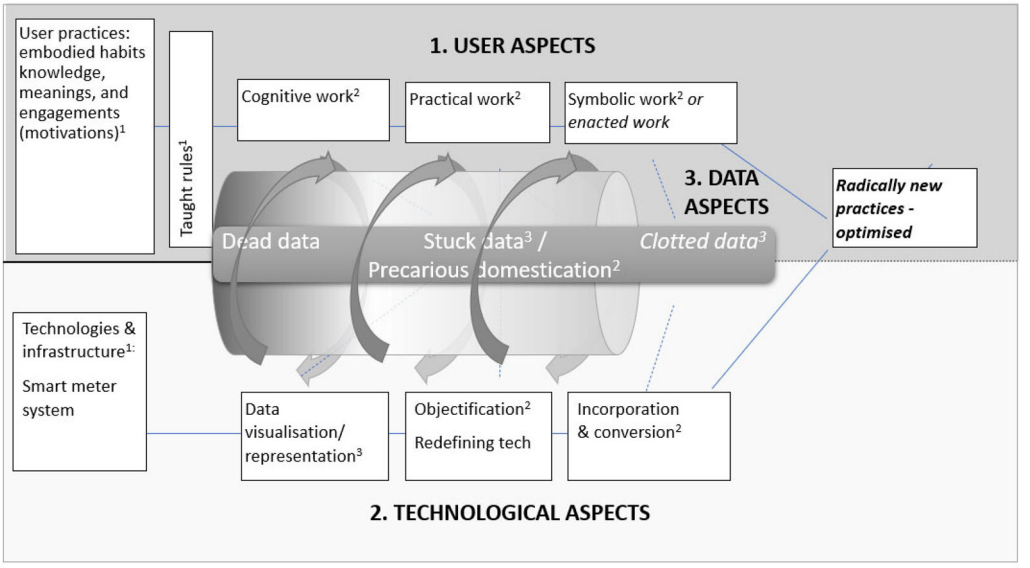

Figure 1. Our conceptual framework as an integration of the work by [1]Gram-Hanssen (2014), [2]Berker (2011) and [3]Nafus (2014). The diagram represents the smart system in its entirety, while the top line refers to the USER aspects, and the bottom line refers to the TECH-side of the system, and the middle line to the outcomes of the user/tech relationship. New practices represent the desired outcome.

The framework integrates what we need to know about the acquired technologies and related infrastructure, the cognitive work and taught rules (by technicians, sales staff, etc.) that are part of acquiring the system, the system's domestication through practical work leading to objectification (as it becomes redefined by their new owners to suit their understanding of its capability and their practice needs), and incorporation within everyday practices, and finally their conversion into part of their owners' identity through symbolic work. This process encourages radically new practices as the data clot for the user. Each term in Figure 1 relates to a specific meaning assigned by the original authors, as indicated by the footnote numbers. The aim of this paper is to explore how this proposed framework aligns with real-world contexts to understand how managers of tourist accommodation use smart systems to adapt at a time of crisis. The framework can be tested as a diagnostic tool to help the creators of smart systems identify where additional support may be required to allow users to truly engage with the data to drive decarbonisation. It also provides users with a more realistic appreciation for the work that must go into using smart systems successfully.

Methods

This study adopts a mixed methods approach within an interpretivist research paradigm in line with the combined tech and human practice nature of the topic. The case study approach combines qualitative research with actual, longitudinal, resource use data, suitable to test our framework and develop practical insights. Table 1 presents the broad characteristics of each of the six case studies, selected based on geography and built environment; key dimensions that influence energy and water use at tourist accommodation (Warren & Becken, 2017). The sites were approached through destination organisations that have a keen interest in accelerating sustainable tourism (e.g. City of Sydney Sustainable Destination Partnership who helped identify potential sites to trial My Green Butler© (MGB)). It is important to note that the nature of the study requires a significant engagement with each site, in terms of getting to know the decision-

Table 1. Information on the six case study businesses (broadly ordered based on how long they have been using MGB and their level of sustainability engagement, with Site 1 being the most advanced and Site 6 just beginning their journey).

Site *& notes*	Built environment	Geography	Management structure	Interviewees (n = 13 across 9 interviews) with assigned codes	Data capturing
Site 1	4 self-contained cottages of 2-4 guests, built of timber, 15-30 years old, sheep shears style,	Temperate; rural, New South Wales, Australia	Owner-manager living onsite	1 interviewee (S1); a self-taught host with experience in pre-school administration and bringing up a young family	Savings based smart metering data 38% bioenergy, 33% electricity, 21% water, 20% gas
Site 2*Currently operating as a quarantine hotel*	415 rooms in one hotel 30 years old, skyscraper, sleeps 830	Sub-tropical; city, New South Wales, Australia	Chain property, Corporate management team	3 interviewees (S2.1; S2.2; S2.3) in 1 interview involving sales and marketing staff (S.2.1 and S2.2) and one qualified engineer (S2.3)	Smart metering identified inefficient energy use in heating by 4 °C and 75% increase in water usage on particular days
Site 3	B&B property 10 guests +500 years old with bunkhouse +40 years old sleeps 45	Maritime; rural, World Heritage site, North West England	Owner-manager living onsite	1 interviewee (S3); a self-taught host with experience in university administration	Baseline establish using utility bills, used smart metering for comparison
Site 4	Timeshare lodges 50 years old 'Scandinavian' style, each lodge sleeps 6	Maritime; rural, World Heritage site, North West England	Corporate management team with time share committee	3 interviewees (S4.1; S4.2; S4.3) in 3 separate interviews. All long-term staff with high level of experience in maintenance, IT technology and timeshare property management	Actions taken based on smart meter data saved 24% electricity, 15% gas
Site 5*The owners have the smart meters installed in a 2nd property*	Regional, 1 h drive from large metropolitan city Holiday house that sleeps 10	Maritime; coastal rural, Victoria, Australia	Owner-manager living onsite	2 interviewees in 1 interview (S5.1; S5.2), both self-taught hosts with a property management background and young family	In the early stages of implementing MGB at this site
Site 6*Recently purchased by owner*	7 cabins	Tropical; rainforest, World Heritage site, Queensland, Australia	2 live-in managers	3 interviewees (S6.1; S6.2; S6.3) in 2 interviews (S6.1; S6.2 + S6.3). New owner (S6.1) has a medical qualification and practiced in pharmacy, S6.2 and S6.3 have onsite management experience	Pre-instal of smart system, using only baseline establish using utility bills

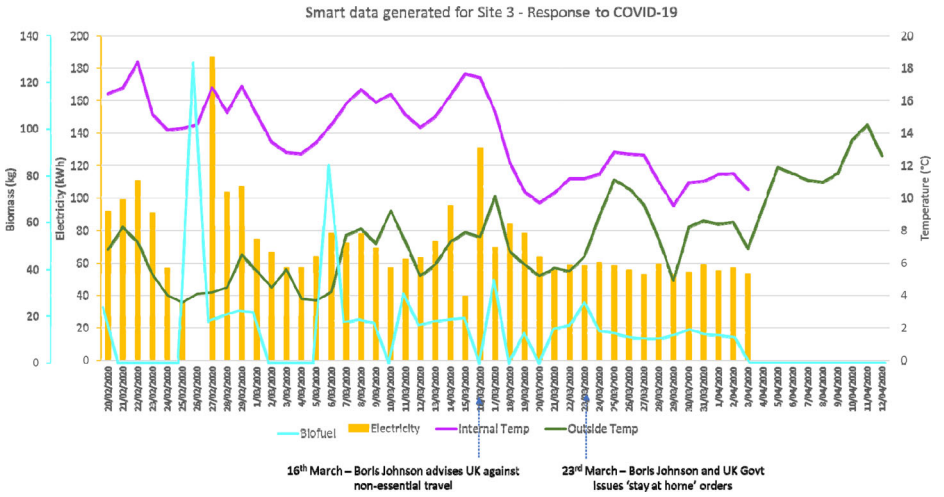

Figure 2. Exemplar smart data output generated for Site 3 and used to discuss the manager's interpretation of data and COVID-19 related events.

makers and practices, setting up the smart system, reporting back, and collecting data. Each case study represents a long-term relationship with the researchers.

There are two major components to the study. The first involves the installation of a smart technology system provided by MGB in the selected businesses (Warren et al., 2017). This stage also requires site audits to understand the geographic, commercial, and technological context, and to capture how the smart system and its attributes (e.g. its representation, objectification, and incorporation) might be deployed. The smart system involves different types of sensors and meters (e.g. electricity, water, room temperature) that are connected to the accommodation's guest reservation system to understand the implications of occupancy on resource use. Data are generated in 15-minute intervals and are available to the managers throughout during the study period. We use energy measures in this study to represent what the smart system can offer managers, but the study as a whole (including the interview questions covered next) covered the entire smart system capturing various resources. An exemplar output that was discussed in the interview with the Site 3 manager is shown in Figure 2.

The second component involves qualitative in-depth interviews undertaken for the purpose of understanding how businesses engage with smart data to reflect on or change their energy practices. A total of nine interviews were carried out with 13 interviewees. Interviewees were shown resource use data for their business before and during the COVID-19 lockdown, plotted in Excel as consumption over time. Importantly, the six businesses are at different stages of their smart technology enabled sustainability journey (Table 1). Managers and/or owners at the case study sites were interviewed online for approximately one hour. Because of the challenges facing the hospitality sector during this crisis, we left it up to the participants whether they preferred to be interviewed separately or together. The interviews were semi-structured and focused on their interactions with the smart-service intervention.

The nine interviews were recorded and transcribed, scanned as a whole to identify elements of the framework in Figure 1, then coded following a deductive process according to the literature from socio-technological studies as presented in Figure 1 and the definitions of concepts presented throughout the literature review. The coding process was discussed among the authors to reach consensus. The data are presented as thick descriptions to present 'detail, context, emotion, and the webs of social relationships that join persons to one another' (Denzin, 1989, p. 83). This serves to illustrate how the elements of the framework translate into practice.

It is important to acknowledge the limitations of this study. The study is logistically complex requiring sites to invest in an innovative, holistic service (MGB) that goes beyond the types of off-the-shelf smart meters deployed by some accommodation providers. The intense level of researcher involvement with each site limits the number of sites available, and also prevents a representative sampling of sites, leaving us with a self-selected convenience sample. This could lead to concerns of bias towards respondents who already have a certain level of familiarity with smart meters or pro-environmental behaviours, but to the authors' surprise and as highlighted in the findings, this was not the case.

Findings

The findings are presented according to the three key aspects shown in the framework of Figure 1.

User aspects

We first address user practices within the *User Aspects* side of our framework. Practices, involving habits, knowledge, meanings and engagements, varied widely between the case studies, and in some cases were heavily influenced by the COVID-19 crisis. Four participants referred to sustainability as being part of their ethos, and illustrated this by reference to waste reduction rather than their carbon footprint, e.g.

> *Recycling is part of our ethos. And we try not to waste anything. We've got chickens, we've got recycling bins, we use newspapers for the fires, or mulch, etc.* [S1].

In a similar vein, S3 also expressed concern about waste, but ties it directly to energy use, demonstrating a high level of understanding of the complex sustainability nexus:

> *my biggest bugbear […] is consumption of products, and plastics and packaging in particular, and the huge amount of waste. And that's energy around that. So all of that plastic packaging is energy being consumed somewhere to produce and make and put on that package and be transported away, and then either recycled or something else* [S3].

Knowledge was highly variable between respondents, with some able to articulate exactly how much energy is used by specific infrastructure within their sites. This is particularly true of Site 4, where interviewees list the energy consumption of each lodge's sauna, drying cabinet, each kitchen stove, as well as the output of the biomass boiler system to heat the lodge. Two of the participants from Site 4 respondents had a strong engineering-based understanding of the site, yet were less articulate in linking guest and staff practices to energy consumption. Meanwhile, Participant S1 (a female, and longer-term user of the smart metering system) had a very good understanding of the practices at her site, e.g.

> *showers use [energy], a lot of people have a long shower, which they don't realize the connection with that. So we usually say to guests, you know, if you have a shower, that's 10 minutes long, it's the same as having a bath, but you can put two kids in the bath rather than just one kid in the shower* [S1].

yet also said the following:

> *I don't really understand. I need to learn more about the correlation between kilowatts, and you know, what's a good amount? And what's a bad amount? So if you told me that I had used five kilowatts today, I would have no idea what that meant* [S1].

When talking about practices, participants demonstrate mixed meanings and engagements towards sustainability, for example S2 interviewees view it as a business requirement to remain competitive:

Table 2. Illustrative responses to whether training on the smart system has been received.

Site 1	"*I don't need training so much as it would be good to just refresh how much things use what an average person uses […] comparisons are good for people to be able to see, well, should we wash this up? Or should we put it in the dishwasher? Things like that*" [S1].
Site 2	"*I can answer that question quickly [no]*" [S2.1].
Site 6	"*No, not really. We had an eco biz audit, which is done by the [state] government. And they went through to look at our consumption. […] gave some recommendations. However, I don't think there was any sort of training given to our managers when they went there. Nor was there, I mean, there were some recommendations, but how to reduce energy consumption with appliances and things? Not really, I think there's a bit of common sense*" [S6.1] and "*just the owner, and my parents […] just things that have been passed to us*" [S6.2].

Table 3. Illustrative responses on the 'work' so far in relation to smart data.

Site 2	"*when you guys send us one report that we are consuming a lot of water in a short period of time, it's complicated to analyse, it's not easy to get. […] without analysing the big data. And to get the big data it takes time […]*" [S2.3].
Site 4	"*you've got to have a baseline, if you don't have a baseline and you can't put things into context, then they are just numbers. I think that's the great thing with digital technology nowadays is you just need to have a bit of an imagination to make it really interesting for people and capture people's imagination and get the engagement*" [S4.1].
Site 5	"*benchmark data is great, isn't it? And obviously, the bills, the bills have that, you know, a typical one average family of five, you know, uses this much energy, I guess we would need those metrics for each utility*" [S5.1].
Site 6	"*So it means that data means nothing to me, unless I have some baseline data. Okay, so if you're giving it to me for the first year, I don't know what I'll be doing it, I would be putting it somewhere […] but once I have some baseline, then you can draw on it, but I don't think it's a one-year project*" [S6.1].

> *it's becoming more and more critical from a corporate perspective and an inbound international, when we're dealing with the international market [who] is miles ahead of us as far as carbon footprint reduction. […] So bottom line is, we are here to make money. And in order to do that, we have to, you know, have these initiatives in place. And of course, yes, we want to do it. You know, this is the right thing to do from the environment, but from a commercial perspective, we have to do it as well* [S2.2].

Similarly, Site 5's owners discuss the business imperative from a green market perspective:

> *I do keep hearing that since COVID, a lot of people are looking for more sustainable tourism experiences. I'm really needing to understand what that looks like [and] understand how we can extend that and therefore promote it as part of what we do as one of our values because obviously there's a cost saving benefit for us* [S5.1].

Given the varied levels of knowledge, we asked each respondent about the training that they have had access to in this area. This is captured as taught rules in Figure 1 and are a key aspect of the framework. Formal training in how best to use smart metering for sustainability outcomes was generally lacking, with the exception of S3. The answers compiled in Table 2 exemplify this.

Only Site 3's respondent replied to this question with confidence:

> *Okay, so we have something called the locally called CAFS. […] it's basically a campaign to encourage the take up of sustainable energy in a number of different settings, but primarily buildings. And that's domestic as well as business. So we've been involved with them for two to three years now. So we've actually held events here, other people coming to us, and then we've gone to other places and looked at their setups and discuss these things. And we were involved in a zoom training session only two or three weeks back about heat pumps, for example* [S3].

The final component of *User Aspects* in our framework are what types of work they engage in. Based on the findings so far, it is evident that nearly all the respondents wanted to use their smart meter data as a baseline to either compare against an ideal figure, or monitor themselves across time (Table 3).

The findings suggest that most respondents are at the early stages of cognitive work, focussed on how they fit in within the broader context of energy consumption, with relatively little understanding of how the smart systems' data will serve them. This perspective is neatly captured by the owner of Site 6 who ponders how to use the smart system:

I guess if I had the data every week, and I saw that, actually, in the quiet week, compared to a busy week, you know, the difference was not as large in the consumption as I expected, then I would need to find out what is sucking energy? And where are we inefficient in our energy consumption or carbon emissions? […] But what actions would I have them do? […] I'd need to have actions for them to, to, to participate in that data. Because one thing is giving data to someone know that they need to actually interact with that data to make it impactful [S6.1].

In a similar vein, S5.1 admits that '*we are not very good at interrogating the data […] I'm a bit alarmed at times, looking at the energy use of that property from a financial point of view*' and follows on with this statement:

I mean, we've had access, theoretically all along, but, you know, I'm a bit of a walking contradiction, because I strongly believe […] if it's not measured, it's not managed, and yet, here I am, you know, busy mother of three going tralalala most days, I don't know where I would fit this in. I feel like if we, if we had some help setting up, you know, the, the benchmark data that we need to be looking at on a month-to-month basis, it's probably something that I could say, okay [S5.2] as well as mowing the lawns and checking the spa water, you're now also responsible for tracking this data and interpreting it and you know, saying, What's it telling us? And what do we need to act on as a result? [S5.1].

In contrast, Sites 1 and 3 have progressed through to practical and perhaps even symbolic work in the case of Site 3. First, S1 described how she uses the data on a day-to-day level:

Well, it helps me advise people like, […] if I could see that they haven't shut the windows, or I can see that yesterday, it was 12 degrees at night and 29 in the day, but their cottage got up to 29 obviously, they didn't shut the window. So by seeing that data from the previous day, I can then say to them the next morning or that night, open your windows tonight it's going to be lovely and cool [S1].

Interestingly, she appears to have stopped short of doing the symbolic work, integrating it into her identity as a manager. Instead she argues that '*It's good if it's… if I don't have to analyse it. […] It's overwhelming. So, I don't want to be the one that's analysing that. I want to be the one that's told: this is what this is, what this means*' [S1].

S3, on the other hand, provided an interesting contrast, already being self-assured in his practices, he is now more interested in what baselines can tell us about the scalability of different interventions, and thinking about the bigger picture:

I'd be interested to see, look at other people's baselines and just try and see judge how that compares […] you know, lots of questions about scalability, aren't there [S3].

S3 is well and truly in the practical and symbolic stages of work, e.g.:

We know that just from watching our electric uses on a on a day-to-day basis, the basis that we were monitoring with the My Green Butler© scheme, it's quite clear that you know, peak periods of cooking, creating quite big spikes on the energy consumed. And that's not un-understandable [sic]. And, you know, if we're not, we're not doing much catering, then those energy peaks will drop. And so that is a big question we keep kind of coming back to thinking about, you know, what our options are from the point of view of a catering business could be [S3].

In this extract he demonstrates first the frequency with which he checks the data, and second that he is constantly questioning what they can do about the 'unwanted' data coming in. Combined with host training programs on energy consumption, his level of familiarity with his infrastructure, his own and his guests' practices and the emotive language that he uses to describe energy consumption (frustrations/bugbear), there is perhaps enough to suggest that S3 is at the third and final stage of work to incorporate smart tech into his life and identity.

Technological aspects

This section refers to how the technology is incorporated in the practices of the various sites, first through visualisation, e.g.:

to actually have them zoned or […] colour-coded or something, you know, like, be the water bills, you're doing really well, like, as if you're a one person household or whatever, you're doing rubbish […] Something the data was a bit visual. So that even if I don't force my managers to interact with that data, it is in a way that can shock you, you know, if you saw the data [S6.1].

For the most part, the sites are at the early of the four stages of acquisition of the technology (Berker, 2011) (Figure 1). The only exception are Site 1 and Site 3. The former offers a good example of redefinition, suggesting building an alarm into the system:

like an alert at two o'clock on my phone would be really handy. Because then, if I could always look at my phone at two o'clock, but I'm always so busy. […] And it's just like, oh my god, you know, and then I get up there and it's boiling hot, and I'm embarrassed because I'm taking people into a not comfortable cottage. So if I got an alert, and it said Cottage temperature: [Cottage 3] 32: [Cottage 4], 27 [Cottage 2]: blah blah blah, I would then know, an hour before so we could take assertive action to make the cottage better [S1].

S1 has clearly thought about how the system's design could best serve her (ensuring guest comfort and avoiding embarrassment as a host), suggesting modifications to the system in line with her own practices. This represents an example of smart tech objectification/redefinition. Site 3 takes it further, incorporating the tech by bringing the data into his daily routine and questioning the relationship with his practice on an ongoing basis:

we talk about it all the time, to be honest, every day is, you know, we're always saying Do we need to be doing this is that, you know, can we turn that off? Is there a way to make this more efficient? Can we encourage people to be doing less with things? And I think one of the one of the good things about being involved with the scheme with yourself is that we were very conscious about that. But it kind of put it more in the frame in terms of having to ask that on a daily basis, rather than we just sort of thought about it [S3].

Data aspects

The final component of our conceptual framework is what happens to the data once the user and technological aspects come together. Across the six sites, there is evidence of dead data, stuck data and clotted data. With regards to dead data, Site 2 is currently operating as a COVID-19 quarantine hotel and as such, feels that their situation is too uncertain and unusual for the data to be useful. In this sense their data are arguably dead:

when you ask about how we analyse the consumption we have now, today, it's mainly because we are having a very strange period that we have no idea of tomorrow, even to compare tomorrow with yesterday [S2.3].

And S2.2 continues '*I think like [S2.3] said, we are working in a very unusual time so between now, and the data that we gather this year, there is going to be potentially completely irrelevant to what happens next year*'. Meanwhile S5.1 provides good examples of both undomesticated systems and stuck data. There is a lack of domestication when she admits that she is not comfortable using the information:

I think it's wonderful that that technology is available, I'm a little bit intimidated by it, I'll be honest, because I feel like I'm so wet behind the ears with this stuff [S5.1].

She therefore asks for

Maybe some tips to improve the result might be helpful. But I suspect once we really kind of get our heads around this, and we have an understanding of what where that power is being used. What's behind those results? We will develop our understanding […] Yeah, I mean, anecdotally, we think it's, it's the power to heat the spa and the hot water. But who knows, we might be surprised once we dig back into that [S5.1].

S5.1 also gives an example of stuck data, where she acknowledges the usefulness of an audit in 2019, but failed to proceed with making any changes

I guess it was just at the time an exercise that we went through just to raise our awareness of, you know, what, what draws the most power? And how can we how can we impact that? […] I guess it was building out our knowledge. But we didn't necessarily do anything with it at the time [S5.1].

She reinforces the 'stuckness' of the data when she says '*we got really excited about what the data was telling us, but then we just didn't continue on. So it's just forming that habit and understanding […]*' [S5.1]. Meanwhile, one of the interviewees from Site 4 relates a personal story around data that had clotted but was lost when the smart metering system became defunct:

> *I had a smart meter attached to my electricity circuit at home […] it certainly modified my behaviour. When I switch the kettle on and I was able to see the dial go into the red, I started putting less water into the kettle and putting my heating down, it might not have had a massive impact on you know, even I was just keen to make a difference. But when I moved supplier […] because I got a better deal, unfortunately, that particular smart meter wasn't compatible* [S4.3].

He then admits that the actions didn't last without the feedback, representing a case of precarious domestication, in the sense that the actions did not stick long-term:

> *… dare say I'm …, because I'm not able to monitor my utility my consumption anymore. I dare say I'm less efficient and less aware of it. If you like or paid, pay less attention to what I'm using, than I might have done previously* [S4.3].

Only two of the sites offer examples of clotted data. The first is Site 1, where S1 begins to put together various strands of data including occupancy, time of year, resource use and building orientation:

> *It makes me think that [Cottage 1] uses a ton of stuff […] I'd really like to see the difference between [Cottage 1] and [Cottage 2] because at the moment, you know, we, if we had the choice of which cottage to put people in, you'd really want to check. You know, you wouldn't want to put them into [Cottage 1], because [Cottage 1] seems to use a lot of everything* [S1].

She describes the difference between them:

> *they're identical, but they're facing different directions. So [Cottage 2] is get is better in winter and [Cottage 1] is better in summer? So [Cottage 2] is warmer in winter and [Cottage 1] is cooler in summer.*

When asked whether the data would prompt any changes for her, she replies: '*Yes, it makes me think that we shouldn't put people in [Cottage 1], first. We should put them in [Cottage 2] because people in [Cottage 1] use more resources*' [S1].

Similarly, Site 3 has a noticeable clotting event around their catering activities and guest behaviour:

> *when I started looking at the electrical figures, for example, I was quite shocked seeing a pattern of the energy consumption, I hadn't realized quite how much our own activity in the building as running the business drove the electrical. So we were thinking about […] if we got 30 guests in the building is that going to drive the energy consumption up? Yes, to some extent. But if we're delivering 30 meals to those 30 guests, that is a massive change in electrical consumption. Whereas the guest going out and eating somewhere else not being in the building here, is a very low level of energy. So not just about the guests, it's about what we're providing to those guests as part of that service as well. And I hadn't appreciated that when we started, I just thought I was a bit straightforward: more guests equals more energy. But it doesn't work like that. It really depends on what the guests are doing, what their expectations are, and what the types of groups are coming in* [S3].

Discussion

This research used the circumstances of the COVID-19 lockdowns in 2020, when there were few guests, to learn about energy profiles in accommodation businesses and how managers engage with consumption data to improve the carbon efficiency of the experience they provide. This study focuses specifically on smart systems as offering solutions to decarbonisation. A framework was developed that illustrates the range of factors that explain why resource savings may not eventuate for accommodation managers even when they have installed smart systems. The smart tech user journey, with its proposed stages, may explain why there is such variability in savings resulting from the installation of smart meters, as well as why smart tech appears to underdeliver in decarbonisation hotels. The user journey draws out the idiosyncrasies of how

smart tech is (or isn't) used. By focussing on the user rather than the product, we avoid the classic case of 'solutionism' or the trend of using technology to fix a real-world problem according to Silicon Valley's foibles Morozov (2013). Ignoring the user's journey is arguably a(n) (over)simplification of how smart systems serve us and may curtail what they can do for us from a sustainability perspective.

Understanding the smart tech user journey as conceptualised in Figure 1 responded to three key gaps in the literature. First, smart systems studies have largely failed to consider the user of the system, particularly at the level of the individual (Garay et al., 2017; McIlvennie et al., 2020). The user aspects are complex in themselves, involving embodied meaning (motivations and engagements) and competency (knowledge and skills), the taught rules around energy and the system, and finally the types of work that are required to domesticate smart technology. Given this, the research provides evidence that benchmarking and certification alone will not be sufficient to change actions. Instead, significant practical and symbolic work needs to follow to generate radical change. Second, this study addresses the paucity of research on commercial residential buildings such as hotels and other forms of tourist accommodation, where the user aspect is multi-layered as it involves manager, staff and guest practices (c.f. Sourvinou & Filimonau, 2018). The resulting complex layers of user and technology – and information outputs (see Figure 2 for an example) – illustrate the laborious journey required to reach a point where the data will clot towards new, radical practices. The findings revealed that only one site had reached a point where an understanding of the data was able to inform sustainability/decarbonisation actions. For this site, Site 3, symbolic work is being performed, as reflected by a deep engagement with the data. This data 'taming' and domestication allowed the full potential of smart data to be activated. This was evident, for example, in the manager testing new resource-saving practices, and weighing up alternative practices for trade-offs in carbon emissions.

The third and most important contribution relates to understanding why smart meters appear to not be living up to their potential as decarbonisation tools. The case studies varied significantly in this journey, ranging from Site 2, whose managers were explicit about the business imperative of 'greening' for its international market, to Site 1 where the manager used some of the energy and building data to inform booking decisions (Figure 3). However, Site 1 despite being quite advanced in the tech journey with firm knowledge of the resource implications of guests' practices, was mainly motivated by the financial savings and security of a small family-run business. Similarly, quite high technical knowledge by the interviewees from Site 4 was not enough to reach a level of domestication to clot the data, perhaps because managers attributed little meaning to the practices surrounding them.

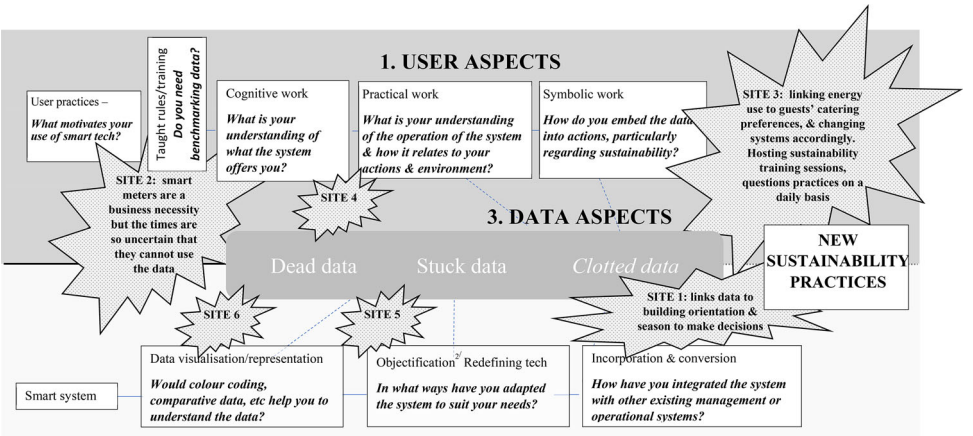

Figure 3. The theoretical framework as a diagnostic tool. To understand where businesses are along the journey, various "diagnostic" questions are proposed in each box that identify different stages. Each site is placed along the journey, with short summary findings presented for three of the six cases to illustrate the links between the data and framework.

If users get stuck at the earlier stages of the journey, they can become overwhelmed by the data raising more questions than bringing answers (Nafus, 2014). Such feeling of disempowerment can ultimately lead to failure of the smart tech system. These types of hurdles should be relevant to the much broader and growing field of smart tourism design (Gretzel et al., 2015). Thus we address the gap identified by Garay et al. (2017) on understanding how processes are embedded within organisational cultures. It is important to understand that smart system users may find that they are presented with a steep learning curve, especially at the initial stages of tech objectification, incorporation and conversion through the necessary work. Some confusion is demonstrated by each participant, not least by S3 who offered the following towards the end of his interview:

> *that might be to do with knowledge, awareness, as much as anything, you know, if you're in blissful ignorance, everything simple. As you kind of raise the agenda and raise more information, things get more complicated. And there are more and more competing elements to that.*

Given that all six case studies were selected because they have demonstrated commitment to carbon reduction and the use of smart systems, the extent to which the 'success' to date varies is an important finding. To support accommodation managers through the evidently challenging data domestication process, systems could be (co-)designed to provide easy-to-read visualisations or alert systems to remind the user of an action. For those working with businesses, be it researchers, consultants, or tech developers, it is important to understand where the decision-makers are on their tech journey, whether they are truly transforming and exploiting the smart data into sustainability actions (c.f. Garay et al.,2017). Figure 3 overlays Figure 1 as a first step towards a diagnostic tool to assess what type of work to focus on, as well as whether the data are likely to be clotted, stuck or dying. To improve the chances for the manager to progress the journey, specific training could be necessary. In addition, a manager could focus on particular aspects of the system, step by step, to learn and embed, for example the role of weather forecasts, particular climatic conditions and resource use; as well as adaptation measures in the property to minimise consumption (e.g. pulling curtains on a hot day).

The following points provide some examples of tools to modify social practices so that the business (manager and staff) achieve resource savings from using smart systems:

a. Regular coaching sessions by qualified practitioners explaining what to look for in smart data.
b. An integrated eLearning programme that accompanies the progressive user stages. For example, an overview of sustainable hospitality for cognitive work with an assessment that collects data and presents it clearly using data visualisation techniques. The programme then progresses to more complex use of SMART data for practical work and how to redefine the tech to suit needs and identify appropriate actions. For symbolic work, the user can be encouraged to think of their own steps to refine their working practices.
c. A diagnostic tool that recommends actions from the nexus of resources and infrastructure (equipment and systems that use the resources). In this case, the technology provides a pathway for staged practical action by processing SMART data that uncover saving opportunities.

To connect the early diagnostic tool with the findings of this research, site summaries are added to Figure 3 to illustrate where businesses are on their way towards new sustainability practices. Ultimately, a tool such as this may assist building carbon literacy and capability in business owners (Whitmarsh et al., 2009) with a particular focus on the role of smart systems. In the words of S4.1, as he inadvertently raises Burgess and Nye (2008) point of double invisibility, without clotted data in context, we are unlikely to see changes in practices:

> *If you can't see what you're doing, if you can't, can't get it in context, as I mentioned earlier, if you don't know that your actions are producing tangible result for what is an intangible measure, you can't see electricity, you can't see, well you can smell gas, but if you can't touch and feel it, then you kind of forget about it. So to me, it's hugely important to have as much visibility as you can. And smart technology I think it enables that, it allows us to really get in people's faces and share the information really quickly with a lot of people.*

Conclusion

The framework developed here and tested against the six cases studies was found to be helpful in pinpointing the weaknesses and opportunities of smart technology to contributing to energy reduction at tourist accommodation, and arguably explaining the variability in savings outcomes reported in the smart tech literature. This is because using smart technology to change resource use practices involves much more than simply installing smart meters and hoping that the data themselves lead to change. Smart technology serves sustainable tourism best when the energy use data generated 'clot' for users in ways that help to practically solve overconsumption and waste by identifying opportunities to conserve energy. This clotting relies on several precursors, including user characteristics and the domestication of technology through various forms of scaffolded labour.

Our proposed journey framework, with associated diagnostic tools to indicate stages along that journey, responds to Sovacool and Hess (2017) call to behavioural change using theories based on relations, which they describe as ones that 'apply their focus across agency, structure, and meaning' (p.733). The more comprehensive the framework, in our case combining three technology related frameworks with social practice theory, the more likely it is to be able to respond to the complexity of real-world context in which behavioural changes are situated. Other framework that could add to our understand of how to translate smart tech data into meaningful actions include absorptive capacity, as described by Zahra and George (2002) and taken up by Garay et al. (2017) and Koop et al. (2019) adaptation of fast/slow thinking into reflective, semi-reflective and automatic information processing routes.

The domestication of smart technology cannot be left to rely on the display of resource use alone, in a data-led feedback format, it must include features that aid its integration, users' education, and the ability to prompt a change in practices. We suggest therefore that tourism managers wishing to engage with smart meters be fully aware of the types of work required to get the most out of their smart systems. This requires considerable commitment beyond the purchase of the technology alone. For those involved in designing smart technology or working managers on carbon reduction programs, the questions posed in Figure 3 are designed to support movement along the individual tech journey.

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