Engaging hotel guests to reduce energy and water consumption: A quantitative review of guest impact on resource use in tourist accommodation

Author

MacAskill, S, Becken, S, Coghlan, A

Published

2023

Journal Title

Cleaner and Responsible Consumption

Version

Version of Record (VoR)

DOI

10.1016/j.clrc.2023.100156

Rights statement

Downloaded from

Griffith Research Online

Cleaner and Responsible Consumption 11 (2023) 100156

Contents lists available at ScienceDirect

Cleaner and Responsible Consumption

journal homepage: www.journals.elsevier.com/cleaner-and-responsible-consumption

Engaging hotel guests to reduce energy and water consumption: A quantitative review of guest impact on resource use in tourist accommodation

S. MacAskill *, S. Becken, A. Coghlan

Griffith Business School (Institute for Tourism), Griffith University, Queensland, Australia

ARTICLE INFO

Keywords:
Sustainable development
Resource use reduction
Behavioural interventions
Agency theory

ABSTRACT

Compared to residential and commercial buildings, hotels use a high amount of resources in their operation, particularly electricity, water and gas. Resource use in hotels is influenced by both hosts and guests, however initiatives to reduce consumption are typically initiated by the host. To improve the effectiveness of host requests aimed at guests to use less resources, it is important to understand how hotel guests contribute to overall consumption. This study assesses quantitative resource consumption and occupancy data from two Australian case study hotels and investigates the impact of guest occupancy on net resource use. Agency theory is adopted as a framework to examine the host (principle) – guest (agent) exchange, and the agency costs associated with discretionary resource usage by the guest. It is found that guest numbers have little impact on net electricity consumption, however, are closely correlated with water consumption in both case studies. The findings suggest that strategies to reduce resource use are to be organised differently between electricity and water, with the former targeted at the hosts and the latter with the guests. Engaging with guests to reduce discretionary water consumption is expected to achieve greater reductions as compared to electricity and gas. The findings have implications for hotel operators and researchers toward designing and implementing effective resource use reduction strategies in hotels, and for understanding hotel resource use in the context of agency theory.

1. Introduction

Increasing public pressure on action towards mitigating the worst effects of climate change are motivating organisations to review their ongoing business practices in the pursuit of greater efficiencies as part of their journey to decarbonise (Coen et al., 2022; Font et al., 2012; Garay et al., 2017; Gössling & Buckley, 2016). Organisational efforts to decarbonise are apparent across all sectors, including hotels, which are the focus of this study. Operational changes which both improve the sustainability performance of organisations, whilst also delivering ongoing operational cost savings with limited impacts to day-to-day operation most easily fit within this prevailing paradigm.

Decarbonising existing tourist accommodation buildings can be segregated into four elements: (1) Infrastructure and efficiency improvements, (2) Behavioural changes, (3) 'Greenification' of energy production and (4) Carbon offsetting (EY, 2021; IEA, 2021). Successfully integrating these elements involves multiple stakeholders; both hosts (hotel operators, management and staff), and guests. Implementing infrastructure and efficiency improvements, sourcing of renewable energy and carbon offsets fall predominantly within the domain of the host. Infrastructure and efficiency improvements include investment in resource efficient building systems, such as HVAC systems, lighting, controls among other measures. Investment in renewable energy includes onsite renewable energy systems and/or renewable energy power purchase agreements from sources offsite. Carbon offsetting examples include purchases of carbon credits. Behavioural changes on the other hand are particularly nuanced; these involve participation by all stakeholders in the day-to-day operation of tourist accommodation, particularly the guest. Encouraging environmentally friendly behaviour in tourist accommodation involves approaches such as nudging (altering choice architecture), increasing pleasure (rewards for desired behaviour), leveraging social norms (establishing expectations) and changing beliefs (providing information) (Coghlan et al., 2023; Dolnicar, 2020). All of these approaches have been studied in existing literature, with varying levels of success in efforts to reduce overall consumption. However, it remains unclear to what extent guests, as compared to hosts,

* Corresponding author.
E-mail address: s.macaskill@griffith.edu.au (S. MacAskill).

https://doi.org/10.1016/j.clrc.2023.100156
Received 26 July 2023; Received in revised form 7 November 2023; Accepted 29 November 2023
Available online 4 December 2023

are responsible for consumption. As a result, this study primarily focuses on investigating the potential benefits of behavioural change.

In this study, the focus is on framing the 'host-guest' relationship with regard to electricity, water and gas use in hotels. We examine this relationship in the context of agency theory, where the principal (host) delegates responsibilities to the agent (guest). The delegated responsibility in this case is framed as a request to use less resources, most commonly through behavioural changes. The agent is entrusted with making decisions and taking actions that align with the best interests of the principal. However, due to differing goals, information asymmetry, and self-interest, conflicts may arise between goals of the principal and the agent, resulting in agency costs. Agency costs are defined as inefficiencies caused by the disparate objectives of the principal and actions of the agent. In the context of this study, one agency cost in the host-guest exchange is discretionary resource usage by the guest above typical practices to fulfil a basic human need (i.e. excessive shower time or thermostat settings).

Whilst both principal and agent are responsible for resource consumption, is it important to identify where the largest resource reductions may be achieved by taking into consideration agency costs, and thus which stakeholder may achieve them. In effect, agency costs (in relation to water, electricity and gas use) will determine where best to direct behavioural interventions targeted towards the guest (or agent) to reduce operational resource use in hotels. Through examination of the influence of guest resource use on hotel consumption, host usage may also be better understood. This study aims to provide insight into contributions of guests (agents) to overall resource consumption in different hotel sizes. This knowledge can serve as a guideline to better direct resource reduction initiatives according to stakeholder groups. The following research questions are investigated:

- RQ1: What influence do guests have on the resource consumption of hotels within the case studies? Influence on electricity, water and gas consumption are ranked.
- RQ2: How does hotel size influence the agency costs associated with guest usage? A small and a large hotel are compared.
- RQ3: How can behavioural change strategies in hotels be optimised? Host and guest resource usage is organised into a matrix.

The study provides a unique and comprehensive quantitative analysis based on smart meter data of hotels of disparate sizes, in order to assist hotel operators, managers, and asset owners to understand guest influence on hotel electricity, water and gas use and enact evidence-based measures to reduce resource consumption.

The remainder of this paper is organised as follows. Section 2 provides an overview of the background information, encompassing a literature review of resource use trends in hotels and identifies the notion of agency theory as it relates to resource use within the tourist accommodation industry. Section 3 presents the research methodology and introduces the case studies. Section 4 outlines the results, contrasting the large and small hotel case study electricity, energy and water usage rates in relation to daily guest occupancy rates. Limitations of the study are also addressed. Section 5 engages with a discussion of the results; the impact of stakeholders on resource consumption categories are ranked. Finally, Section 6 concludes the paper with a review of the findings and implications.

2. Background

2.1. Resource use characteristics of hotels

Buildings consume high amounts of electricity, water and gas in their annual operations. Collectively, they account for approximately 28% of global energy-related greenhouse gas (GHG) emissions each year (UN, 2022). Hotels, in particular, are characterised with high resource use as compared to similarly sized residential and commercial buildings, however their consumption characteristics can vary significantly depending on location, size, amenity, star rating among other factors (Bohdanowicz and Martinac, 2007; Ricart et al., 2023, Önüt and Soner, 2006. Hotels often consist of multiple functional areas, including guest rooms, kitchen and dining areas, amenities for recreation, office space, business centres, conferencing facilities among other spaces (Yao et al., 2015). Several studies have suggested that energy and water costs in hotels amount to approximately 6–10% or more of a hotels' operational budget, whereby energy costs account for the lions share (60–70%) of that total (Becken, 2013; Coles, 2014; Energy Star, 2007).

The detailed breakdown of resource-consuming features in hotels differs; however, the highest-consuming elements are generally consistent across mechanically ventilated buildings that are similarly constructed. Both hosts and guests influence resource use in hotels, albeit to varying degrees. The breakdown of typical energy and water use, including the stakeholders which influence their consumption is outlined in Table 1 below. The highest electricity-consuming features in hotels include HVAC systems (cooling and heating) and lighting, which collectively account for over 50% of total consumption (Australia, 2012; EnergyStar, 2007). The highest water-consuming features include kitchens and public areas, showers, toilets, and taps in guest rooms. Showers account for the largest share of water consumption in guest rooms (Deng and Burnett, 2002; Kanako et al., 2016).

Considering that resource use in hotels is shared between hosts and guests, gaining insight into the specific allocation of resources and determining the stakeholders who wield the most significant influence within each respective category lays the groundwork for exploring strategies to reduce resource consumption. This exploration will be further examined towards the end of this section, with a focus on agency theory.

2.2. Pro-environmentalism in hotels

Pro-environmental action among guests and hosts has been assessed in existing literature. Guest resource consumption is the result of preferences and fulfilling social practices such as maintaining thermal comfort, showering, toilet and tap use (Warren et al., 2018a). Each action is associated with discretionary resource use by the guest, including decisions made by the guest on shower length, lighting time, and thermostat settings. Tourism has been found to be associated with hedonistic attitudes by guests (Juvan and Dolnicar, 2014), indicating that pro-environmental actions may have lower priority compared to guests' behaviours at home (Dolnicar et al., 2017). However there exists contrary research which suggests that pro-environmental actions can improve guest experiences (Warren et al., 2018b), and many actively seek out hotels which promote environmentally friendly credentials (Demir et al., 2021; Han et al., 2010, 2011). Guests who have been shown to engage with pro-environmental behaviour were found to act based on two dominant motivators: self-interest and self-concept (Bolderdijk et al., 2013; Evans et al., 2013; Lindenberg and Steg, 2007). As described by Dolnicar et al. (2017), self-interest goals aim to maximize personal utility, while a positive self-concept relates to individual moral norms and feeling good about oneself when engaging in environmentally friendly behaviour (Khan and Dhar, 2006; Sachdeva et al., 2009).

The literature extensively documents how resource use in hotels can be reduced through infrastructure and operational settings changes of equipment by the host. These include 'back of house' upgrades to energy and water-intensive building systems, such as HVAC chillers, pumps and heating systems, as well as implementing energy-efficient technologies like air economisers, heat and energy recovery ventilation systems, demand control ventilation, building automation systems, LED lighting upgrades, and controls (Barberán et al., 2013; Mechri and Amara, 2021; Raftery et al., 2018; Yao et al., 2015, Önüt and Soner, 2006). Another aspect includes infrastructure choices which provide guests with the ability to make pro-environmental choices whilst fulfilling basic needs, such as investment into ceiling fans, openable windows with flyscreens,

Table 1
Energy and water use breakdown in Australian hotels in 2012.

Energy use breakdown			Water use breakdown		
Category	Percentage	Stakeholder of Influence	Category	Percentage	Stakeholder of Influence
HVAC[a]	52%	Host & Guest	Kitchen & Public Areas	37%	Host
Lighting	20%	Host & Guest	Guest Showers	33%	Guest
Equipment	11%	Host & Guest	Cooling towers	25%	Host
Pool heating[b]	6%	Host	Guest Toilets	11%	Guest
Domestic hotwater[b]	2%	Host & Guest	Leaks & Unaccounted for	16%	Host
Other	9%	Host	Guest Ice Machines	4%	Guest
			Guest Sinks	4%	Guest
			Laundry	0%	Host & Guest

[a] Heating, ventilation and air-conditioning.
[b] Energy use breakdown for hot water is dependent on gas or electric hot water systems.
Source: (Australia, 2012; SPU, 2002)

hooks for hanging towels or display screens providing feedback on resource consumption (Warren et al., 2017).

2.3. Agency theory and costs in the context of resource reducing measures in hotels

Agency theory, as initially conceptualised by Jensen and Meckling (1976), analyses the relationship that develops in an exchange when an individual (the principal) concedes authority to another (the agent) to act in her or his name, so that the objectives of the principal are benefited by the decisions of the agent. According to the theory, separating ownership from control can result in costs (or inefficiencies) for the principal, known as agency costs. Agency costs arise because agents arguably pursue interests that do not necessarily coincide with those of the principal (Cuevas-Rodríguez et al., 2012). The theory has been used in a wide range of fields, including economics (Spence and Zeckhauser, 1971), finance (Fama, 1980), political science (Mitnick, 1975), organisational behaviour (Eisenhardt, 1985) and sociology (Pratt and Zeckhauser, 1985). Agency theory in a hotel host-guest relationship is arguably a symbiotic exchange, where the objectives of each stakeholder acting in the role of principal differ. A guest (as a principal) may enter into a financial agreement with a host (as an agent), with the objective of being provided with comfortable and enjoyable hospitality for an agreed timeframe. Conversely, a host (as a principal) may agree to engage with the guest (as agent), with the objective of financial, social or reputational gain supported by the actions and experience of the agent. In this study, we focus on the host-guest (principle-agent) exchange in the context of a broader decarbonisation strategy by the host (principle), and targeted requests for guest (agents) to use less energy, water and gas whilst staying in tourist accommodation.

Both hotel hosts and guests have an impact on resource use in tourist accommodations. However, measures aimed at reducing energy, water, and gas consumption have achieved varying degrees of success, resulting in agency costs for the host. In a systematic literature review of 94 studies investigating sustainability communication in tourism, it was determined that there is a current lack of understanding on how to design effective sustainability messages (Tölkes, 2018). Some existing measures include host efforts to communicate with guests to encourage towel reuse (Baca-Motes et al., 2013; Goldstein et al., 2007, 2008; Mair and Bergin-Seers, 2010; Reese et al., 2014), shower time reduction (Pereira-Doel et al., 2019; Tiefenbeck et al., 2019), mindful energy use (Wang et al., 2017; Warren et al., 2017) among others. These appeals target reductions in discretionary resource use among guests, but do not assess guest impact on hotel consumption overall. This paper argues that the agency costs involved in the host-guest relationship differ depending on the type of resource. Furthermore, it emphasises the importance of considering the distinct influences that hosts and guests have on energy, water, and gas consumption in hotels when designing effective wholistic sustainability measures to reduce resource use.

3. Research methodology

3.1. Research context

The study involves two Australian case study hotels that were recruited for a research project focusing on messaging and behavioural change within the hotel industry which started in 2020. Each case study represents a different category of tourist accommodation and contexts. The first case study (large hotel) is an inner-city hotel situated in Sydney's central business district. Constructed in 1999, this five-star hotel consists of 415 spacious guest rooms each with ensuite bath, shower, and toilet, in addition to conferencing facilities, 10 function spaces catering from 4 to 370 people, contemporary restaurant and bar indoor heated swimming pool, sauna, jacuzzi, steam room and day spa, and a 24-h concierge. The facilities are contained within 23,790m^2 of gross floor area (GFA) across 37 levels.

The second case study (small hotel) is a three-star hotel situated in the UNESCO listed World Heritage site of the Daintree Rainforest in north Queensland. The hotel offers 7 private cabins, set amongst the flora and fauna of the rainforest, including outdoor spa (plunge pool) and a small bar and restaurant on site. It is operated by live-in caretakers throughout the year. The cabins are approximately 24m^2 including ensuite shower, sink and toilet facilities. They have been originally constructed in 2001 and have been retrofitted with updated air conditioning, lighting and water fixtures in 2018.

Whilst the hotels differ in their assembly, the guest rooms share similar characteristics including size and amenity. Both hotels are served by domestic scale natural gas fuelled hot water systems. Table 2 includes a systems comparison between the two hotels.

3.2. Data

The case study hotels are graphed over a three-month period (December 2021–February 2022) to show the influence of daily ($n = 90$) occupancy rates on electricity, energy and water consumption. The total 'energy' consumption value is derived to address gas usage for guest hot water consumption, since both hotels operate on gas-fuelled hot water generation systems. Smart meters have been installed at both sites to measure ongoing energy and water consumption; the meters report consumption figures wirelessly to a cloud-based system in 15-min intervals. The incremental measurements through the day have been aggregated to produce a daily consumption figure for each case study. Occupancy data are collected through the hotels' booking management systems and has been linked to the daily consumption data. For a fair comparison between the large and small hotels, the energy and water consumption data presented in this study is reflective of the consumption figures of the hotel rooms only. Hotel amenity areas have been excluded.

The dataset was then analysed to determine the influence of hotel guests on resource consumption through a statistical correlation for each

Table 2
Hotel functional comparisons for the Australian case study.

Feature	Large hotel	Small hotel
General description	Large 37 storey luxury hotel located in the Sydney central business district. The hotel caters to business and vacationing clientele. The hotel is nestled in a block of similar sized skyscrapers of mixed uses, including office and residential towers.	Eco-resort located in the Daintree Rainforest. The resort includes 7 self-contained cabins, a restaurant and small plunge pool. Typical cabins are a simple wooden frame construction. Naturally ventilated with openable windows, curtains and a AC split-system. Single pane glazing, likely no roof/wall/floor insulation. Units are generally shaded under the rainforest canopy. Typical occupancy is 2 people.
Year constructed	1999	2001
Last major refurbishment	2012	2018
Hotel Star Rating	5 Star	3 Star
Gross Floor Area (Conditioned)	23,790m^2	218m^2
Guest Rooms	415 guest rooms	7 guest lodges (self-contained)
Hotel Amenities	Conferencing and Exhibition spaces Pool Spa Hot tub and Sauna Bar and Restaurant	Bar and restaurant (unconditioned) Plunge pool
In room amenities	Kettle (1L) Mini-fridge (70L) TV (45″) 2x bedside lamps 8x Ceiling downlights Iron Ensuite bathroom, including sink, toilet, bathtub and shower.	Kettle (1L) Mini-fridge (70L) TV (32″) 2x bedside lamps 6x Ceiling downlights Ensuite bathroom including sink, toilet and shower.
Room size(s)	Various sizes 32–52m^2	24m^2
Typical room rate	280-350$ AUD per night.	460-480$ AUD per night.
HVAC System	Variable refrigerant flow (VRF) system with Central Energy Plant (CEP) and in room Fan Coil Units (FCU) with occupant controllable thermostat. Cooling loads are serviced by the CEP. Heating loads are serviced by in room electrical heating element located within FCU. Set point (adjustable): 18–30 °C.	Split system air-conditioning unit 2.4kw. Automatic shut off after 2 h of continuous use (via a button located on the wall). Set point range (fixed): 22–24 °C.
Hot Water Supply	Domestic scale natural gas boilers in series serving hot water storage tanks.	Domestic on-demand hot water system serving each lodge. Natural gas fuelled.
Cold Water Supply	Mains water.	Natural bore water collected on-site.
Energy Supply	100% from electricity grid.	Off-grid. 17 kW Solar array, battery storage and 2x diesel generators.

resource type. As an additional data validation check, benchmarking of resource consumption against existing datasets was undertaken. The 'Hotel Sustainability Benchmarking Index' by Ricaurte et al. compiles resource consumption data from a global sample of hotels (Ricaurte and Rehmaashini, 2021); it was used as a primary basis for comparison. The benchmarking serves a dual purpose, firstly to situate the case study hotels within a broad sample of similarly located and sized hotels, and secondly to report on the performance of the hotels in this study in order to add to the body of literature on resource use profiles of Australian hotels.

3.3. Limitations

The study presents findings based on a limited sample size and geographic location of two case studies. Whilst the selected case studies are domestically distributed across varying climate zones which may share similarities with other countries (mild temperate and tropical), both examples are located in Australia and are subject to comparable jurisdiction with regard to building codes which influence electricity, energy and water consumption data. The small hotel case study represents a niche market segment, therefore the consumption distribution patterns may fall outside of a typical distribution of comparably sized hotels with similar amenity.

4. Results

4.1. Large hotel guest-room consumption

Figs. 1 and 2 assess the large hotel. In Fig. 1, hotel energy consumption is presented separately to electricity consumption; the delta between the two outputs represents the influence of the energy-water nexus for hot water consumption. Large hotel occupancy rates vary widely throughout the week. The lowest occupancy rate observed was 8%, peaking each weekend to upwards of 73%; on average, the occupancy rate was 25% during the study period. Electricity consumption per day (kWh) is shown to fluctuate across the days (minimum 4257 kWh to a maximum of 6170 kWh per day), however, does not present a clear trend with the occupancy rate. The average daily consumption was 5308 kWh, equating to a typical electricity spend of AUD $1,486[1] per day for all guest-room electricity consuming plant and equipment (ie. heating, ventilation and cooling (HVAC), lighting and electrical appliances), excluding hot water generation. Aggregate energy consumption, inclusive of hot water generation, increases the daily kWh consumption of the hotel by 10% on average. The maximum daily energy consumption in the period was 7102 kWh, equating to a typical energy spend of AUD $1,545[2] for servicing guest-room demands.

Fig. 2 presents the same occupancy data juxtaposed against the daily total water consumption data (litres). The water consumption rate for the large hotel is shown to statistically correlate with the weekly spikes in hotel occupancy. The maximum daily guest consumption in the sample period totalled 71,846 L; 25,669 L of the total comprised of hot water usage. The minimum daily guest consumption totalled 20,652 L; 6997 L of hot water usage respectively. The average water consumption per guest per day was 226 L.

4.2. Small hotel guest-room consumption

The small hotel guest-room consumption is presented in Figs. 3 and 4. Small hotel occupancy rates are generally high through the period, showing less predictable weekly fluctuations as compared to the large hotel case study. This is likely attributed to the small hotels' function as a vacation destination, whereby guests typically stay for leisure for several days, often extending into the weekdays. The average occupancy rate for the period was 82%, ranging from a low of 14% to a high of 100%.

Similarly, to the large hotel case study, electricity consumption per

[1] Based on a typical electricity cost of 0.28c\kWh. As quoted under 'AGL Business User Standing Offer' AER (2023). *Energy Made Easy*. Australian Energy Regulator. Retrieved May 5th from.

[2] Based on an average hot water consumption rate of 13,015 L of hot water per day attributed to guest room usage. An energy conversion rate of 0.17 MJ/L gas to hot water is applied. At the time of writing, the Sydney commercial spot price for a mains gas connection is AUD 18.99 $/GJ. The value is a function of electricity and gas cost combined, including an inefficiency factor of 44% to account for heat losses (Raftery et al., 2018)

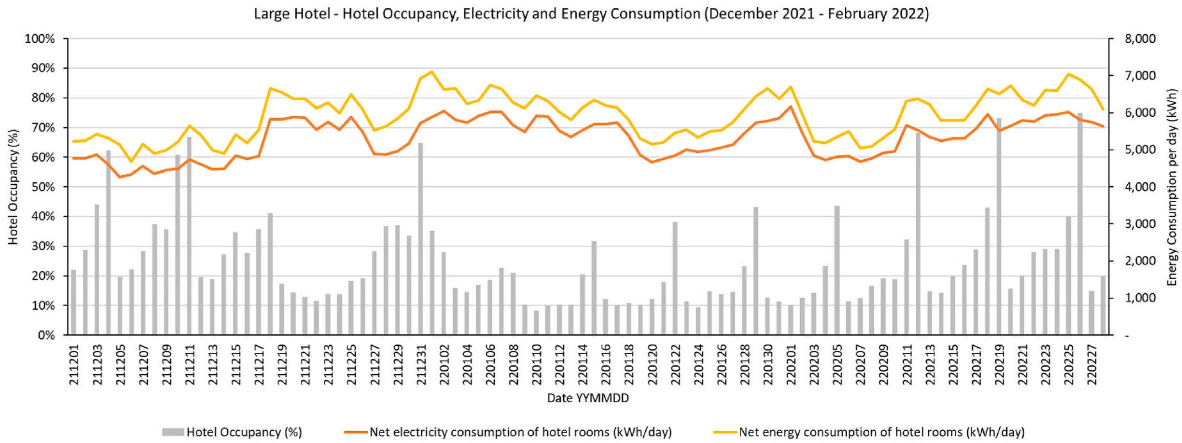

Fig. 1. Large hotel occupancy, electricity, and energy consumption.

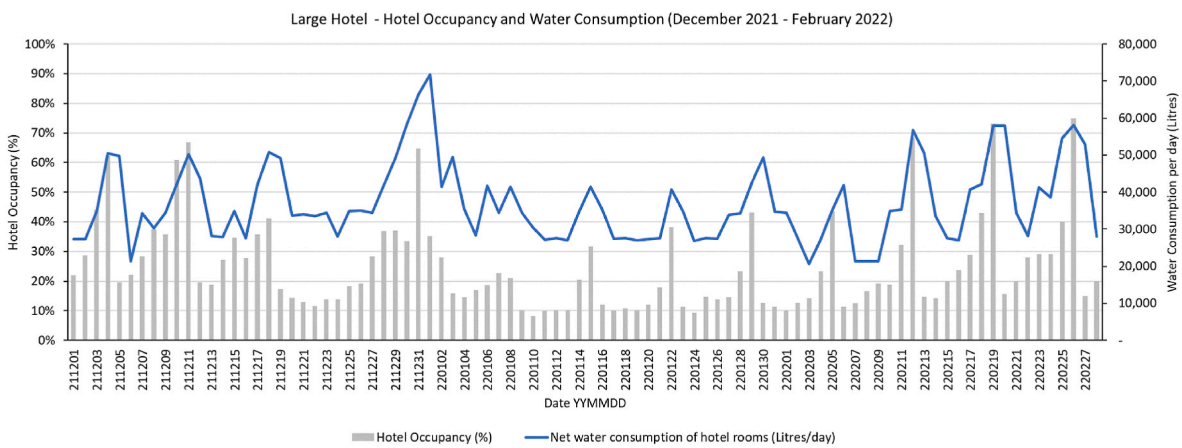

Fig. 2. Large hotel occupancy and water consumption.

day (kWh) is shown to fluctuate across the days (minimum 8 kWh to a maximum of 69 kWh per day) (Fig. 3). Again, electricity consumption does not present a clear trend with the occupancy rate. The average daily consumption was 16 kWh, equating to a typical electricity spend of approximately AUD $27[3] per day for all guest-room electricity consuming plant and equipment, excluding hot water generation. Aggregate energy consumption, inclusive of hot water generation, increases the daily kWh consumption of the hotel by 102% on average. The high impact of hot water generation in the small hotel case study is attributed to the comparatively low electricity demand from the decentralised split-system HVAC units equipped to each cabin. Guests at the small case study hotel are provided the option for natural ventilation through openable windows and ceiling fans, which are a preferred mode of air conditioning within the cabins. When considering the energy impact of hot water generation, the maximum daily energy consumption in the period was 79 kWh, equating to a typical energy spend of AUD $38[4] per day to service guest-room demands.

Fig. 4 shows the small hotel occupancy versus the guestroom water consumption. Similarly to the large hotel, the water consumption is shown to correlate with changes to the occupancy rate. The maximum daily guest consumption in the sample period was 1788 L; 762 L of the total comprised of hot water usage. The minimum daily guest consumption totalled 150 L; 60 L of hot water usage respectively. Water consumption rates per person are considerably lower in the small hotel case study, averaging 88 L per day per person.

4.3. Pearson Correlation Coefficient analysis showing comparable impact of occupancy versus resource consumption

A Pearson correlation and statistical significance analysis was undertaken to assess the relative impact of occupancy on electricity, energy and water consumption in both case studies. Occupancy rates are found to correlate with both electricity, energy and water consumption, however to varying degrees, as shown in Table 3.

Both the large and small hotel case studies demonstrate comparatively similar correlations regarding guest impact on hotel water consumption; Water consumption is highly correlated and is statistically significant with occupancy rates in both case studies.

In contrast, energy and electricity consumption correlation with occupancy is less pronounced between the hotel types. Occupant correlation to water consumption does not correlate with short term changes in energy use in the large hotel case study. A plausible explanation for this phenomenon is due to the design of the hot water system, which is centralised, and is reliant on large quantities of pre-heated water stored in insulated water tanks. The resulting impact on energy

3 Based on an electricity cost of 1.7$\kWh. The small hotel case study operates predominantly on diesel generators; therefore, the electricity cost is derived diesel consumption figures collected for the study.

4 Based on an average hot water consumption rate of 344 L per day attributed to guest room usage. An energy conversion rate of 0.17 MJ/L gas to hot water is applied. The local liquefied petroleum gas cost is $3.40/kg. A conversion factor of 25 MJ/kg is applied for LPG (ELGAS, 2023). The value is a function of electricity and gas cost combined, including an inefficiency factor of 44% to account for heat losses (Raftery et al., 2018).

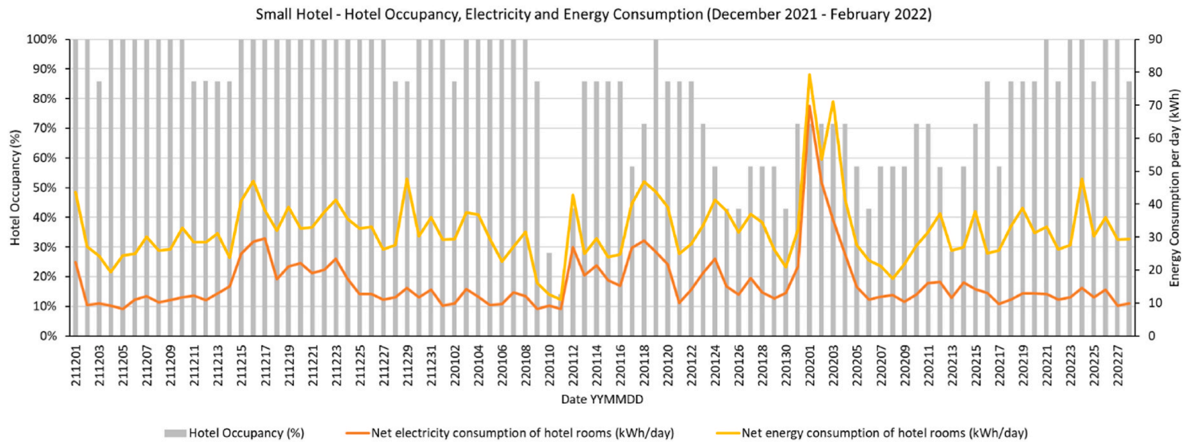

Fig. 3. Small hotel occupancy, electricity, and energy consumption.

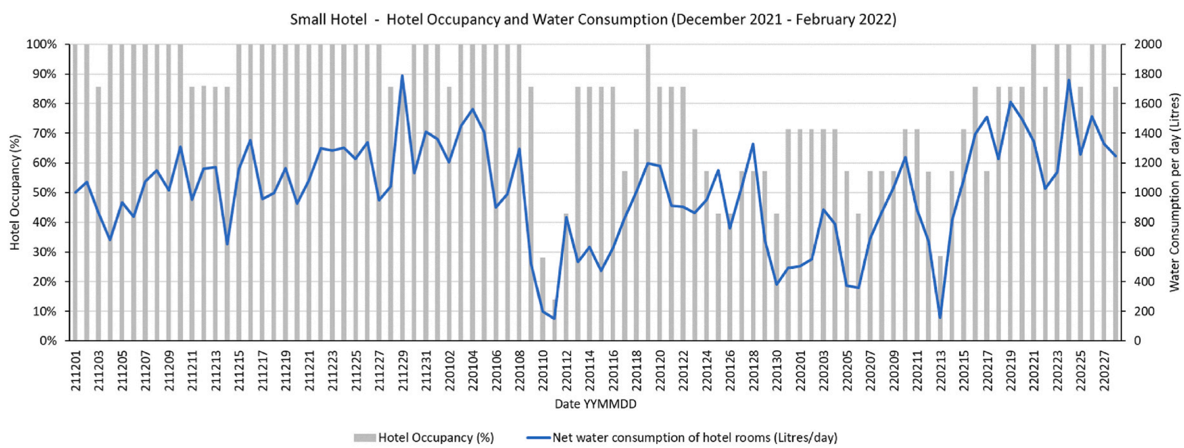

Fig. 4. Small hotel occupancy and water consumption.

Table 3
Correlation table of hotel occupancy and energy and water consumption for large and small case study hotels.

	Measure	1	2	3	4
Large hotel	1. Occupancy	–			
	2 Electricity Consumption	0.18	–		
	3 Energy Consumption	0.08	0.95***	–	
	4 Water Consumption	0.57***	0.28*	0.56***	–
Small hotel	1 Occupancy	–			
	2 Electricity Consumption	0.06	–		
	3 Energy Consumption	0.13	0.82***	–	
	4 Water Consumption	0.58***	0.17	0.28***	–

Note: $^*p < .05$, $^{**}p < .01$, $^{***}p < .001$, two-tailed, N = 90.

consumption is therefore delayed and disjointed from daily hotel occupancy rates, whereas electricity and water consumption are immediate. Small hotel energy consumption is weakly correlated to occupancy, however significantly more so than electricity, outlining the influence of the energy-water nexus, and the impact that guests have on hot water use.

There is no correlation between occupancy and electricity use in the small hotel case study and a weak correlation between electricity and occupancy in the large hotel case study. The results share similarities with findings from Yao et al. who investigated electricity usage and hotel occupancy in a sample of hotels in Shanghai. Their study revealed that, in order to maintain occupant comfort, core electricity-consuming hotel systems continued to operate as normal despite low occupancy (Yao et al., 2015). The results highlight the indeterminate nature of forecasting electricity demand for guests in the tourist accommodation sector, since electricity consumption is highly associated with building design characteristics of major systems, such as HVAC, lighting, appliances, and hot water generation.

4.4. Benchmarking electricity, energy, and water usage per guest

The hotel case studies have been benchmarked against comparable benchmarks in order to situate them in a wider context (Table 4). The large hotel performs within 2% of the reported benchmarks outlined within existing global databases, whereas the small hotel uses 83% less energy than the benchmark (Ricaurte and Rehmaashini, 2021).

5. Discussion

Resource conservation and efficiency are foundational starting points for decarbonising hotel buildings. Both hosts and guests are important to the transition. This study has outlined that water use is the primary resource where hotel guests have influence to reduce their consumption. In the context of agency theory, it is found that water use has the highest agency cost and therefore measures to engage with the guest to reduce discretionary water use should see the greatest reduction. Among the options for decarbonising hotel operations, investment decisions focused on infrastructure and efficiency changes are largely irrelevant to hotel guests, however behavioural changes are found to be effective tools in existing literature (Belz and Peattie, 2009; McKenzie-Mohr and Schultz, 2014). It is worthwhile to unpack the guest

Table 4
Case study benchmarking against the Cornell Hotel Sustainability Benchmark.

	Resource use per guest and per guest room			Comparable energy Benchmark[c]	Comparable water Benchmark[c]
	Electricity[a]	Energy[b]	Water		
Large hotel	35 kWh/day/guest 0.58 kWh/m^2 211.7 kWh/m^2/year	38 kWh/day/guest 0.70 kWh/m^2 255 kWh/m^2/year	226 L/day/guest	258 kWh/m^2/year[d]	449 L/day/guest
Small hotel	1.54 kWh/day/guest 0.10 kWh/m^2 36.5 kWh/m^2/year	3 kWh/day/guest 0.19 kWh/m^2 69 kWh/m^2/year	88 L/day/guest	167 kWh/m^2/year[e]	659 L/day/guest

[a] Electricity consumption only. This figure does not include a factor for gas use for hot water generation.
[b] Energy consumption inclusive of gas use. A conversion factor of 0.27 kWh per MJ of LPG gas has been applied.
[c] These benchmarks seek to match the case study hotels with similar amenity climate zone in accordance with the Cornell Hotel Sustainability Database (Electricity M6 & Water M8).
[d] Mean (all hotel – mild temperate climate).
[e] Mean (economy hotel in tropics). The calculation is based on energy data of 982 hotels located within 'Tropical', 'Tropical Monsoon' and 'Tropical Wet' climate zones. The benchmark represents the mean of the three climate zones. The climate zones are consistent with 'Zone A' (tropical or equatorial zone) of the Köppen-Geiger climate zone classification system.

experience with regards to discretionary resource usage during a typical hotel stay in order to understand the limitations of various strategies aimed at resource use reduction. Discretionary resource usage is defined as those resources used to fulfill a function beyond practices related to a basic human need (Warren et al., 2017), and is considered an agency cost in the host-guest (principal-agent) exchange.

The authors posit three reduction definitions which combine existing academic theories and practical research whilst also organising the agency cost of hotel stakeholder groups. The reduction categories are organised through the perspective of guest water use.

5.1. Reductions by design

Reductions by design involve changes to form and function to amenities which may influence guest behaviour indirectly. For example, a utilitarian bathroom design versus a luxurious design conducive to long stays and resource using behaviour. Reductions by design could be perceived as problematic in a hotel setting as they require creativity and innovation in order to maintain a high-quality guest experience. Research has suggested that the contrary can also be true, innovative design choices can add elements of novelty, delight and learning which has been shown to result in positive feedback by guests (Warren et al., 2017). The decision to invest in 'reductions by design' is within the remit of the 'host', namely the hotel operator, management and asset owner.

5.2. Reductions by infrastructure changes

Reductions by infrastructure changes involve technical characteristics of plant, equipment and fittings. Examples include fixture selections and hot water system design. As discussed in the background section, showers are one of the largest water consuming activities in hotel guest rooms (Deng and Burnett, 2002; Kanako et al., 2016). Water consumption for shower use is a function of fixture flow rates, water pressure and shower time. Fixture flow rates and water pressures are typically standardised within a range of acceptable performance criteria (such as Australia's WELS ratings); however, shower time is not standardardised, and is discretionary upon the user (guest). Investment decisions to invest in efficient water fixtures and associated infrastructure are within the remit of the hotel operator, management and asset owner.

5.3. Reductions by behaviour changes

Lastly, reductions by behaviour changes involve sustainability focused messaging or requests for users to change their behaviour to conserve resources. Examples of effective 'reductions by behaviour' include shower timers with the aim to raise awareness of guest shower time (Pereira-Doel et al., 2019). Drawing from Dolnicar (2020) approaches for designing environmentally friendly tourist behaviour, which include nudging (shower timers), increasing pleasure (prizes, vouchers), leveraging social norms (social reference points) and changing beliefs (provide information), a systematic literature review of existing studies which investigated behavioural change in hotels found that nudging was most consistently successful at delivering desired outcomes, followed by changing beliefs (Demeter et al., 2023). As shown in this study, meaningful reductions in water use by behavioural changes are dependent on discretionary usage of guests.

5.4. Ranking the effectiveness of interventions by resource and stakeholder

Based on the findings of the study, the effectiveness of resource reducing measures are ranked according to the stakeholder and decarbonising element in Figure 5. As shown in the image, the influence of the hotel guests is high in relation to reducing water consumption, followed by reducing energy consumption and electricity consumption. In the case of hotel management, operators and asset owners (hosts), the influence is reversed. Host involvement is important to reducing overall electricity consumption, followed by energy and water consumption.

6. Conclusion

The case studies presented in this paper provide insight into the influence that hotel guests, via hotel occupancy rates, have on electricity, energy and water consumption rates over a three-month operational period. It is found that hotel occupancy rates are highly correlated with water consumption, however show no correlation with net electricity consumption in the small hotel case study, and a weak correlation in the large hotel case study. Energy consumption is moderately correlated to occupancy by proxy of gas use for hot water generation.

The findings have implications for researchers, hotel managers, operators and asset owners seeking to engage with stakeholders, particularly guests, to reduce electricity, water, and gas/energy consumption in hotels. The effectiveness of various interventions to reduce resource use is dependent on influence of the stakeholder. For example, our findings demonstrate that initiatives (such as behavioural interventions, including messaging and nudging) to reduce water consumption are well placed with the guests. The influence of guest water and energy use (also commonly referred to as the energy-water nexus) is correlated in the case studies due to the use of gas-fuelled hot water systems, therefore 'guest-focused' strategies to reduce water use will also extend to reduced energy use. In contrast, electricity use is shown to fluctuate independently of hotel occupancy rates, therefore suggesting that guest

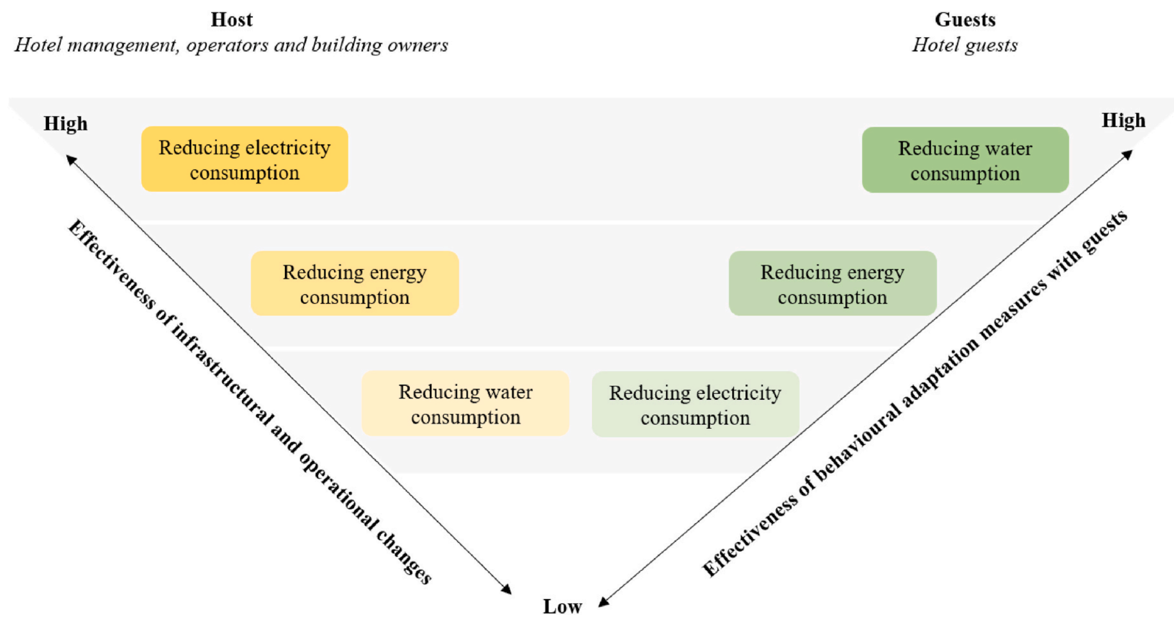

Fig. 5. Influence of key stakeholders towards reducing resource use in hotels.

behaviour has little effect on hotel electricity consumption. Reductions by design or infrastructure changes, including a review of operational settings may be considered in first instance. The results suggest that agency of electricity reducing measures is better placed with the hotel operator or asset owner to undertake a review of hotel electricity consuming systems in search of opportunities for reduction.

The results show that there is no suitable 'singular strategy' when embarking on a resource use reduction campaign in hotels. Strategies should first consider the influence of the various stakeholders involved, the targeted resource type and tailor the proposed intervention to suit. In the context of agency theory in reducing resource usage in hotels, the findings demonstrate that the agency cost associated with host requests for guests to use less resources are nuanced and differ by the targeted resource.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Susanne Becken reports financial support was provided by Australian Research Council.

Data availability

Data will be made available on request.

Acknowledgements

The authors would like to acknowledge funding support from the Australian Research Council (DP200100972), the case study partners, and technical support for the quantitative data collection by the project industry partner, WISE Sustainability.

References

AER, 2023. Energy Made Easy. Australian Energy Regulator. Retrieved May 5th from.

Australia, C. o, 2012. Baseline Energy Consumption and Greenhouse Gas Emissions in Commercial Buildings in Australia.

Baca-Motes, K., Brown, A., Gneezy, A., Keenan, E.A., Nelson, L.D., 2013. Commitment and behavior change: evidence from the field. J. Consum. Res. 39 (5), 1070–1084.

Barberán, R., Egea, P., Gracia-de-Rentería, P., Salvador, M., 2013. Evaluation of water saving measures in hotels: a Spanish case study. Int. J. Hospit. Manag. 34, 181–191. https://doi.org/10.1016/j.ijhm.2013.02.005.

Becken, S., 2013. Operators' perceptions of energy use and actual saving opportunities for tourism accommodation. Asia Pac. J. Tourism Res. 18 (1), 72–91.

Belz, F.-M., Peattie, K., 2009. Sustainability Marketing : a Global Perspective. John Wiley and Sons.

Bohdanowicz, P., Martinac, I., 2007. Determinants and benchmarking of resource consumption in hotels—case study of hilton international and scandic in Europe. Energy Build. 39 (1), 82–95. https://doi.org/10.1016/j.enbuild.2006.05.005.

Bolderdijk, J.W., Steg, L., Geller, E.S., Lehman, P.K., Postmes, T., 2013. Comparing the effectiveness of monetary versus moral motives in environmental campaigning. Nat. Clim. Change 3 (4), 413–416. https://doi.org/10.1038/nclimate1767.

Coen, D., Herman, K., Pegram, T., 2022. Are corporate climate efforts genuine? An empirical analysis of the climate 'talk-walk' hypothesis. Bus. Strat. Environ. 31 (7), 3040–3059. https://doi.org/10.1002/bse.3063.

Coghlan, A., Becken, S., MacAskill, S., 2023. Designing sustainability changes in a tourist accommodation context from a systems perspective. Front. Sustain. Tourism 2. https://doi.org/10.3389/frsut.2023.1289009.

Coles, T., 2014. Energy practices among small ? and medium?sized tourism enterprises: a case of misdirected effort? J. Clean. Prod. 111 (Part), 399–408.

Cuevas-Rodríguez, G., Gomez-Mejia, L.R., Wiseman, R.M., 2012. Has agency theory run its course?: making the theory more flexible to inform the management of reward systems. Corp. Govern. Int. Rev. 20 (6), 526–546. https://doi.org/10.1111/corg.12004.

Demeter, C., Fechner, D., Dolnicar, S., 2023. Progress in field experimentation for environmentally sustainable tourism - a knowledge map and research agenda. Tourism Manag. 94 https://doi.org/10.1016/j.tourman.2022.104633.

Demir, M.D.c., Rjoub, H.M., Yesiltas, M.S., Xue, B.E., 2021. Environmental awareness and guests' intention to visit green hotels: the mediation role of consumption values. PLoS One 16 (5).

Deng, S.-M., Burnett, J., 2002. Water use in hotels in Hong Kong. Int. J. Hospit. Manag. 21 (1), 57–66. https://doi.org/10.1016/S0278-4319(01)00015-9.

Dolnicar, S., 2020. Designing for more environmentally friendly tourism. Ann. Tourism Res. 84, 102933 https://doi.org/10.1016/j.annals.2020.102933.

Dolnicar, S., Knezevic Cvelbar, L., Grün, B., 2017. Do pro-environmental appeals trigger pro-environmental behavior in hotel guests? J. Trav. Res. 56 (8), 988–997. https://doi.org/10.1177/0047287516678089.

Eisenhardt, K.M., 1985. Control: organizational and economic approaches. Manag. Sci. 31 (2), 134–149.

EnergyStar, 2007. Energy Star Building Upgrade Manual Facility Type: Hotels and Motels. U. S. E. P. Agency. https://www.energystar.gov/sites/default/files/buildings/tools/EPA_BUM_CH12_HotelsMotels.pdf.

Evans, L., Maio, G.R., Corner, A., Hodgetts, C.J., Ahmed, S., Hahn, U., 2013. Self-interest and pro-environmental behaviour. Nat. Clim. Change 3 (2), 122–125. https://doi.org/10.1038/nclimate1662.

EY, 2021. Global Accomodation Sector: the Road to Net Zero Emissions. https://app.box.com/s/4ffylkg4jetbx98infh7wowd6l89m0hc.

Fama, E.F., 1980. Agency problems and the theory of the firm. J. Polit. Econ. 88 (2), 288.

Font, X., Walmsley, A., Cogotti, S., McCombes, L., Häusler, N., 2012. Corporate social responsibility: the disclosure–performance gap. Tourism Manag. 33 (6), 1544–1553. https://doi.org/10.1016/j.tourman.2012.02.012.

Garay, L., Font, X., Pereira-Moliner, J., 2017. Understanding sustainability behaviour: the relationship between information acquisition, proactivity and performance. Tourism Manag. 60, 418–429. https://doi.org/10.1016/j.tourman.2016.12.017.

Goldstein, N.J., Griskevicius, V., Cialdini, R.B., 2007. Invoking social norms: a social psychology perspective on improving hotels' linen-reuse programs. Cornell Hotel Restaur. Adm. Q. 48 (2), 145–150. https://doi.org/10.1177/0010880407299542.

Goldstein, N.J., John Deighton served as, e, Mary Frances Luce served as associate editor for this, a, Cialdini, R.B., Griskevicius, V., 2008. A room with a viewpoint: using social norms to motivate environmental conservation in hotels. J. Consum. Res. 35 (3), 472–482.

Gössling, S., Buckley, R., 2016. Carbon labels in tourism: persuasive communication? J. Clean. Prod. Part B 111, 358–369. https://doi.org/10.1016/j.jclepro.2014.08.067. Part B).

Han, H., Hsu, L.-T., Sheu, C., 2010. Application of the Theory of Planned Behavior to green hotel choice: testing the effect of environmental friendly activities. Tourism Manag. 31 (3), 325–334. https://doi.org/10.1016/j.tourman.2009.03.013.

Han, H., Hsu, L.-T.J., Lee, J.-S., Sheu, C., 2011. Are lodging customers ready to go green? An examination of attitudes, demographics, and eco-friendly intentions. Int. J. Hospit. Manag. 30 (2), 345–355. https://doi.org/10.1016/j.ijhm.2010.07.008.

IEA, 2021. Net Zero by 2050: A Roadmap for the Global Energy Sector.

Juvan, E., Dolnicar, S., 2014. The attitude-behaviour gap in sustainable tourism. Ann. Tourism Res. 48, 76–95. https://doi.org/10.1016/j.annals.2014.05.012.

Kanako, T., Takayuki, O., Yasutoshi, S., 2016. Water use patterns in Vietnamese hotels: modeling toilet and shower usage. Water 8 (3), 85. https://doi.org/10.3390/w8030085.

Khan, U., Dhar, R., 2006. Licensing effect in consumer choice. J. Market. Res. 43 (2), 259–266. https://doi.org/10.1509/jmkr.43.2.259.

Lindenberg, S., Steg, L., 2007. Normative, gain and hedonic goal frames guiding environmental behavior. J. Soc. Issues 63 (1), 117–137. https://doi.org/10.1111/j.1540-4560.2007.00499.x.

Mair, J., Bergin-Seers, S., 2010. The effect of interventions on the environmental behaviour of Australian motel guests. Tourism Hospit. Res. 10 (4), 255–268. https://doi.org/10.1057/thr.2010.9.

McKenzie-Mohr, D., Schultz, P.W., 2014. Choosing effective behavior change tools. Soc. Market. Q. 20 (1), 35.

Mechri, H.e., Amara, S., 2021. Investigation and analysis of energy and water use of hotel buildings in Tunisia. Energy Build. 241 https://doi.org/10.1016/j.enbuild.2021.110930.

Mitnick, B.M., 1975. The theory of agency : the policing "paradox" and regulatory behavior. Publ. Choice 24 (1), 27–42. https://doi.org/10.1007/BF01718413.

Önüt, S., Soner, S., 2006. Energy efficiency assessment for the Antalya Region hotels in Turkey. Energy Build. 38 (8), 964–971. https://doi.org/10.1016/j.enbuild.2005.11.006.

Pereira-Doel, P., Font, X., Wyles, K., Pereira-Moliner, J., 2019. Showering Smartly. A Field Experiment Using Water-Saving Technology to Foster Pro-environmental Behaviour Among Hotel Guests.

Pratt, J.W., Zeckhauser, R., 1985. Principals and Agents : the Structure of Business. Harvard Business School Press.

Raftery, P., Geronazzo, A., Cheng, H., Paliaga, G., 2018. Quantifying energy losses in hot water reheat systems. Energy Build. 179, 183–199. https://doi.org/10.1016/j.enbuild.2018.09.020.

Reese, G., Loew, K., Steffgen, G., 2014. A towel less: social norms enhance pro-environmental behavior in hotels. J. Soc. Psychol. 154 (2), 97–100.

Ricart, S., Villar-Navascués, R., Reyes, M., Rico-Amorós, A.M., Hernández-Hernández, M., Toth, E., Amelung, B., 2023. Water–tourism nexus research in the Mediterranean in the past two decades: a systematic literature review. Int. J. Water Resour. Dev. 1–27. https://doi.org/10.1080/07900627.2023.2207686.

Ricaurte, E.J., Rehmaashini, 2021. Hotel Sustainability Benchmarking Index 2021: Carbon, Energy, and Water.

Sachdeva, S., Iliev, R., Medin, D.L., 2009. Sinning saints and saintly sinners:the paradox of moral self-regulation. Psychol. Sci. 20 (4), 523–528. https://doi.org/10.1111/j.1467-9280.2009.02326.x.

Spence, M., Zeckhauser, R., 1971. Insurance, information, and individual action. Am. Econ. Rev. 61 (2), 380.

SPU, 2002. Hotel Water Conservation: A Seattle Demonstration [Report]. https://www.seattle.gov/documents/Departments/SPU/Documents/HotelWaterConservation.pdf.

Star, E., 2007. Energy Star Building Upgrade Manual Facility Type: Hotels and Motels. U. S. E. P. Agency. https://www.energystar.gov/sites/default/files/buildings/tools/EPA_BUM_CH12_HotelsMotels.pdf.

Tiefenbeck, V., Wörner, A., Schöb, S., Fleisch, E., Staake, T., 2019. Real-time feedback promotes energy conservation in the absence of volunteer selection bias and monetary incentives. Nat. Energy 4 (1), 35–41. https://doi.org/10.1038/s41560-018-0282-1.

Tölkes, C., 2018. Sustainability communication in tourism – a literature review. Tourism Manag. Perspect. 27, 10–21. https://doi.org/10.1016/j.tmp.2018.04.002.

UN, 2022. Global Status Report for Buildings and Construction. U. Nations. ISBN No: 978-92-807-3984-8. https://globalabc.org/sites/default/files/2023-03/2022%20Global%20Status%20Report%20for%20Buildings%20and%20Construction_1.pdf.

Wang, W., Krishna, A., McFerran, B., 2017. Turning off the lights: consumers' environmental efforts depend on visible efforts of firms. J. Market. Res. 54 (3), 478–494. https://doi.org/10.1509/jmr.14.0441.

Warren, C., Becken, S., Coghlan, A., 2017. Using persuasive communication to co-create behavioural change – engaging with guests to save resources at tourist accommodation facilities. J. Sustain. Tourism 25 (7), 935–954. https://doi.org/10.1080/09669582.2016.1247849.

Warren, C., Becken, S., Coghlan, A., 2018a. Sustainability-oriented Service Innovation: fourteen-year longitudinal case of a tourist accommodation provider. J. Sustain. Tour. 26, 1784–1803. https://doi.org/10.1080/09669582.2018.1511721.

Warren, C., Becken, S., Nguyen, K., Stewart, R., 2018b. Impact of a sustainability smart service on daily resource use in self-contained B&B style tourist accommodation. J. Clean. Prod. 201, 599–608. https://doi.org/10.1016/j.jclepro.2018.08.063.

Yao, Z., Zhuang, Z., Gu, W., 2015. Study on energy use characteristics of hotel buildings in shanghai. Procedia Eng. 121, 1977–1982. https://doi.org/10.1016/j.proeng.2015.09.195.