

Article

An Advanced Eco-Solution to Address the Excessive Consumption of Water, Electricity and Towels/Linen at Luxury Hotels/Resorts: An Incentive-Linked Smart Meter System to Influence Consumer Behaviors

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Abstract

Due to environmental challenges, the global luxury hospitality industry faces increasing pressure to reduce its consumption of natural resources while maintaining service quality. In this paper a conceptual study is conducted to identify three primary problems of the tourism industry and highlight their impact on sustainable water resources and ecosystems: excessive water, electricity and towel/linen consumption in luxury hotels and resorts. This paper proposes a solution that uses a digital smart meter system linked to guest rooms. It is activated upon check-in, and guest participation is optional. It uses tangible or intangible incentives—such as discounts upon departure for future stays or for hotel laundry/meals/beverages—that rationalize consumption without affecting the quality of basic services. This approach may be implemented either independently by a single hotel or collaboratively through strategic alliances among multiple hotels, thus enabling customers to redeem their incentives/credits at any participating property. Guests are grouped into three consumption levels: high-saving guests (high incentives), average-saving guests (average incentives) and third-level guests (low/below-average incentives). Adopting this approach helps luxury hotels/resorts reduce their operational costs and enhance their image by applying green marketing in practice. Moreover, this conceptual paper proposes the provision of badges, including international environmental certifications, to hotels that adopt this responsible approach. This mechanism is a modern model that directly benefits all involved parties: service providers, customers/guests, environmental organizations and the environment.

Keywords: sustainability; advanced eco-solution; smart meter system; incentive program; luxury hotels; luxury resorts; mobile application; guest eco-wallet; influencing consumer behavior



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1. Introduction

The global hotel industry plays a vital role in the tourism and economic development of many countries, but its high operational demands place significant strain on water and energy systems (e.g., [1,2]). Hotels consume considerably more sustainable resources per guest than the average household, largely because of guests' high expectations of comfort, cleanliness and luxury (e.g., [3–5]). Guests often overuse water and electricity through lighting and air-conditioning, and water consumption is inflated by long showers, excessive washing and frequent towel changes (e.g., [6,7]). The reputation of the hospitality sector

increasingly depends on its ability to operate responsibly and transparently regarding environmental issues, including the ways it encourages employees to engage in environmentally friendly behavior [8,9]. Therefore, addressing the overconsumption of water, electricity and towels/linen in hotels is both an environmental imperative and a strategic business priority (e.g., [10]).

Hotels are among the most resource-intensive service settings, as daily operations—from guest showers and room lighting to the laundering of towels/linen—demand substantial quantities of energy and water (e.g., [11–13]). Despite ongoing efforts to implement sustainability initiatives, many hotels struggle to find effective strategies that encourage guests to modify their consumption behaviors without compromising satisfaction or perceived service quality [14]. Traditional awareness campaigns, such as informational signage or environmental appeals, often yield inconsistent results, suggesting the need for more robust behavior change mechanisms [15].

Within this context, incentives have emerged as a promising tool for promoting pro-environment guest behavior. Incentive-based strategies—whether financial, experiential or symbolic—can reinforce desired actions by providing guests with tangible or intangible rewards for adopting sustainable practices (e.g., [16,17]). It is also feasible to implement an incentive policy that does not entail direct financial expenditures for the hotel(s), such as discounts, vouchers or loyalty points. Such a policy can encourage environmentally responsible guest behavior while incurring minimal operational costs (e.g., [18,19]). Prior research in marketing and environmental psychology has indicated that incentives can positively influence consumers' willingness to participate in conservation efforts by enhancing motivation, strengthening engagement and reframing sustainable actions as personally beneficial (e.g., [20,21]). Applying these principles to hotel settings offers a practical pathway for reducing resource consumption while maintaining high levels of guest satisfaction. However, the empirical understanding of how incentive structures can be designed and implemented effectively within hotels remains limited.

This conceptual paper aims to address a critical gap in sustainable luxury hospitality by exploring how incentive strategies can encourage hotel guests to reduce their consumption of water, electricity and towels/linen during their stay. Specifically, it examines both guest perceptions and hotel operational considerations to identify incentive mechanisms that use smart meter systems to be environmentally effective, operationally feasible and aligned with guest expectations. The objective is to evaluate the effectiveness of these technology-driven strategies and determine which types of incentives are most likely to promote sustainable behavior without compromising guest satisfaction. This study seeks to determine how digital technology-enabled incentives can be designed and implemented to effectively encourage hotel guests to reduce their consumption of water, electricity and towels/linen during their stay.

By addressing both practical and behavioral dimensions, this conceptual paper contributes to the development of evidence-based, technology-enabled approaches for integrating sustainability into luxury hospitality experiences. This paper also contributes to the sustainability and hospitality literature by highlighting the urgent need for effective environmental programs that guide guest behavior toward sustainability goals without compromising the quality of luxury hotel services. It further contributes by addressing a critical yet frequently overlooked issue: the active involvement of consumers and guests in sustainability pathways within luxury hospitality contexts, where the overconsumption of water, energy and towel/linen is particularly pronounced. Moreover, this paper adds value to ongoing debates on sustainable tourism and behavioral change by reframing guests as partners and collaborators in sustainability efforts, rather than as passive recipients of environmental policies and initiatives.

2. Methods

This paper adopts a conceptual and narrative literature approach, synthesizing the existing scholarship to develop theoretical insights rather than undertaking a systematic review (e.g., [22,23]). This work uses the existing guest/customer-based research on resource consumption and sustainability practices in the luxury hospitality sector, focusing on interventions for reducing water, electricity and towel/linen use. This narrative literature approach is designed not only to contextualize and articulate the research problem but also to critically examine the existing scholarship to identify key gaps in the field ([24,25]). It highlights the absence of comprehensive studies that integrate real-time feedback mechanisms, multi-resource monitoring and tiered incentive structures. By systematically revealing these limitations, this review underscores both the originality and the necessity of the present study (e.g., [26,27]).

This review considered English-language articles published between 1 January 2000 and 27 November 2025, and the primary sources used were peer-reviewed journal articles indexed in Scopus and Web of Science, ensuring that only high-quality and credible academic work informed the analysis. After applying the selection criteria and screening procedures, a total of 33 articles were identified as suitable for inclusion, and these studies formed the core evidence base for this work. This paper excluded engineering, medical/health, manufacturing and hotel employee/staff eco-behavior articles, as these domains were not pertinent to the research focus.

2.1. Literature Review Process

A structured search strategy was applied, combining keywords related to luxury hotels, resorts, resource consumption, water and energy conservation, towel/linen management, smart technologies and behavioral incentive programs. Articles were screened for relevance through a multistep process. First, titles and abstracts were reviewed to exclude irrelevant studies. This was followed by a full-text assessment to identify research directly addressing sustainable practices in hospitality and technology-driven behavioral interventions.

The literature was analyzed thematically, allowing for the identification of key challenges, patterns and gaps in current research. This method facilitated the synthesis of findings into a conceptual framework, highlighting the role of smart meter systems and incentive programs as clever solutions for reducing resource consumption without compromising guest experience. By focusing on high-quality, peer-reviewed sources and adopting a systematic analytical approach, this conceptual paper ensures rigor, reliability and relevance, providing a strong foundation for both theoretical insights and practical applications in sustainable luxury hospitality.

2.2. Literature Analysis Procedure

The author examined the identified articles through the process described in Section 2.1, concentrating on their content, the connections and compatibility between studies, their usefulness in providing relevant contextual information and their alignment with established philosophical research frameworks. The outcomes of these evaluations are presented in Table 1. The author then linked specific categories of contextual information to each conceptual framework, and these associations are also summarized in Table 1. For example, articles containing supportive contextual information were reviewed, and the results of these reviews are in Section 3. An analysis of the available literature revealed three major environmental issues related to the market of luxury hotels and resorts: the excessive consumption of water (e.g., [11,28]), excessive consumption of electricity (e.g., [12,29]) and excessive consumption of towels/linen (e.g., [30,31]).

Table 1. Summary of relevant guest-based articles.

Author/s	Journals	Identified Challenges/Consumptions	Types of Industries
[32]	Sustainability	Water	Hotels
[11]	Water	Water	Hotels
[14]	International Journal of Hospitality Management	Water	Hotels
[12]	Sustainability	Energy	Hotels
[10]	Journal of Cleaner Production	Water–energy	Tourist accommodation
[1]	Energy and Buildings	Energy and water	Hotels
[33]	International Journal of Hospitality Management	Water	Hotels
[3]	Sustainability	Water	Hotels
[34]	International Journal of Hospitality Management	Linen	Hotels
[6]	Urban Water Journal	Water	Hotels
[35]	Environment, Development and Sustainability	Energy and water	Hotels
[36]	Tourism Management	Towels	Hotels
[37]	Journal of Travel Research	Towels/electricity	Hotels
[29]	Journal of Cleaner Production	Electricity	Hotels
[2]	International Journal of Hospitality Management	Water	Hotels
[38]	Journal of Consumer Research	Towels	Hotels
[30]	Tourism Management	Towels	Hotels
[5]	Tourism management	Water	Not specified
[31]	Tourism Management,	Water	Hotels
[7]	International Journal of Hospitality Management	Water	Hotels
[39]	International Journal of Hospitality Management	Water	Hotels
[40]	International Journal of Hospitality Management	Water	Hotels
[13]	Journal of Business Research	Towels and linen	Hotels
[41]	Energy and Buildings	Electricity	Hotels
[42]	Applied Energy	Water/energy	Hotels
[43]	Cleaner and Responsible Consumption	Energy and water	Hotels
[44]	Energy and Buildings	Energy	Hotels
[45]	Science of The Total Environment	Energy	Hotels
[46]	Tourism Management	Water	Hotels
[47]	Sustainability	Water	Hotels
[48]	Journal of Environmental Management	Water	Hotels
[28]	Energies	Water	Hotels
[49]	Environment and Behavior	Towel	Hotels

3. Results

3.1. Excessive Water Consumption

The average water consumption of hotels in urban areas is high [39,46]. For example, refs. [37,43] showed that hotel water consumption exceeds that of home residences. According to [32], although some hotels have attempted to implement water-saving and sustainability measures, their water consumption still remains well above the international benchmark of 140 L per guest per night. Such high water consumption increases the burden on water sources, treatment systems, management and sustainable targets [32]. Hotels use water in various areas, such as guest rooms, laundry areas, gardens (irrigation), swimming pools and saunas and restaurants (e.g., [43,48]). Furthermore, many tourist destinations

known for having luxurious hotels, such as Qatar and the United Arab Emirates, suffer from a scarcity of usable water [50,51]. This pressure on water resources poses challenges for water suppliers, requiring further efforts to address these issues. This problem is exacerbated in the case of megacities, where water consumption reaches extremely high rates, such as in Tokyo, Shanghai, Beijing, São Paulo, Mexico City and Delhi ([42,52,53]; see Table 1).

Island hotels and resorts face increased issues regarding excessive water consumption because they rely on water desalination and transport, which double the cost and energy per liter of water consumed [54]. For example, a comparative study was performed on the carbon footprint of the energy and water consumed by three-, four- and five-star hotels in the Canary Islands (Spain), which use desalinated seawater. This paper links water/energy consumption to carbon footprints and therefore to environmental impact [35]. Ref. [55] focused on the Maldives, where the consumption and treatment of fresh water are a serious concern. This is because most luxury resorts rely on reverse osmosis desalination plants to meet high tourist demands [55]. According to [56], resorts in the Maldives tend to have high levels of water consumption and sewage per guest-night, which range from 600 to 800 L per guest-night. Desalination provides potable water, but it generates highly saline wastewater, which is typically discharged directly into the surrounding coastal waters [56]. This concentrated saline discharge can significantly compromise delicate coral reef ecosystems and near-shore marine life, which are vital for biodiversity and the protection of the country's natural coastline (see Table 1).

3.2. Excessive Electricity Consumption

Electricity is the largest energy source of hotels, especially most luxury hotels and resorts, and its uses include air-conditioning, lighting, heating and guests' personal devices [41,43]. One study examined the energy performance of 29 hotels in Singapore using survey data. Analyzing how building features and operations influence energy use, it found an average annual energy use intensity of 427 kW h/m². This work stated that all hotels use electricity and gas, and some also rely on diesel for generators or hot water. Weak correlations between electricity use and occupancy suggest a need for better energy management at low occupancy rates ([46]; see Table 1).

3.3. Excessive Towel/Linen Consumption

The excessive consumption of towels and linen is addressed in this section as it concerns both high water and electricity consumption. The washing and drying of towels and linen are among the most significant sources of water and energy waste in luxury hotels and resorts (e.g., [31,45]). Some field studies have demonstrated that towel reuse programs reduce laundry and water consumption in hotels [36]. Therefore, some hotels have adopted similar water conservation programs or other programs designed to reduce the number of towels used or the frequency of bed linen changes (e.g., once every two days). These methods can reduce water use and the number of washing and drying cycles [31,36]. Ultimately, this considerably reduces the amount of water and energy used and decreases the greenhouse gas emissions produced by operating washers and dryers (see Table 1).

Overall, the existing literature lacks comprehensive studies that integrate real-time feedback, multi-resource monitoring, and tiered incentive mechanisms tailored to luxury hotel guests. Consequently, there is a need for advanced approaches that employ tiered incentives while enabling guests to monitor their resource consumption in real time. Such methods can offer a wider range of promotional benefits and redeemable reward points, thereby encouraging more sustainable consumption behaviors among luxury hotel customers.

4. Importance of Conservation and Changes in Guest Behavior

4.1. Operational and Environmental Justifications

Resource conservation directly reduces the operating costs of luxury hotels/resorts and improves the efficiency of their energy, water and towel/linen use. It also fosters positive environmental initiatives and enhances their corporate image as environmentally responsible establishments. Implementing resource conservation strategies in luxury hotels and resorts serves as a critical mechanism for reducing operating expenditures by enhancing the efficiency of electricity, water and towel/linen management systems. Research indicates that electricity typically accounts for approximately 4% to 8% of total hotel revenues, yet the integration of energy-efficient practices—such as occupancy-based HVAC controls and smart lighting—can yield savings of 20% or more on these utility costs [57]. Similarly, water conservation initiatives, including the installation of low-flow showerheads and faucet aerators, have been documented to reduce daily room costs while maintaining guest satisfaction [58]. Overall, a significant portion of water consumption is influenced by guest behavior, such as lengthy showers, the use of many towels, daily towel changes and air-conditioning empty rooms. Ref. [43] indicated that engaging with guests about water consumption yields clearer results than technical campaigns alone. These savings are further bolstered by linen and towel reuse programs, which directly reduce laundry-related energy and water consumption, leading to a measurable increase in the property's financial performance and net operating income within the competitive hospitality landscape.

Beyond immediate fiscal benefits, environmental initiatives foster positive market perceptions and enhance the corporate image of luxury establishments. In the hospitality sector, pro-environmental practices and green certifications have been shown to command a measurable 'green premium,' as consumers increasingly associate sustainability with luxury quality. Empirical research by [59] indicates that while not all guests are willing to pay more, a significant segment of hotel guests with high levels of environmental concern express a willingness to pay premiums and more. Furthermore, rather than just a price increase, these initiatives drive financial value through increased booking intentions; for instance, ref. [60] found that favorable environmental images significantly strengthen brand loyalty and the intention to revisit. This environmental stewardship aligns with broader corporate social responsibility (CSR) objectives, which enhance stakeholder engagement and provide a differentiated competitive advantage in the high-end service market.

4.2. Challenges Hindering Current Strategies

Many luxury hotels and resorts implement environmental initiatives, such as information cards, posters and signs encouraging guests to reuse towels and conserve water, but these strategies largely fail to achieve the desired reductions in resource consumption. Traditional methods include the installation of low-flow fixtures, energy-efficient lighting and 'reuse your towel' signs, but these approaches expect guests to respond voluntarily without direct incentives. Despite the increase in environmental awareness campaigns, guests often prioritize comfort and convenience over sustainability, resulting in consistently high levels of towel replacement and water consumption. Similarly, efforts to reduce electricity consumption through key card systems face significant limitations. Many guests circumvent these systems by using duplicate key cards or leaving one card in the slot to keep the air-conditioning and lighting running while they are out of the room. Therefore, this conceptual paper proposes a proactive mechanism that uses incentives and intelligent monitoring (e.g., [31,36,37,43]).

5. Proposed Solution: Optional Electronic Incentive System for Guests

The existing literature has extensively addressed the topic of influencing consumer behaviors (e.g., [61–63]). Several methods have been developed. The most important ones include the use of direct incentives based on guest behavior [64–66]. Extrinsic customer incentives, such as discounts, vouchers and loyalty points, effectively modify consumer behavior by directly altering the perceived cost–benefit ratio of a purchase or action [67]. These mechanisms operate through economic and psychological channels. First, they enhance the perceived value of a good or service, making it more appealing and thus increasing the probability of immediate action [68]. Second, the perceived benefit often exploits phenomena such as present bias, in which customers overvalue the immediate reward (discount or point accrual) relative to the longer-term cost (e.g., [69,70]). Although incentive strategies have been examined in the prior literature and applied to influence or attract consumer behavior, the following section provides valuable insights into enhanced approaches that contribute more effectively to environmental sustainability programs and objectives.

5.1. *The General Concept of the Improved System Proposed in This Paper*

Upon check-in, guests are offered the option to participate in an environmental rewards program. The program activates a feature that tracks the water, electricity and towel use in each room. The daily water and electricity consumption are displayed against predefined limits, and towel use is calculated as the number of times towels are changed each day. Guests are assured that their participation will not influence the quality of essential services and that no penalties will be applied if use limits are exceeded. The program is intended solely as a voluntary contribution to environmental sustainability. Guests are also informed that they may withdraw from the program at any time. It is highly recommended that this system be integrated with a dedicated ‘Guest Eco-Wallet’ mobile application. This digital ledger serves as a central repository to quantify guest resource savings as ‘Eco-Credits’ or points, which are dynamically categorized into three performance tiers. Beyond guest engagement, this platform functions as a strategic B2B (Business-to-Business) promotional engine. For example, when offering rewards, such as third-party car rental discounts or local tour vouchers, the system generates a dual-benefit financial ecosystem. First, it provides a high-value incentive for guests to adopt sustainable behaviors. Second, it serves as a sophisticated branding tool for external service providers; these partners benefit from increased brand exposure and customer acquisition, while the hotel reinforces its image as a sustainability leader. In this context, the promotional features transcend mere rewards, acting as a collaborative marketing strategy that enhances brand awareness and equity for all stakeholders involved. Additionally, this mobile application can be administered and promoted either independently by a single hotel, collaboratively through strategic alliances among multiple hotels, or by internationally recognized environmental organizations such as the United Nations Environment Programme (UNEP) and/or the United Nations Development Programme (UNDP).

5.2. *System Overview and Core Functionality*

A. Technical Field and System Overview

This environmental system may leverage the advantages of the Internet of Things (IoT) and Information and Communication Technology (ICT) frameworks. It is mainly designed for the luxury hospitality sector and aims to harmonize high-end guest services with environmental stewardship by monitoring and influencing the consumption of water, electricity and towels/linens. However, non-luxury hotels/resorts can also benefit from the advantages of this technology. The system architecture is bifurcated into two essential com-

ponents: (1) a calculation component and (2) a digital receiving component. The first aspect consists of hardware sensors installed within each guest suite to track resource usage. The second component is a centralized software platform that receives this raw data, calculates consumption rates and converts them into tiered performance levels linked directly to the guest's profile. The second component is linked directly to the hotel reception desk via a digital platform managed by front office staff. This platform can be seamlessly integrated into the hotel's Property Management System (PMS) or operated as a standalone system. As mentioned earlier, participation is entirely voluntary, and the system is designed to be non-punitive, ensuring that luxury service standards are never compromised regardless of a guest's resource usage. Furthermore, guests can withdraw from the program at any time.

B. ICT Architecture and Concrete Technologies

To operate effectively within a luxury environment, this system employs a sophisticated ICT infrastructure characterized by high precision and low interference.

- Water consumption: Any water-based sensing technology can be used, such as hardware calculation layers where water consumption is monitored via ultrasonic flow meters that measure liters (L) without impacting water pressure.
- Electricity consumption: Electricity usage is tracked through smart sub-meters capable of measuring real-time kilowatt-hours (kW h).
- Towel and linen consumption: This can be calculated using radio frequency identification (RFID) tags embedded into fabrics and tracked by scanners located in bathrooms or laundry chutes to record daily replacement frequencies. Alternatively, it can be calculated manually by housekeeping staff during their routine daily bathroom cleaning and preparation procedures.
- Network and integration: Data is transmitted from the room to the hotel's backend via a Low-Power Wide-Area Network (LPWAN), Zigbee mesh or any other appropriate technology, ensuring that the system does not compete with the guest Wi-Fi for bandwidth. This data is then fed into an API-driven integration layer that bridges the building management system (BMS) with the Property Management System (PMS), allowing the hotel to synchronize room data with guest identities securely.

C. The Operational Mechanism and the Five-Stage Guest Journey

The system's influence on consumer behavior is facilitated through a transparent five-stage process. At 'check-in', guests are offered the option to participate in the environmental program. Once consent is granted, the activation stage begins, initializing the in-room sensors. In the 'third stage', the system activates the feedback interfaces, including the in-room TV, door-mounted meters or a dedicated 'mobile application', displaying instant water, electricity and linen metrics. Automated monitoring follows, where sub-meters transmit data to the reception desk's management software. Finally, the 'issuance stage' occurs at the end of each day or stay, where a summary of use is provided alongside a 'reward record' for redemption. More details about these five processes are presented in Section 5.3 (below).

D. The Guest Eco-Wallet and Behavioral Incentive Tiers

The core behavioral driver of this environmental system is the 'Guest Eco-Wallet', a digital ledger within the mobile app that categorizes guests into three consumption tiers based on predefined 'normal use' limits.

- Economic Consumption (High-Saving): Guests who significantly conserve resources receive 'Generous Rewards,' such as vouchers for fine dining, free island tours or substantial discounts on future stays.

- Normal Consumption (Average-Saving): Guests that meet standard targets are categorized as average-savers and receive ‘Average Rewards,’ including beverage vouchers or laundry credits.
- High Consumption (Below-Average): Guests that exceed limits receive ‘Base Rewards’ or simple participation badges.

This tiered approach uses tangible incentives to nudge guests toward more sustainable habits without the use of penalties.

E. Data Security and Privacy Safeguards

Given the granular nature of the data collected, the system can incorporate any strict privacy-by-design security protocol. For example, all data transmissions can be protected by the Advanced Encryption Standard (AES) (such as using AES-256 end-to-end encryption to prevent unauthorized access [71]). Furthermore, the system utilizes AES-256, a widely adopted benchmark used to secure sensitive data across financial, healthcare and government sectors. Its 256-bit symmetric key provides extremely strong protection while enabling fast and efficient encryption and decryption, making it well suited for IoT applications such as smart metering systems. Also, data tokenization can be used where consumption statistics are linked to a temporary digital token rather than the guest’s legal name or private details. This ensures that while the system can reward the guest, their specific behavioral patterns are decoupled from their permanent identity and are purged from the active server upon checkout. This ‘Zero-Risk’ architecture ensures that guest privacy is maintained at a luxury standard while fostering a transparent environment for sustainable contributions.

5.3. Operational Flow and Operation Mechanism

As mentioned earlier, in this incentive program, daily consumption limits are specified for normal use, and actual consumption is accordingly categorized into three levels: economic consumption (generous rewards), normal consumption (average rewards) and high consumption (below-average incentives; see Figure 1).

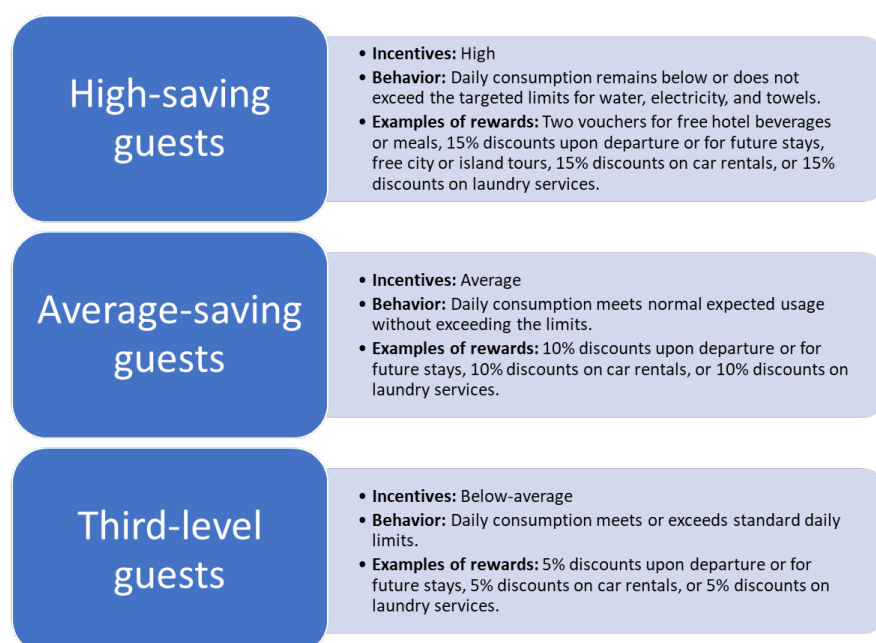


Figure 1. Guest categorization and incentives based on resource-saving behavior.

The operation mechanism consists of five main stages (see Figure 2). The first step is the guest agreement upon check-in. The second step involves program activation in the guest room, and the third step is the activation of the in-room display or smart meter systems with mobile applications. To influence guest behavior and ensure that the reward system is transparent and clear, the hotel should place a screen for guests that displays the levels of their water, electricity and towel consumption. For example, this system can be linked to the in-room TV screen, or a simple meter can be installed on room doors to display use rates. Another option is to link smart meter systems to mobile applications. The following data can be displayed to the guest: room number, instant consumption of water (L), instant consumption of electricity (kW h) and daily replacement of towels/linens. The fourth step involves automated monitoring. The room's sub-meters are linked to the building management system at the reception desk through specified software data. The fifth step comprises the issuance of a reward record at the end of each day/stay and informing the guest about reward redemption options. At the end of the guest's day/stay, a summary of their use and the assigned reward is provided. These rewards can include vouchers for hotel beverages or meals, discounts upon departures or for future stays, free city or island tours or discounts for car rentals or laundry services.

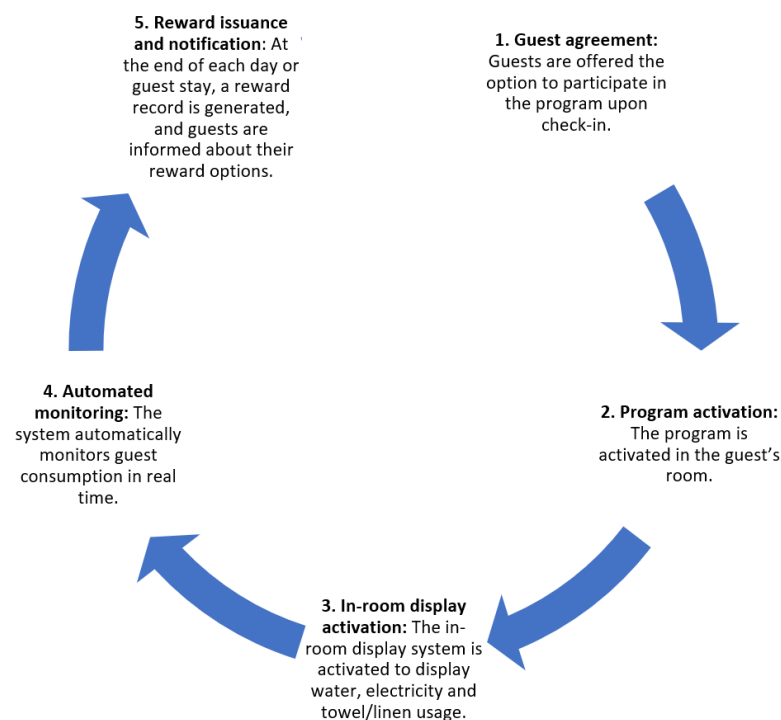


Figure 2. Operational flow of the proposed environmental rewards program.

5.4. Implementation Requirements

The implementation of the smart meter system involves several key steps to ensure its effectiveness and user acceptance. First, daily consumption limits are established in accordance with realistic and context-specific criteria, allowing hotels and resorts to manage resources without compromising guest comfort. Second, staff members receive comprehensive training on system operations, ensuring that they can effectively monitor use, respond to alerts and support guests in sustainable practices. Third, strict measures are implemented to protect the confidentiality and privacy of guest data, maintaining trust and complying with data protection regulations. Finally, the system features a simple and visually appealing display interface, which is designed to provide clear feedback to staff and guests, thus encouraging engagement and facilitating behavioral change. Together,

these steps create a robust framework for promoting sustainable resource consumption while maintaining operational efficiency and guest satisfaction (see Figure 3).

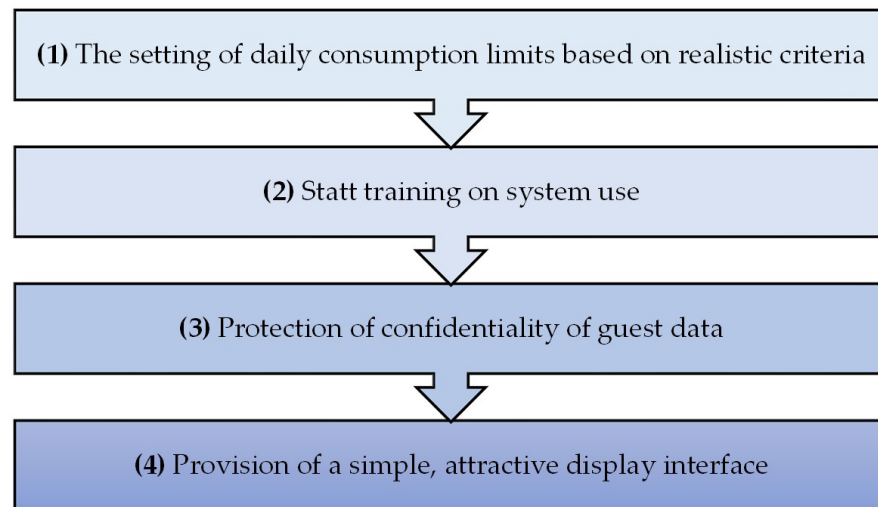


Figure 3. Implementation requirements/processes.

6. Benefits for Luxury Hotels and Resorts

6.1. Operational Benefits

The proposed smart meter system offers substantial operational benefits by enabling luxury hotels and resorts to monitor and manage water, electricity and towel/linen consumption more efficiently (e.g., [70]). Through real-time data collection and analysis, the system enables management to identify patterns of excessive use, detect inefficiencies and implement timely corrective measures. As a result, the overall resource consumption is reduced, directly lowering utility and laundry expenses while enhancing cost control [72]. In addition, by preventing unnecessary strain on equipment—such as water heating systems; heating, ventilation and air-conditioning units; and laundry machinery—the system contributes to the extension of asset lifespans and minimizes unexpected breakdowns [73]. This reduction in operational stress leads to fewer service interruptions and less downtime, thus supporting smoother day-to-day operations and improved service continuity across the hotel or resort.

6.2. Environmental Certification and Green Marketing

Participating luxury hotels and resorts can obtain environmental certifications from organizations such as (1) the Intergovernmental Panel on Climate Change, (2) the United Nations Framework Convention on Climate Change, (3) the World Water Council and (4) the World Health Organization (e.g., [74,75]). These certifications enhance a hotel's reputation and establish it as a 'certified green hotel', boosting its marketing capabilities.

6.3. Community Sustainability

Reducing resource consumption in luxury island hotels supports the sustainability of local ecosystems and communities [76]. The efficient use of water, energy and towels/linens helps protect sensitive environments, such as coral reefs and freshwater aquifers, while minimizing the ecological footprint of the tourism industry [77]. These practices promote long-term environmental resilience and foster positive engagement with local stakeholders, aligning tourism development with both conservation and community wellbeing [78].

6.4. Guest Satisfaction and Competitive Advantage

The optional and interactive smart meter system proposed in this study is likely to enhance guest satisfaction by enabling positive participation in sustainability initiatives. Coupled with awards and rewards, it creates a sophisticated, modern hotel experience that reinforces luxury service while promoting eco-friendly behavior [79]. This approach provides hotels with a competitive advantage, strengthening brand reputations in an increasingly environmentally conscious market [80].

7. Implications for Luxury Hotels and Resorts

7.1. Managerial Implications

The proposed smart meter system with incentive programs provides luxury hotels and resorts with a practical tool to reduce their excessive consumption of water, electricity and towels/linen without compromising service quality. By segmenting guests according to their consumption levels and offering tailored rewards, hotels can lower operational costs, optimize resource management and strengthen their brand reputation through demonstrable sustainability practices (e.g., [81,82]). This approach demonstrates that environmentally responsible measures can be seamlessly integrated into premium hospitality experiences.

7.2. Consumer Behavior Implications

The system uses behavioral incentives to encourage voluntary reductions in resource use, highlighting how subtle reward mechanisms can effectively influence guest behavior [80]. By promoting responsible consumption, hotels can foster long-term sustainable practices among guests, demonstrating that eco-friendly behavior is compatible with luxury service standards [83].

7.3. Environmental and Societal Implications

The widespread implementation of this solution could result in measurable reductions in water and energy consumption, contributing to the preservation of local ecosystems and a lower ecological footprint for the luxury hospitality sector. Recognition programs and environmental certifications for participating hotels may incentivize broader adoption, amplifying positive economic, environmental and societal effects [76].

7.4. Research and Policy Implications

This conceptual paper provides a framework for further research on technology-driven, incentive-based interventions in consumer-focused industries. Policymakers and environmental organizations can use these findings to support similar initiatives through certifications, grants or policy incentives, demonstrating the value of combining technological innovation with behavioral strategies to achieve sustainable outcomes.

8. Discussion and Limitations

8.1. Challenges of Privacy and Guest Participation

The efficacy of a smart meter framework in luxury hospitality is inherently contingent upon navigating the ‘privacy paradox,’ where guests express significant concern over real-time monitoring and data surveillance despite the potential for personal or environmental gain (e.g., [84–86]). To mitigate these hesitations, the integration of social and material incentives is essential, as tangible rewards can effectively offset perceived privacy risks by recalibrating the user’s internal cost–benefit analysis (e.g., [87]). Furthermore, the implementation of global environmental advocacy programs, such as the United Nations Environment Programme’s (UNEP) ‘ActNow’ campaign or the UN Tourism (UNWTO) sustainability initiatives, can significantly reduce ‘fear of monitoring’ concerns by reframing

data collection as a collective ethical contribution rather than individual surveillance. However, addressing these concerns at a technical level requires a ‘privacy-by-design’ model, utilizing robust anonymization schemes like differential privacy to ensure that consumption patterns cannot be traced back to individual identities (e.g., [88]). Ultimately, establishing genuine informed consent through clear disclosures regarding data encryption is crucial for building the institutional trust necessary for long-term scheme acceptability and sustained guest engagement (e.g., [89,90]).

8.2. Failure Challenges and Proposed Strategies

This environmental initiative/program, like any other, is subject to both success and failure in the pursuit of achieving its intended goals. For example, there may be resistance or low participation among certain guest groups, and the desired behavioral changes may not be achieved due to weak or poorly communicated incentives. This paper offers some suggestions for addressing failure should it occur. First, hotel operators can exempt program participants from the environmental tax applied by some hotels and resorts, especially targeting first- and second-tier guests who have already achieved savings in water and electricity consumption. Second, hotel and resort operators can increase the value of discounts and benefits offered to guests, making participation more attractive and rewarding. Redemption options can also be expanded to include additional services such as restaurants, gift shops and other on-site amenities. Third, promotional efforts can be strengthened by broadening the scope of environmental campaigns and placing advertising materials in prominent and visible locations for guests. Finally, regular feedback mechanisms, such as surveys or digital engagement tools, can be implemented to monitor guest perceptions and preferences, allowing operators to adjust the program in real time to improve participation and effectiveness.

8.3. Challenges of Technical Costs and Return on Investment

The proposed system requires an initial investment in meters, screens and training, but this can be recouped through resource savings in the medium term. Environmental organizations can be involved in this transition, during which they can offer free goods or services, such as free measuring devices. Based on the hotel size, occupancy and guest participation, such investments can yield positive returns within a few years, highlighting the practical and economic viability of the proposed scheme. Implementing smart metering and incentive schemes in luxury hotels requires an initial investment in devices, installation, software and staff training. However, this investment can be recouped through long-term reductions in energy and water consumption. To estimate the financial viability of the proposed scheme, we suggest a simple return on investment (ROI) framework, as shown in the formula below, where net savings from resource reductions are compared to the initial investment, allowing hotel managers to estimate payback periods and assess financial feasibility:

$$\text{ROI (\%)} = (\text{Net Savings from Energy/Water Reduction} - \text{Initial Investment Cost}) / \text{Initial Investment Cost} \times 100$$

8.4. Challenges of Maintaining Service Quality

Ensuring consistent service quality is essential, regardless of a guest’s participation in the incentive program. All guests should receive the same level of attention, comfort and hospitality; program participation is entirely voluntary and non-intrusive. Clear communication can be facilitated through multilingual informational materials, in-room instructions and direct explanations from staff, ensuring that guests understand the program without compromising their experience. By integrating the system seamlessly into existing services,

hotels can promote sustainability initiatives while maintaining high standards of service and guest satisfaction.

8.5. Monitoring and Evaluation Challenges

One of the challenges of this system is the periodic measurement of performance indicators. The effective implementation of the smart meter system requires the systematic monitoring and evaluation of key performance indicators. Metrics such as guest participation, resource savings, guest satisfaction and financial and environmental returns should be tracked regularly to assess both short-term outcomes and long-term behavioral changes. Continuous evaluations allow hotels to identify areas for improvement, adjust incentive structures and ensure that the system remains effective, adaptive and aligned with sustainability and service quality objectives.

9. Future Research and Conclusions

As this study is primarily conceptual, several avenues for future empirical investigations are suggested to validate and extend the proposed framework:

First, future research should empirically investigate the willingness of luxury hotel guests to participate in these environmental programs. Second, it is essential to explore the hotel management's intentions and strategic attention in regard to adopting such a program. This includes investigating internal drivers—such as corporate social responsibility (CSR) goals and cost reduction motives—and perceived barriers, such as initial capital investment, staff training requirements and potential disruptions to the luxury guest experience. Third, comparative pilot studies between participating and non-participating guest rooms are recommended to provide robust quantitative evidence of the system's impact on the consumption of water, electricity and linens.

Fourth, researchers may examine how the incentive program performs across hotels of different categories, sizes and service models, as well as in diverse climatic regions, to identify context-specific adaptations. Fifth, longitudinal studies are necessary to assess whether behavioral changes persist over time—both during repeated stays at the same property and across multiple hotel brands. Sixth, comprehensive economic and operational analyses should evaluate returns on investment (ROIs) and potential effects on guest spending to offer a clear view of the system's commercial feasibility. Seventh, investigating the psychological mechanisms underlying guest participation, specifically the differential effects of monetary versus non-monetary incentives, could enhance engagement strategies. Finally, research into advanced technology integration—such as linking smart meters with AI-driven analytics and gamification—could further optimize guest interactions and provide the real-time feedback necessary to enhance sustainability initiatives.

In conclusion, the excessive consumption of water, electricity and towels/linen at luxury hotels and resorts is a significant environmental challenge. Engaging guests in conservation efforts through an electronic incentive mechanism is a pioneering step towards sustainable hospitality. This conceptual paper presents an advanced and improved solution that employs voluntary guest participation. It involves an interactive digital system that tangibly/intangibly rewards environmentally responsible behavior. It demonstrates that the challenge lies not only in technology and efficiency but also in changing guests' behavior to make them partners in environmental responsibility. This system balances guest comfort with environmental responsibility, delivers tangible financial savings and enhances a hotel's standing as a modern, environmentally responsible establishment. Integrating technology, incentives and transparency into the guest experience makes this solution a practical model for implementing the principles of responsible tourism in the twenty-first century.

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