

ASSESSING THE ENVIRONMENTAL IMPACT OF SMART HOMES

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Abstract: *This study examines the potential of smart homes to contribute to sustainable living by evaluating their environmental impact and resource efficiency. Through a comparative analysis, we assess energy efficiency, renewable energy integration, automation capabilities, sustainable materials, life cycle assessment and cost-benefit considerations. Valuable information about the viability of smart houses as ecologically clean housing solutions for a more sustainable approach to modern life was revealed.*

Key words: *remote control and scheduling, reduced energy consumption, optimize setting*

JEL: Q4, O3

1. Introduction

The concept of the "smart home" has gained significant traction in recent years, offering homeowners a range of technological innovations to enhance convenience, security, and energy efficiency. These homes are equipped with various sensors and devices that collect data on energy consumption, temperature, humidity, and more. This constant data stream can be harnessed not only for optimizing comfort and convenience but also for increasing environmental awareness. Residents can access real-time information about their resource usage, carbon footprint, and environmental impact.

By equipping with cutting-edge technologies the automation systems, promises improved comfort, convenience, and energy efficiency for homeowners. However, alongside these advantages, it is essential to examine the environmental consequences of this technological transformation. This study presents a comparative analysis of the positive and negative environmental impacts of smart homes.

2. Main perspectives

The smart home electricity service system is mainly composed of a main station system, a communication channel, a home intelligent interactive terminal and smart electric devices (Lin et al., 2018)

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Real-time Data for Environmental Awareness. This real-time data serves as a powerful educational tool. It can help individuals and families understand the immediate consequences of their lifestyle choices on the environment. For example, seeing a spike in energy consumption during peak hours or noticing excessive water usage can encourage people to take immediate actions to reduce their impact.

Customized Environmental Goals. Another key aspect is the ability of smart homes to set and monitor customized environmental goals. Residents can establish targets for reducing energy consumption, water usage, or waste generation. Smart home systems can then provide suggestions and automate adjustments to help achieve these goals.

For instance, if a homeowner sets a goal to reduce electricity consumption by 20%, the smart home system can automatically optimize lighting, heating, and cooling, or suggest changes in usage patterns. This personalization encourages more sustainable living practices, as it tailors recommendations to each household's unique circumstances.

Contribution to Smart Grids and Energy Efficiency. Smart homes do not exist in isolation; they can be part of broader smart grid systems. These interconnected systems can communicate with utilities and grid operators to optimize energy usage for entire neighbourhoods or communities. When smart homes collectively adjust their energy consumption based on grid demands, it can reduce the need for bigger plants and inefficient energy generation methods.

This integration into smart grids contributes to overall energy efficiency, lowers greenhouse pollutions, and promotes renewable energy adoption. It is an essential step towards building a more sustainable and resilient energy infrastructure.

Feedback Loop for Sustainable Choices. Intelligent environments can create a feedback loop that encourages sustainable choices. By providing immediate feedback on resource consumption and environmental impact, residents become more conscious of their decisions. Over time, this can lead to behavioural changes, such as reduced energy waste, more efficient appliance usage, and better recycling practices.

The increasing use of renewable energies sources in new buildings (either private or public) into the growing smart grids will be the most significant and effective means of decreasing CO₂ emissions to the atmosphere.

Moreover, data from smart homes can be anonymized and aggregated to provide valuable insights to policymakers and urban planners. This data can help in designing more eco-friendly cities and regions by identifying areas with high resource consumption and guiding targeted interventions.

The importance of smart home design in the context of mitigating the negative environmental impacts of smart homes cannot be overstated. Smart

home design plays a pivotal role in determining how efficiently and sustainably a smart home operates. In Table 1 are several key reasons why smart home design is essential in this context.

Table 1. Relative importance of smart home design factors considering user perception

Lifestyle balance	Securing long-term safety in use	Reducing environmental load	Relative importance
Operation of an integrated system	Standby power supply system	Response to change in inhabitant lifecycle	high
Sufficient number of power outlets	Standby power cut-off devices	Electricity consumption data management	
Proper form of the switches	Securement of safety in wet areas	Preparation for remodelling	
Adjustable lighting	Design of accessible storage spaces for network facilities	Use of modular furniture	low

Source: Buildings, MDPI.(Chang, 2022)

3. Environmental impact.

Switching to a smart home can potentially affect the environment, both positively and negatively. The overall impact depends on various factors, including how the inhabitants use and configure your smart home devices, the energy sources that power them, and the actions they take to mitigate potential negative consequences. Here are some ways in which switching to a smart home can affect the environment in positive way:

- Energy efficiency;
- Resource conservation;
- Renewable energy integration;
- Transportation efficiency.

However, it is crucial to recognize that the adoption of smart home technologies is not without its environmental consequences. There are negative environmental impacts generated by smart homes, shedding light on the various ways in which the integration of technology into our living spaces can have adverse effects on the environment. Here, a short list of them is shown:

- electronic waste;
- energy consumption of data centers;

- manufacturing and supply chain impact;
- complexity and maintenance.

It is important to note that while smart homes can have negative environmental impacts, they also offer opportunities for significant energy savings and resource conservation when used responsibly. Many of these negative impacts can be mitigated through sustainable practices, such as proper disposal of e-waste, energy-efficient data centres, and the use of renewable energy sources to power smart devices.

4. Comfort and energy consumption

The number of smart devices in a home can have a significant impact on comfort and energy consumption. While more devices can enhance convenience and customization, they also provide opportunities for energy-efficient automation and optimization. The key is to strike a balance between comfort and energy efficiency to create a smart home that meets your needs while minimizing energy waste.

In following graph, (Figure 1) “Comfort” generally increases as the number of installed devices increases. The curve might start steep and then gradually level off. “Energy consumption” might increase slightly as more devices are installed

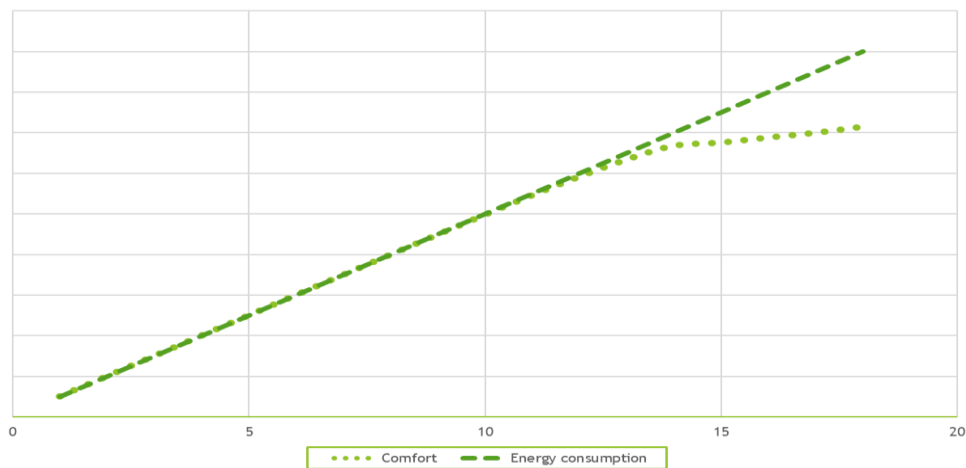


Figure 1. Appliances number impact

In this graph, a positive correlation between comfort and the number of installed devices is observed. As more smart appliances and devices is added to smart home, comfort should generally increase. The relationship may not be linear, and there might be diminishing returns, meaning that adding a few devices can significantly improve comfort, but as you keep adding more, the incremental comfort gain may decrease. The graph might start with a steep incline, indicating

a rapid increase in comfort as the first few devices are installed. After a certain point, the slope of the graph might become less steep, showing that the additional comfort gained per new device decreases.

On the other hand, the utilization of renewable energy in smart homes is an interesting option to save energy supplied by the electric grid and hence save money and reduce electricity bills with the possibility of profiting from selling surplus energy to the electric grid (Enas Magdi Saadawi et al., 2022).

Smart devices often come with energy-saving features, such as energy-efficient sensors, scheduling capabilities, and adaptive controls. As adding more smart devices, the potential to improve energy efficiency increase. For instance, a smart thermostat can optimize heating and cooling based on habitants schedule, reducing energy waste. Nevertheless, once smart devices added to smart home, energy consumption increase slightly due to the energy needed to power and operate these devices.

5. Conclusion

The environmental impact of smart homes is a complex interplay of positive and negative factors. While these homes significantly enhance energy efficiency, resource conservation, and waste reduction, they also pose challenges related to electronic waste, data centre energy consumption, and manufacturing practices. The responsible adoption and use of smart home technologies, coupled with a commitment to sustainability, are key to maximizing their positive impact on the environment while mitigating potential drawbacks. Smart homes, when designed and employed thoughtfully, hold the potential to be a vital contributor to a more sustainable and environmentally conscious future

By optimizing energy consumption, conserving resources, and reducing waste, they can contribute to sustainability efforts. However, concerns related to electronic waste, data center energy consumption, and manufacturing practices must be addressed to ensure that the overall environmental impact of smart homes remains positive.

Smart homes play a crucial role in assessing and mitigating their environmental impact by offering real-time data, customization of environmental goals, contributing to smart grids, and fostering a feedback loop for sustainable choices. They empower individuals to make informed decisions and collectively contribute to a greener future.

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