

Post-Occupancy Evaluation Framework for Smarthomes

A Techno–Human–Social Perspective

Dr. Sooim Shin

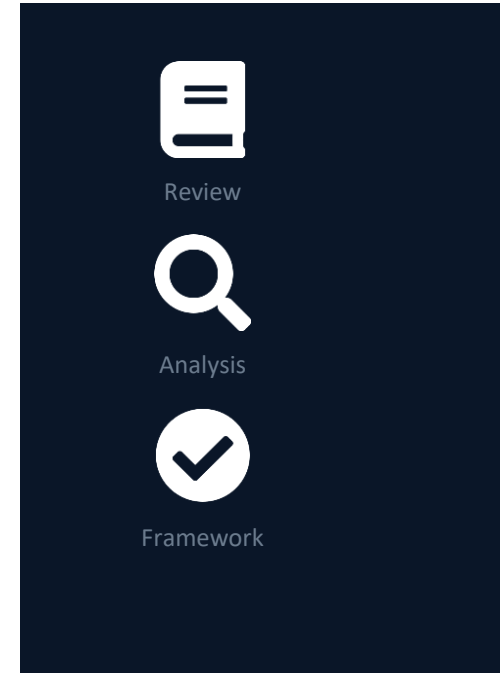
Housing and Community Research Institute, Anyang, Republic of Korea

trua52@gmail.com



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Introduction & Background



Context

- AI technologies rapidly expanding in residential environments
- Smarthomes optimize energy via automated control, predictive algorithms, real-time feedback
- Evaluations predominantly focused on energy savings and technical efficiency
- Human and social dimensions largely overlooked [1]



Research Gap

- Existing POE frameworks cannot evaluate AI-based services that interact with residents
- Users' understanding of AI, perceived control, and trust are not assessed
- Social impacts of smarthome technologies remain unexamined
- Need for integrated framework beyond physical performance

Literature Review (1): Conventional POE



POE: A methodology for assessing building performance during actual use, integrating technical criteria (thermal comfort, acoustics, energy) and user satisfaction [2][3]

Key Studies in POE Development

Leaman (2003)

Highlighted need for standardized indicators, data sharing, stronger links between research and practice [5]

Roberts et al. (2019)

Identified non-standardized indicators, unclear cost responsibilities, weak integration with construction processes [4]

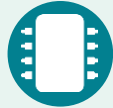
Mustaffa et al. (2022)

Bibliometric analysis confirmed POE focus on physical performance in residential, office, and public buildings [3]

Elsayed et al. (2023)

Systematic review of EU residential POE: mixed methods (surveys, interviews, on-site measurements) remain standard [2]

Literature Review (2): Smarthome & New Challenges



Smarthome & AI-based Services

Aagaard et al. (2023) [6]

Auto-ethnography of learning to live with smart technologies — reveals challenges of user adaptation, learning curves, and acceptance processes

Alborzfar & Berardi (2015) [7]

POE framework for LEED-certified residences — expanded scope to include usability, user behavior, and operational feasibility alongside physical indicators

Li et al. (2018) [1]

State-of-the-art/practice review — identified gap between technical metrics and lived user experience in building evaluation



Emerging Evaluation Challenges

1

User Learning & Acceptance

AI systems require ongoing adaptation; residents' understanding evolves over time

2

Data Ethics & Privacy

Continuous data collection raises concerns about surveillance, consent, and transparency

3

Platform Interoperability

Heterogeneous systems and protocols create evaluation complexity

4

Institutional & Regulatory

Need for policy frameworks and institutional support for smart housing

Limitations of Conventional POE



Narrow Scope

Focused on physical performance (thermal comfort, acoustics, energy) — AI interaction and service quality unassessed



One-off Assessment

Single point-in-time evaluation — cannot capture evolving user behavior and learning with smart systems



Non-standardized

Limited comparability across cases due to inconsistent indicators and unclear cost responsibilities [4]



Missing Dimensions

User acceptance, trust, data ethics, social equity, and long-term sustainability are not addressed [6]

→ Integrated framework needed: Technology + Human + Society

Research Purpose & Methodology



Research Purpose

To propose a smarthome-specific POE framework grounded in a Techno–Human–tal perspective that enables comprehensive evaluation of AI-based smarthome services beyond energy savings alone.

Two-Step Development Process

1

Comprehensive Literature Review

- POE-related studies
- Smarthome technology research
- AI-based residential service evaluation



2

Framework Construction

- Analysis of existing evaluation items
- Restructuring into three domains
- Attention to AI understanding, perceived control, trust, social impacts

THS-POE Framework

Techno–Human–tal Post-Occupancy Evaluation



TECHNOLOGY

- Energy Efficiency
- System Reliability
- Data Security



HUMAN

- Usability
- Perceived Control
- Satisfaction



SOCIETY

- Acceptability & Equity
- Ethics
- Sustainability

Framework Indicators & Methods

| Domain | Primary Indicator | Secondary Indicators | Measurement Methods |
|------------|--------------------|--|---|
| Technology | Energy Efficiency | Energy consumption, reduction rate | Data analysis, expert evaluation |
| | System Reliability | Error rate, response time, data privacy | System logs, expert assessment |
| Human | Usability | Ease of learning, ease of operation | User surveys, semi-structured interviews |
| | Satisfaction | Emotional satisfaction, intention of continued use | User surveys, semi-structured interviews |
| Society | Acceptability | Equity, accessibility, ethics | User surveys, semi-structured interviews, expert Evaluation |
| | Sustainability | CO ₂ reduction, maintenance systems, policy support | Quantitative data, expert assessment |

** Objective performance metrics + Subjective user assessments combined for holistic evaluation*

Key Characteristics & Stakeholder Perspectives

Multi-Stakeholder

Designers, developers, operators, policymakers, residents

Longitudinal

Initial operation → Stabilization → Long-term use

Technology-Neutral

Modular, comparative across heterogeneous systems

Stakeholder Mapping by Domain

| Domain | Focus | Primary Stakeholders |
|------------|--|--|
| Technology | Energy efficiency, system reliability, data security | Designers, system developers, facility managers |
| Human | Usability, perceived control, emotional response | Housing operators, service providers, user-centered design teams |
| Society | Equity, accessibility, ethics, sustainability | Policymakers, local governments, public housing authorities |

Conclusion & Future Work



Key Contributions

- Proposed THS-POE: integrated framework treating Technology, Human, and Society as equally important evaluation dimensions
- Enables comprehensive evaluation of AI-based smarthome services beyond energy savings
- Provides a foundation for cumulative and comparative smart city evaluation research



Future Directions

- Refine indicators through expert consultation (Delphi method)
- Apply expert-based weighting (e.g., AHP) for context-specific prioritization
- Empirically validate framework across diverse residential contexts and housing types
- Develop longitudinal case studies tracking user behavior evolution over time
- Position THS-POE as a basis for evidence-based smart city housing policy

Thank You

Dr. Sooim Shin · trua52@gmail.com

Housing and Community Research Institute, Anyang, Republic of Korea

