Digital Heating Controls in Practice: User Behaviour and Perceptions in a Living Lab

Findings from the Project InWaMod

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Motivation and Research Gap

- Smart heating systems and smart thermostats can save energy, but real-world outcomes often fall short
- Research on smart thermostats has focused mainly on owner-occupied housing; rental housing and tenants' perspectives remain underexplored

Research questions

- How do tenants use and perceive smart heating control in a modernised multi-family building?
- Where do mismatches between system logic and everyday practices occur?

Living Lab

- WBS 70 prefabricated panel housing, renovated 2020/2021
- Apartments have wall radiators, but no conventional thermostat valve
- Heating is controlled by tablet interface in each apartment

Left: Renovated living lab; heating control system user interface (right). Source: jenawohnen GmbH.

Smart Heating Logic in Theory

Objective

- reduce energy consumption
- lower mold risk
- improve comfort

Building-level

Heating optimisation

- Central control optimises heating curve and supply temperature

Apartment-level

Indirect open-window detection

- sudden temperature drops at radiator-mounted sensors trigger an automatic reduction in heating

Night setback and optional absence mode

- activated via tablet or double door lock

Preconfigured heating profiles

- Profile 1: Heating in the morning and between 3 p.m. and 10 p.m.
- Profile 2: Continuous heating from 6 a.m. to 10 p.m.

Mixed-Methods Research Design

Standardised face-to-face survey (n = 97)

- Sociodemographics and housing situation, comfort and temperature satisfaction, heating and ventilation practices, tablet use & system experience

Semi-standardized Interviews (n = 15)

- 6 high consumers, 5 low consumers, 4 atypical cases
- Qualitative content analysis with deductive and inductive coding

- F2F-Survey
- In-Depth-Interviews
- Households heating energy use (set-point-temp, ventilation)
- Heating costs

Key Findings: Comfort Concerns Despite High Energy Standards

Around one-third of residents report notable heating-related problems

- **25 %** say their apartment does not get warm enough in winter
- **30 %** experience heating costs as a financial burden
- **33 %** perceive the heating response as very slow

⚠ **Paradox:**

A building with a *good* energy standard and *automated* controls still generates notable comfort dissatisfaction.

Slow thermal response of the low-temperature heating system is frequently misinterpreted as a *technical defect* rather than as a physical property of the system.

Key Findings: High Usability ≠ High Utility

Perceived Usability ✓

- 60 % use tablet daily or several times/day
- Majority find operation easy, most feel no additional training needed

Perceived Utility ✗

- 40 %: preset profiles don't match individual needs
- 50 %: system delivers desired temperature control
- 31 % consciously activate absence mode when leaving
- 33 % see system as unnecessary luxury with added costs

"I'm not entirely satisfied with the heating control, because it's hardly tailored to my needs. … If I end up controlling it manually myself, I don't need all the rest of it." — Resident ID 81 (low consumer)

Key Findings: Legacy Mental Models & System Opacity

Common misconceptions/issues:

- Tablet set-points are often treated like thermostat levels
- Residents expect the same setting to produce the same temperature in every room

Source: https://www.ifs-ev.org/die-frostschutz-einstellung-gewaehrleistet-keinen-schutz/

- "Absence mode" confusion: frost symbol alone means only a minor setback (target 17-19 °C during heating time) in most rooms, substantial temperature reduction requires additional absence mode
- Multiple activation routes (absence mode) in combination with the lack of a set-point temperature display create uncertainty

Key Findings: The Tilt-Window Problem

Ventilation behavior in the winter

- 18 % of households tilt windows in the morning (Mean: 45 min.)
- 11 % of households tilt windows overnight
- tilt ventilation more common in high-consumption households

Source: Dan Gold, Unsplash

Tilted windows are not detected reliably

- system detects fully open windows via temperature drop → shuts off heating
- ↯ tilted windows: minimal air exchange, no reliable detection → system keeps heating against heat loss (rebound risk)

Implications: Design Recommendations

Greater transparency

- real-time system status (absence mode on/off)
- visible target temperatures
- clearer explanation of thermal inertia

User-centred configurability

- flexible schedules & room-independent app control (smartphone)
- clear separation of frost protection from absence mode

Better sensor technology

- dedicated window contacts for reliable detection of tilt ventilation

→ Smart heating requires not only good automation, but also transparent interfaces, adaptable functions, and informed users – and this is especially relevant in the rented housing sector.

Thank you!

Further project information:

https://www.iwu.de/forschung/handlungslogiken/inwamod/

Chapter Reference

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