

# USER ENGAGEMENT WITH SMART HOME TECHNOLOGY FOR ENABLING BUILDING ENERGY FLEXIBILITY IN A DISTRICT HEATING SYSTEM

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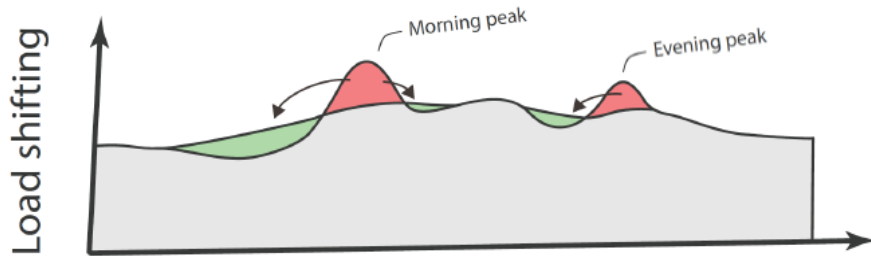
# RESEACH QUESTION

- **How do space-heating and comfort practices (re)configure when smart home technology is integrated in households?**
  - **Focus on users and engagement with SHT, including:**
    - **Aspects of control**
    - **Know-how and competences**
    - **Notions of comfort and convenience**



Credit: [www.telekom.com](http://www.telekom.com)

# Peak demand in the district heating system



Credit: Hedegaard, R. 2019. Investigation of the Energy Flexibility Potential of Danish Residential Building Archetypes.

- ▶ Short-term peak demand: Weekdays from 06:00 – 09:00 and 17:00 – 20:00
- ▶ Problem: Peak demand is covered by oil- or natural gas fueled boilers
- ▶ Solution: Demand-side management for load shifting demand
- ▶ This entails the use of ICT, increased automation – Smart home (energy) technology

# End-users: From passive to active

- Energy flexibility is possible, but we need more active end-users + increased use of automation
- Examples:
  - Traditional demand response
    - ToU-Tariffs, feedback etc.
  - Automated demand response
    - ICT, automation
    - Smart home technology



Credit: Faisalj75, videoblocks.com

# Methodology

- 'Sayings and doings' reveals space heating practices
  - Uncovering the invisible and ordinary consumption
- Qualitative methods – Interviews and observations studies within households
  - Semi-structured interviews (1 – 2 hours)
  - "Home tours"
  - "Show and tell"
- 20-25 households (On-going - 16 interviews so far)
- Variation between informants: Gender, age, educational background, building type, smart home setup



Table 1. Overview of the study cases.

Name and location	Building	People	Technology	Interview details
Måneparken Trekroner Roskilde	31 apartments 1 and 2 bedrooms Built in 2004	Social housing for students. Mostly single living tenants, the rent is 500 - 800 euros per month. Few apartments with couples.	District heating. Radiators in rooms, floor heating in the bathroom. Control by Danfoss CC Link© and Leanheat© technology.	4 interviews: 1 male and 3 females. Occupants: 1-2 Age: 21-25 All students
Frikvareret, Nordhavn, Copenhagen	29 terrace houses 100 - 200 m <sup>2</sup> Built in 2016	Ownership – prices start at 800,000 euros. Mostly families from upper-middle-class. Also couples.	District heating. Floor heating in all rooms. Control by digital on-wall thermostats, and fuel-shift controlled by the utility.	4 interviews: 4 males and 3 females. Occupants: 2-5 Age: 35-58 Senior-level jobs
Sundmolehusene Nordhavn Copenhagen	72 apartments and 11 terrace houses 45 - 210 m <sup>2</sup> Low-energy building Built in 2017	Ownership – prices from 270,000 euros to over 1 million euros. Differentiated household composition, but mainly upper-middle-class and upper-class.	District heating. Floor heating in all rooms. Control by digital on-wall thermostats and external control (centralized) during a limited time period.	4 interviews: 3 males and 3 females. Occupants: 2-4 Age: 21- 58 Senior-level jobs and 2 students.
Havnekanten Nordhavn Copenhagen	86 apartments 55 - 146 m <sup>2</sup> Low-energy building Built in 2016	Ownership – prices from 300.000 to 1.4 million euros. Differentiated household composition, but mostly families from upper-middle-upper class.	District heating. Floor heating in every room. Control by Danfoss CC link© system with the possible scheduling. Sensors in the whole apartment.	4 interviews: 3 males and 2 females. Occupants: 1-4 Age: 35-56 Senior-level jobs.

- Four study cases
- Preliminary findings
- 16 interviews and home tours (Variance in gender, age, educational background and household composition)
- Good level of building envelope thermal performance → higher flexibility potential (longest flexibility intervals, 7 hours)

# Study Cases

- Trekroner
  - Måneparken, BOSJ
- Nordhavn, København
  - Havnekanten
  - Sundmolehusene
  - Rækkehusene

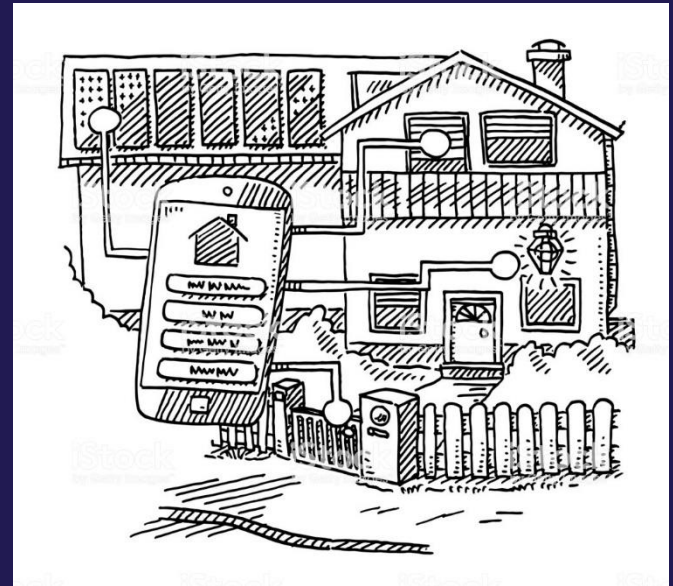


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# 3 insights

1. The importance of embodied know-how
2. “Comfort is king”
3. Smart home technologies are scripted towards  
a certain use - maybe not used as intended

Preliminary results  
– How do users  
engage with smart  
home technology?





# 1. The importance of embodied know-how

- Users who are familiar and have more experience with advanced ICT technologies:
  - engage more with SHT
  - take advantage of advanced features
  - Learn by experimentation and handle break-downs
  - Adjusts the system to everyday life
- Contrary users with less experience with advanced ICT technologies
  - engage less with SHT
  - seldom take advantage of advanced features
  - rely on preinstalled features
  - learn through manuals etc. – intermediaries are important
  - Create workarounds in order to cope with everyday life

*John: I sometimes feel like, that it is so automated here (house), that we really can't control anything. I can have that feeling. But the question is how much I would do, if I could.*

*Interviewer: So you say that in terms of being able to control the heat and the building...?*

*John: Yes, but the whole thing.. Without being particularly technical competent, it seemed that having the old-fashioned oil boiler was a little easier to intuitively understand, and figure out what was 'up and down' .  
(John 45)*

## 2. “Comfort is king”

- Comfort is very important for occupants – but it is experienced very differently (a feeling)
- Comfort is dynamic – changes throughout time
- Comfort is about being in control (highly valued by users) and controlling in a convenient way
- SHT can enable flexibility, but must not compromise comfort
- General notions of comfort in the households: 23-26 degrees, ‘must be able to walk around in t-shirt and bare feet year around’
- Comfort is closely tied to practices – e.g. different notions of comfort in the bedroom and in the bathroom

*“In fact, I often think that (the heat) is a bit in the background. Most of the time, I think my comfort is more or less about whether I'm feeling safe and happy, versus whether it's about being warm -too hot or too cold”  
(Line 25)*

*“I really think that you should be able to run around your own home without feeling that you need to put on extra clothes or that you have to wear an extra shirt”  
(Kristina 23).*

### 3. Smart home technologies are scripted towards a certain use

- Engagement with SHT varied from being used as a simple on/off device to a careful scheduling tool
- Occupants often create workarounds, as the technology interfered with other practices in their everyday life
- Energy flexibility potential is challenged by
  - Norms (e.g. notion of cold bedroom, airing practices)
  - Other materials in the household (E.g. windows and doors)
  - Competences

*“I think I ran it (preinstalled schedule) in the beginning, because I thought it was super. Later on I wanted to do it my own way. But I also think it was made for such a 9-16 job or something like that” (Lasse 24)*

*“Yes, I bought it (analogue thermometer) because I just had to see if it said the same thing. I think I bought it because the problem with the heat control in the bathroom didn't really work, so I brought it there to investigate what the temperature really (Charlotte 52)*

**THANK YOU FOR LISTENING**

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