SMART HOME TECHNOLOGY ENABLING FLEXIBLE HEATING DEMAND: IMPLICATIONS OF EVERYDAY LIFE AND SOCIAL PRACTICES

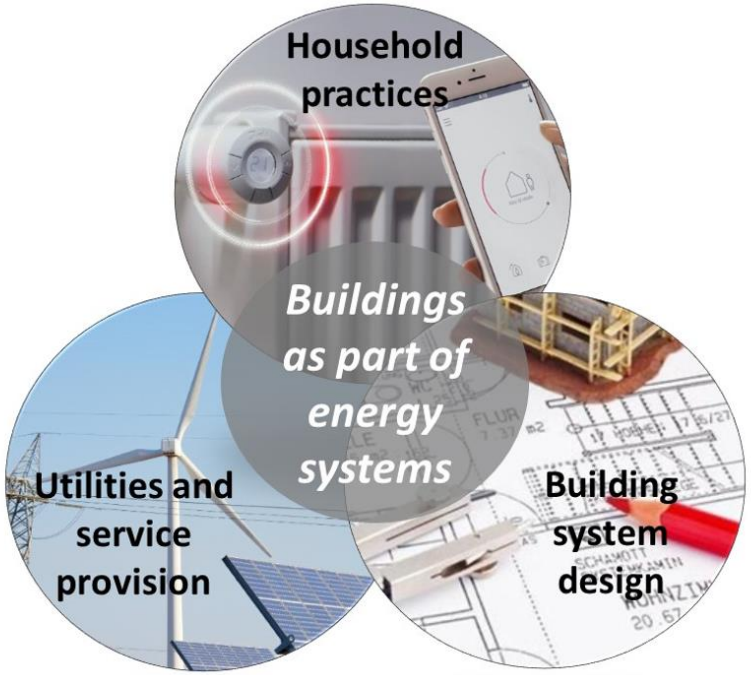
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InterHUB: Intermittent energy – Integrating Households, Utilities and Buildings



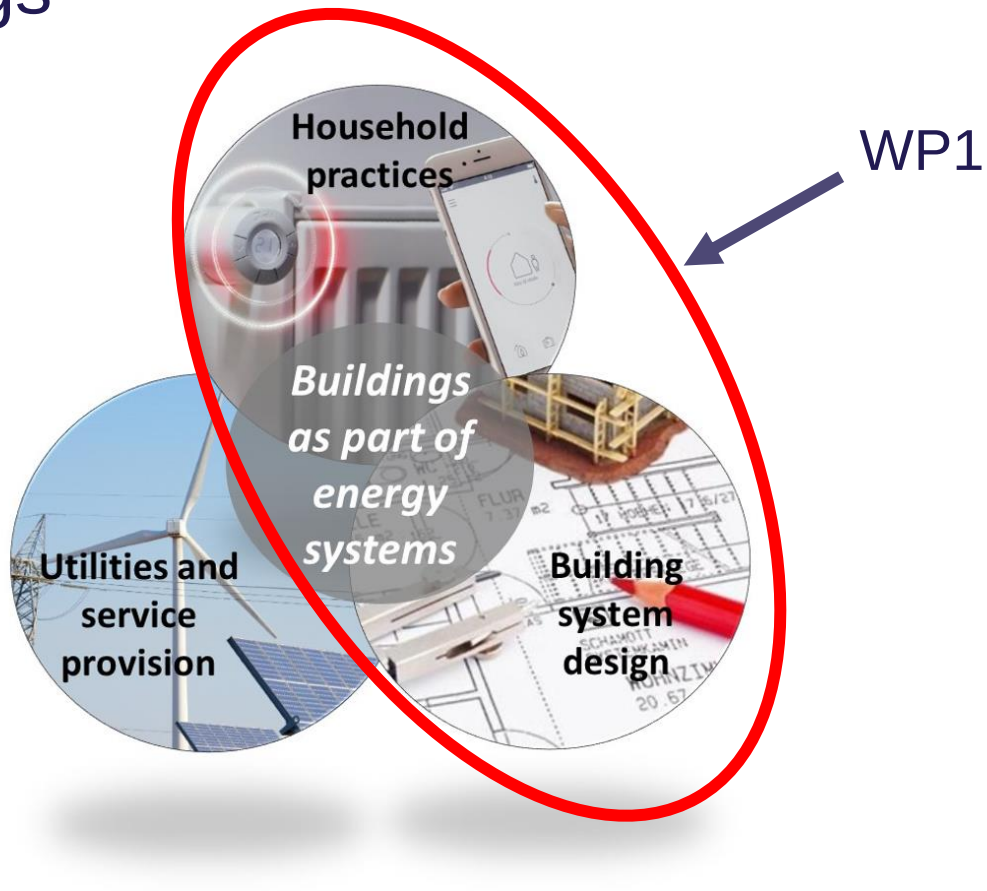
- **Increased share of intermittent energy in the DH-system**
- **Integrating households in the DH-system**
- **Interdisciplinary apporach**

Read more on: interhub.aau.dk

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Source: Project description

InterHUB: Intermittent energy – Integrating Households, Utilities and Buildings



Workpackage 1:

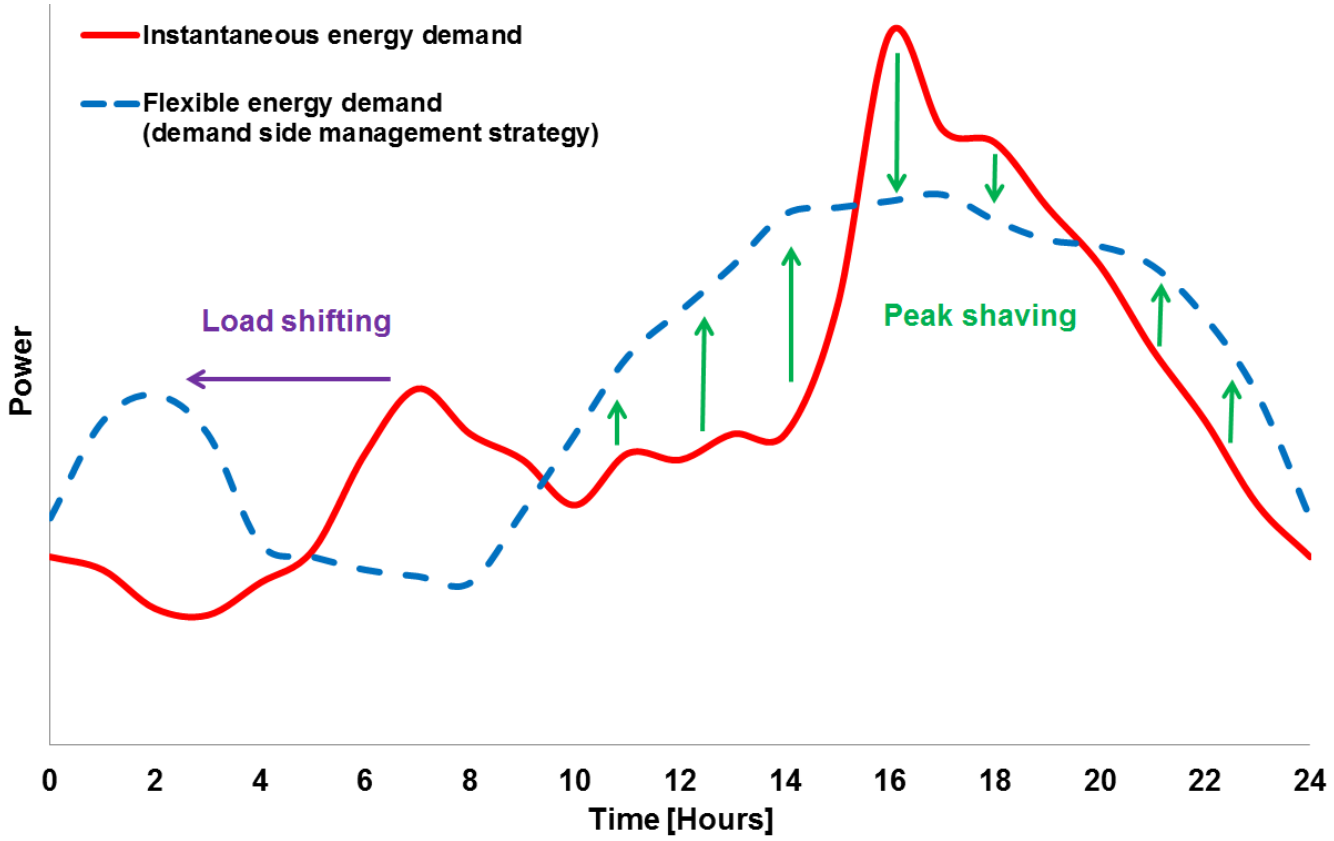
- Objectives
  - Understand how new routines and practices develop
  - Understand how notions of comfort develop
  - **Localize new and existing buildings with different control systems**
  - Understand how indoor climate control is perceived
  - **Understand the implications of control being performed by household, utilities and others**

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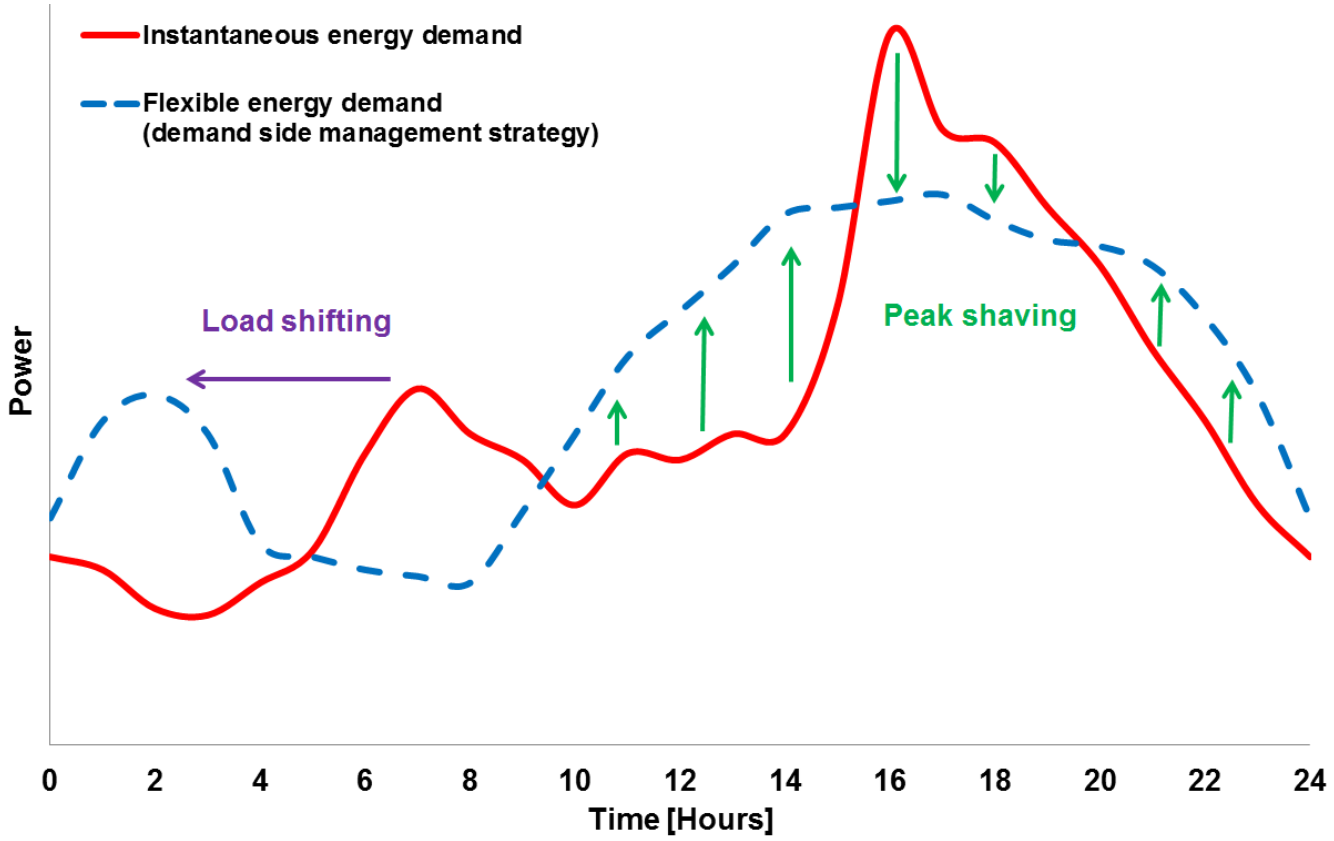
Enabling a flexible heating demand in households



Three focuses

- 1. Focus on the district heating system
  - Different load-profile than electricity
  - 64 % of all Danish households are connected to DH
  - Increased share of RES in the future
  - Flexibility within the grid

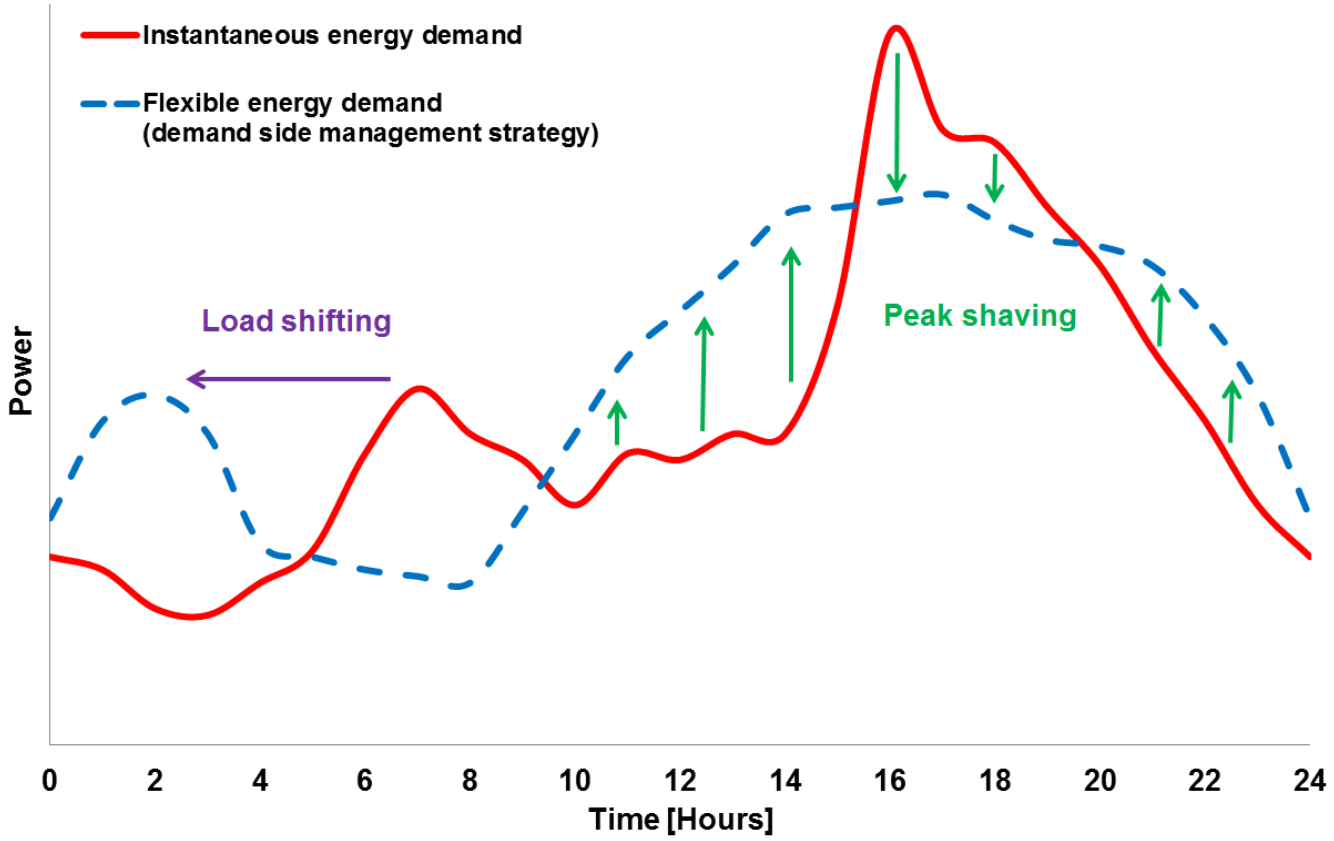
Enabling a flexible heating demand in households



Three focuses

- 2. Focus on households
  - 1/3 of total energy consumption is used in households
  - → 90 % is used for space heating
  - Potential: Taking advantage of the thermal mass

Enabling a flexible heating demand in households



Three focuses

- 3. A need for increased flexibility – balancing demand and production
  - Load-shifting
  - Peak-shaving

Theoretical approach

- Theories of practice and (energy) consumption; Schatzki, Reckwitz, Warde, Gram-Hanssen, Shove, Strengers
- In order to understand energy consumption, we must understand practices (Methodological tool)
  - ‘Sayings and doings’ reveal practices
  - Uncover the inconspicuous (ordinary) and ‘invisible’
- What is energy for?
  - We consume the services/conduct the practices that use energy
- We must understand the different elements which constitute a practice → SHT must therefore be understood in that context.

“(…) energy is used not for its own sake but as part of, and in the course of, accomplishing social practices” *(Shove, Walker 2014 p, 47)*.

Why Smart Home Technology?

- Increased automation as a potential solution for e.g. enabling flexibility
- Two-way communication reacting to user preferences and DR-signals.
- Control and monitoring by users (both inside and outside of the household)
- Demand-side-management
  - Demand response (e.g. ToU) or Automated Demand Response





Technical components of smart home technology

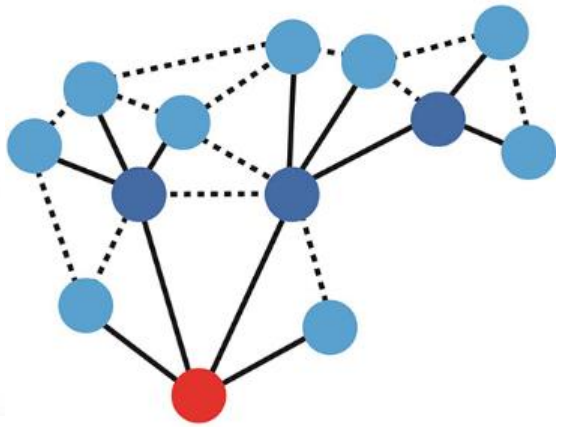
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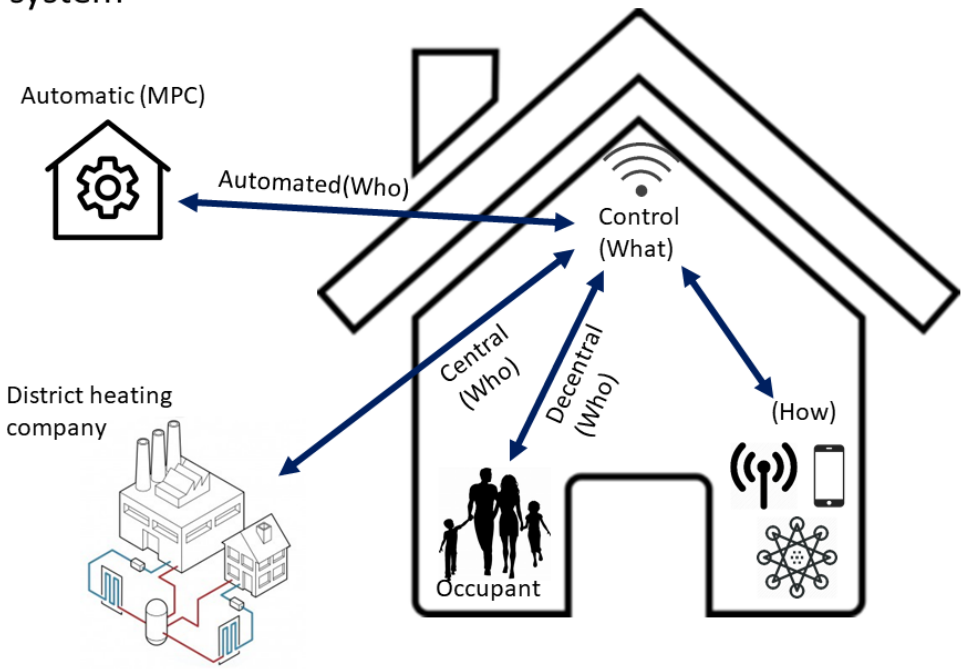
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- 1. Measurement devices
- 2. Sensing devices
- 3. Communication networks
- 4. Energy smart devices
- 5. Gateway/hubs

Case studies: A classification of smart home technologies in the Danish DH-system

The **How**, **Who** and **What** of the smart home technology in a district heating system



The How, Who, What and Why of SHT in a DH-system

- How: ..is control performed: e.g. set and forget, algorithmic, direct/manual interaction
- Who: ..controls: Decentral, central, automated
- What: ..is controlled: Stand-alone, integrated
- Why: .. Is the project/case initiated: time shifting, decreasing energy demand etc.

Table 2. Cases on smart home technology in a district heating system.

Case name and project manager	How	Who	What	Why (Incentives)
Bolig+[1] (Philanthropic Association)	Simple control, set and forget	Decentralised	Stand-alone solution (Z-wave)	Reduce energy demand, improve indoor climate and comfort
Havnekanten, Energy Lab Nordhavn[2] (Research institute)	Simple control, set and forget, set-points, MPC	Centralised, decentralised	Stand-alone solution (Wi-Fi)	Time shift energy demandImprove indoor climate and comfort
BetterHome[3] (Private co.)	Simple control, set and forget	Decentralised, automated	Stand-alone solution (Wi-Fi, Bluetooth)	Reduce energy demand, improve indoor climate and comfort
Vedvarende energireduktioner[4] (Public housing association)	Simple control, set and forget, MPC	Decentralised, automated	Stand-alone solution (Bluetooth, Wi-Fi)	Reduce energy demand
Sundmolen, Energy Lab Nordhavn (Research institute)	Set-points, Simple control, set and forget	Centralised, Decentralised	Stand-alone solution (Wi-Fi)	Time shift energy demandwithout decrease in comfort
Frihavnstårnet, Energy Lab Nordhavn[5] (Research institute)	Set-points, Simple control, set and forget	Centralised, Decentralised	Integrated solution (Wi-Fi)	Time shift energy demandwithout decrease in comfort
Albertslund konceptet[6] (Municipality)	Simple control, set and forget	Decentralised	Stand-alone solution (Z-wave)	Reduce energy demand
Rækkehusene, Energy Lab Nordhavn, (Research institute)	Simple control, set-points, rule-based	Centralised	Stand-alone solution	Time shift energy demandwithout decrease in comfort
MCHA: Minimum Configuration – Home Automation[7] (Research institute)	Rule-based, simple control, set and forget	Decentralised	Integrated solution	Reduce energy demand, improve indoor climate and comfort
MiniCO2 Husene – Kyotohuset[8] (Philanthropic Association)	Simple control, set and forget	Decentralised, automated	Integrated solution	Reduce energy demand
PreHEAT for District Heating[9] (Private co.)	MPC	Automated	Stand-alone solution	Time shift energy demandwithout decrease in comfort, Reduce energy demand
Two private households in Sønderborg Municipality[10]	Simple control, machine learning, set and forget	Decentralised	Stand-alone solution (Wi-Fi)	Reduce energy demand
SmartHjem Varmestyring[11] (Utility co.)	Simple control, set and forget	Decentralised	Stand-alone solution	Reduce energy demand
Ryesgade 25 + 30[12] (Private company)	Simple control, set and forget	Decentralised	Integrated solution (Wi-Fi)	Reduce energy demand, improve indoor climate and comfort
Revalue[13] (Research institute)	MPC, set and forget	Automated, decentralised	Integrated solution	Reduce energy demand, improve indoor climate and comfort
RESPOND[14] (Research institute)	Simple control	Automated, centralised	Integrated solution	Time shift energy demandwithout decrease in comfort, Reduce energy demand
Sunde boliger[15] (Philanthropic Association)	Simple control, set and forget	Decentralised	Stand-alone solution	Improve indoor climate
VPP4SGR – Virtual Power Plant[16] (Research institute)	MPC	Automated	Stand-alone solution	Time shift energy demandwithout decrease in comfort, Reduce energy demand
Villa in Vestbjerg[17] (Private household)	Simple control, set and forget	Decentralised	Integrated solution	Improve indoor climate and comfort
Procesværktøjer til 360° indeklimarigtig energirenovering[18] (Private co.)	Simple control	Decentralised	Integrated solution	Reduce energy demand, improve indoor climate and comfort
EnergyFlexHouse[19] (Research institute)	Simple control, set and forget	Decentralised, automated	Integrated solution	Time shift energy demand
CITIES – Center for IT Intelligente Energi Systemer i Byer[21] (Private co.)	MPC	Automated	Stand-alone solution	Time shift energy demand
The Silo, Nordhavn[21] (Private co.)	Simple control, set and forget	Decentralised	Integrated solution	Reduce energy demand, improve indoor climate and comfort

Study cases

- Desktop review of 21 case areas in Denmark
- Locating new and existing cases
- Specifically on DH-heating, SHT and real-world setting

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Characteristics of the study cases

- On how to control: Simple control and set and forget together with automated control (machine learning, MPC)
- On who control: Decentral control together with algorithmic control
- On what is controlled: Both stand-alone and integrated solutions
- On why: Multiple incentives for integrated SHT

Study Cases

Aarhus
- Vejlby Vest, Alboa

Trekroner
- Måneparken, BOSJ

Nordhavn, København
- Havnekanten
- Sundmolehusene
- Frihavnstårnet
- Rækkehusene



The study cases show that..

- SHT seems to aim at delivering:
  - ➢ **Flexibility** and **convenience**
  - ➢ **Energy savings** and **comfort**
- Occupants seem to be perceived as passive in terms of enabling flexibility → Automated control is seen as the solution
  - → Users engagement is important for preferences and overriding.

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Discussion and future research



But..

- Visions of SHT may be contradictive
- We must remember that SHT **is part** of everyday practices
- Users will interfere and create workarounds
- Therefore we must understand how users engage with smart home technologies and investigate how space-heating/everyday practices reconfigure when these technologies are integrated into households.

Discussion and future research



THANKS FOR LISTENING!

Smart home technology enabling flexible heating demand: implications of everyday life and social practices

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