# Use and Operation

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# Behavioural plasticity and its consequences

# The "problem" with humans: Behavioural Plasticity

*Plasticity, then, in the wide sense of the word, means the possession of a structure weak enough to yield to an influence, but strong enough not to yield all at once. (William James, 1890)*

# Yield and resist

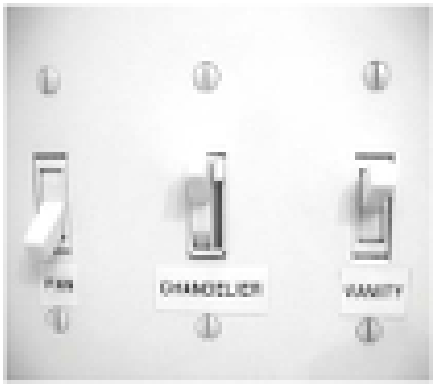
## Resistance: The power of routines

- A host of cognitive biases e.g. "confirmation bias" (Tversky/Kahnemann 1972) (common among scientists, too!)
- Folk theories e.g. about thermostats (Kempton 1986)
- Patterned routines and habits as one aspect of social practices (among scientists too!)

## Plasticity: "yield, but only conditionally"

- Domestication (Berker et al. 2006): mutual adaptation of technolgy/building and occupant
- Social practice (Shove et al 2012): connections between skills, meanings, things as key to understand stability and change
- Example: Folk labeling (Granderson et al. 2014)

# Examples for folk labels



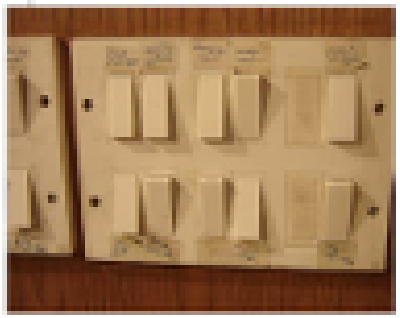


Figure 1:

# (Thermal) comfort between standardisation and adaptation

# The standard model for thermal comfort

- PMV/PPD: Predicted mean vote/Predicted Percentage Dissatisfied
- based on questionnaires and experiments in a climate chamber
- takes into account: air temperature, mean radiant temperature, relative humidity, air speed, metabolic rate, and clothing insulation
- does not account for plasticity

# Adaptive thermal comfort

- (NS-)EN15251: Indoor temperature adjusted according to mean daily outdoor temperatures 7-30 days before the day in question (in naturally ventilated and mixed mode buildings)
- dimensions of adaptation covered by the standard
  - Behavioral (e.g. clothes)
  - Physiological (e.g. sweat)
- dimensions not covered
  - individual differences
  - gender
  - culture (e.g. which clothes are deemed appropriate)

# Some findings

- Factors influencing yield and resistance in Norwegian households
  - deeply ingrained cultural values ("good and warm homes", puritan asceticism)
  - family interaction (e.g. teenagers)
  - interaction with life in other buildings (e.g. work places)
- Domestication of Powerhouse Kjørbo as success factor
  - extended testing and adaptation in the early occupancy period
  - occupant complaints as rather imprecise but important "sensors"

# The all-important middle-men

# Standard approach

- Good technology just works - bad technology needs constant care
- Administration, maintenance, operation as low status work
- Delegate low status work to machines

# Our approach

- The shock of the old (Edgerton 2006)
  - Things break down, become outdated, gain a second, third, fourth life or are abandoned quickly
  - High performance machines/buildings that depend on too many specific external and internal conditions are prone to break-down
- Some findings
  - teaching how to use advanced buildings is not a one-time job
  - good facilities managers know their buildings **and** their occupants

# Concluding remarks

# Ongoing research activities

- Living lab
- Evaluation of ZEB pilots
- Implementation of zero emission buildings (PhD Ann Kristin Kvellheim)

# Closing the performance gap while catering for high comfort expectations

"Behind the back" (= not needing end-users' collusion) energy efficiency is always preferable, but

- has to be verified
- occupants' tolerance levels **can** be de/increased
  - errors decrease tolerance
  - the **possibility** (not necessarily the enactment) of plasticity increases tolerance
- from "what is acceptable" to "how can acceptance be made more likely"
- Even better: Creating opportunities for mutual adaptation that is beneficial to the goal
- Facilities management as mediator between technology and use

# The Trondheim Living Lab

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# About the building

# History

- Early design phase (around 2012)
  - Used extensively in teaching
  - Designed collaboratively by students and researchers
  - Mimicking the Norwegian “hytte” (= cabin, a second home “close to nature” that about 50% of the Norwegian population has access to)
  - Modular design
- Was later turned into a more traditional construction project that includes state-of-the-art solutions (available on the market) provided by the industry partners of the ZEB center

# Technology 1

- 100 m2, 500 m3
- A “christmas tree” of advanced building technology
- roof integrated PV
- facade integrated solar thermal connected to the water based energy storage tank
- compact functional cells in three parallel rows (340x135 cm) that have two layers to provide flexibility
    1. structural frame
    2. equipment and finish

# Technology 2

Designed to have a very low energy demand that is balanced by the energy produced on-site over the building's life time (+ embodied energy)

- hermetic, highly insulating roof construction
- water-to-water heat pump that provides heating, hot water and ventilation
- output of the heat pump is connected with a 2-stage heat storage tank
- heat pump is coupled with a ground heat-exchanger buried in the back yard
- space heating can be provided through a low-temperature radiator and floor heating (+ ventilative heating)
- extensive monitoring equipment

# Social science research in the living lab

# Qualitative social science

## Standard qualitative research

- aims at understanding motivations and complex constellations that are difficult to measure quantitatively
- depends on additional empirical work (from the literature) to achieve relevance beyond the case under study
- mainly based on (retrospective) accounts (interviews) or (participant) observation

## Qualitative experiments

Mixed methods approach: explores a stimulus - response - relation by qualitative means

# Research questions

1. Which factors increase or decrease the lab's occupants' a) ability and b) willingness to succumb to the building's behavioural script?
2. Which occupant practices interfere to which degree with the building's zero emission goal?

# Methods

- Semi-structured interviews (before, under, after the occupancy period)
- Observation, occupancy detection
- Group discussion
- Energy consumption data

# Thank you for your attention!

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