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**DOI**

[10.13140/RG.2.1.3561.8167](https://doi.org/10.13140/RG.2.1.3561.8167)

**Publication date**

2016

**Document Version**

Final published version

**Citation (APA)**

Ioannou, T., Itard, L., & Kornaat, W. (2016). *Analysis of comfort related behavior for better prediction of heating and electricity consumption in residential dwellings*. Poster session presented at CLIMA 2016 - 12th REHVA World Congress, Aalborg, Denmark. <https://doi.org/10.13140/RG.2.1.3561.8167>

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# Analysis of comfort related behavior for better prediction of heating and electricity consumption in residential dwellings

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Paper ID. 370

## Research Questions

- Which measurable parameters (including occupant behaviour) influence the actual energy use in dwellings?
- How can prediction models for energy consumption be improved?

### Sub-questions:

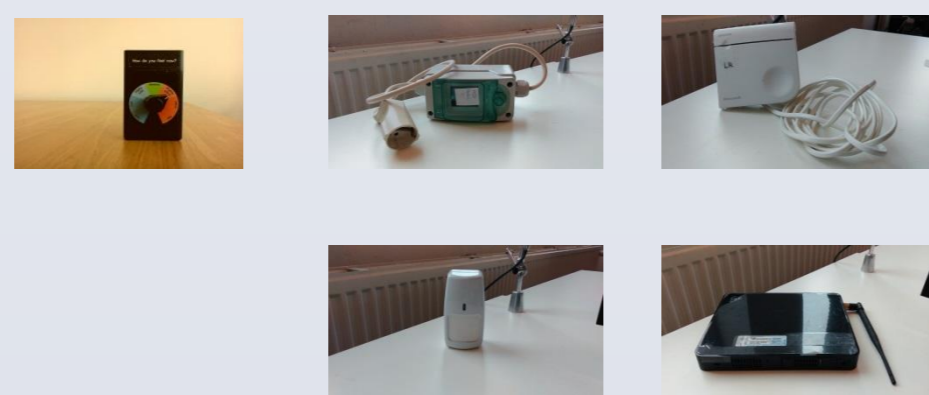
- What is the bandwidth and average behaviour for use of electrical appliances, thermostat settings, occupancy of rooms, ventilation, radiator settings, hot tap water use, sun shades and how do these data relate to actual energy use?
- Is it possible to define behavioural groups in relation to actual energy use?
- Is there a relationship between type of installation, dwelling characteristics, behaviour and energy use?
- Is it possible to determine a bandwidth of user profiles to be fed in calculation software in order to get a probability of energy use (distribution) instead of one value?
- How can prediction (simulation) models be improved in order to match better actual statistical data?
- What is the relationship between predicted and actual comfort in Dutch residential dwellings, how can comfort models be improved and how do they relate with the energy consumption of the residential sector.

## Research Campaign

### Sensors in each house:

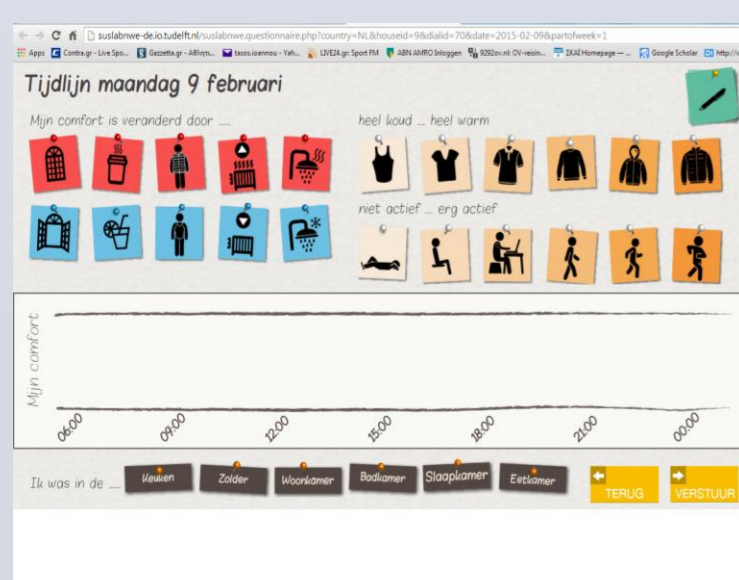
- Living Room, Kitchen, Bedroom 1 and 2: **Honeywell** CO<sub>2</sub>, T, Hu and PIR
- Boiler, Heat pump, Mechanical Ventilation Pumps: **Eltako** Electricity Meter
- I/O Comfort Dial
- Youless online electricity monitoring on the meter

Heating System	Heat Pump	HR boiler	Local stove
<b>A+B</b>	4	9	-
<b>F</b>	-	17	2

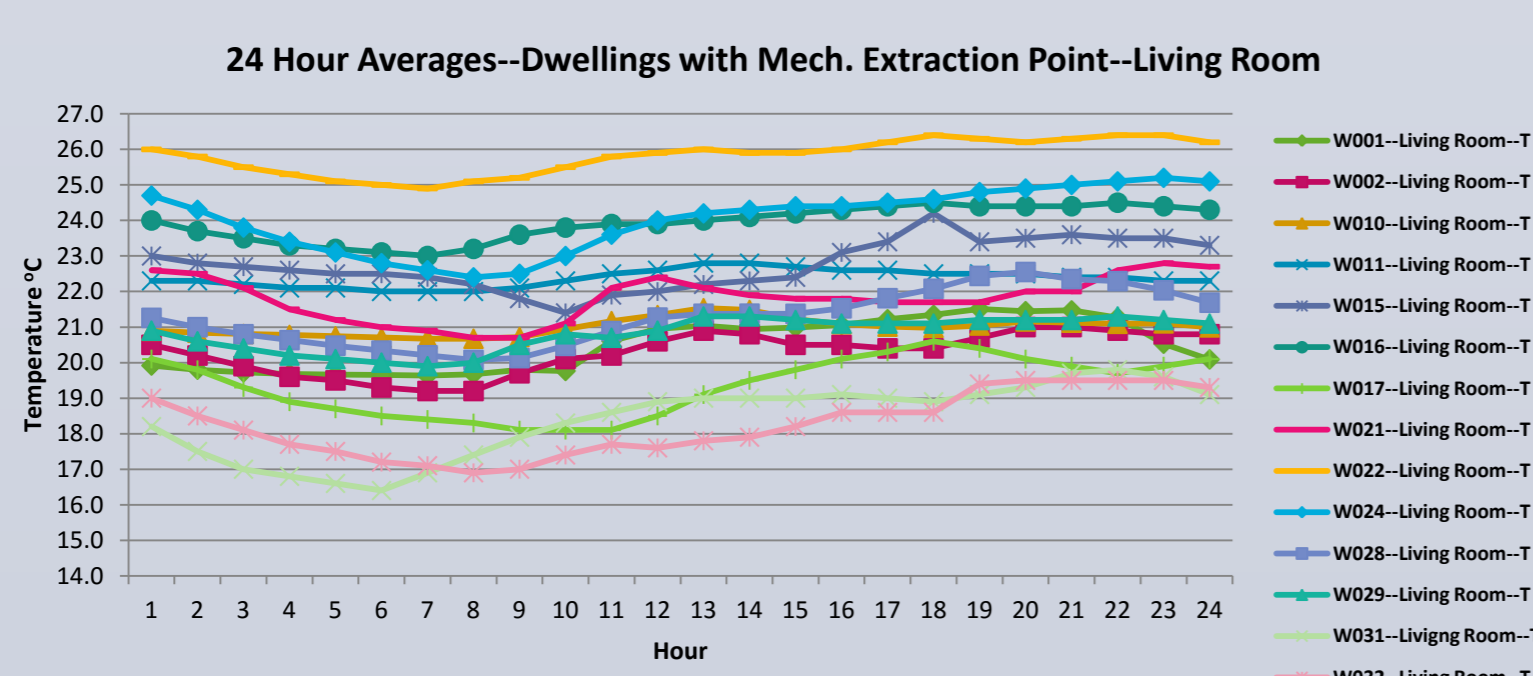


## Data

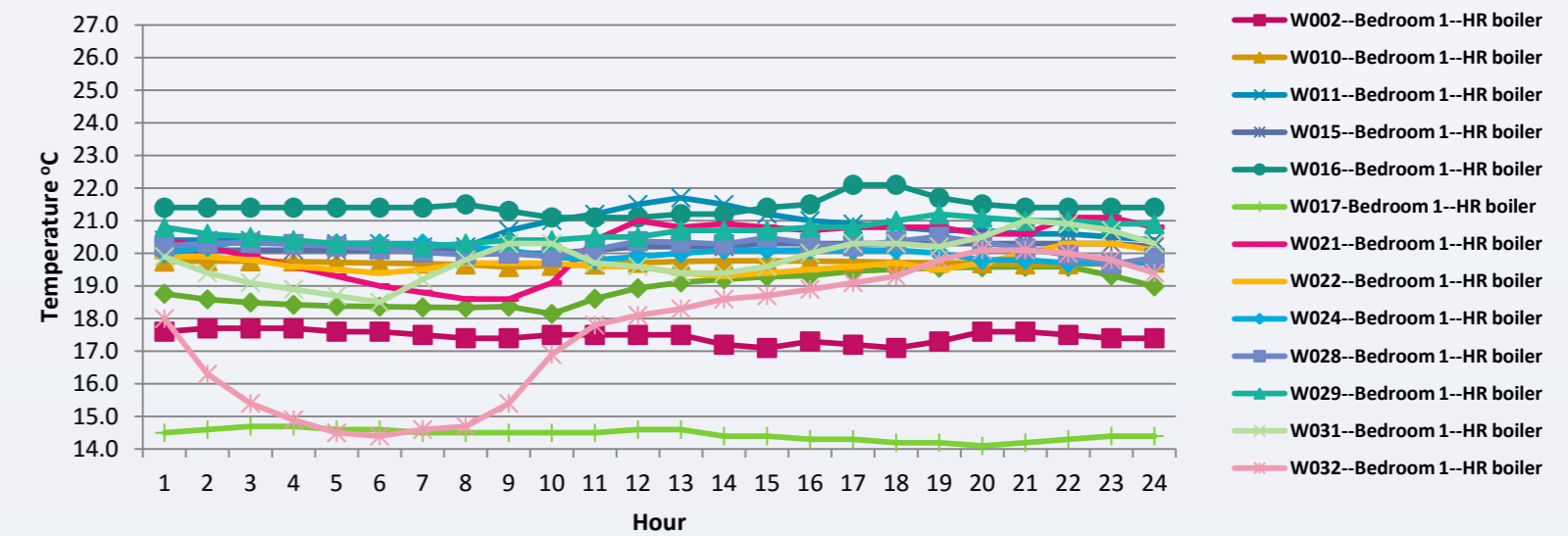
- Initial Survey for Qualitative data (age, income level, sex, type of thermostat, type of heating system, ventilation patterns, thermostat level etc.)
- Quantitative data every 5 minutes (CO<sub>2</sub>, T, RH, motion, heating/ventilation systems' pump consumption)
- Qualitative Comfort data for a period of 2 weeks for each household



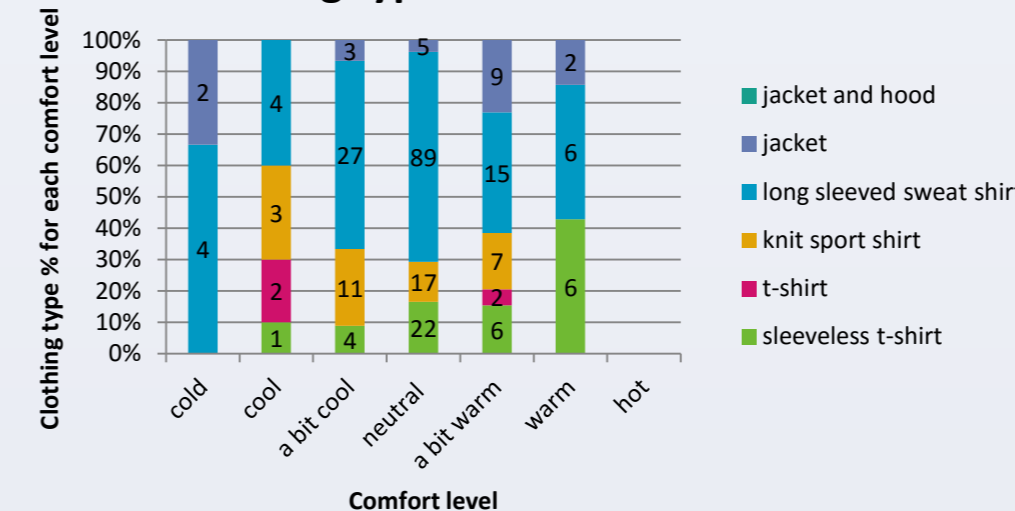
## Results



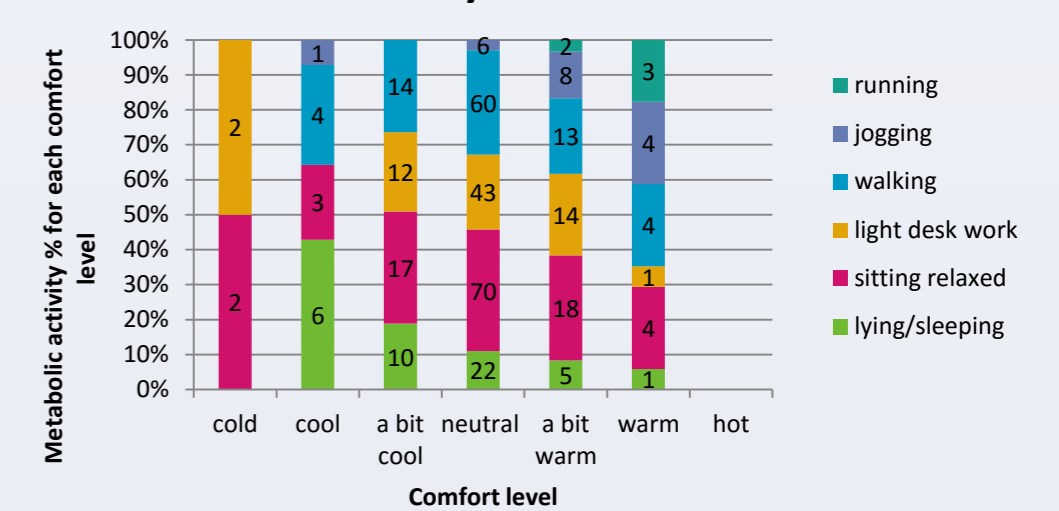
## 24 Hour Averages--Natural Ventilated Dwellings with Mechanical Extraction Points--Bedroom 1



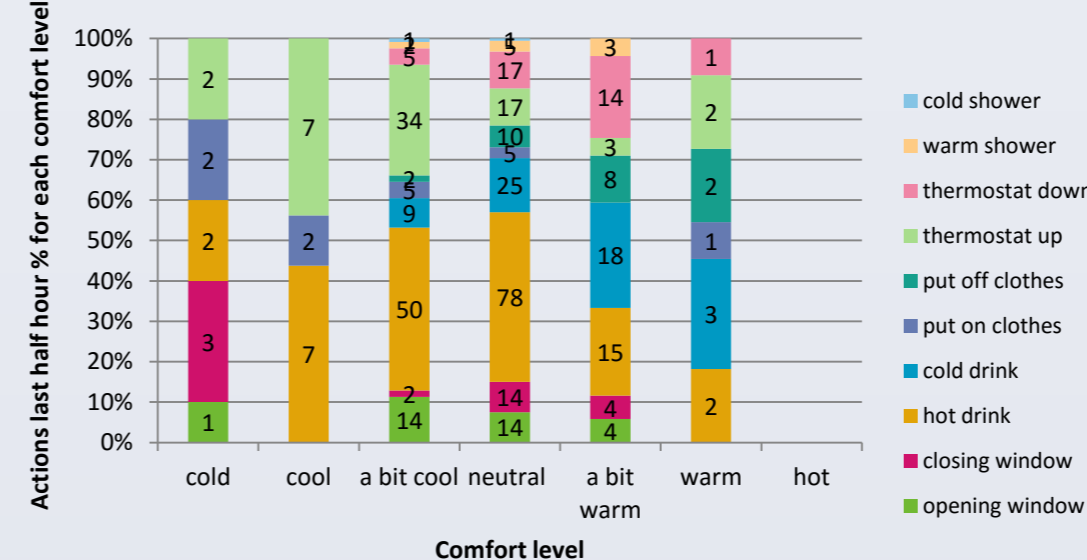
### Clothing type for all comfort levels



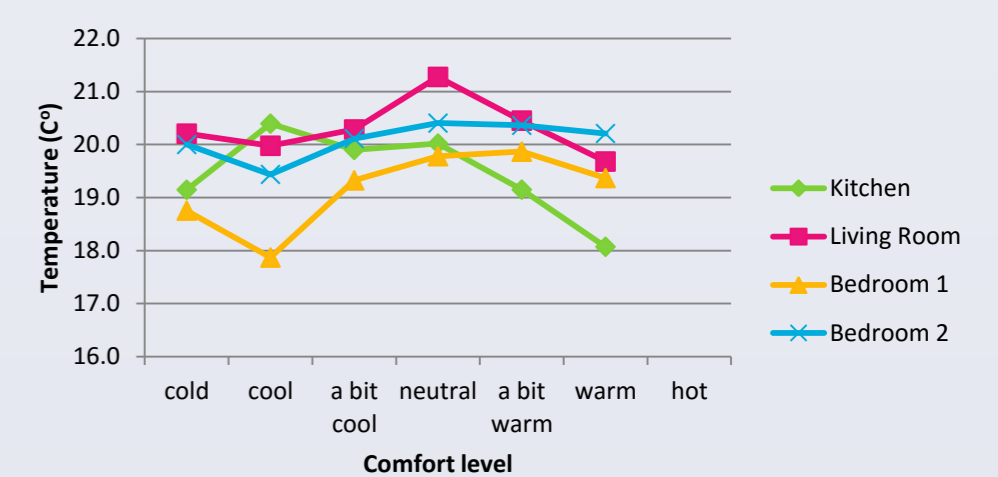
### Metabolic activity for all comfort levels



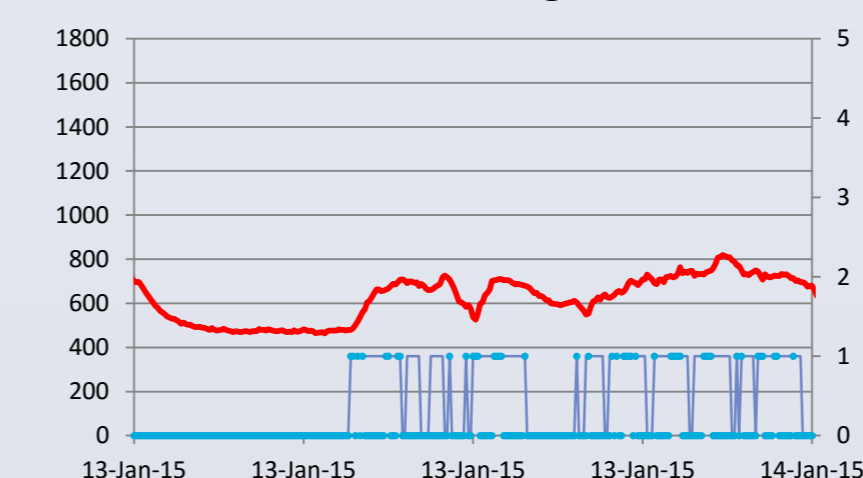
### Actions last half hour for all comfort levels



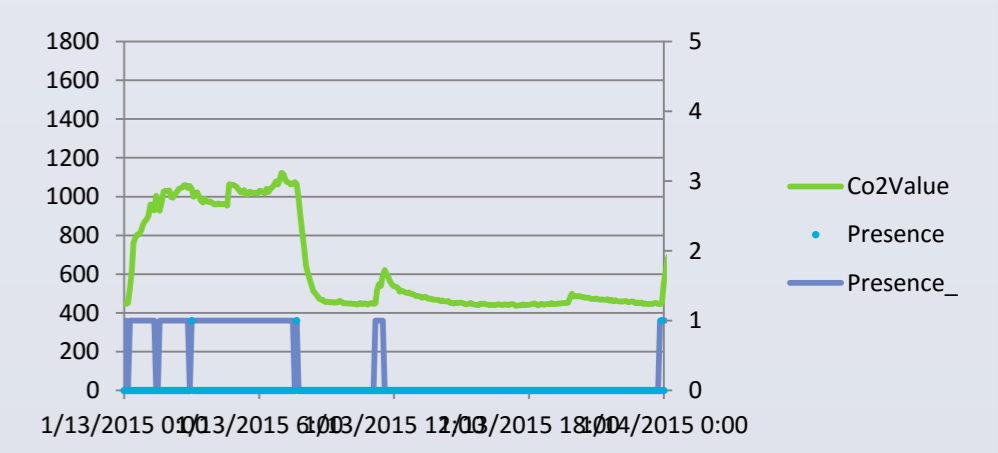
### Average temperature for all rooms per comfort level



### Living Room



### Bedroom 1



## Conclusions

- Differences in the temperature spread between living rooms and bedrooms which leads to the conclusion that simplified one zone models for the energy calculations of dwellings are flawed.
- With the exception of a few hours in two living rooms (W031 and W032) all other living rooms and for the whole day the temperature lies above 18 °C which is the temperature suggested for the calculations of the national simulation software.
- The Dutch notion that bedrooms are not heated during the night seems to be false. Apart from 3 bedrooms (W002, W017 and W032) all the other ones have either a more or less constant temperature profile or a fluctuating one with temperatures well above 18 °C. More than half of these dwellings are F labeled which means that there must be heating during the night.
- A combination of motion detection and CO<sub>2</sub> gives a good prediction of the actual presence. This can be expanded based on the monitoring data and can give further possibilities for analysis. The occupancy profile calculations focus on the presence and not on the number of persons present. In case the number of persons in the household is known, rules can be added for this purpose. For instance if a person is detected in a bedroom, there should be at least one occupant less in for instance the living room. Furthermore 1 and 2 person bedrooms can be defined. This gives additional information about the possible number of persons when there is presence predicted in a room.