Influence of Energy-efficient Renovation on Energy Use & Thermal Comfort in Swedish Single-family Residential Buildings from the Million Program

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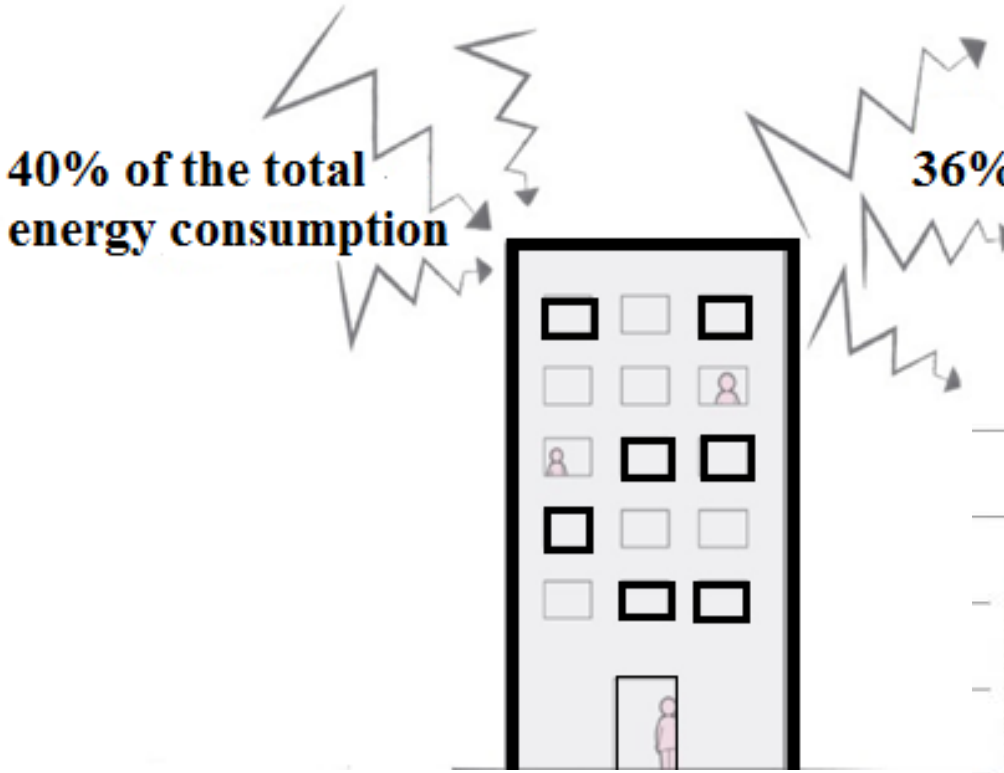
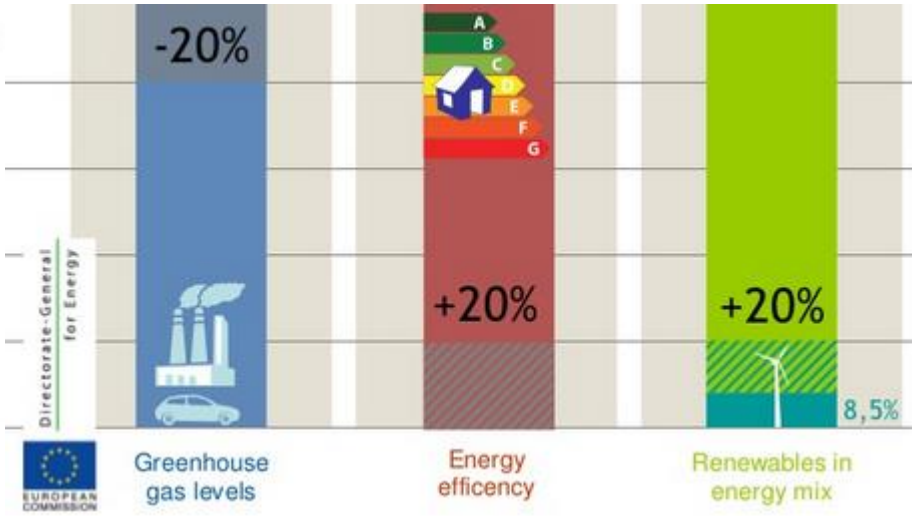
BACKGROUND





Source: JRC Europe,2015

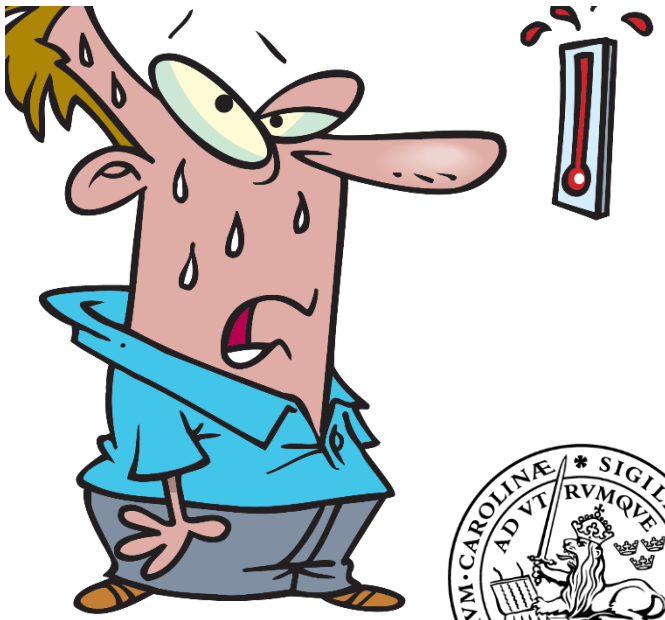
'20 20 20' target

BACKGROUND

SINGLE FAMILY RESIDENCES FROM THE MILLION PROGRAM

- **Cold during winter**
- **Warm during summer**

THERMAL COMFORT



RESEARCH QUESTION & OBJECTIVES

What is the influence of energy-efficient renovation on thermal comfort in Swedish single-family houses built during the Million program?

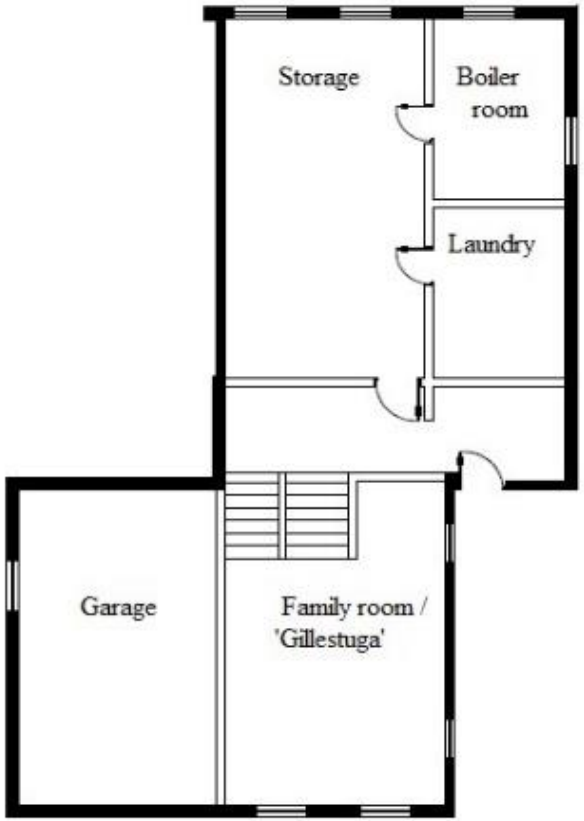
- *What are the factors contributing to energy use and what are the possible renovation measures?*
- *Which renovation measures have a major impact on the thermal comfort of the occupants?*
- *What are the changes in the thermal comfort of the occupants before and after adopting the proposed renovations aimed through efficient energy use?*

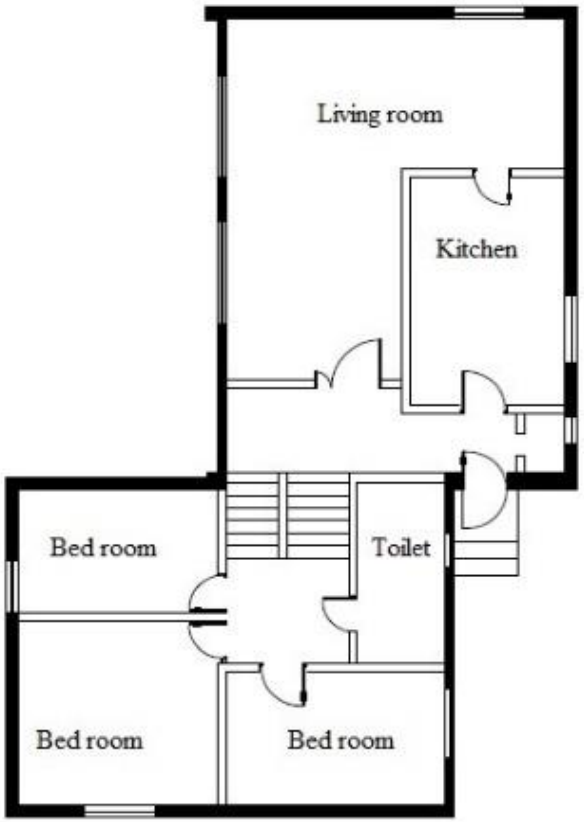
CASE STUDY BUILDING 1

- Location:

Outside Gothenburg

- Built period: 1968
- Floor area : 235m²

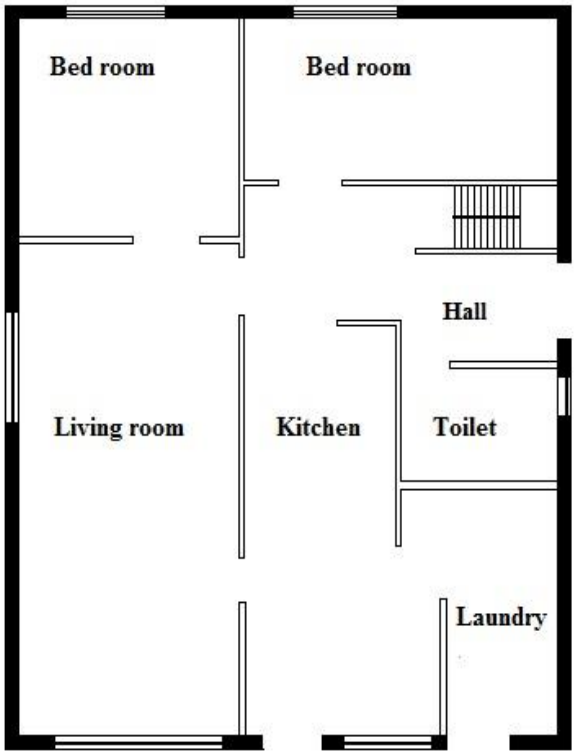


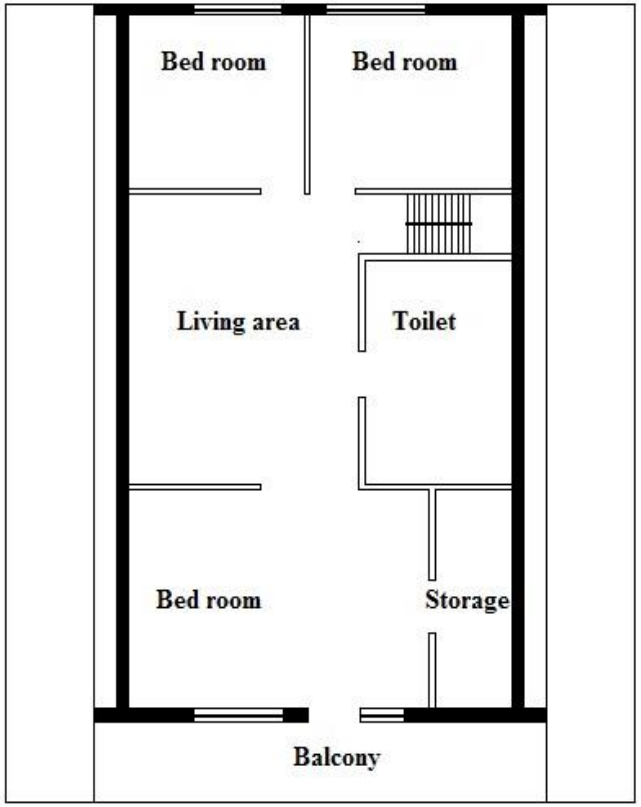


PLAN

CASE STUDY BUILDING 2

- Location: Near Stockholm
- Built period: 1975
- Floor area : 150 m²





PLAN

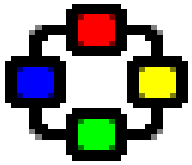
ACTIVITY DIAGRAM

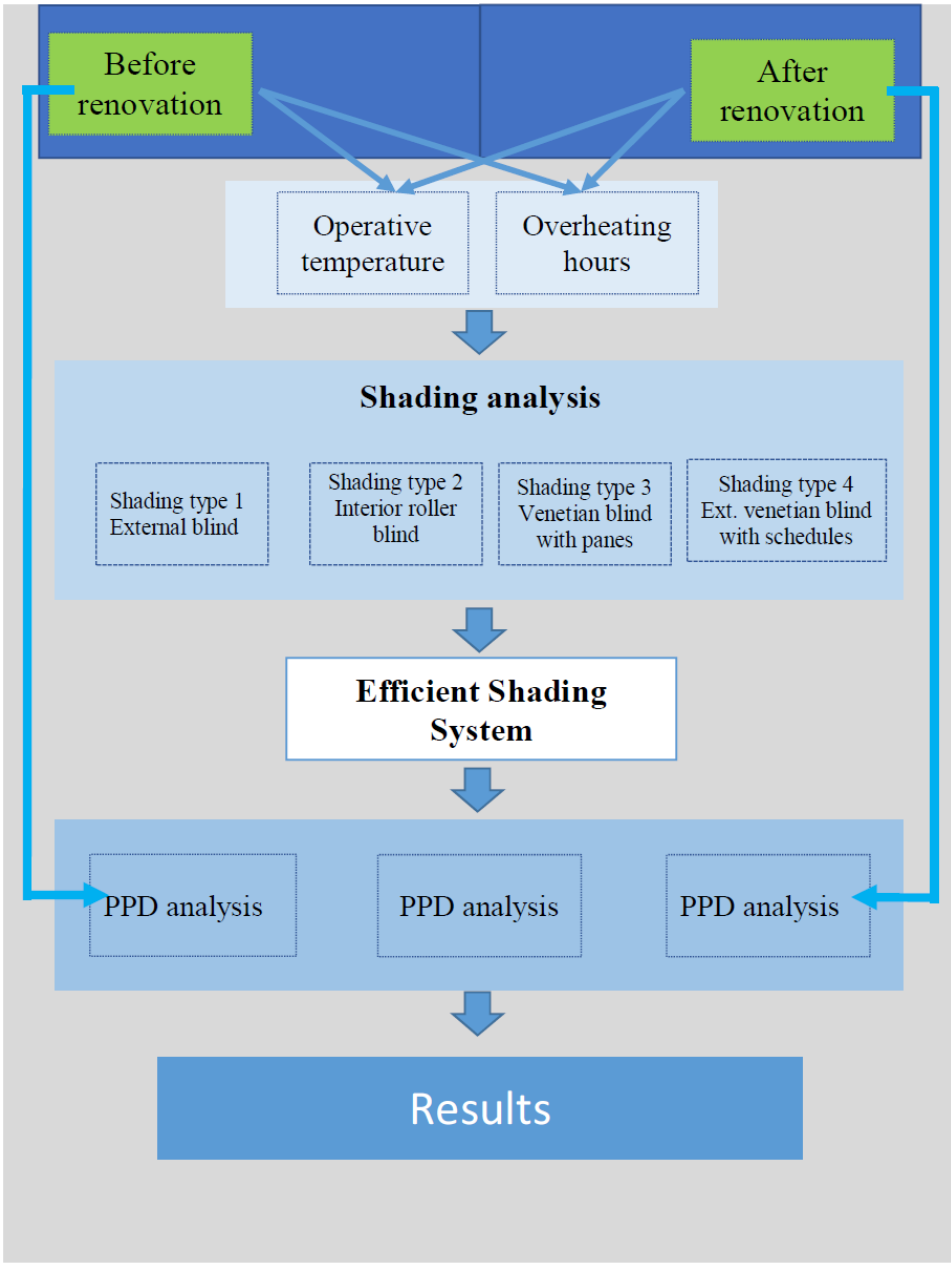
SIMULATION PARAMETER

- THERMAL COMFORT

PARAMETRIC STUDY ANALYSIS

- IDA ICE

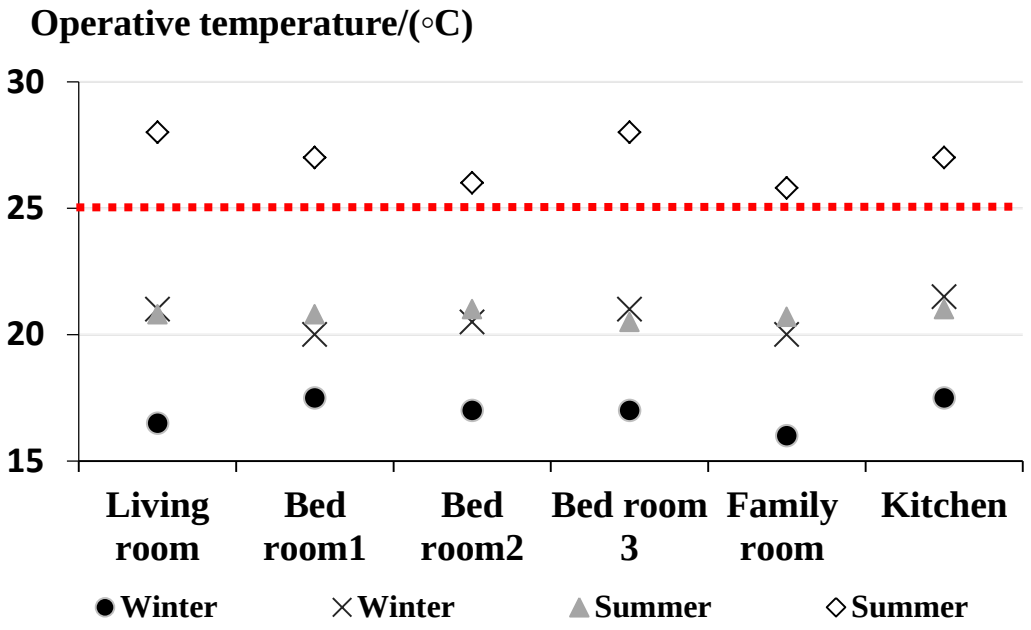




OPERATIVE TEMPERATURE - BUILDING 1

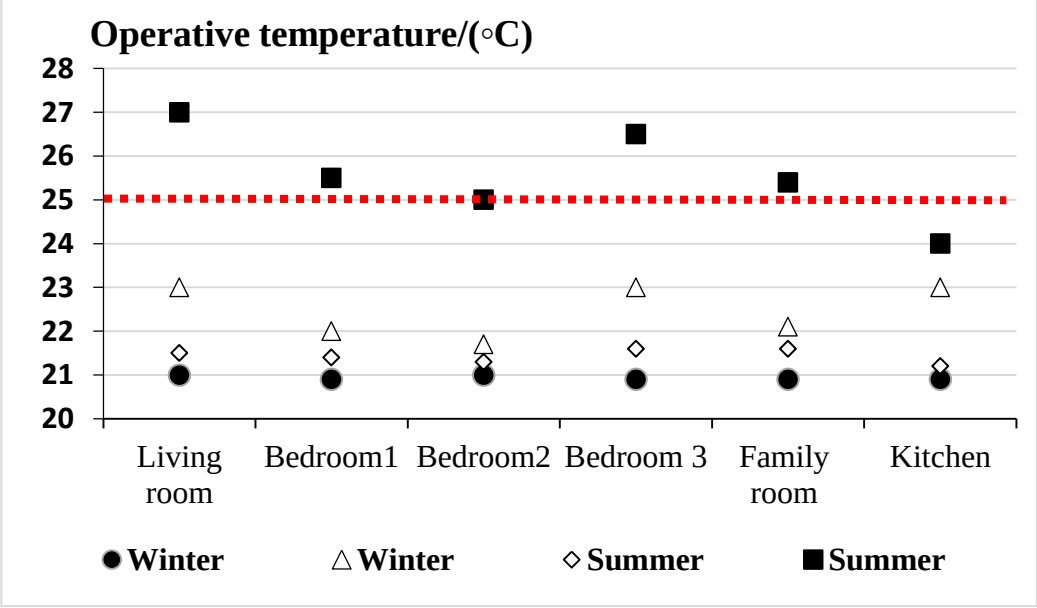
Before renovation

- MAX. OPERATIVE TEMPERATURE 28 °C
- MIN. OPERATIVE TEMPERATURE 15.5 °C



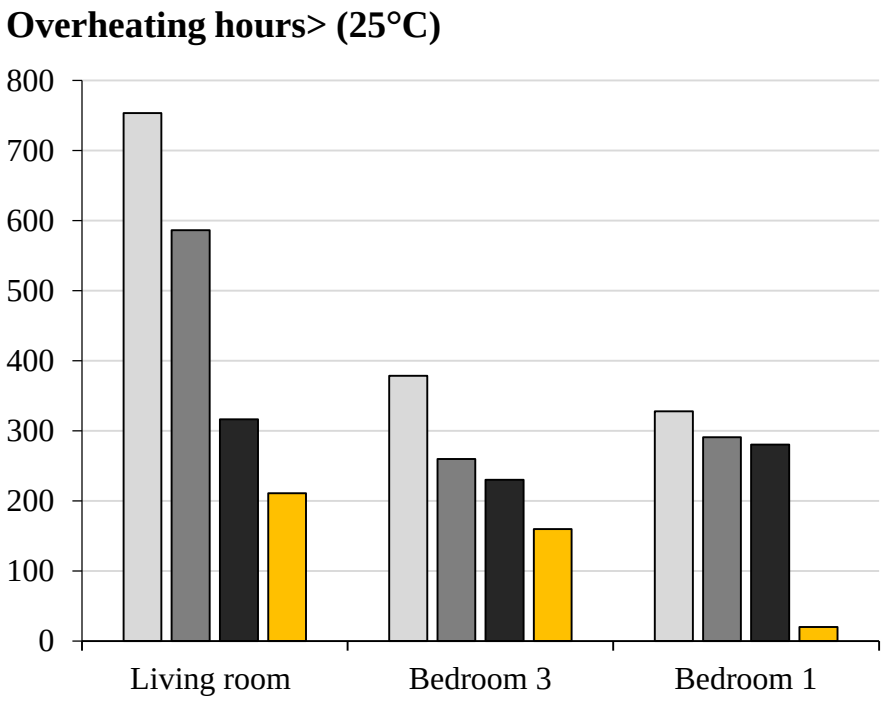
After passivehouse renovation

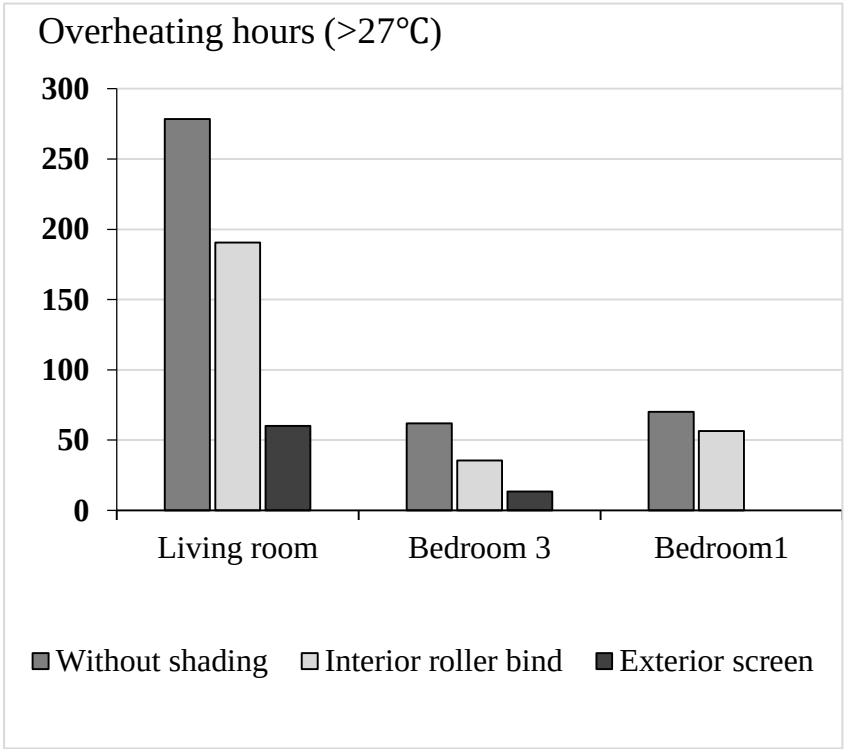
- MAX. OPERATIVE TEMPERATURE 27 °C
- MIN. OPERATIVE TEMPERATURE 21 °C



OVERHEATING HOURS AFTER RENOVATION - BUILDING 1

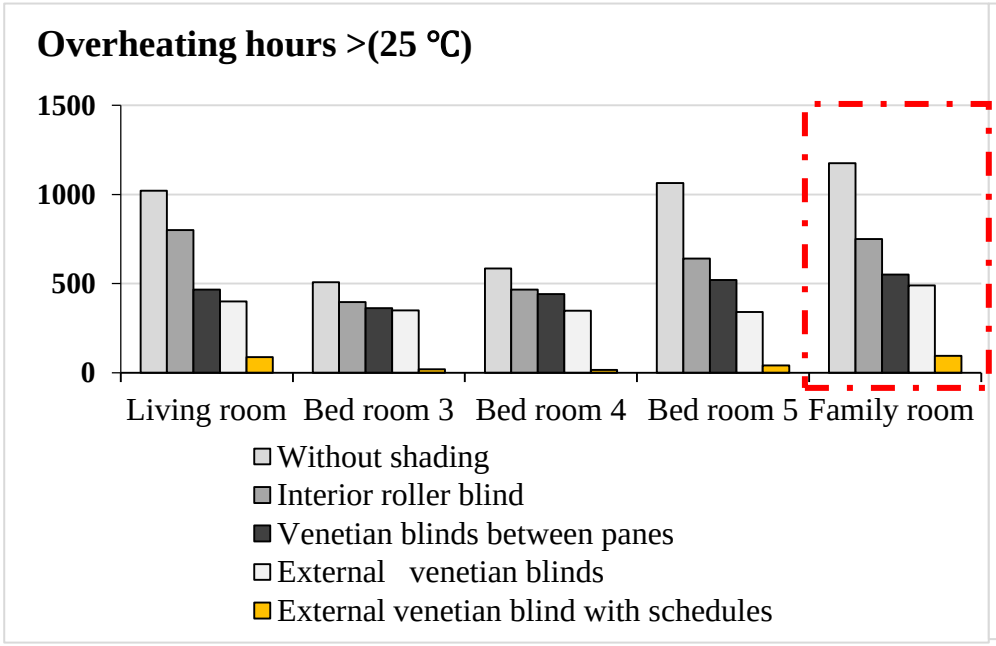
	Glass type	Shading device	U-value without shading ($W/m^2 \cdot K$)	U- value with shading ($W/m^2 \cdot K$)
1.	3mm low-emissive glass	Interior roller blind	1.53	1.27
2	Triple-glazed with low-e film	Exterior screen	1.12	1.08
3	Triple pane low emissive glass	Exterior venetian with schedules	1.12	1.01

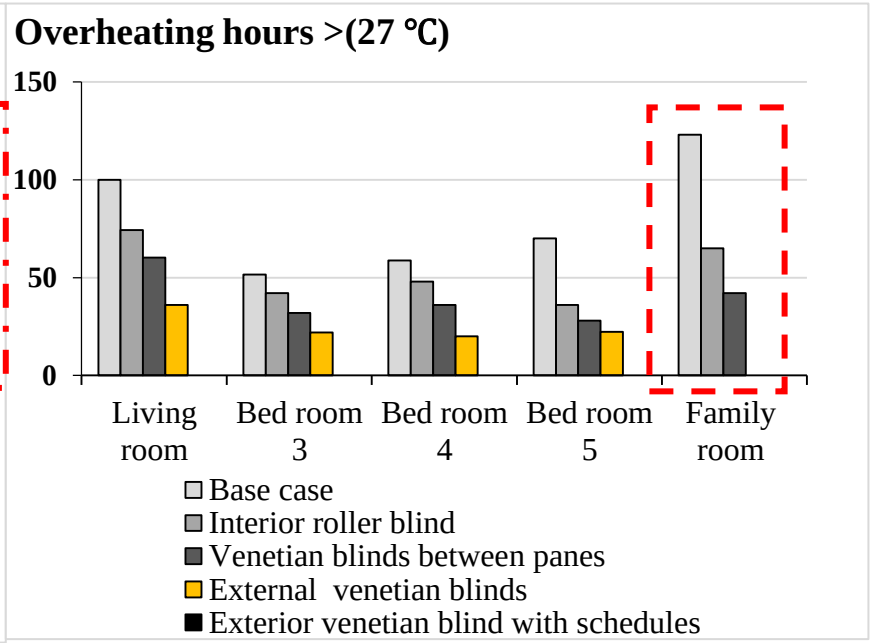




OVERHEATING HOURS AFTER RENOVATION - BUILDING 2

Glass type	Shading device	U-value without shading ($W/m^2 \cdot K$)	U value with shading ($W/m^2 \cdot K$)
Double high solar gain low emissive	External blind	1,75	1,5
Triple pane clear glass	Interior roller blinds	1,86	1,57
Triple pane suspended low-e-film	External venetian blind with schedules	1,12	1,016
Venetian blind between two panes	-	0,91	0,83





OPERATIVE TEMPERATURE AFTER RENOVATION

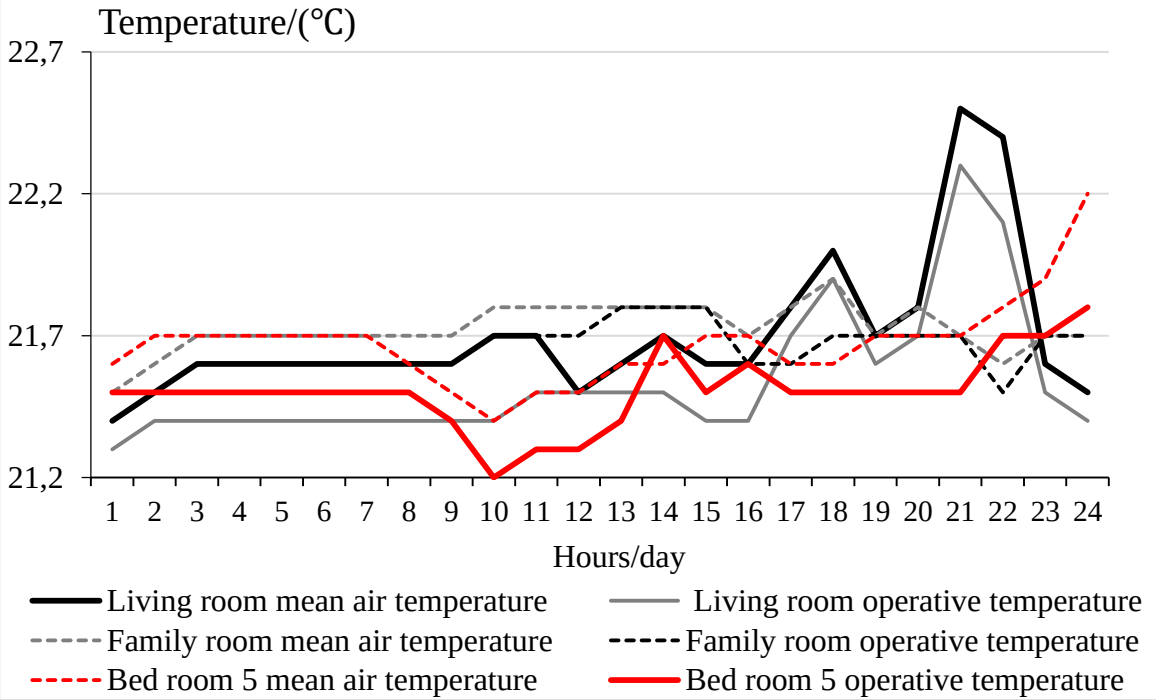
Case study building 2

Max op.temp January 21

Livingroom 22,3 °C

Familyroom 21,9 °C

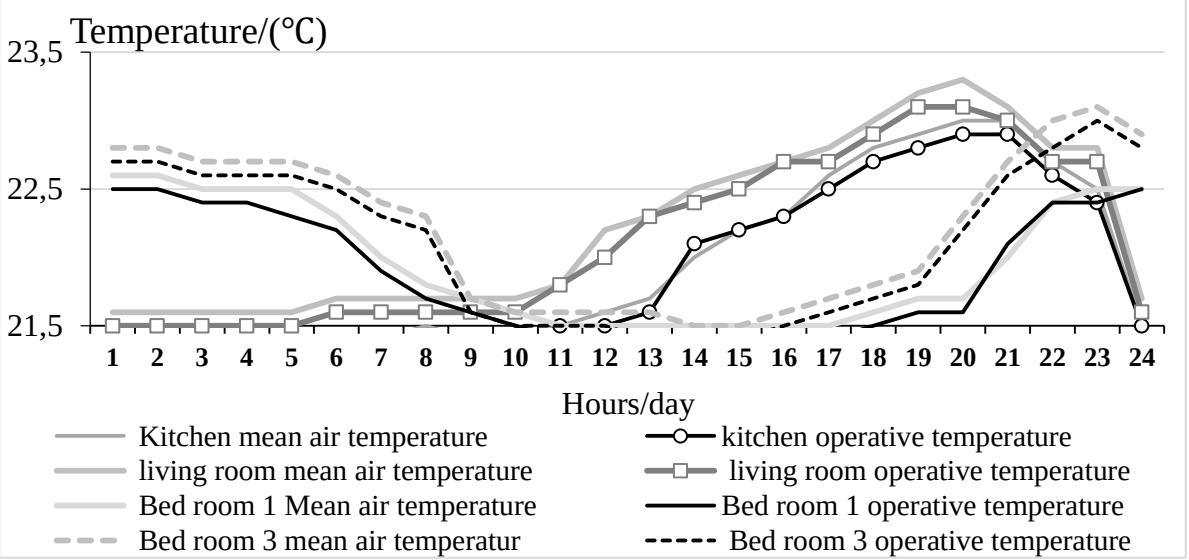
Bedroom 5 21,8 °C



Case study building 1

Max op.temp January 21

- Livingroom 23,3°C
- Bedroom 1 22,4°C
- Bedroom3 23°C
- Kitchen 23,2°C

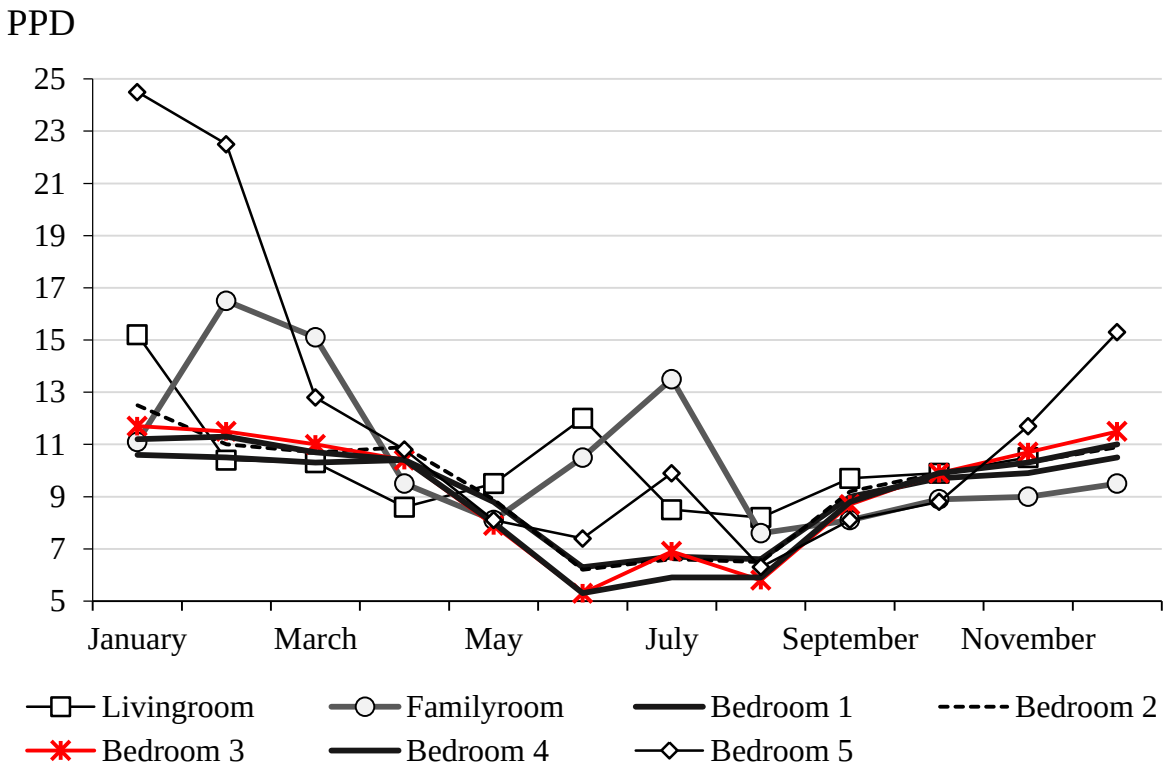


PPD ANALYSIS IN THE EXISTING CASE STUDY BUILDING 2

Thermal climate	Bronze	Silver	Gold
PPD (%)	≤ 20%	≤ 15%	≤ 10 %

- Higher PPD (*Predicted percenatage of dissatisfied*) levels during winter > 20

- Average PPD >10

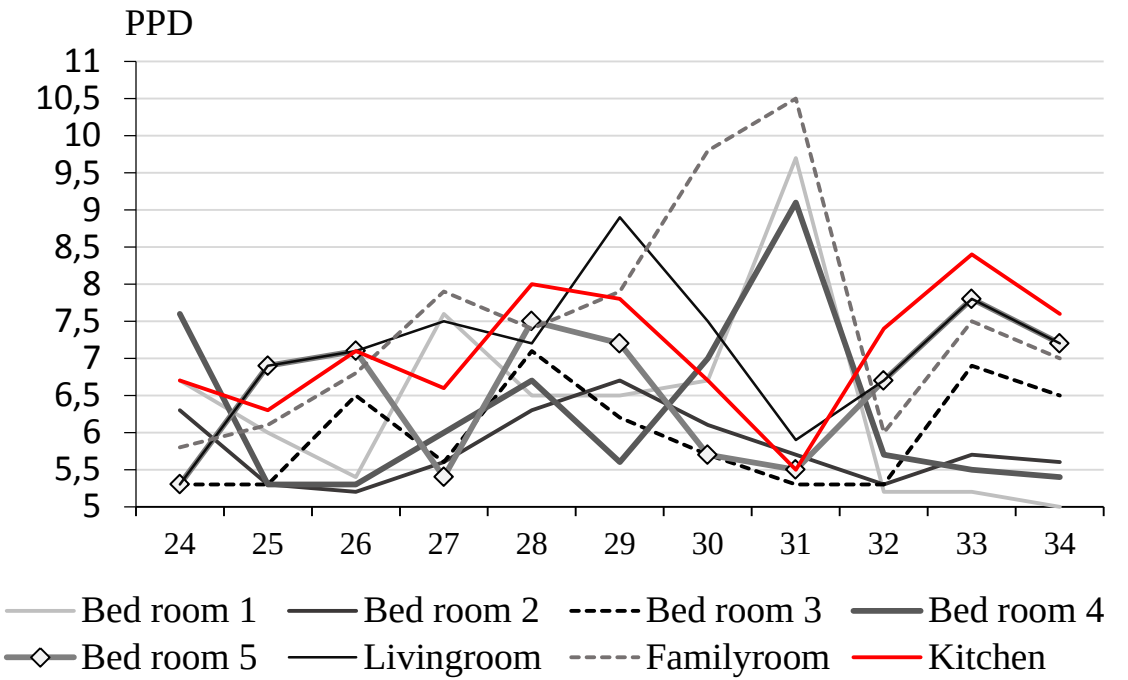


PPD ANALYSIS IN THE RENOVATED CASE STUDY BUILDINGS - SUMMER

Case study building 2

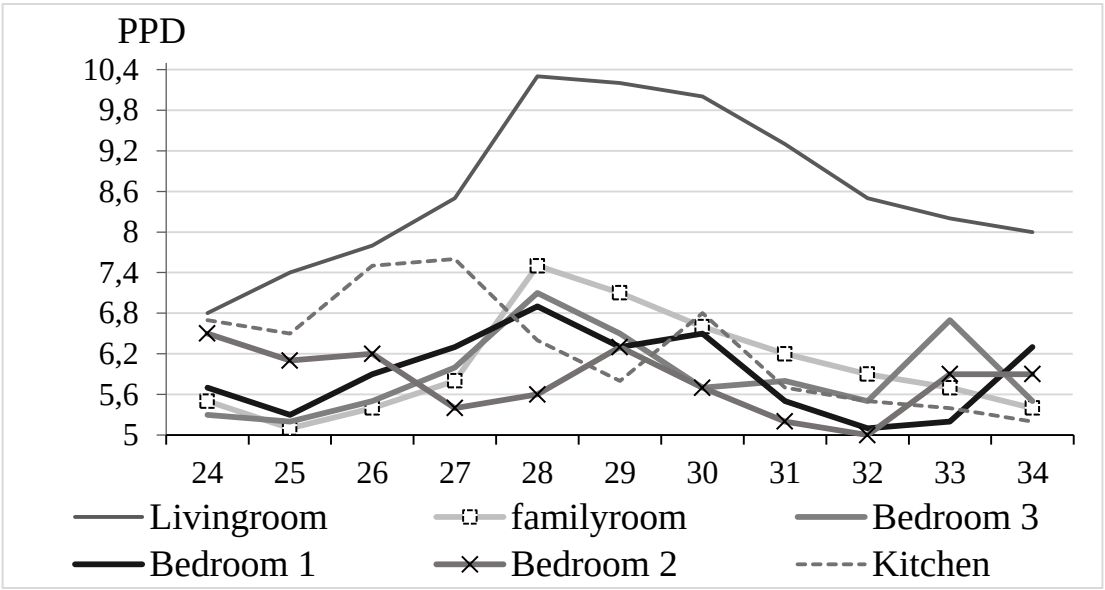
Max PPD

- Family room 10,5%
- Bedroom1 9,7%
- Bedroom 4 9,1%



Case study building 1

- Livingroom 10,2%
- Kitchen & family room 7,5 %

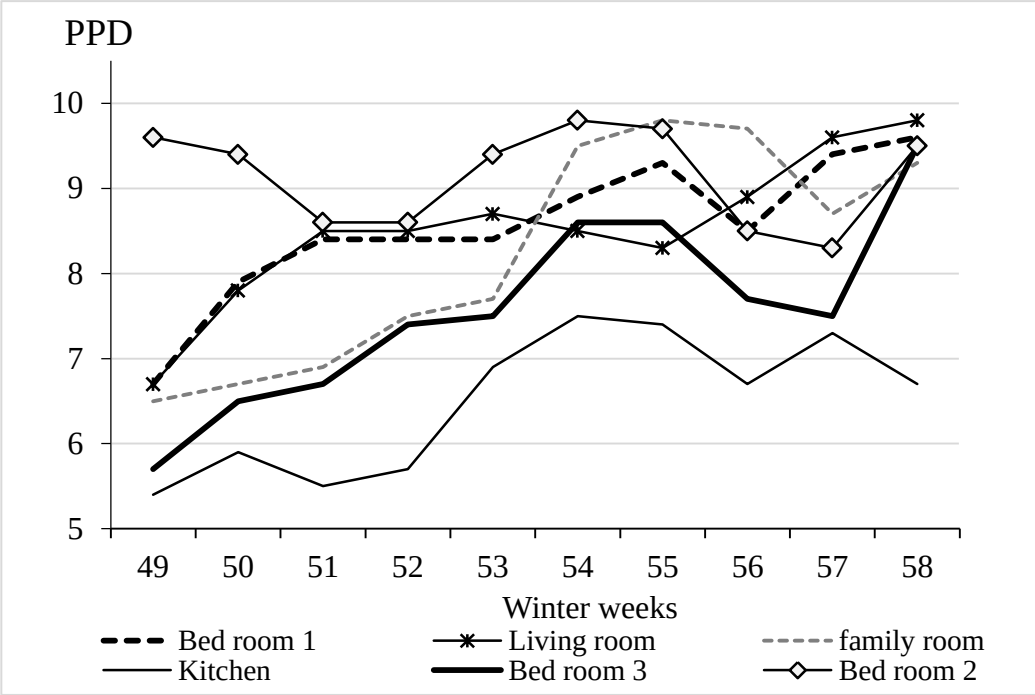


PPD ANALYSIS DURING WINTER

Scenerio after renovation

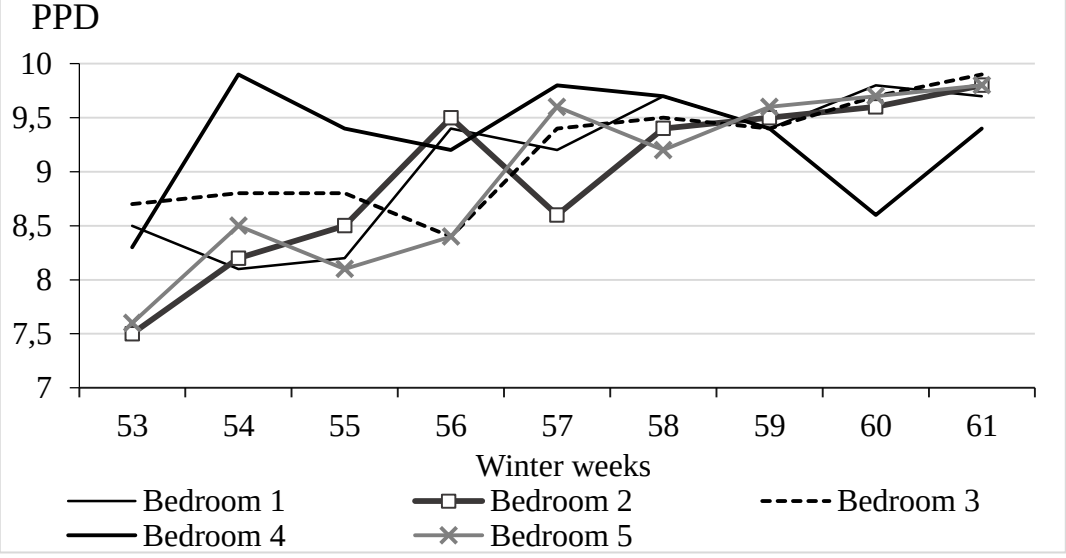
Building 1

- 5 – 9.5%



Building 2

- 7.5 – 9.7%



CONCLUSIONS

- Energy use according to **Swedish passivehouse standard** after renovation
- **Shading** implementation & **orientation**
- Satisfactory indoor thermal environment after renovation
- Comparative analysis between **simulated** and **scientific equations** for comfort temperature
- Attained **PPD** level below 10% after renovation

Thank you all for your attention