Analysis of Modelling & Simulation Data in Buildings

Azin Farahani
HumanIC Project · Granlund Oy · 30 June 2026

TALK 1	EX 1	BREAK	TALK 2	EX 2
20 min	20 min	5 min	20 min	20 min

Granlund

Before you open any software,

what problem are you solving?

What kind of problems can simulation solve?
How different can the approaches be?

Today: Two Problems, Two Paths

For each: level of detail needed · software choice · results to focus on

PROBLEM 1

Energy Efficiency

- Is the building meeting energy requirements?
- How can we reduce purchased energy?
- Which measures give the best result?

→ BLOCK 1 · Exercise 1

PROBLEM 2

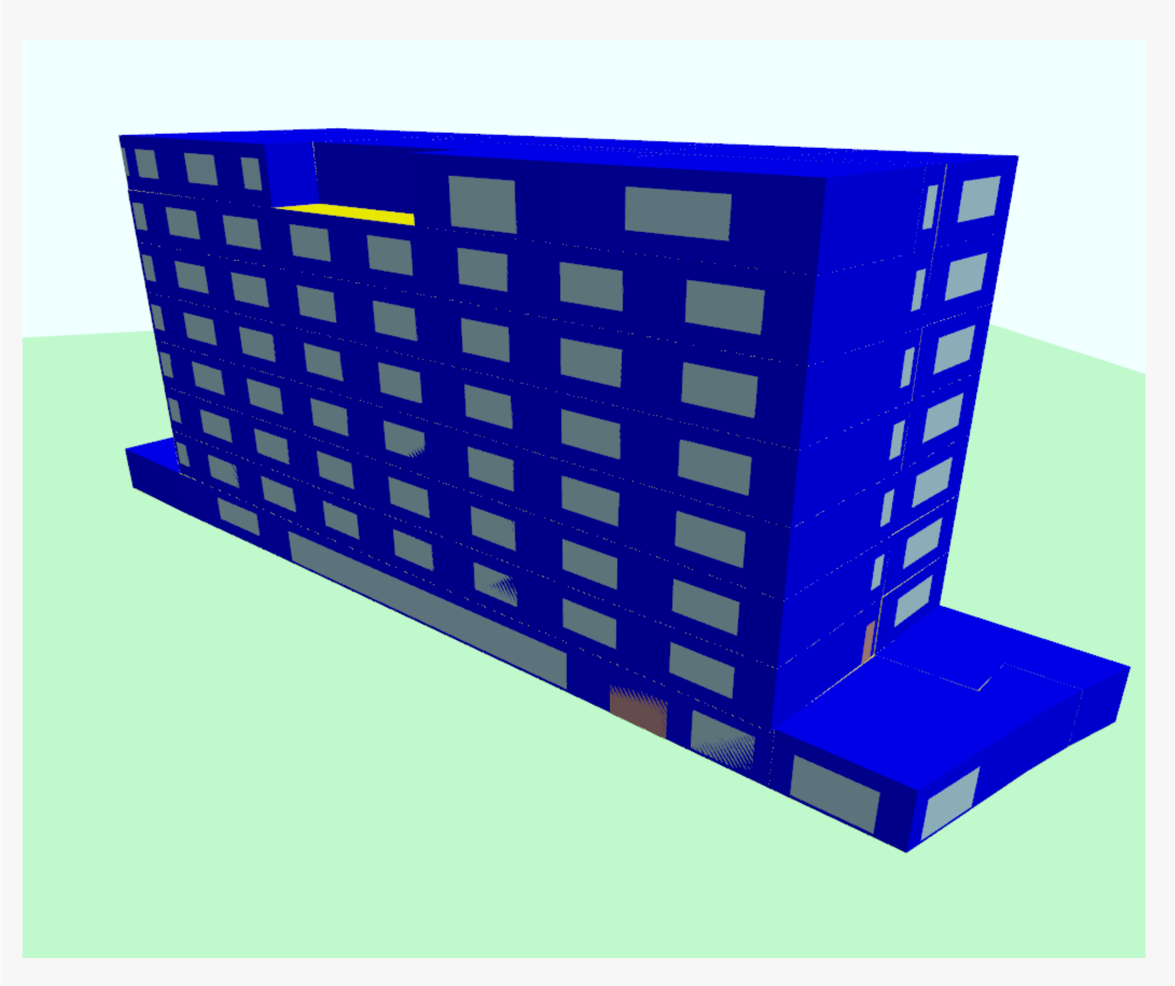
Indoor Conditions

- Will occupants be comfortable in summer?
- Is there a risk of overheating?
- Which rooms are most critical?

→ BLOCK 2 · Exercise 2

We Have a Building: Where Do We Start?

Following the energy efficiency path · our example: a new hotel



1 **What is the goal?**

Meet energy code · optimise a measure · compare systems

2 **How do we divide the building?**

Thermal zoning

3 **What inputs do we need?**

Defined by the requirements and standards we must meet

4 **Which tool?**

Depends on the question, more on this shortly

Defining Thermal Zones

The building is divided into zones, each simulated as a single thermal unit

Adjacent environments

Exterior · ground · unheated spaces · other conditioned zones. Each boundary needs a thermal resistance and boundary condition.

Construction details

Walls and windows with different U-values may justify separate zones. Thermal bridges at zone boundaries matter.

System & function of the zone

Hotel room · lobby · restaurant · kitchen — different setpoints, schedules, and internal gains. They behave differently.

Defining Requirements → List of Inputs

Requirements

Starting point:

- Country building code

(e.g. Finnish E-luku)

- EU EPBD requirements
- LEED · BREEAM · client targets

→ defines your inputs

→

Envelope

Walls · roof · floor · U-values
Windows · glazing ratio · g-value
Solar shading geometry

Ventilation system

Supply & exhaust air flows
Fan efficiency
Heat recovery unit (HRU) efficiency

Setpoints

Heating setpoint · cooling setpoint
Occupied vs unoccupied schedules

Internal gains

Occupancy (people, activity level)
Lighting load (W/m²)
Equipment & appliances

Note: detailed HVAC system design (sizing, distribution) is a separate simulation problem

Weather Files

The climate drives the building's energy behaviour, the weather file choice matter.

TRY / TMY

Test Reference Year
Typical Meteorological Year

Statistically representative year, average of many years. Used for annual energy calculations and code compliance.

Used for:

Energy certificates · code compliance · design work

Current climate

Measured recent years
(e.g. last 10–30 years)

Actual recorded weather. Slightly warmer than older TRY files. Captures recent climate trends.

Used for:

Calibration · comparing to measured building data

Future climate

Morphed / downscaled
climate projections

TRY file modified with climate change projections. Hotter summers, milder winters.

Used for:

Resilience studies · long-term investment decisions

Running the Model: Results & Sanity Checks

Before you trust the results, check that the model is behaving correctly

What outputs you get:

Annual energy demand (kWh/m²/yr)
The headline number for code compliance

Purchased energy
Changes when you change the heating/cooling system

Heating & cooling loads
Do NOT change with system choice, only with envelope/gains

Hourly power demand
Defines the peak demand and maximum needs

End-use breakdown
Heating · cooling · ventilation · lighting · DHW

Sanity checks:

- Is heating demand highest in January–February?
- Is cooling demand highest in July–August?
- Does the end-use split make sense for a hotel?
- Is DHW a significant share? (it should be for hotels)
- Do heating loads change when you change the system? (they should not)
- Is total energy demand in a plausible range?

Energy Efficiency Measures

Discussion: passive vs. active measures, how do you decide? What is the role of financial analysis?

1 Envelope

Better insulation
Improved windows
Airtightness

2 Shading

External blinds
Fixed overhangs
Glazing ratio

3 Ventilation

Higher HRU efficiency
Demand-controlled
Night setback

4 System choice

Air-to-water or GSHP
Replaces boiler
→ biggest drop in purchased energy

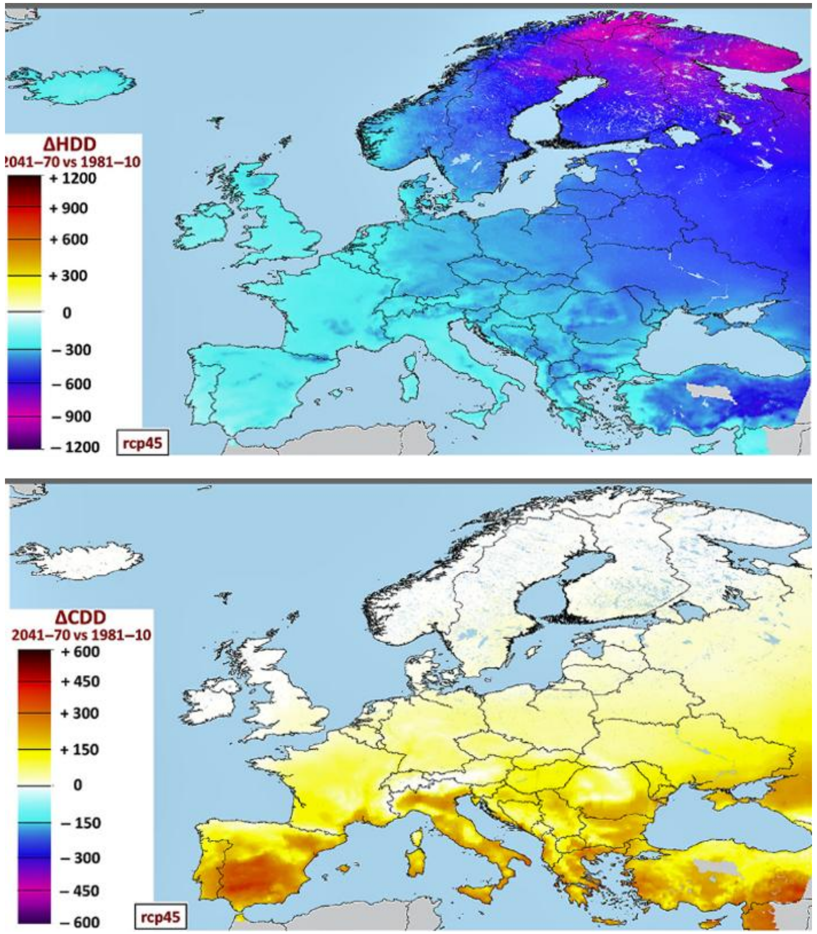
5 PV panels

On-site generation
Reduces purchased electricity

6 Battery

Stores PV surplus
Shifts consumption
Smoothed demand

Resilience: How Will the Building Perform in Future Climates?



Changes of heating and cooling degree-days in Europe from 1981 to 2100, Spinoni, Jonathan et al. 2018, https://doi.org/10.1002/joc.5362

Same building, same systems, different weather file → different picture

What changes in future climate:

- Heating demand decreases, milder winters
- Cooling demand increases, hotter summers
- Overheating risk grows significantly

What this means for systems:

- A system sized for today may be undersized for 2050 cooling loads
- Passive measures become more critical
- Long-lived buildings should be designed for future climate

This is a bridge to Block 2, where we look at indoor conditions and overheating in detail

EXERCISE 1

Find the Best Solution

Hotel building · simulation results from multiple runs · 20 minutes

1 Compare purchased energy

You have results from multiple simulation runs, different envelope, HVAC, and system combinations. Compare purchased energy ($kWh/m^2/yr$) across all scenarios.

3 Understand what changed

For each measure tested, estimate its contribution. Which measure had the biggest single impact on purchased energy?

2 Find the best solution

Which combination gives the lowest purchased energy? Is it the same as the lowest heating load? Why or why not?

4 Discuss

Would you recommend the 'best' solution to the client? What other factors would you consider?

Annual energy cost = (Total DH × 65) + (Total Electricity × 80),
Payback vs. baseline = investment cost ÷ annual savings.

5 min Break

Why Does Overheating Matter in Nordic Climates?

The well-insulated building paradox

The paradox:

- Well-insulated buildings retain heat in summer just as effectively as they retain it in winter
- Residential buildings are mechanically ventilated but not cooled
- Airtight envelopes and big windows can trap sun heat

Climate trends in Finland:

- Warming at ~2× the global average rate
- Longest heatwaves recorded in 2010, 2014, 2018, 2021
- Heatwave frequency, intensity & duration all increasing

Health impacts:

- Cardiovascular stress, blood flow disorders
- Increased mortality risk among elderly during heatwaves
- Sleep disruption, night temperatures stay high in insulated buildings

Field data — Helsinki apartments:

- Average summer 2020: 76% of apartments exceeded 27°C
- Hot summer 2021: 96% exceeded 27°C, 3× more degree hours than 2020
- Newer buildings (post-2012 code) had lower risk, but still overheated during hot summers

Farahani et al. (2024), Building Research and Information

We're moving to a different problem, indoor conditions.

What needs to change in our simulation approach?

Think about: zoning · time resolution · weather file · outputs · tools

What Changes for an Indoor Conditions Study

Same physics engine, very different model setup and outputs

	Energy efficiency approach		*Indoor conditions approach*
Zoning	Grouped by floor or orientation (one zone = several rooms)	→	Room by room, each space has its own temperature, gains, ventilation
Time resolution	Annual or monthly totals Hourly timestep sufficient	→	Hourly or sub-hourly, peak temperatures happen fast and matter
Weather file	TRY — statistically average year for annual energy balance	→	Hot summer file (e.g. 2018) or future climate — worst case matters
Key outputs	kWh/m²/yr · purchased energy End-use breakdown	→	Operative temperature per zone · degree hours above threshold · peak temp
Tool	Granlund EC · Riuska Fast, compliance-focused	→	IDA ICE (Equa), detailed radiation, solar gains per surface, occupant behaviour

Defining Overheating , No Universal Standard

Different countries use different metrics, thresholds, and calculation methods

Some international approaches:

EN 16798 Adaptive comfort, threshold varies with running mean outdoor temperature **CIBSE TM52** 3 criteria: exceedance hours, daily weighted exceedance, upper limit temperature **% hours** % of occupied hours above a fixed threshold (e.g., 25°C or 27°C)

In Finland — Ministry of Environment (D3/2018) + health regulations:

Design criterion (new buildings):

Max. 150 degree hours above 27°C

- Calculated for June–August using TRY2012 weather data
- Applies to new apartment buildings (≥3 floors)
- Applies regardless of cooling system type or ventilation strategy
- 1 degree hour = 1 hour of indoor temperature 1°C above 27°C

Three health thresholds:

27°C	**Comfort limit** Code compliance threshold
30°C	**Health concern** Significant health risk begins
32°C	**Health hazard** Acute risk, especially elderly

Farahani et al. (2024) · Ministry of Environment Finland (D3/2018)

Why More Detailed Tool for Indoor Conditions

Enough calculation detail to produce trustworthy overheating results

What more detailed simulation tools models:

- Solar radiation per surface, each wall and window calculated separately
- Long-wave radiation between surfaces, hot ceiling, floor, walls all contribute to operative temperature
- Detailed HVAC, real fan curves, coil performance, control logic
- Occupant behaviour, window opening, blind control, occupancy schedules
- Sub-hourly timesteps, catches fast temperature peaks
- Room-by-room outputs, temperature, PMV, degree hours per zone

Key outputs for overheating:

- Operative temperature (°C), hourly per zone
- Degree hours above 27°C / 30°C / 32°C
- Peak temperature, when and where
- Time above threshold, % of summer hours

Operative temperature:

= average of air temperature + mean radiant temperature

- A room can feel much hotter than the air temperature if walls, ceiling or floor are warm
- Top-floor rooms: roof heats up → high radiant temperature even if ventilation keeps air cool

Reading the Results: What to Look For

From simulation output to actionable conclusions

What to check:

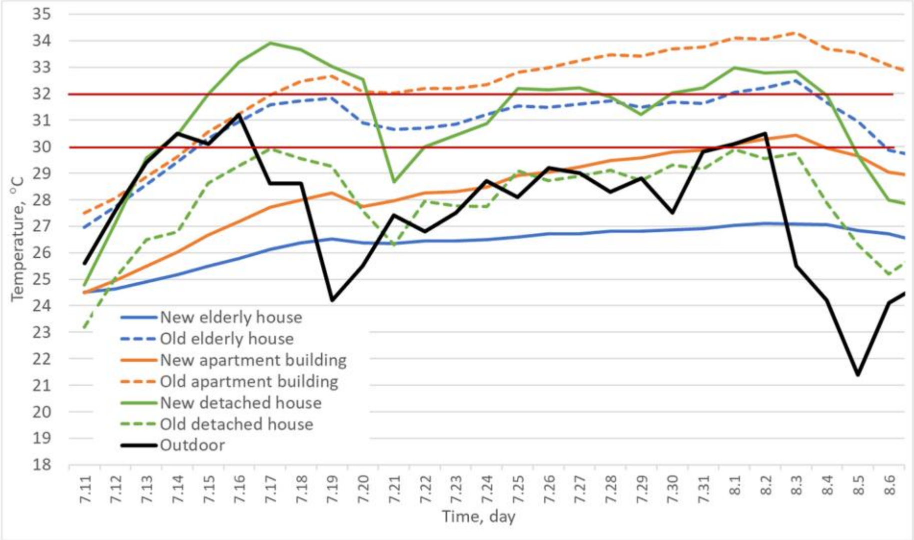
Which rooms overheat most?
Compare degree hours per zone — south/west facing, top floor, open-plan

When does peak occur?
Which week, which hour of day — useful for mitigation timing

How far above threshold?
150 °Ch is the limit — is it 200? 500? 2000? Scale matters

Night vs. day pattern
Does the building cool down overnight? Indicates thermal mass behaviour

Sanity check
Does the hottest room face south/west? Is it on the top floor? Expected?



How to interpret degree hours:

< 150 °Ch → compliant

150–500 °Ch → borderline, passive measures likely sufficient

> 500 °Ch → significant overheating, active cooling likely needed

You've found which rooms overheat.

What measures do you use to fix it?

And how would you decide between passive and active solutions?

Passive

Shading · night ventilation
Thermal mass · window properties

Active

Mechanical cooling
Ventilation boost · split units

Consider

Cost · energy use
Future climate · which rooms?

EXERCISE 2

Find the Best Solution

Multiple simulation cases · calculate overheating · find the best mitigation · 20 minutes

1

Calculate degree hours per case

You have hourly operative temperature outputs for multiple simulation cases — each with a different mitigation measure. Calculate degree hours (June–August) for each case.

2

Find the best solution

Which case gives the lowest degree hours? Which cases pass the 150 °Ch threshold? Is any single measure sufficient, or do you need a combination?

3

Understand what changed

For each measure, estimate its contribution. Which had the biggest single impact?

4

Discuss

Would you recommend the best-performing solution? Consider: does it work in future climate too? What is the cost and energy trade-off?

Data is sorted descending for duration curve.

Thank you for your attention!