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Documentation of the performance gap

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Problem

It is the general experience that energy efficient new or renovated buildings perform differently than expected with regard to energy consumption. The buildings often have higher energy consumption than expected.

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Why

- errors in the input to the design tool or the design tool cannot handle specific features of the building correctly,
- changes in the design of the building and/or constructions as well as energy service systems during the building process,
- other demands and usages than the standard conditions used in the applied design tool,
- different climatic conditions compared to the weather data used in the design tool,
- faults, inadequate balancing and bad commissioning of the building constructions and the energy service systems of the building.

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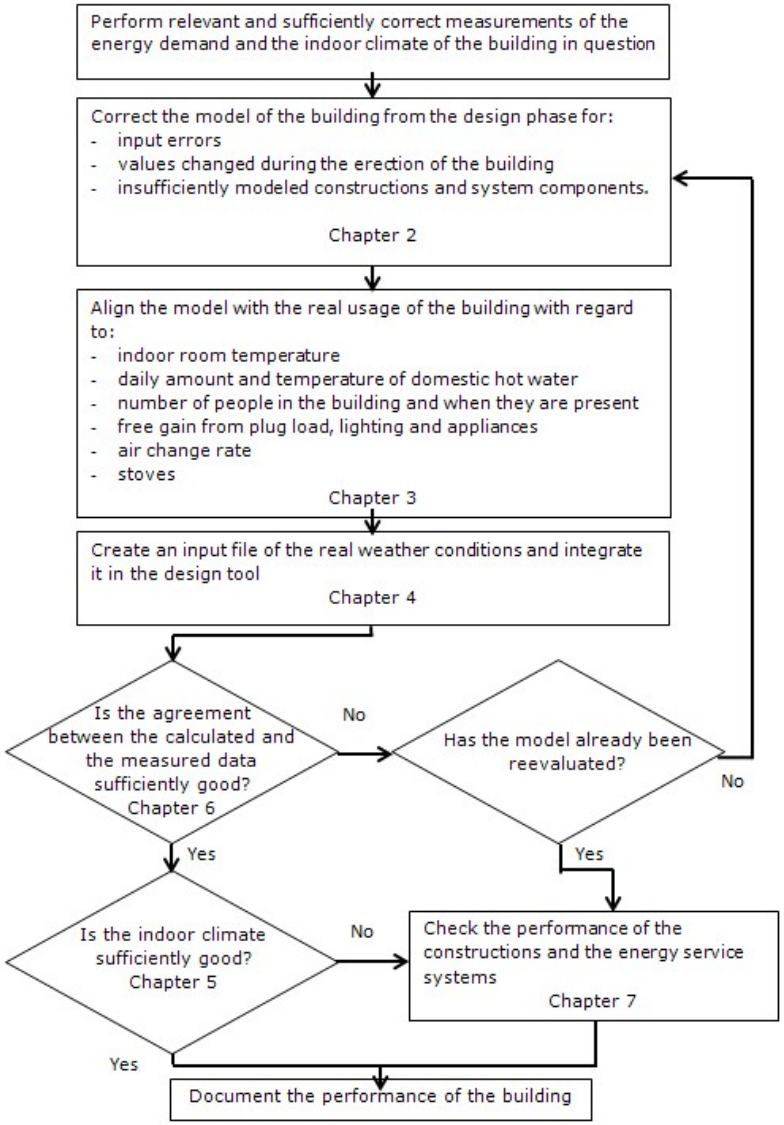
How to compare



Guideline on Documenting the Performance of Built Low Energy Buildings
https://www.teknologisk.dk/strategisk-forskningscenter-for-energineutralt-byggeri/dokumentation-af-bygningers-energiforbrug/38997,2

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Two xamples

before

after

Renovation:
Sems Have

New building:
BOLIG+

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Aim

- Both buildings: annual primary energy demand: 20 kWh/m² (primary energy factors: district heating: 0.6 and electricity: 1.8).
- For Sems Have the production from PV may be subtracted the demand, while this is not possible for BOLIG+
- BOLIG+: energy neutral in the sense that the same amount of primary energy and its usability should be produced at the building as is used in the building including both energy for operating the building and the energy use of the occupants in the apartments

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Sems Have

Designed heating demand: 25.5 kWh/m²,
Measured consumption: 53.8 kWh/m²
Difference: 111 %

28 % less heating degree-days during the measured year, so the measured consumption was weather corrected to: 63.2 kWh/m²

Compared to the design case:
The indoor temp was 3 K higher
The ventilation flow rate was 35 % higher
The infiltration was 43 % higher

The model of the building gave with these changes in input: 41.9 kWh/m²

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Sems Have

Including the ventilation systems' heat losses which were not accounted for: 45.8 kWh/m²

Including a more correct amount of hot pipes in the cellar: ~63.2 kWh/m²

Electricity demand of the buildings
Design case: 6.1 kWh/m²
Measured: 6.6 kWh/m²

PV production
Design case: 3.8 kWh/m²
Measured weather corrected: 4.7 kWh/m²

Primary energy demand
Design case: 20.0 kWh/m²
Based on measurements: 30.2 kWh/m²
Difference: 51 %

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Designed heating demand: 43.5 MWh,
Measured consumption: 47.3 MWh
Difference: 9 %

	Design	Measured
Room temperature	20 °C	22.8 ° C
Heat gains from persons	1.5 W/m²	1.03 W/m²
Heat gains from appliances	3.5 W/m²	2.4 W/m²
Mechanical ventilation	0.32 l/s/m²	0.347 l/s/m²
Infiltration	0.07 l/s/m²	0.064 l/s/m²
DHW	175 l/m²	162 l/m²
Temperature of DHW	55°C	54° C

The heating degree-days was during the measured year 3,033 compared to 3,200 in the design model

The model of the building gave with these changes in input: 36.8 MWh

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In the original calculations there were not accounted for floor heating in the bath rooms during the summer

The length of hot pipes was longer than anticipated during the design phase

Including the above in the model of the building the heat demand is: 43.8 MWh
Difference: ~0 %

Electricity demand of the buildings
Design case: 1.8 kWh/m²
Measured: 2.1 kWh/m²

Primary energy demand
Design case: 20.0 kWh/m²
Based on measurements: 21.2 kWh/m²
Difference: 6 %

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Energy neutrality ???

The PV systems produced 26 % less than designed. The occupants of the flat and the building used a bit more electricity than designed, so the buildings is not energy neutral

If the PV production and the electricity use of the flat were as expected:

Primary energy demand:	80.4 MWh
PV production:	72.4 MWh
Difference:	11 %

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Conclusion

- The calibration exercises on Sems Have and BOLIG+ show that it is not recommendable to judge the performance of a building by simply comparing the designed energy demand with the actual measured energy consumption.
- Calibration of a model of a building based on measurements is an important method to gain more knowledge of the actual energy performance of buildings.