Evaluation of Danish Residences' Hygrothermal Performance: Investigating Whether Accounting for Moisture Dynamics of Biobased Materials Can Promote Their Use in Buildings

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Indoor Environmental and Energy Engineering

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https://kirkebjergsoepark.dk/materialer/

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MATERIALSERS FUGTDYNAMIKS INDVIRKNING PÅ INDEKLIMAET

- Termisk masse
  - Lager varme
  - Udjævner temperatursvingninger
- Fugtkapacitet


Evaluating Moisture Dynamics in Building Design: Impact on Indoor Environment in Residences of Biobased or Conventional Materials

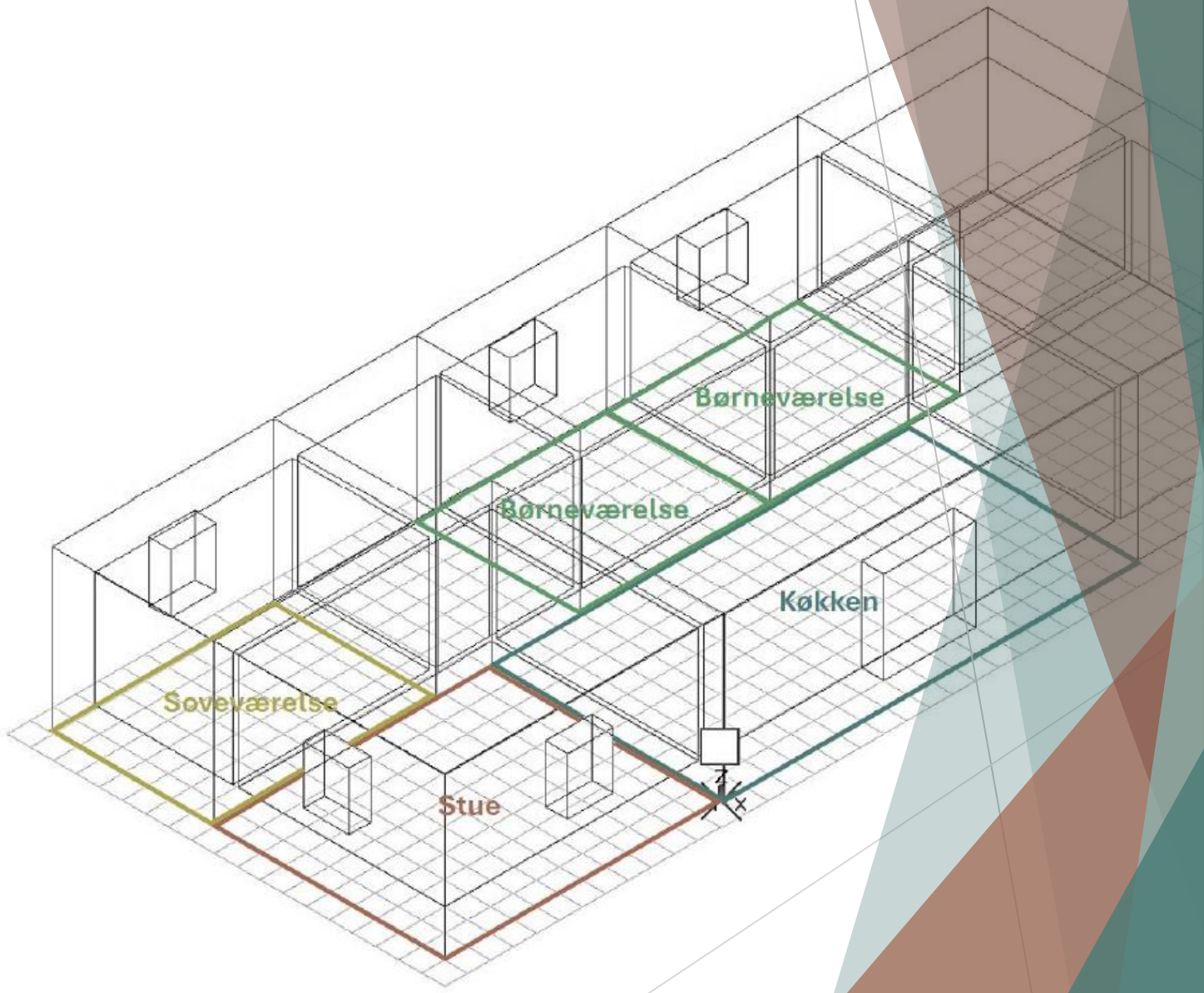
Abstract

1. Introduction

Modellen

Metode

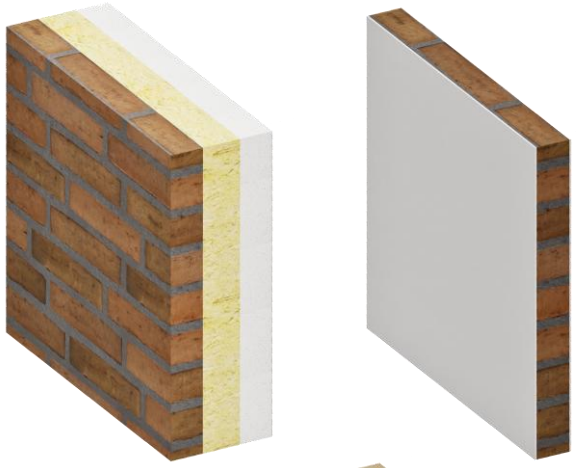
- Dynamiske indeklimasimuleringer
- Validering med måledata
- Enfamiliehus
  - Fire rumtyper: Soveværelse, børneværelse, køkken og stue



Konstruktioner

Konventionelle materialer

Tagkonstruktion



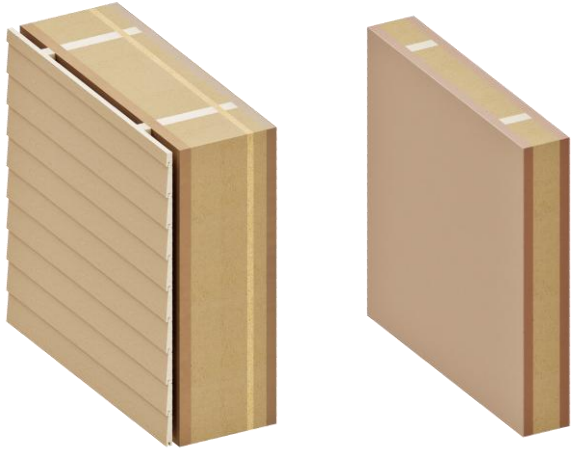
Ydervæg

Indervæg

Terrændæk

Biobaserede materialer

Tagkonstruktion



Ydervæg

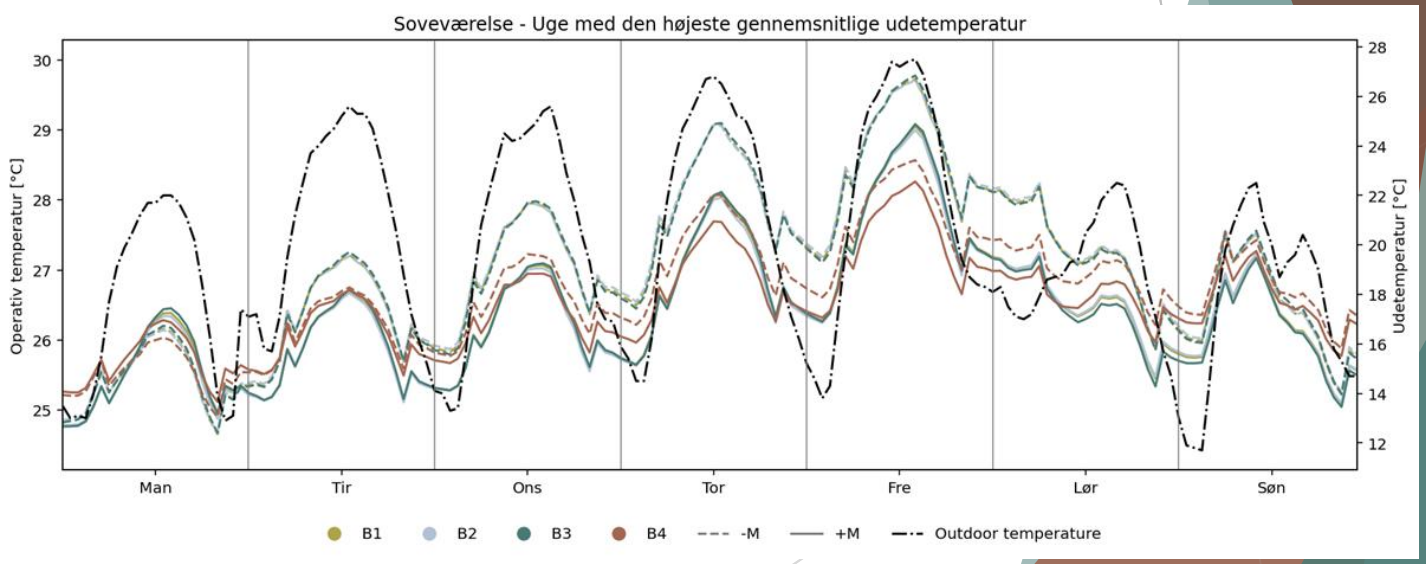
Indervæg

Terrændæk

Materialers fugtdynamiks indvirkning på indeklimaet

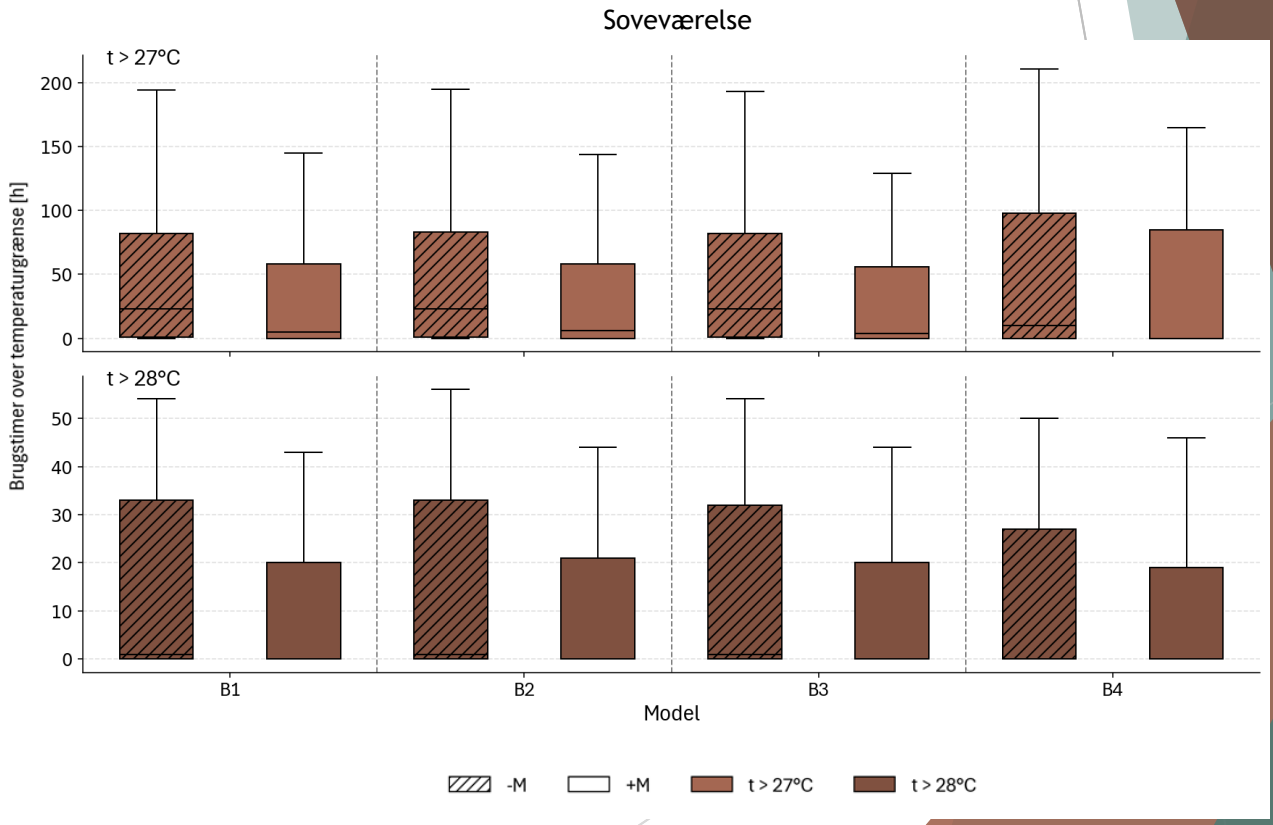
Evaluering af termisk komfort

- Operativ temperatur
- Fugttransport og bunden varme reducerer temperatur
  - - M ekskluderer fugttransport og bunden varme
  - + M inkluderer fugttransport og bunden varme



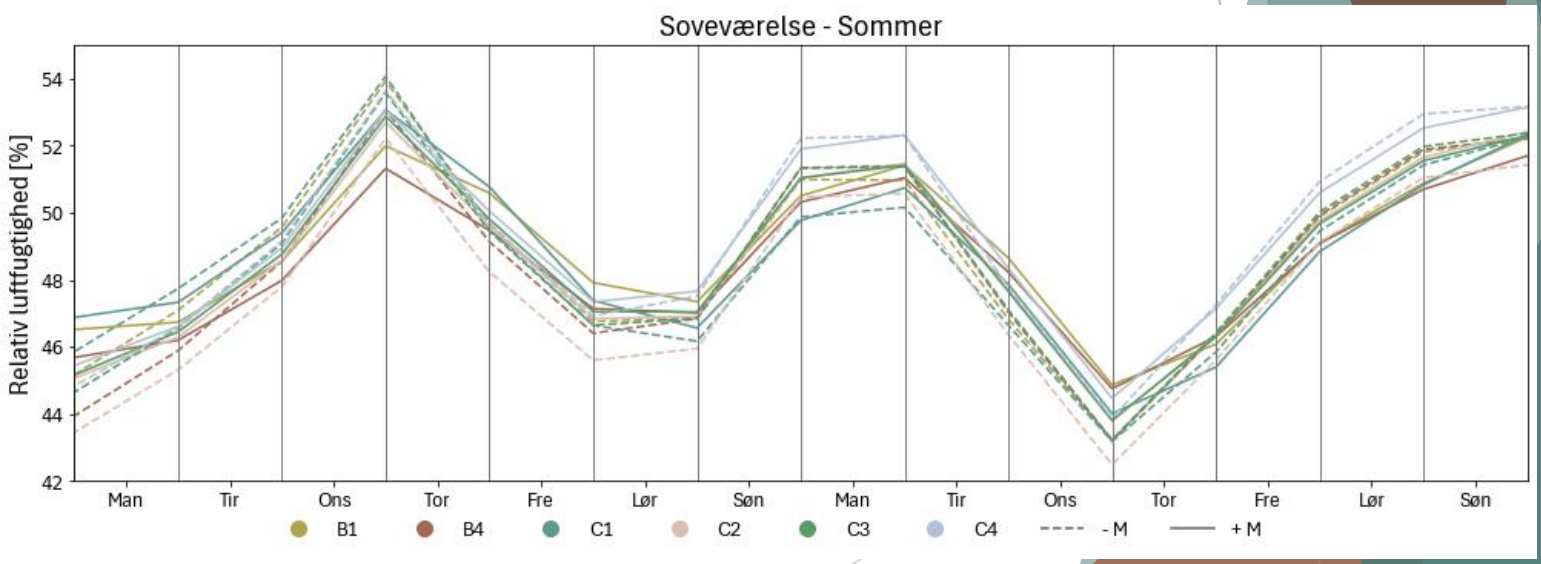
Overtemperatur

- Bygningsreglementets vejledning for antal timer over hhv. 27°C og 28°C



Regulering af relativ luftfugtighed

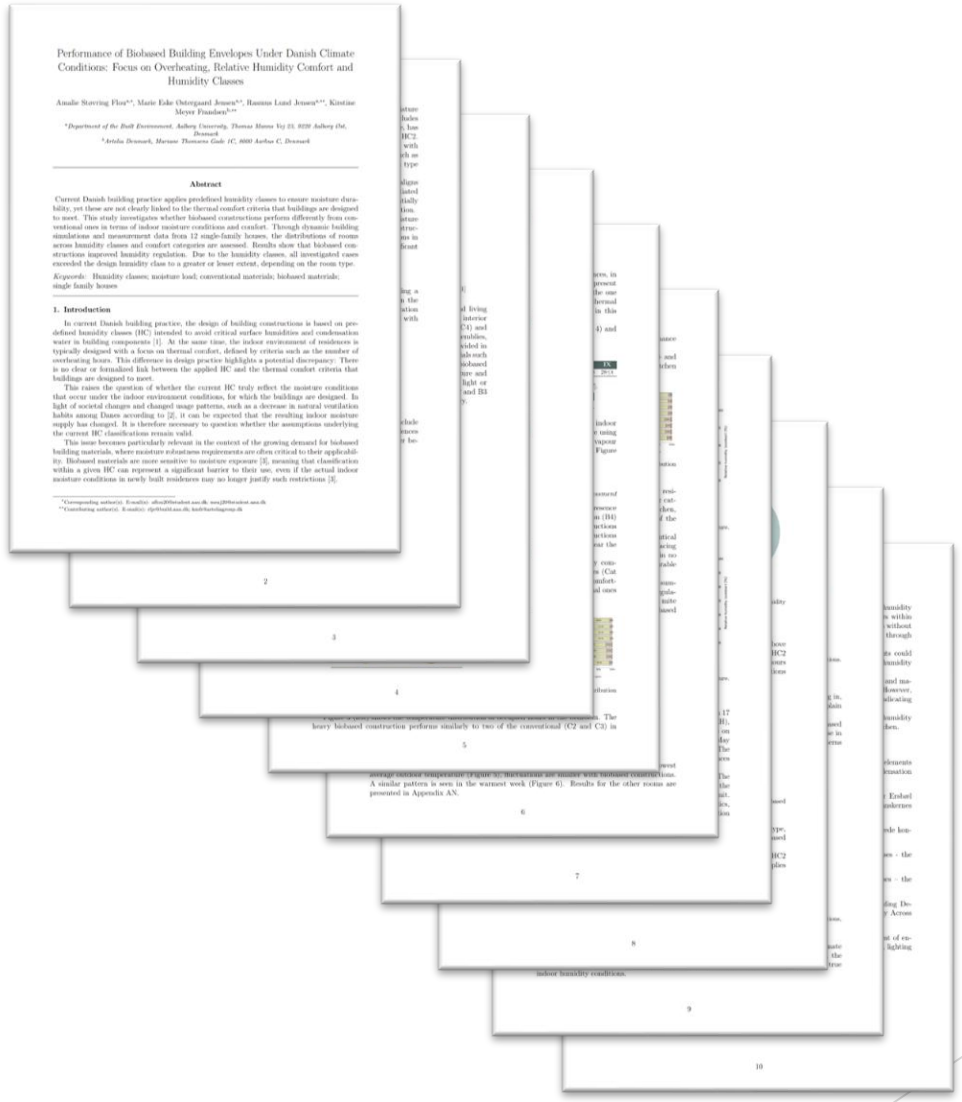
- Fugttransport og bunden varme reducerer svingninger og øger antal timer i komfortkategori I
- Gælder på tværs af alle rumtyper
- Den dæmpende effekt er størst for biobaserede materialer



Klassificering af boliger i fugtbelastningsklasser

KLASSIFICERING AF BOLIGER I FUGTBELASTNINGSKLASSER

- Fugtforhold
- Hensigtsmæssigt at inddele i fugtbelastningsklasser
- Fugtteknisk dimensionering

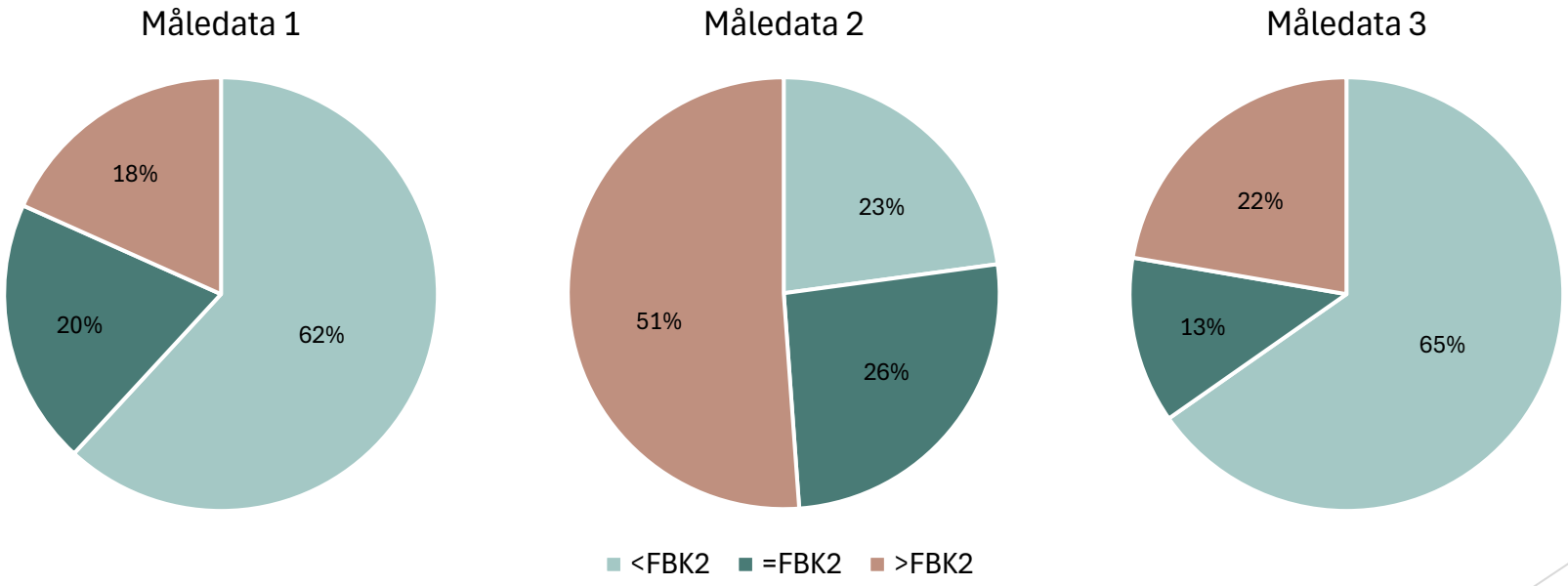

Performance of Biobased Building Envelopes Under Danish Climate Conditions: Focus on Overheating, Relative Humidity Comfort and Humidity Classes

Abstract

1. Introduction

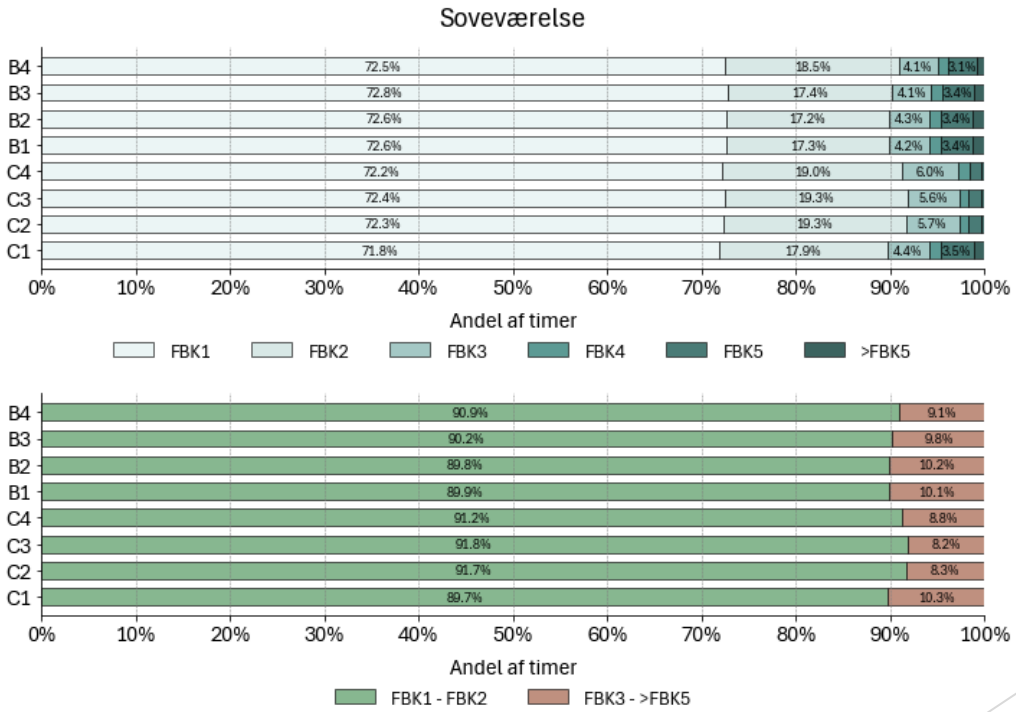
Ibrugtaget boligers placering i fugtbelastningsklasser

- 12 enfamiliehuse
- Fugtbelastningsklasse 2 (FBK2)
- Høje udetemperaturer



Luftfugtigheds-klassificering af boliger

- Timer i alle fugtbelastningsklasser
  - Rumtyper
  - Konstrukionssammensætninger



Afrunding

Fugttransport og bunden varme

- Giver anledning til lavere temperaturer og dermed færre overtemperaturstimer
- Reducerer svingninger i den relative luftfugtighed, hvilket øger den atmosfæriske komfort

Der forekommer timer både i, over og under den dimensionsgivende fugtbelastningsklasse

- De højeste fugtbelastningsklasser forekommer ved højere udetemperaturer

EVALUATION OF DANISH RESIDENCES' HYGROTHERMAL PERFORMANCE: INVESTIGATING WHETHER ACCOUNTING FOR MOISTURE DYNAMICS OF BIOBASED MATERIALS CAN PROMOTE THEIR USE IN BUILDINGS

The Danish building sector is responsible for approximately one-third of the nation's CO_2 emissions. Achieving the 70% reduction target by 2030 therefore requires a significant shift toward lower-carbon construction materials. Biobased materials absorb CO_2 during growth, storing carbon and delaying its release. This results in lower emissions compared to conventional materials.

EFFECT OF MATERIALS' MOISTURE DYNAMICS ON THE INDOOR ENVIRONMENT

METHODOLOGY

Through dynamic indoor environment simulations of eight single-family houses; four with conventional constructions (C) and four with biobased constructions (B), the impact of including moisture dynamics and latent heat on the indoor environment has been investigated. Conventional constructions use mineral-based materials, while biobased constructions use biobased materials.

RESULTS

- Inclusion of moisture dynamics reduces the number of overheating hours

Table: Temperature ranges for assessment of thermal indoor environment.

I	II	III	IV	V	VI	VII	VIII	IX
18≤ t < 20	20≤ t < 22	22≤ t < 23	23≤ t < 24	24≤ t < 25	25≤ t < 26	26≤ t < 27	27≤ t < 28	28≤t

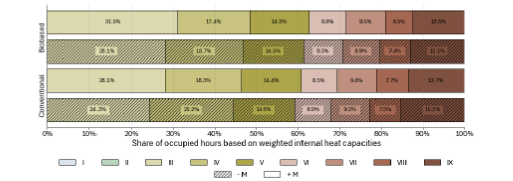


Figure: Temperature distribution in ranges by occupied hours, weighted by internal heat capacity, for one room type in conventional and biobased constructions, when moisture dynamics are excluded (-M) or included (+M).

- Inclusion of moisture dynamics lower the indoor operative temperature, across all room and construction types

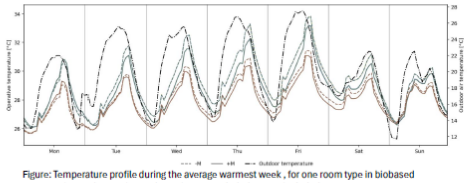


Figure: Temperature profile during the average warmest week , for one room type in biobased constructions, when moisture dynamics are excluded (-M) or included (+M).

- Inclusion of moisture dynamics increase the share of hours within the favourable comfort category (Cat I)

Table: Relative humidity ranges for the four comfort categories.

Cat IV-	Cat III-	Cat II-	Cat I	Cat II+	Cat III+	Cat IV+
RH<20	20≤ RH<25	25≤ RH <30	30 ≤ RH≤50	50<RH≤60	60<RH≤70	70<RH

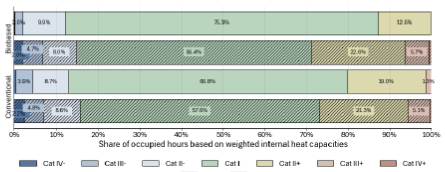


Figure: Relative humidity distribution in comfort categories by occupied hours, weighted by internal heat capacity, for one room type in conventional and biobased constructions, when moisture dynamics are excluded (-M) or included (+M).

- Inclusion of moisture dynamics reduce fluctuations in indoor relative humidity, especially in rooms of biobased constructions

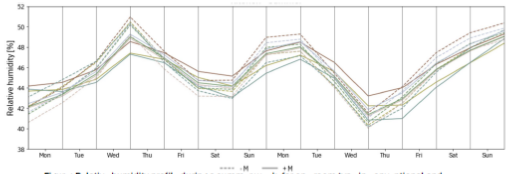


Figure: Relative humidity profile during a summer week, for one room type in conventional and biobased constructions, when moisture dynamics are excluded (-M) or included (+M).

- Biobased materials have a higher moisture capacity, but is does not compensate for their reduced heat capacity. They can only match the thermal performance of heavy conventional constructions to a limited extent. This limitation applies if indoor temperature is not to be effected.

CLASSIFICATION OF SINGLE-FAMILY HOUSES IN HUMIDITY CLASSES

METHODOLOGY

Current humidity class classifications may be inaccuracy due to changed indoor moisture conditions, limiting the use of moisture-sensitive biobased materials. The humidity class categories humidification of indoor air based on use and ventilation. At present, single-family houses are designed for humidity class 2 (HC2). Through measurements and dynamic indoor environment simulations of single-family houses, the relevance and representativeness of the designated humidity class have been evaluated.

RESULTS

- Occupied single-family houses fall below, within and above humidity class 2. The proportion varies from house to house.

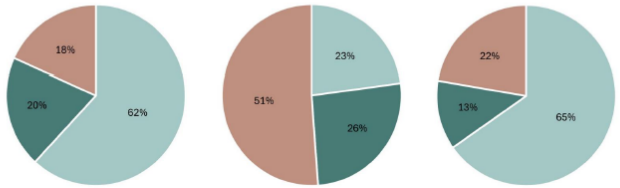


Figure: Share of hours below, within and above humidity class 2 for single-family houses built in different years and located in different geographical regions.

- Simulated single-family houses fall into all humidity classes, with the majority falling below the designated design class across all rooms and construction types. Generally, higher humidity classes are observed predominantly during the summer months.

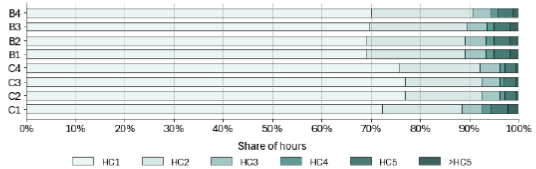


Figure: Share of hours in the different humidity classes, for one room type in conventional and biobased constructions.

- The study raises the question of whether the humidity classes are overestimated during the winter months and underestimated during the summer months.

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