AGGREGATED BUILDING ENERGY MODELLING AND PARAMETRIC VARIABILITY STUDY

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Aggregation and typologies

Gianniou et al., Aggregation of Building Energy Demands for City-scale Models, Building Simulation 2015, Hyderabad

Aggregation based on archetype buildings

$$Y = \sum_{j=1}^{N} EUI(j)A(j)$$

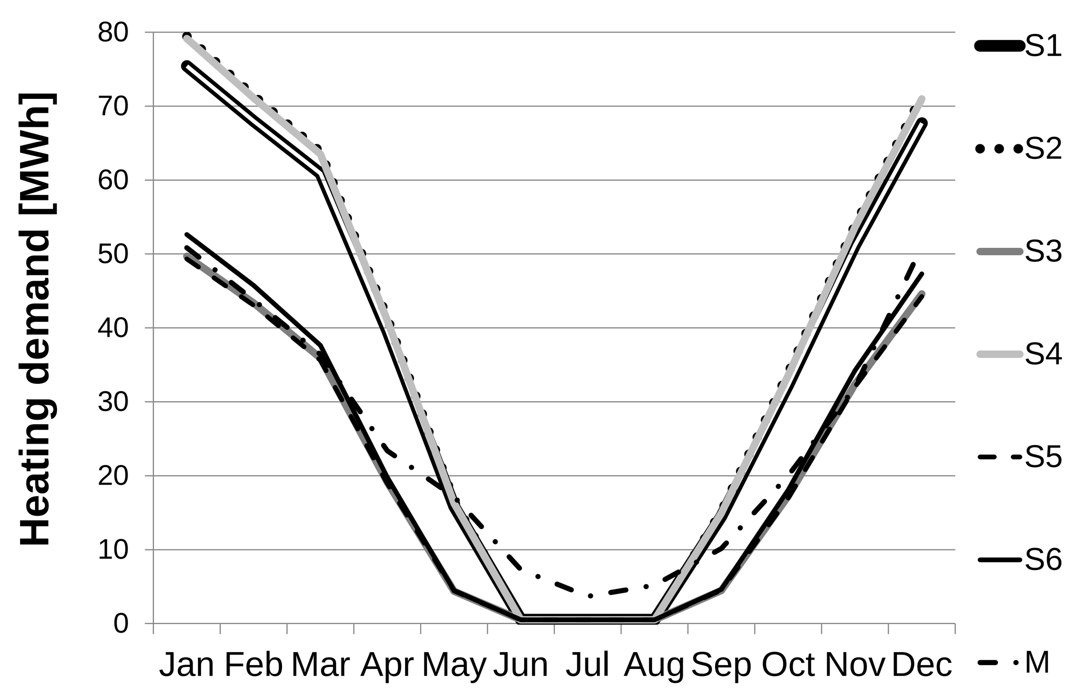
where
Y = total energy demand of the examined building stock [kWh]
j = building type
N = total number of building types describing the stock
EUI = energy demand per floor area [kWh/m^2] for each building type
A = total floor area [m^2] of all buildings included in the respective type

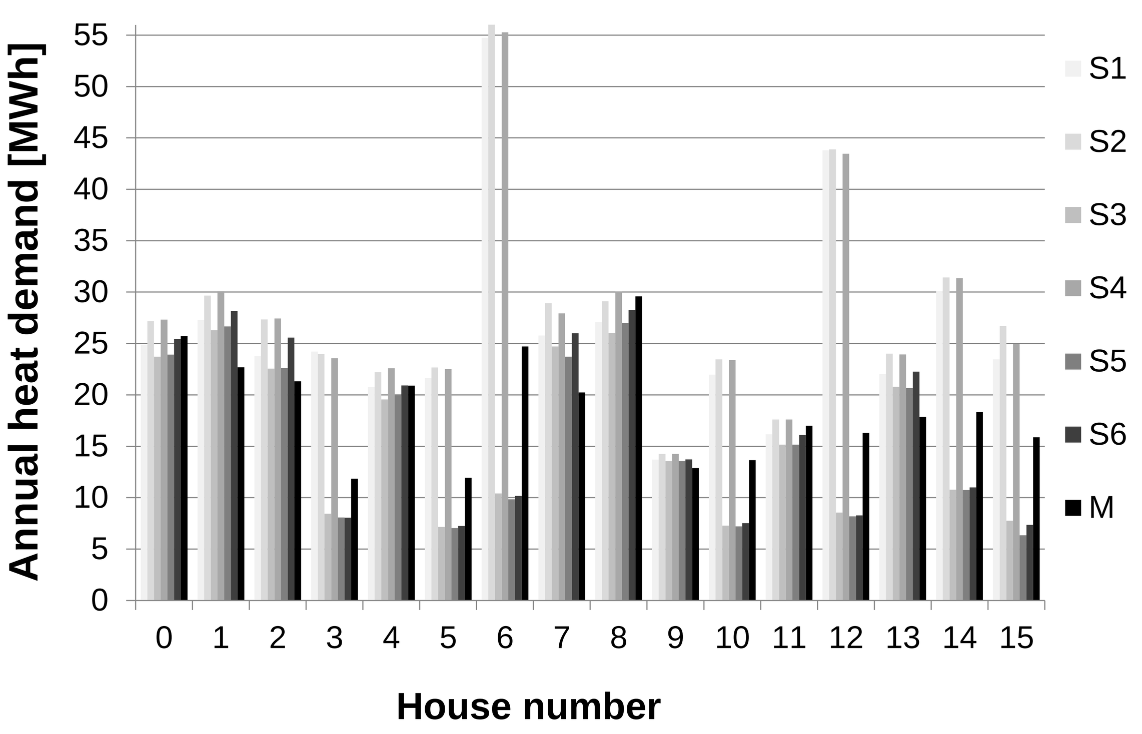
Table 1: Characteristics of the examined building types

Building type	Construction period	No. of incl. buildings	Total floor area (m^2)
A	1931-1950	2	238
B	1951-1960	2	180
C	1961-1972	10	1,530
D	1973-1978	1	117
E	1979-1998	1	122

Information levels

S1: information about building structure
S2: information about building structure and geometry
S3: information about building structure and energy refurbishment
S4: information about building structure, geometry and occupancy
S5: information about building structure, energy refurbishment and occupancy
S6: full information about building
M: Measurements of heat consumption





Aggregation and simulation tools

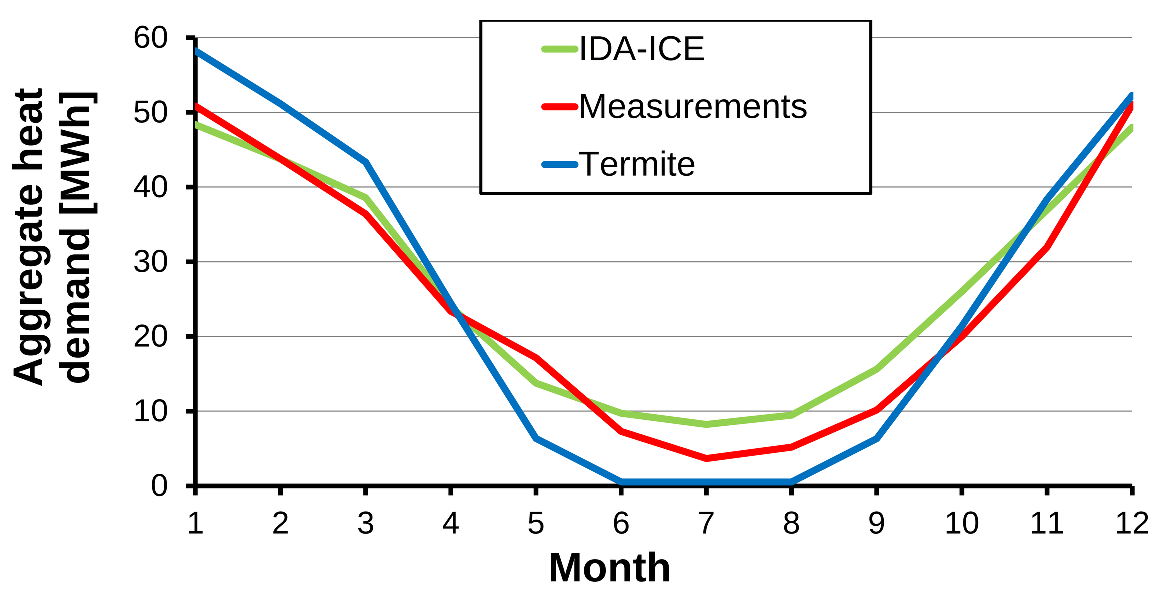
Gianniou et al., Building Energy Demand Aggregation and Simulation Tools – A Danish Case Study, CISBAT 2015, Lausanne

Modelling

16 single-family houses

Simplified building simulation tools (quasi-steady-state methods) → Termite (Be10) → Single-zone models → Danish Reference Year climate file

Detailed building simulation tools (dynamic methods) → IDA ICE → Multi-zone models → Real weather data



Monthly aggregate heat demand results from IDA ICE and Termite compared to measured data

Findings

- Uncertainty in describing physically the examined houses affected both simple building models (Termite), which require fewer inputs and more advanced models (IDA ICE).
- At aggregate level, IDA ICE archetype models represented slightly better the heat demand of the 16 single-family houses than Termite.
- The suitability of simulation tools depends highly on the purpose of analysis.
- The combination of quasi-steady-state and dynamic energy simulation methods could be the solution towards fitting measured consumption data.

Parameter identification for variability of building energy demands

Gianniou et al., Identification of Parameters Affecting the Variability of Energy Use in Residential Buildings, CLIMA 2016, Aalborg

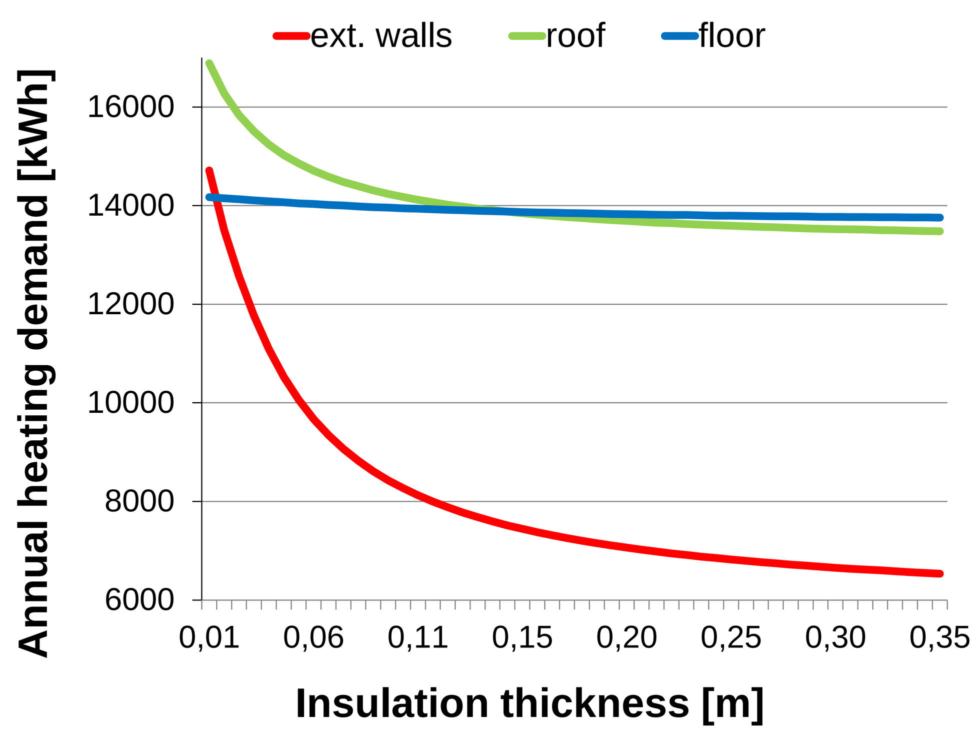
A typical Danish single-family house of the 1940's was used as a reference building.

The parametric analysis was made with open source software MOBO (multi-objective building performance optimization).

A set of parameters was investigated upon their effect on building energy use and specifically space heating demand in an old typical Danish house.

Table 2. Examined parameters for sensitivity analysis

Parameters	Min. value	Max. value	Ref. value
Thermal transmittance of glazing (W/m^{2}K)	1	3	1.5
Infiltration rate (ACH)	0.1	1	0.4
Number of occupants	0	6	3
Orientation (deg)	0	350	50
Insulation thickness in roof (m)	0.001	0.32	0.095
Insulation thickness in ext. walls (m)	0.001	0.32	0.01
Insulation thickness in floor (m)	0.001	0.35	0.019



Findings

- The parameters resulting to the greatest variations in space heating demand were the insulation thickness of external walls and roof.
- The infiltration rate and number of occupants had significant although lower impacts on heating demand.
- These findings are highly dependent on the structure of the examined reference building, which in this case was poorly insulated.
- The weight of the building envelope properties on the energy use is outlined also due to the cold Danish climate, which leads to increased heat losses during the winter period.

Future plans

- Apply **data mining** techniques (i.e. clustering) to a large dataset of thousands of residential buildings to identify the features of the buildings that the clustering and building typologies should be based on. (Collaboration with UCD and Århus Affaldvarme)
- Compare white-box building modelling with black-box and grey-box modelling at a **district** level. (Collaboration with UCD)
- Create an **urban building energy model** using city simulation tools to validate the above-presented aggregation techniques and results.

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