CIBSE Application Manual AM11 'Building Performance Modelling'

Chapter 4: Energy Modelling

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Role of energy demand models [Section 4.2]

Two general types of modelling:

1. Regulatory compliance (Ch3)
2. Bespoke modelling

Many tools consider both applications

What is the goal of your study?

Don’t confuse the approaches!

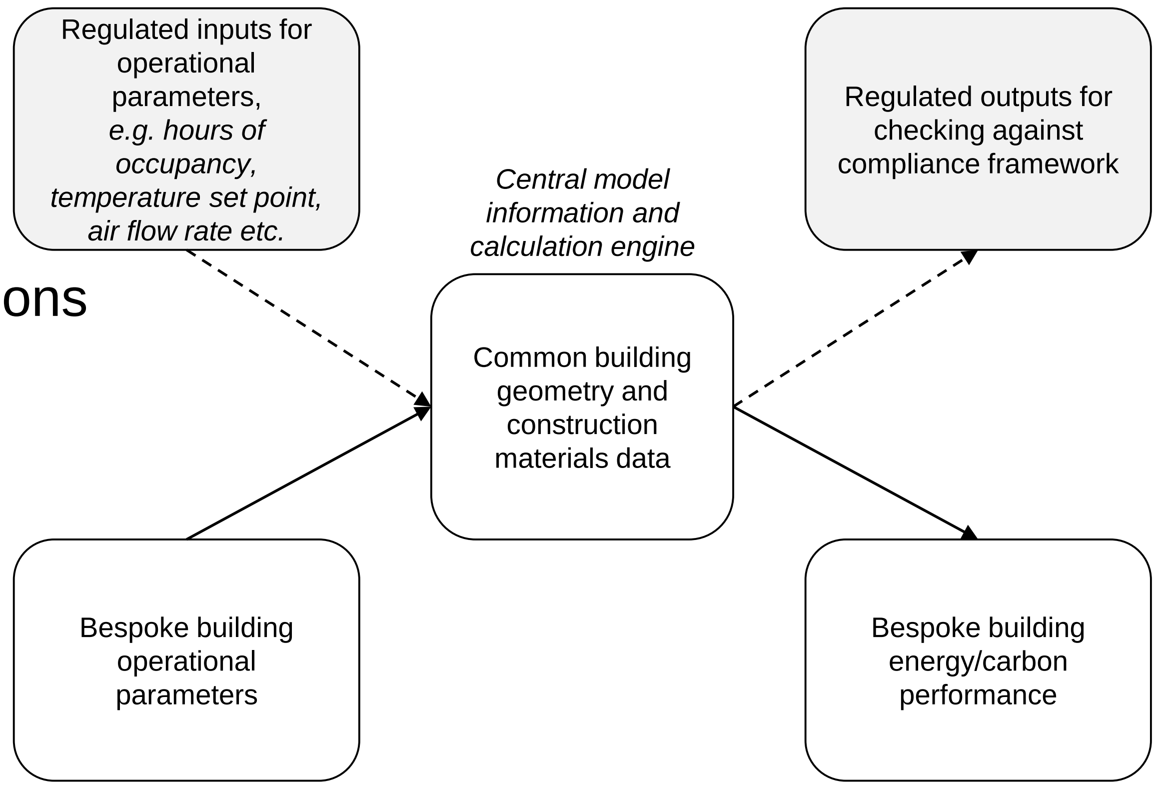

Figure 4.1 - Use of common central model for multiple applications

Limitations of energy modelling [Section 4.3]

Watch the [performance] gap!

- Only a model
- Real people!
- Weather
- Differing calculation processes

- Complete a sensitivity analysis to test the significance of your assumptions within reasonable limits
- Calibration/Baselining of models on existing buildings
- More verification of models on completion

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Energy demand sources [Section 4.4.1]

Table 4.1 Building energy demand sources and general calculation approaches

Energy demand sources	General Calculation Approach
Heating	Various 'energy balance' methods
Cooling	Various 'energy balance' methods
Fans, pumps and controls	Scheduled against time and heating/cooling/ventilation requirements. Plant specific data used to determine demand (e.g specific fan power W/l/s)
Fixed lighting	Scheduled against estimated period of use, and potentially corrected for daylight-linked control where appropriate (with verifying degrees of sophistication)
Domestic hot water	Scheduled against occupancy numbers and building/room type
Small power	Often estimated relative to room type (e.g. classroom, office etc). Power generally estimated relative to floor area (W/m^2), or broken down to specific equipment if known
Catering	Not widely considered, however may be significant depending on kitchen size/type. Can be estimated from equipment type or from number of meals per day using benchmarks (CIBSE, 2009)
Process loads	Often estimated directly from equipment type and hours of operation
External lighting	May be scheduled against hours of non-daylight and area served
Lifts/escalators	Often ignored, although may be significant depending on building type/size. Can be estimated from vertical rise and number of passengers transported (CIBSE, 2010, CIBSE 2012).

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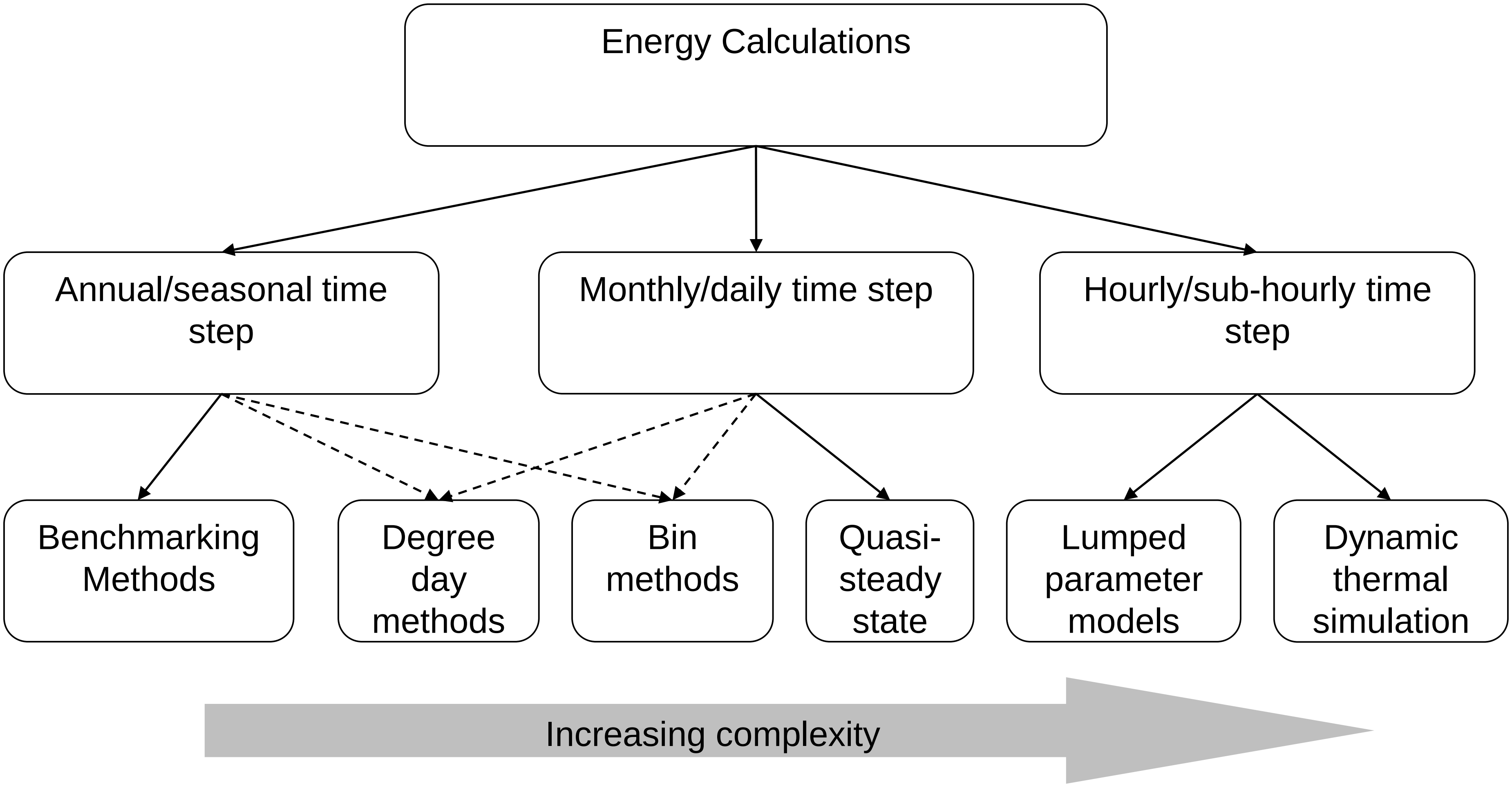
Energy demand models [Section 4.4.2]

Figure 4.3 – Building energy model categorisations



Dynamic thermal modelling of heating and cooling energy demand [Section 4.5]

Types of dynamic thermal modelling can be categorised according to the solution of the 2D conduction equation (partial differential equation)

- Numerical Methods
  - Finite difference approach using the method of discretisation
  - Solved using iterative techniques
  - Solution of thousands of simultaneous equations

- Response Factor Methods
  - Uses Laplace transforms to allow an algebraic solution
  - The ‘response’ to simple excitations (impulses) is determined in terms of heat flux
  - Strings of impulses are used to represent changing conditions, which are then superimposed to give a cumulative result

Setting up dynamic thermal models [Section 4.6]

Geometry and Zoning [Section 4.6.1]

- Keep it simple!
- Wall thickness – room volume
- Joining spaces – ignoring internal partitioning
- Splitting spaces – adding dummy partitions
- Special cases
  - Vertical zoning atria
  - Celling/floor voids
  - Structure coupled heating and cooling systems
- Working from imported geometries (BIM)

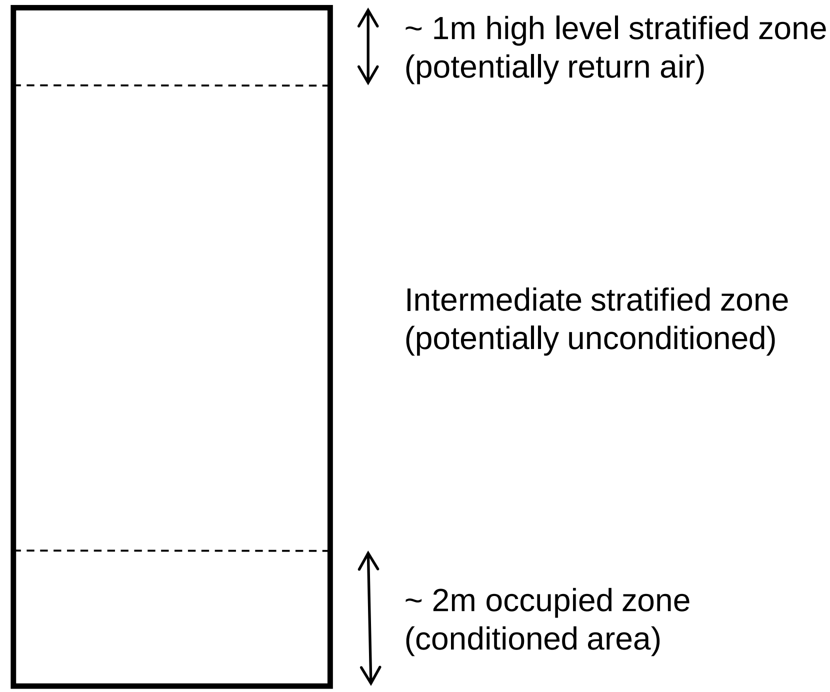


Figure 4.5 – Zoning layout of atrium space

Choice of climate data [Section 4.6.2]

- Complete year selections <u>and</u> short sequence tests:
  - Cold start
  - Heat wave
  - Transitional periods – cold to hot
  - Peak conditions (internal temperatures, response times and peak loads)

- Annual Modelling
  - Test reference years
  - Climate change weather data in the application of energy modelling

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Material Properties [Section 4.6.3]

- Considering thermal mass
- Complex multi-layer construction (e.g. rain screen cladding)
- Need for modelling thermal bridges

Solar Shading [Section 4.6.4]

- Again – keep it simple! Use a simple sensitivity check to check level of detail necessary
- Complex issues – semi-transparent shading elements, external reflections, moving shading elements

Daylighting [Section 4.6.5]

- Linking daylight models to energy models (dimming lighting)
- Sky type
- Lighting control strategy

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Ventilation and infiltration [Section 4.6.6]

- Infiltration seasonal values, peak values and scheduled vs. zonal airflow models
- Selection of opening properties
- User behaviour regarding window control (unexpected behaviour and sensitivity)

Occupancy/ Equipment/Lighting profiles [Section 4.6.7]

- 'Realistic' modelling of user behaviour
- Scheduled profiles vs. demand based relationships (adaptive set-points and controls)

Dealing with non-thermal energy loads [Section 4.6.8]

- e.g. lifts, external lighting, domestic hot water, and catering fuel consumption
- Generally scheduled loads - may be considered separately to analysis software

Control of plant [Section 4.6.9]

- Seasonal efficiency and fan powers vs. complex controls
- Lags, standing/distribution losses, part-load performance etc. (see Ch8.)

… and finally:
Future trends in energy modelling [Section 4.8]

- Building Information Modelling (BIM) – model zoning and access to material data
- Evolution of regulation – more detailed system modelling
- Embodied energy/carbon and lifecycle thinking
- Modelling for climate change
- Validation and cross-checking reality
- Optimisation of design decisions