Quality Assurance in the use of energy and environmental performance prediction software

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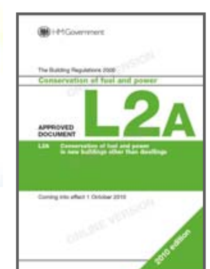
Agenda

- Why do we need QA in Building simulation software?
- Factors affecting quality.
- Software users are the main source of error.
- Common user errors.
- Tool, Training and Quality control.
- Methods of reducing human errors.

Drivers in the use buildings energy and environmental modelling software

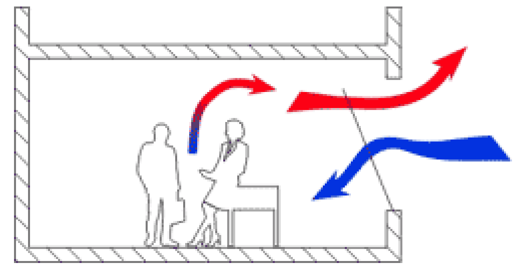
- Innovation.
- Passive Design.
- BREAM, DREEAM, CEQUAL, LEED, Energy Star.
- Building Regulations Part-L Carbon Emission Target (since 2006).
- Advances in Computer Technology.

(Manual and steady state methods are not suitable for today's dynamic buildings.)



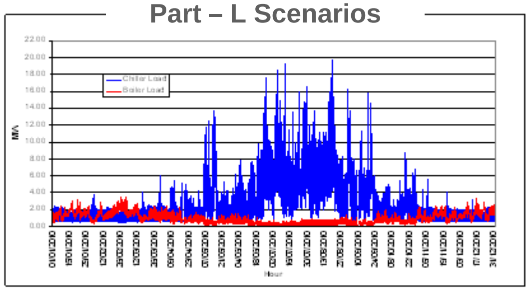
Why QA in simulation?

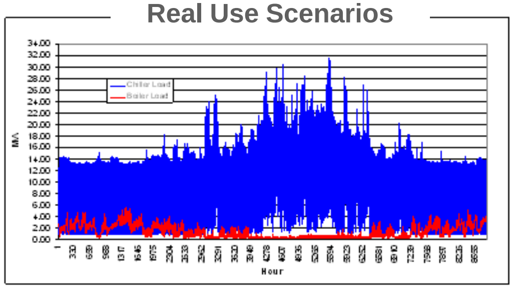
- A naturally ventilated design that is retrofitted with fans.
- A cooling system that makes people sweat.
- A school’s air flow system that leaves pupils gasping for air.
- A PFI project that loses funding because it does not get EPC rating of 40.
- A CHP that works only 30 days a year.



The impact of simulation on design

- Simulation results drive the energy and environmental design of buildings.
- Part-L/SBEM calculations are for compliance not design, but it is used for design because that is the go/no go.
- Must check design using proper simulation with real data not SBEM which is a steady state calculation and the Part-L data which is only a generalisation of activity types.
- Comfort assessment, excluded form Part-L, itself a big mistake, needs simulation and CFD modelling.
- Façade optimisation.
- Value engineering.
- Whole life cost.



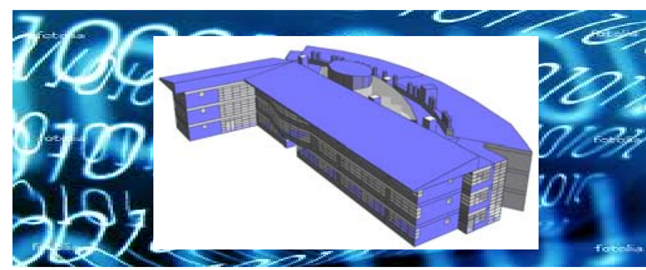


What is a model?

- A representation of real world, e.g. a building its systems and thermal processes, through a set of input data within a software tool.
- Consequently it is a simplified representation of reality that must fit the software capability.
- Model is the combination of data and of software.
- Software determines the limits and nature of model's behaviour.
- Data defines the behaviour of the model.
- Simulation is simply exposing the model to varying climate and user interaction with the building.
- A modeller creates the model within a software tool.

Reliability of model and simulation results

- Reliability of Software.
- Availability of reliable data.
- Reliability of Modeller.
- Modelling process.



Reliability of software

- Capability: Does it model important processes involved? ☑
- Verification: Does it do what it has been designed to do? ☑
- Validation: Does it adequately represent the real-world behaviour? ☑
- Support: Does it have commercial support? ☑

(“Software essentially requires infinite testing.” Software QA Standard)

Software capability

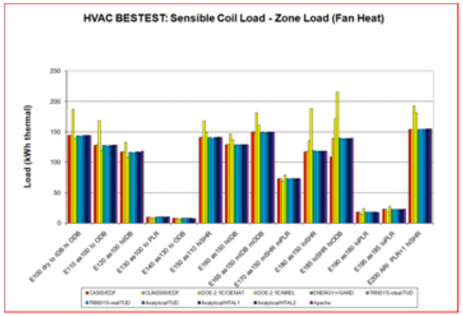
- All software simplify the real world objects and phenomena.
- This imposes limitation in their use.
- Level of complexity increases if closer representation is sought.
- Examples:
  - Stirred tank assumption.
  - Thermal mass: Admittance method, 2-TC, 3-TC, Finite difference, response factor.
  - Combined surface coefficients vs. separate convective and radiative surface coefficients.
  - Solar radiation distribution inside a space.
  - Air flow

Software verification

- Errors in the software coding (software bugs).
- Software industry uses well established software verification tests.
- Tests are inevitably limited to certain conditions.
- Some bugs may only show up when software is used in practice.
- No software will ever be bug free, but the longer the code lives the fewer bugs survive.
- Users rely on software vendors to provide them with verified software.

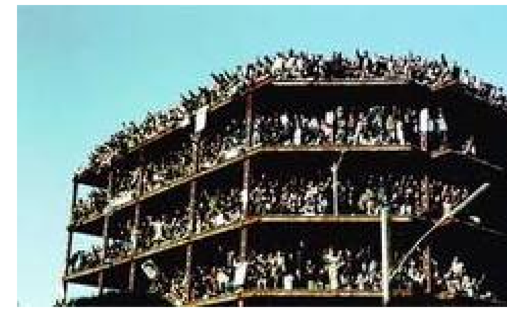
Software validation

- The degree of accuracy of software in representing the real-world processes.
- Validation exercises in the eighties and nineties.
  - Example: BRE/SERC analytical and empirical validation exercises reported in the CIBSE Journal and CIBSE National conference in 1993.
  - IEA BESTEST validation now an ASHRAE Standard.
  - Validation exercises helped identify bugs in participating software.
  - The two UK commercially available software packages approved for Part-L calculations were both involved. The main engines have not changed much.
  - CEN and CIBSE have developed validation tests for EPBD and Part-L.



Reliability of data

- Availability of data, e.g.
  - New materials.
  - Existing buildings materials.
  - Pressure coefficients for air flow modelling.
  - Plant and controls performance.
- Uncertainty in data.
  - Tests carried out for limited conditions.
  - Construction and installation workmanship.
- The unpredictability of some data
  - How a building is operated.
    - Occupants behaviour.
  - Weather.



Is he in or his he out?

Modeller errors

- Software selection.
- Translation of reality into software.
- Data selection.
- Data entry.
- Interpretation of results.
- Presentation of results.

Modeller and software

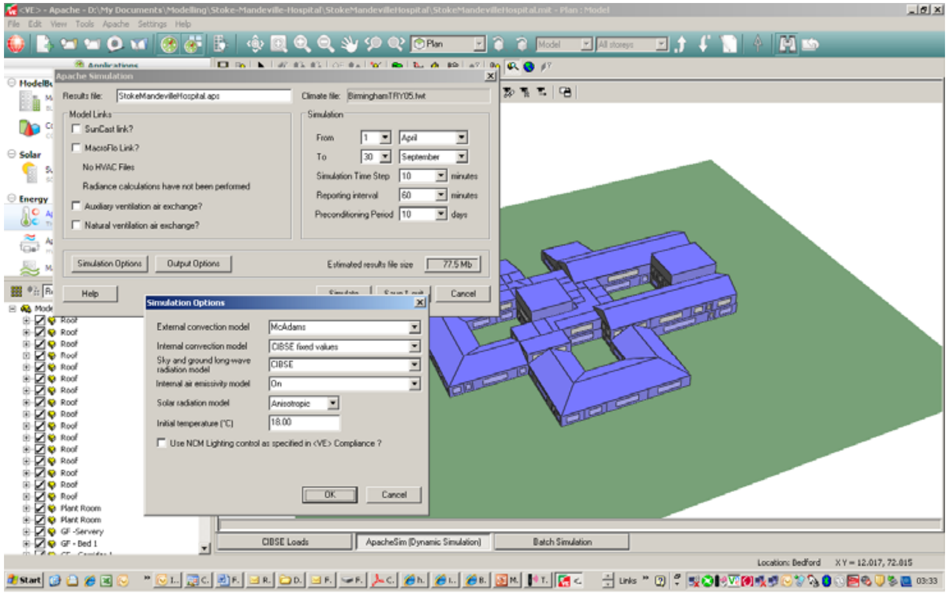
- Is modeller aware of:
- Software's capability, validity and pedigree?
- How the main thermal processes are modelled in software?
- How the input data is used by the software?
- What is the software sensitivity to importa[nt] data?
- What are the limitations of software in representing a process?

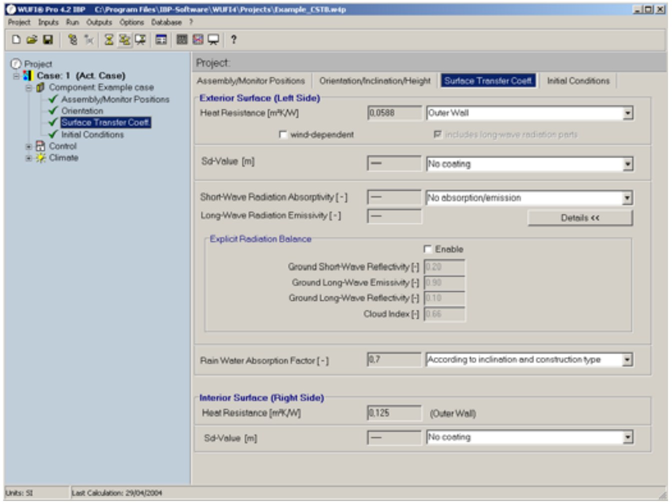
Modeller and data

- Importance of data in processes modelled.
- Sensitivity of results to data.
- Setting up of simulation parameters
  - Time step.
  - Pre-conditioning.
- Data entry errors.

Modeller and software user interface

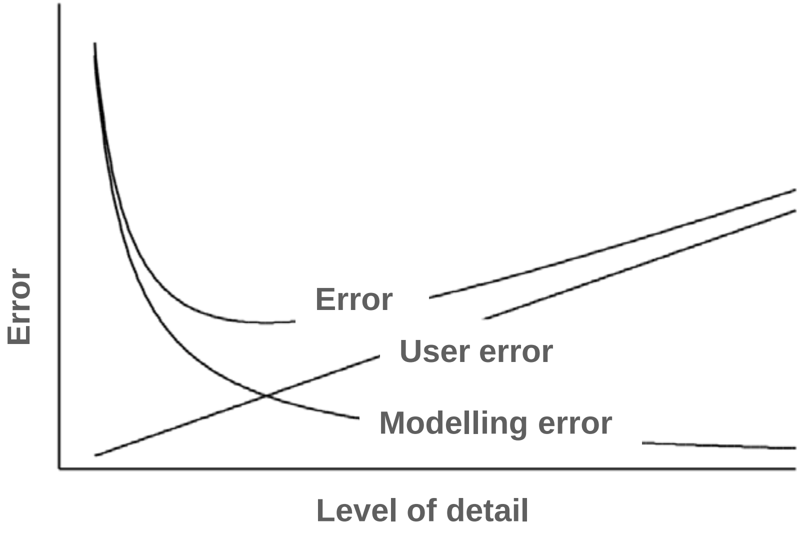
- Use of default data.
- Ticking the right boxes.





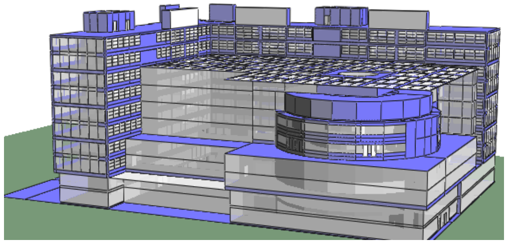
Managing quality and expectations

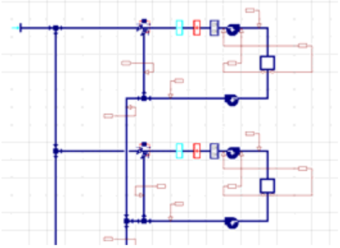
- Models are as good as the input data.
- Not all processes can be modelled accurately.
- A compromise between modelling cost and accuracy of results.

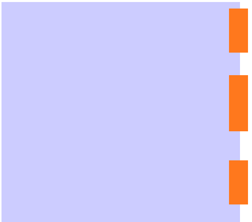


Simplification of real world into software model

- Modelling atrium.
- Modelling plant.
- Modelling air flow through windows.

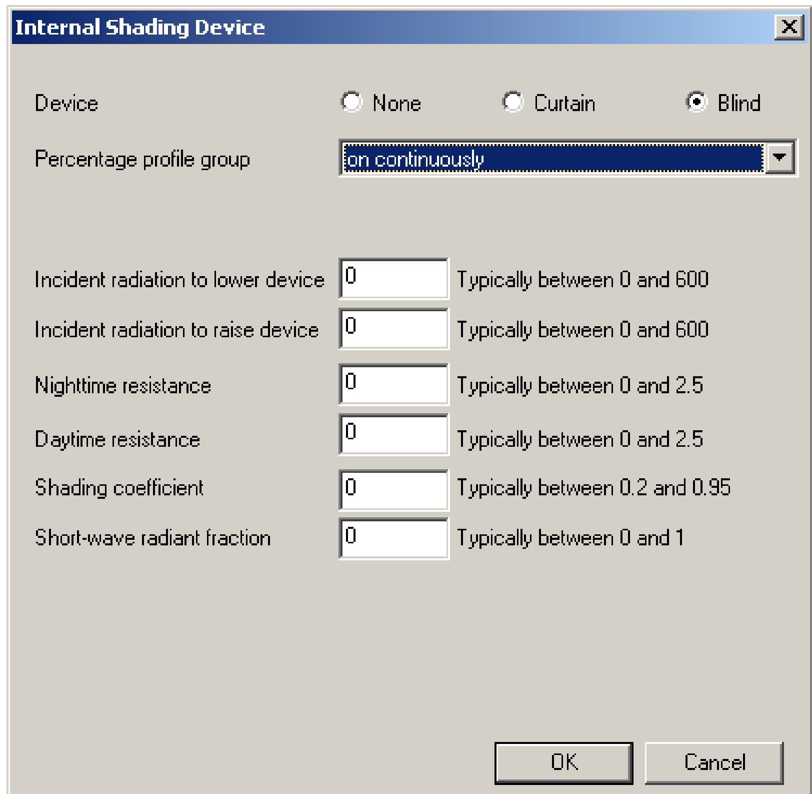






Input data entry

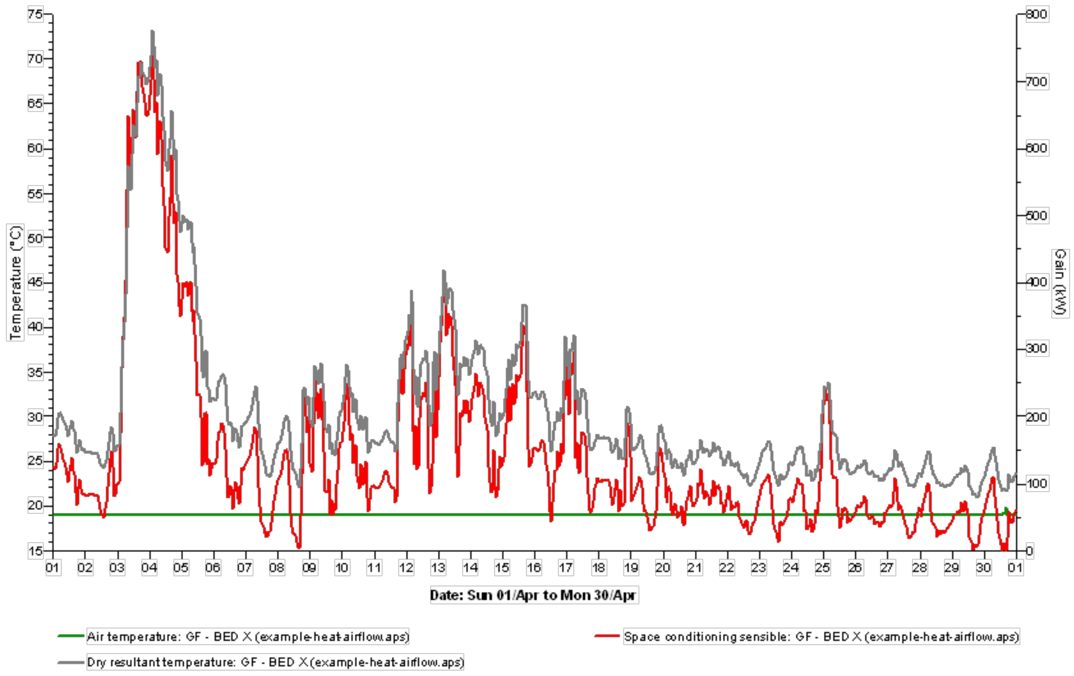
- Example: Ambiguous data dialogues - Blinds on/off?



Input data entry

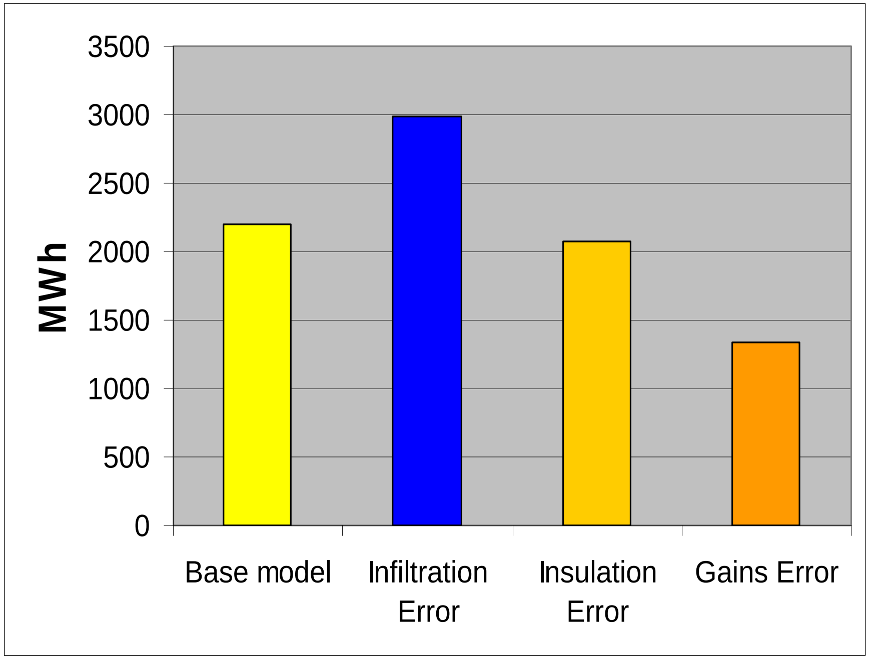
- Example: Heating left on when ventilating to avoid overheating.

Temperature (°C)					
Var. Name	Min. Val.	Min. Time	Max. Val.	Max. Time	Mean
Air temperature	19	05:30,04/Apr	19.83	16:30,30/Apr	19
Dry resultant temperature	20.97	18:30,29/Apr	73.2	01:30,04/Apr	30.73



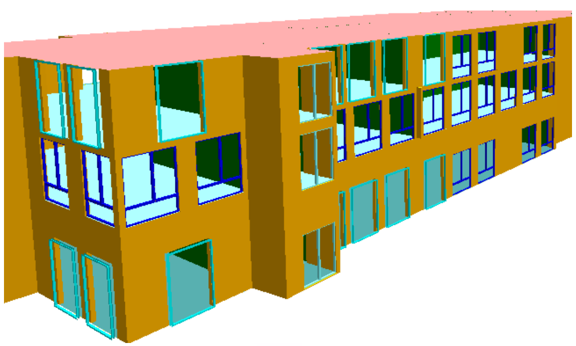
Input data entry

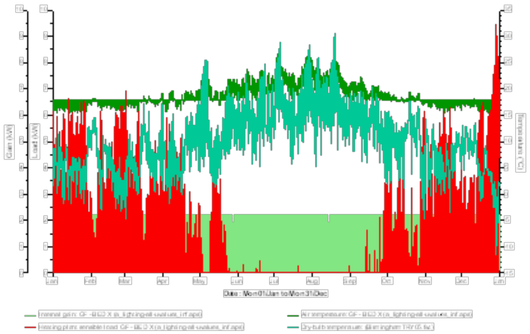
- Examples of typing errors for bedrooms (1/5th total area) in a hospital of 8000m^2:
  - infiltration 2.5ach instead of 0.25.
  - Insulation conductivity of 0.023 W/mK instead of 0.040.
  - Gains of 25 kW instead of 25W.



Reducing Modeller Errors

- Model verification
- Model validation
- QA system





Model verification - 1

- Global representation of building:
  - Geometry visual check. ☑
  - Orientation (north matches plans?). ☑
  - Location and weather data. ☑
  - Areas of various main space types. ☑
  - Areas of Activity types. ☑
  - System types entered as design spec? ☑
  - Exposed slab vs. false ceiling. Raised floors. ☑
  - Construction types and U-values. ☑
  - Air flow paths ☑
  - Shading devices? ☑
  - Free cooling by air? ☑

Model verification - 2

- Component details:
  - Infiltration rate. ☑
  - Internal gains & Occupancy Profiles. ☑
  - Plant details and controls. ☑
  - Radiant heating/cooling values. ☑
  - Fresh air amount and schedule ☑
  - Details of internal and external shading devices. ☑
  - Lighting details and controls. ☑

Model validation

- Unlike verification ‘Validation’ is a matter of judgement.
- Is the behaviour close to the reality?
  - Conceptual validity- Does the model adequately represent the real world system. We are limited with what the software offers. The knowledge of the modeller of the software capabilities and his skills in using such knowledge to closely represent a real-world system is paramount here.
  - Behavioural validity- Is the model generated behavioural data characteristic of real-world system behavioural data? Sensitivity analysis can help identifying whether such behaviours are realistic.

    [Pegden et al (1995) on business systems]
- Believability- Does the engineer/modeller believe in the results? This depends on the experience of the modeller and reviewer of their model.

How to validate a model?

- Scrutiny of results, not only the target results, but data driving the thermal performance:
    - Air flow, infiltration.
    - Solar gains.
    - Internal gains
    - Conduction gains and losses.
- Inspect the shape of the internal gains, plant load and air and mean surface temperature for sample spaces.
- Compare total loads (kWh/m2) against benchmarks for similar building types, bear in mind differences in servicing level, envelope/floor ratio and glazing ratio.
- Check peak loads against expected engineering benchmarks, e.g. BSRIA Rules of Thumb. Note the latter may be out of date, but still helpful if differences are of an order of magnitude.

A typical modelling process

1. Modelling Brief: Define design question.
2. Gather information.
3. Create model or revise existing model.
4. Analyse results.
5. Discuss with Design team.
6. Design satisfactory?
7. No: Identify alternative design options and start from steps 4.
8. Yes: Report and report Review.
9. Submit report.

A typical modelling process with QA

1. Modelling Brief: Define design question
2. Analyse problem and Select Software.
3. Gather information.
4. Create model or revise existing model.
5. Analyse results.
6. Verify model and validate results.
7. Model and results satisfactory?
8. Yes: Discuss with Design team; No: Start from step 4.
9. Design satisfactory?
10. No: Identify alternative design options and start from steps 4.
11. Yes: Report and report Review.
12. Submit report.

Formal QA

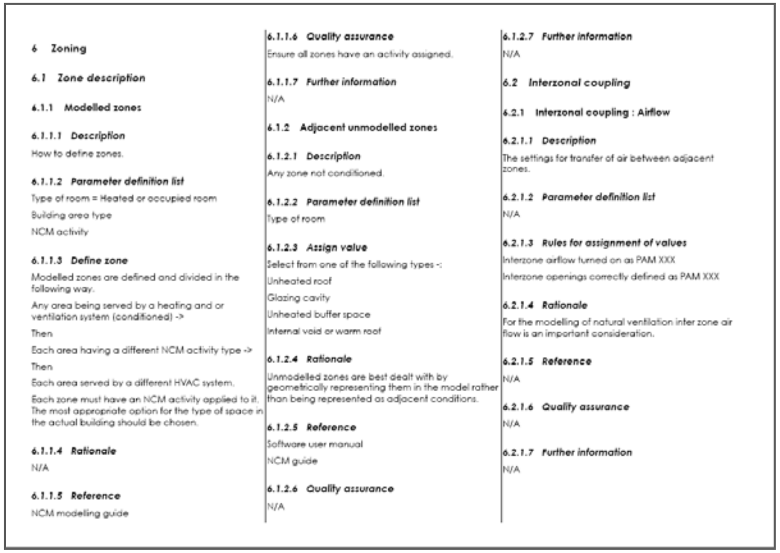
- Larger companies have ISO 9000
- These give a framework for QA needed for simulation activities.
- Formal QA is mainly concerned with doing what is in the QA procedures, and documenting it so trails can be audited if needed.
- These systems normally do not include any specific details on simulation work.
- Simulation QA system must be defined in line with formal requirements.
- Detailed procedures for house keeping and Documentation are normally required.
- These can be sometimes off putting. A pragmatic approach should be adopted.
- Training and qualification for carrying out tasks is taken into account.
- The principle of Risk and reward/penalty must be borne in mind when setting up such procedures.

Modelling QA

- Modeller
  - Uses data templates already created, validated and used for other jobs where relevant.
  - Carries out model verification tests above.
  - Carries out model validity tests above.
  - Revises model and reports.
- A colleague checks the model
  - Carries out model validation tests above.
  - If model fails validation tests colleague carries out verification tests.
  - Record errors found (ideally in a central error logbook).
- Company rules
  - Training of staff.
  - House keeping of models, results, and reports.
  - Level of quality control.

Performance Assessment Methods (PAMs)

- **Purpose**: Defines the purpose of the assessment.
- **Applicability**: Defines the applicability of the PAM, e.g. of building types, climate zones, computational requirements, validation method, user qualification, etc.
- **Output**: Information required from the method and the way they should be presented. For each parameter it also encourages the PAM author to give a QA check.
- **Configuration**: Defines the sub-models to be used where appropriate.
- **Context**: Defines the building type, site, climate, etc.
- **Zoning**: Defines how zoning of the spaces should be carried out where appropriate.
- **Building Description**: Defines the details of geometry, construction, shading devices, etc.
- **Building Operation**: Defines ventilation system, occupancy and internal gains, HVAC and lighting systems, etc.



6 Zoning

6.1 Zone description

6.1.1 Modelled zones

6.1.1.1 Description

How to define zones.

6.1.1.2 Parameter definition list

Type of room = Heated or occupied room

Building area type

NCM activity

6.1.1.3 Define zone

Modelled zones are defined and divided in the following way.

Any area being served by a heating and or ventilation system (conditioned) ->

Then

Each area having a different NCM activity type ->

Then

Each area served by a different HVAC system.

Each zone must have an NCM activity applied to it. The most appropriate option for the type of space in the actual building should be chosen.

6.1.1.4 Rationale

N/A

6.1.1.5 Reference

NCM modelling guide

6.1.1.6 Quality assurance

Ensure all zones have an activity assigned.

6.1.1.7 Further information

N/A

6.1.2 Adjacent unmodelled zones

6.1.2.1 Description

Any zone not conditioned.

6.1.2.2 Parameter definition list

Type of room

6.1.2.3 Assign value

Select from one of the following types -:

Unheated roof

Glazing cavity

Unheated buffer space

Internal void or warm roof

6.1.2.4 Rationale

Unmodelled zones are best dealt with by geometrically representing them in the model rather than being represented as adjacent conditions.

6.1.2.5 Reference

Software user manual

NCM guide

6.1.2.6 Quality assurance

N/A

6.1.2.7 Further information

N/A

6.2 Interzonal coupling

6.2.1 Interzonal coupling : Airflow

6.2.1.1 Description

The settings for transfer of air between adjacent zones.

6.2.1.2 Parameter definition list

N/A

6.2.1.3 Rules for assignment of values

Interzone airflow turned on as PAM XXX

Interzone openings correctly defined as PAM XXX

6.2.1.4 Rationale

For the modelling of natural ventilation inter zone air flow is an important consideration.

6.2.1.5 Reference

N/A

6.2.1.6 Quality assurance

N/A

6.2.1.7 Further information

N/A

The role of software vendors

- Software manuals- Current documentation is not satisfactory.
- Clearer statements on software capabilities.
- Use their support team feedback to regularly inform users of modelling tips and QA checks.
- Clearer data entry screens.
- Adopt and implement PAMs. Both TAS and IES now are implementing workflow capabilities into their software. They could work with users and develop PAMs for their software for some frequently used design questions.

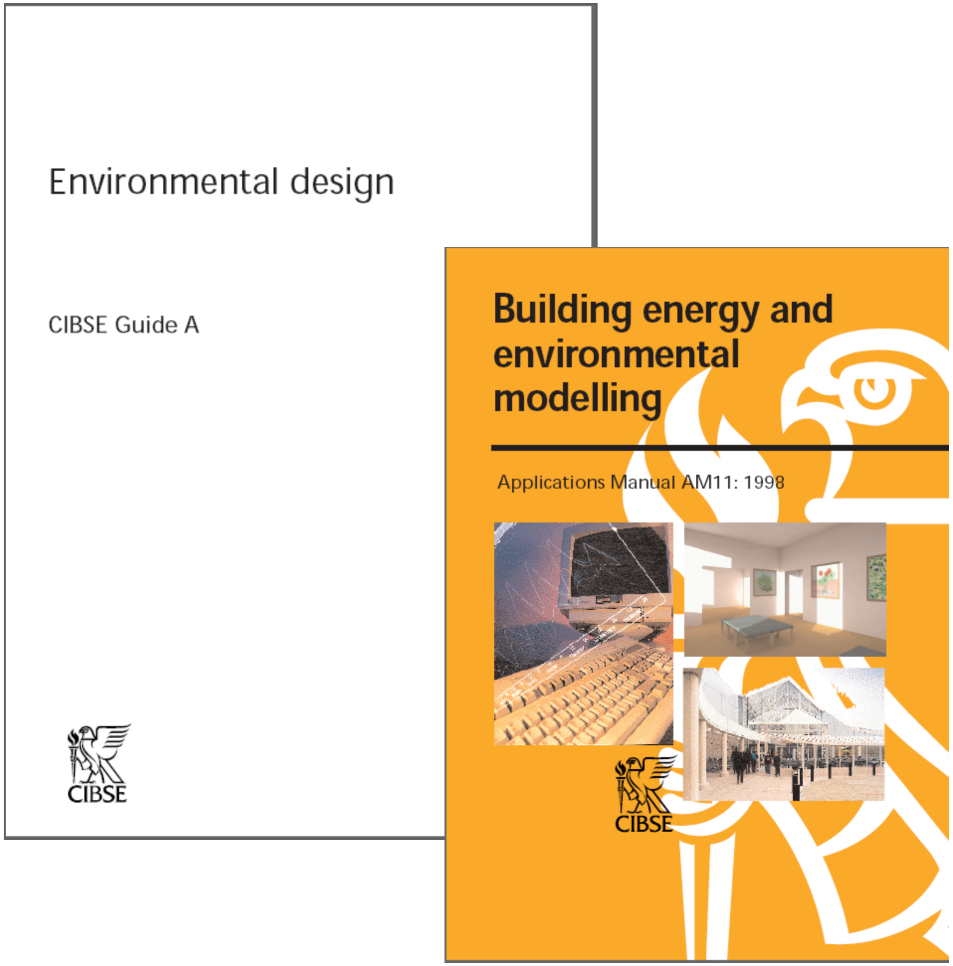
QA and the Gap Between EPC and DEC

- QA does not answer the gap between Predicted Performance and Performance in use.
- Nevertheless an important issue of client confidence, which must be addressed.
- Compliance (Part-L) Scenarios will always be standard scenarios and different from specific ‘Real Life’ scenarios.
- Analysis of DEC and EPC lodgements could help narrow the gap.
- Could CLG provide access to anonymous data to researchers?
- Quality of design depends on using the relevant realistic in use scenarios.
- Is it CIBSE’s role to share knowledge and provide template and guidance for this?

CIBSE Guide A and AM 11

- Guide A 2011 is planned to include a Section on QA in calculations.

- Energy and Environmental Modelling Application Manual AM 11 is being revised after 12 years.



Summary and Conclusions

- Using simulation software in the absence of QA is risky.
- Appropriate software tool, modeller training and quality control are essential for quality design.
- Adopting Simple QA does not need to be costly.
- Software vendors have a major role in helping QA: Better Manuals, Issuing Regular QA circulars, Adopting PAMs.
- Government can help providing feedback from its EPC and DEC registries and provide funding for guidance in closing the gap between the design and in use performance.
- CIBSE is taking QA seriously and can provide further support, but needs member input and funding.

Thank You