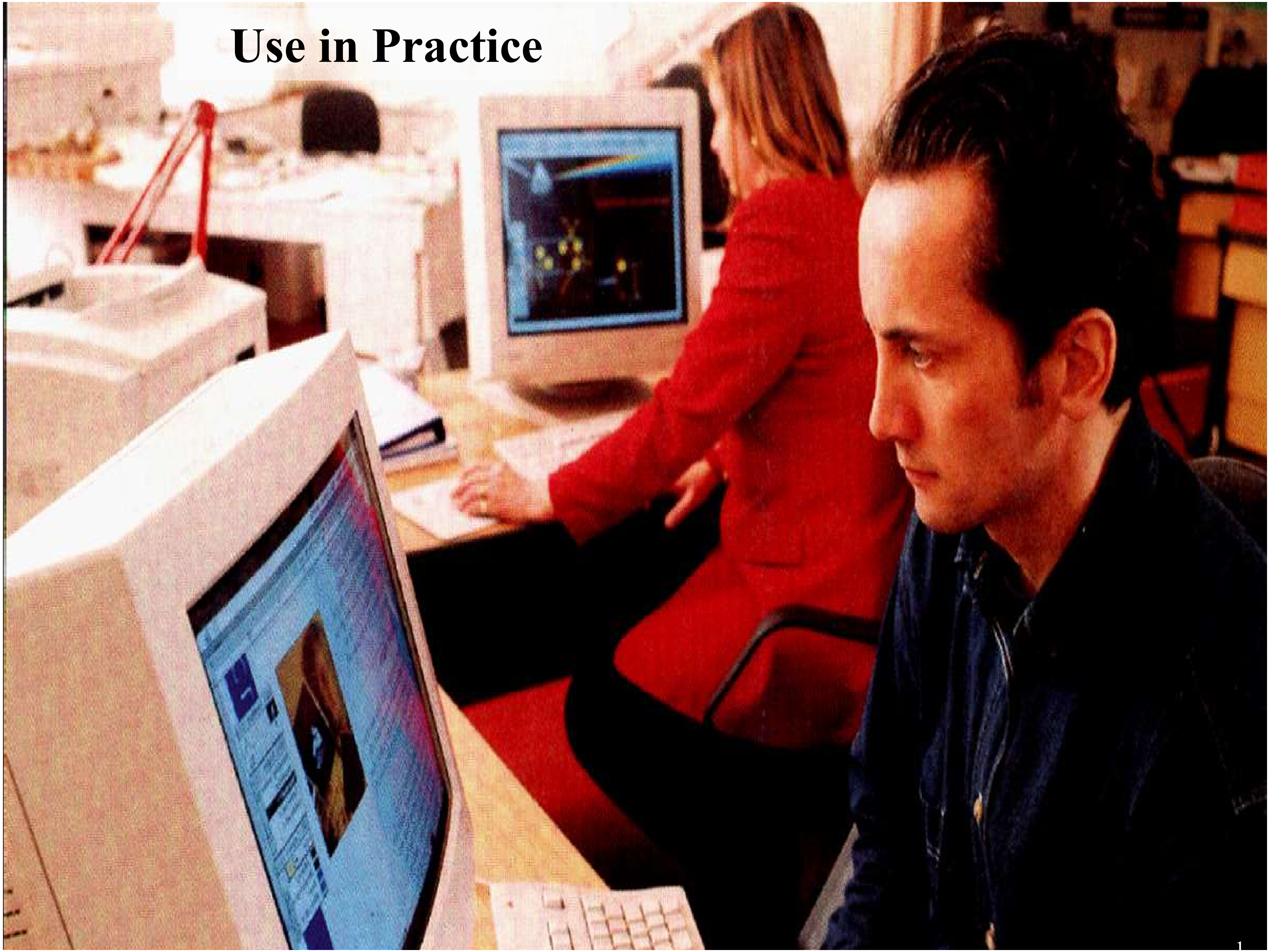
Use in Practice

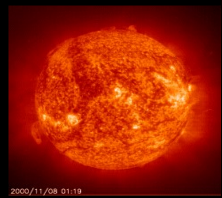
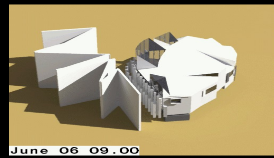


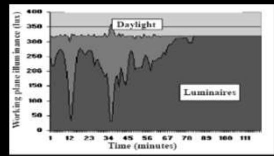
Simulation goals

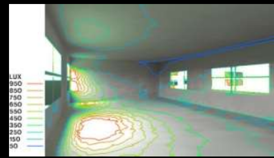
- *High integrity representation* of the dynamic, connected and non-linear physical processes that govern the different performance aspects that impact on the overall acceptability of buildings and their energy supply systems, existing or planned.

- *Performance domain conflation* to represent the interactions and conflicts that occur between problem parts and give rise to the need for practitioners to make performance trade-offs.

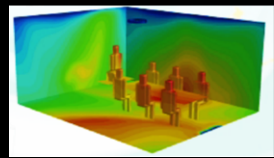
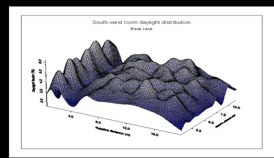
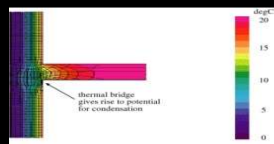
- *Design process integration* to embed high fidelity tools within work practices in a manner that adds value and, in the long term, supports virtual design through the interactive manipulation of a design hypothesis with performance feedback in real time.



Virtual design benefits

Integrated simulation helps practitioners to:

- conform to legislative requirements;
- provide the requisite levels of comfort;
- attain indoor air quality standards;
- embody high levels of new and RE technologies;
- incorporate innovative EE & DSM solutions;
- lessen environmental impact.

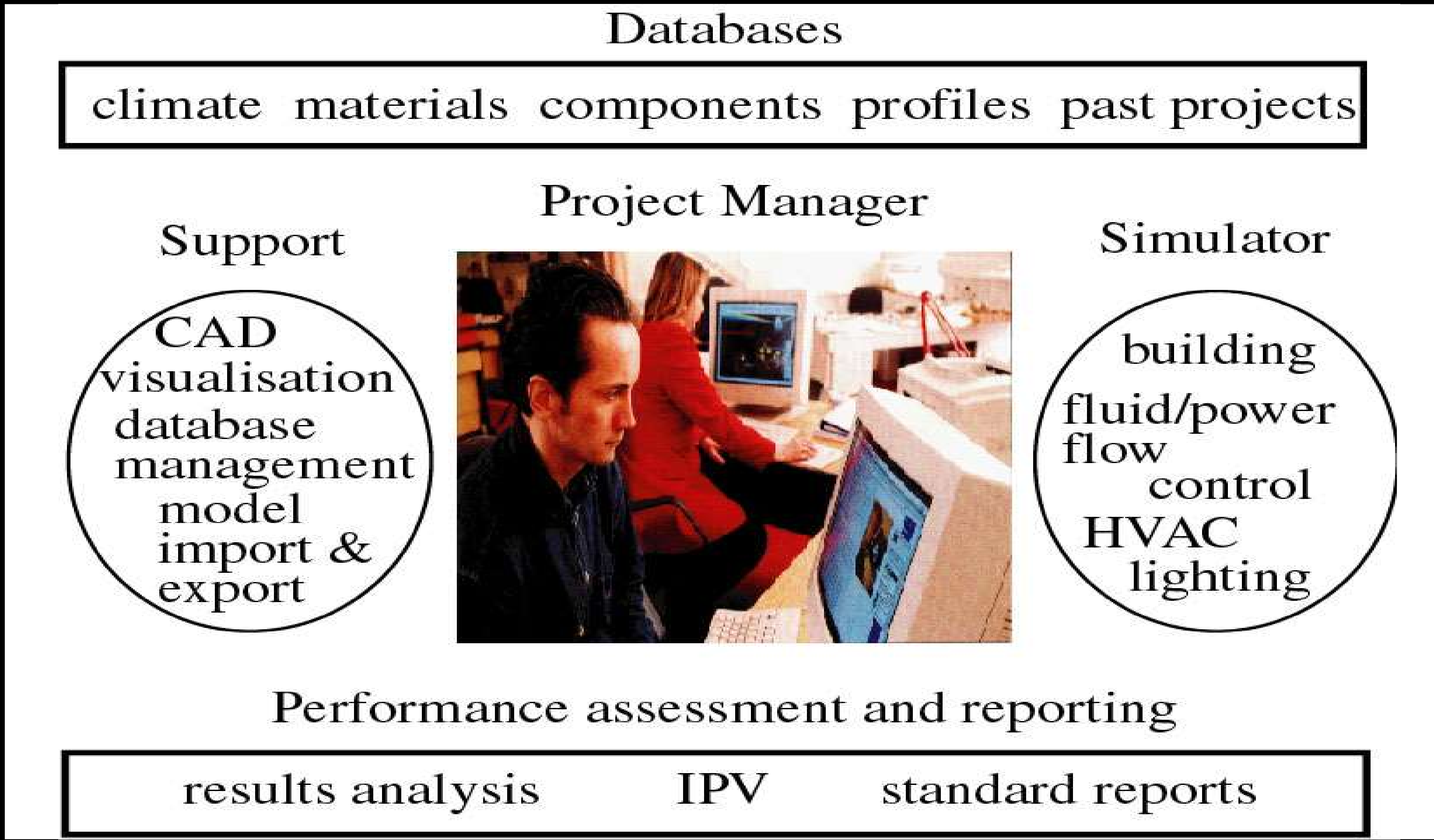
Defines a new best practice:

- respects temporal aspects and interactions;
- integrates all technical domains;
- supports co-operative working;
- links life cycle performance to health & environmental impact;
- use set to expand in Europe with the advent of the EPBD.

The approach is rational:

- gradual evolution of the problem description;
- action taken against performance outputs at discrete stages.

Components of an integrated energy simulation program

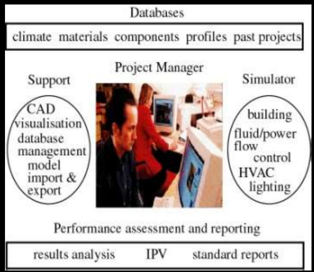


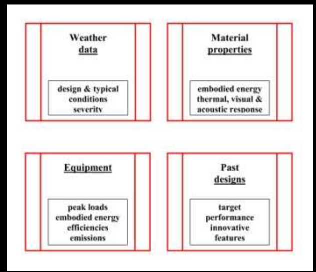
Issues: database maintenance; project management; problem abstraction.

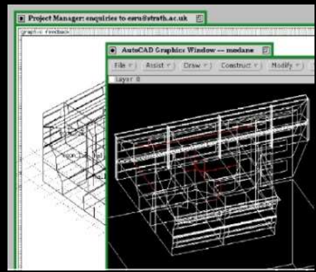
Simulation in design: behaviour follows description

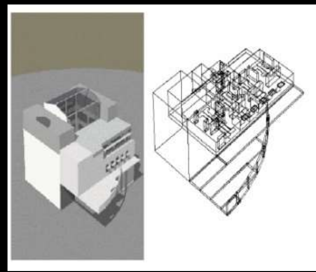
pre-constructed dbs →	performance indicators
+ geometry spec. →	visualisations, shading *etc*
+ constructional →	embodied energy *etc*
+ operational data →	energy demand profiles *etc*
+ boundary conditions →	‘no-system’ comfort *etc*
+ special materials →	PV, switchable glazings *etc*
+ control systems →	energy use, system response *etc*
+ flow network →	ventilation, heat recovery *etc*
+ HVAC network →	component sizing, systems design *etc*
+ CFD domain →	IAQ, comfort, ventilation η *etc*
+ power network →	DSM, RE integration *etc*
+ enhanced resolution →	thermal bridging *etc*
+ moisture network →	condensation, mould & health

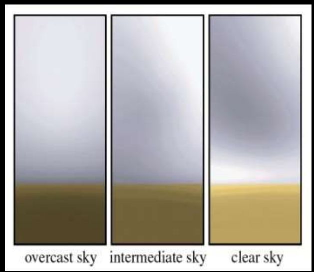
Incremental model building - effort and reward

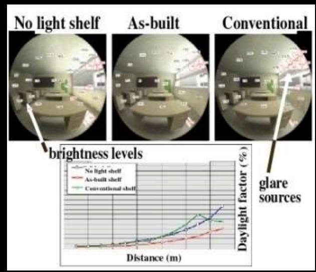


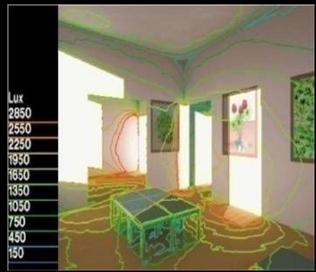


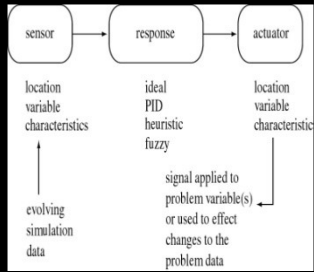


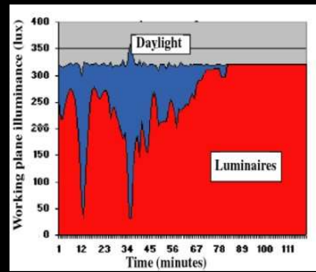


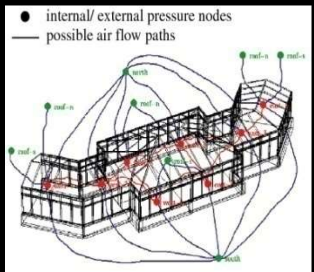


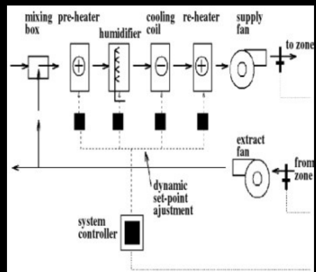


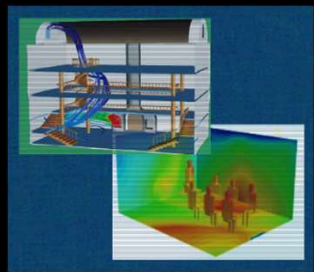


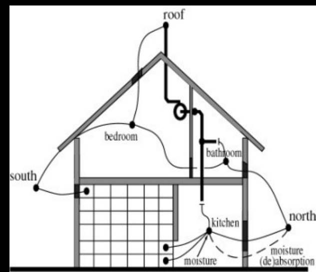


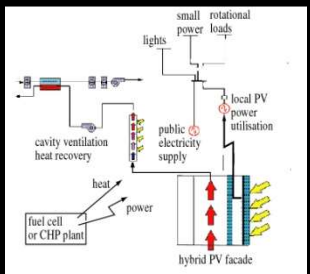


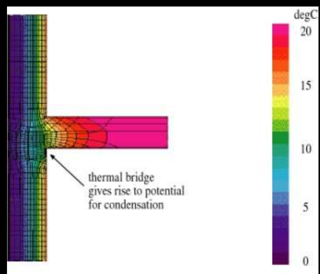


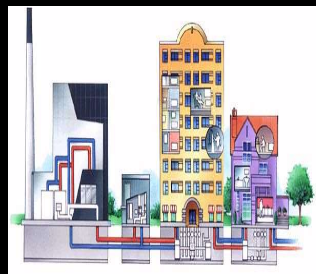


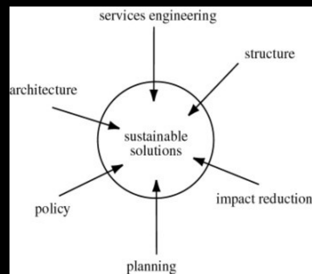






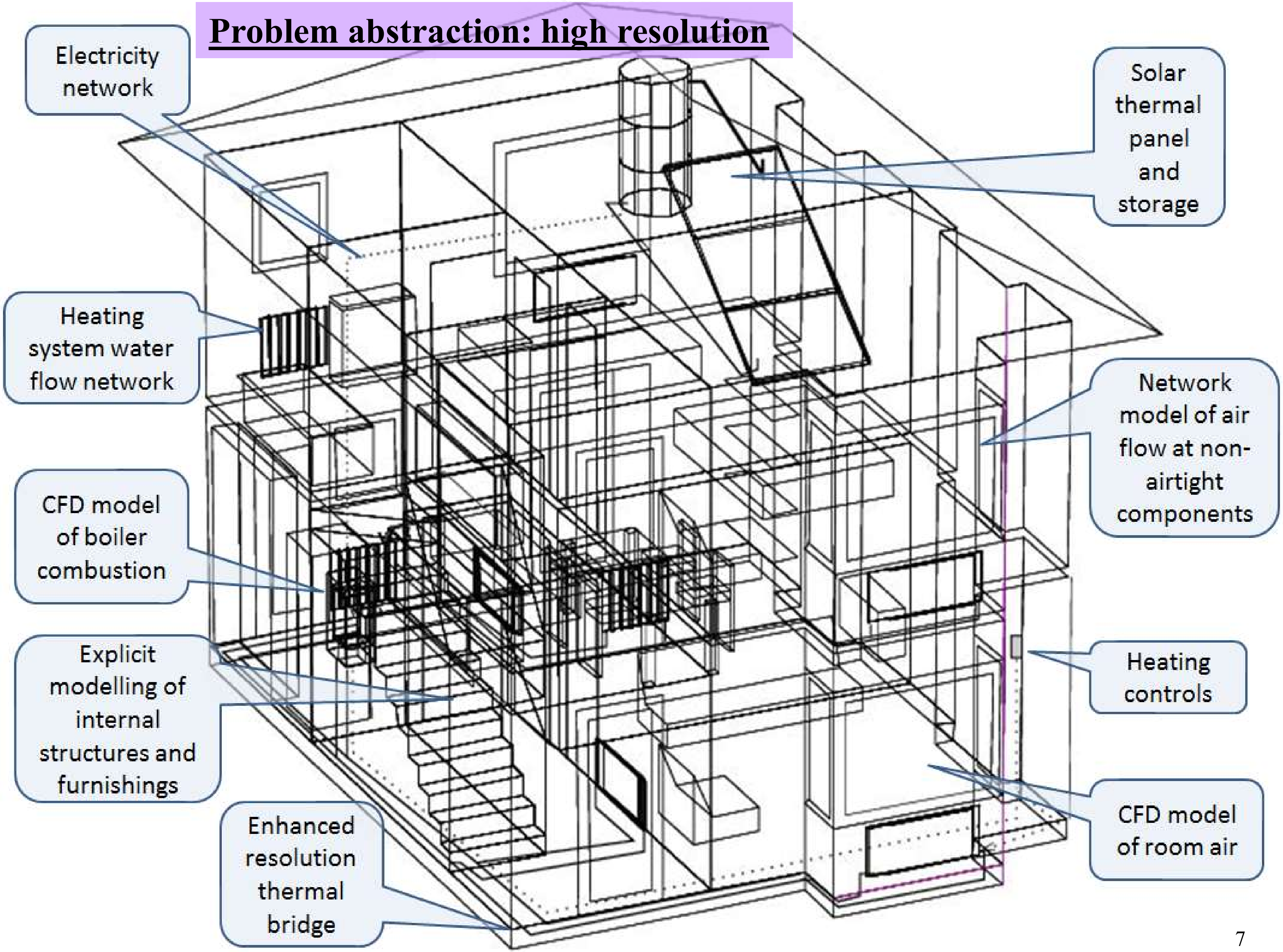






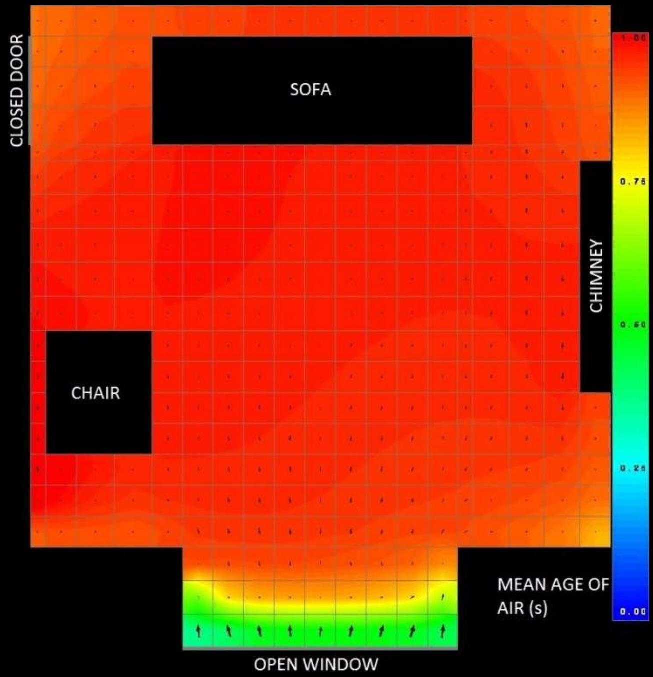
increasing effort

Problem abstraction: high resolution

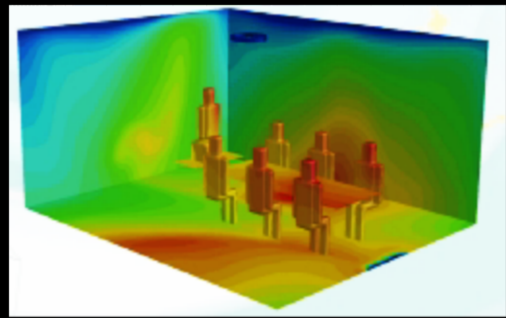


Automatic inclusion of content and plant entities in visualisations and daylight utilisation studies.

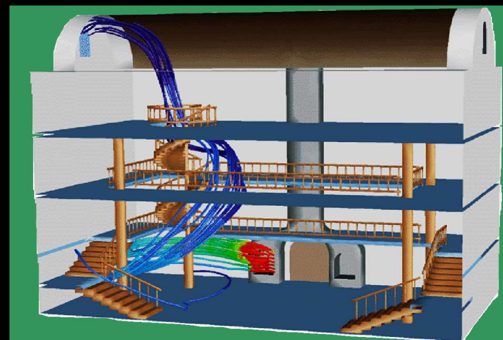
Consideration of comfort and well-being.



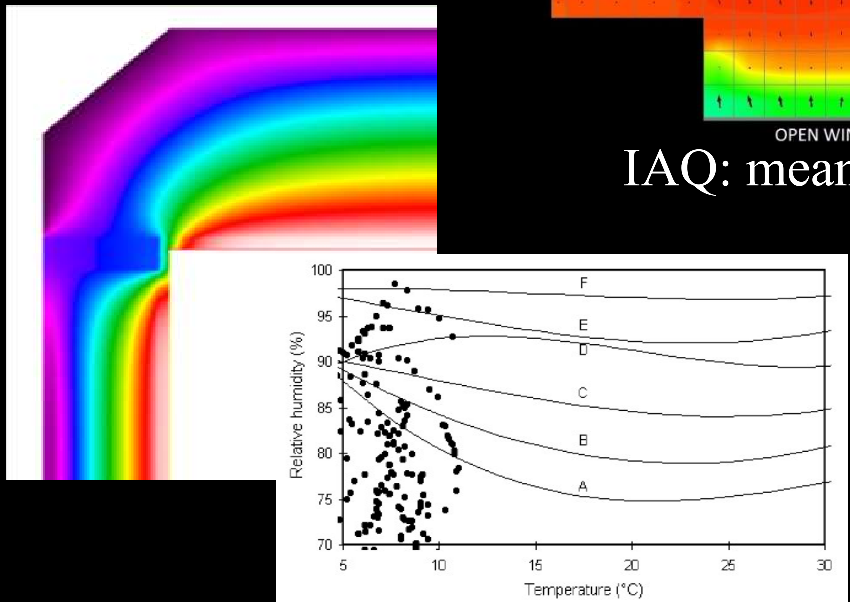
IAQ: mean age of air



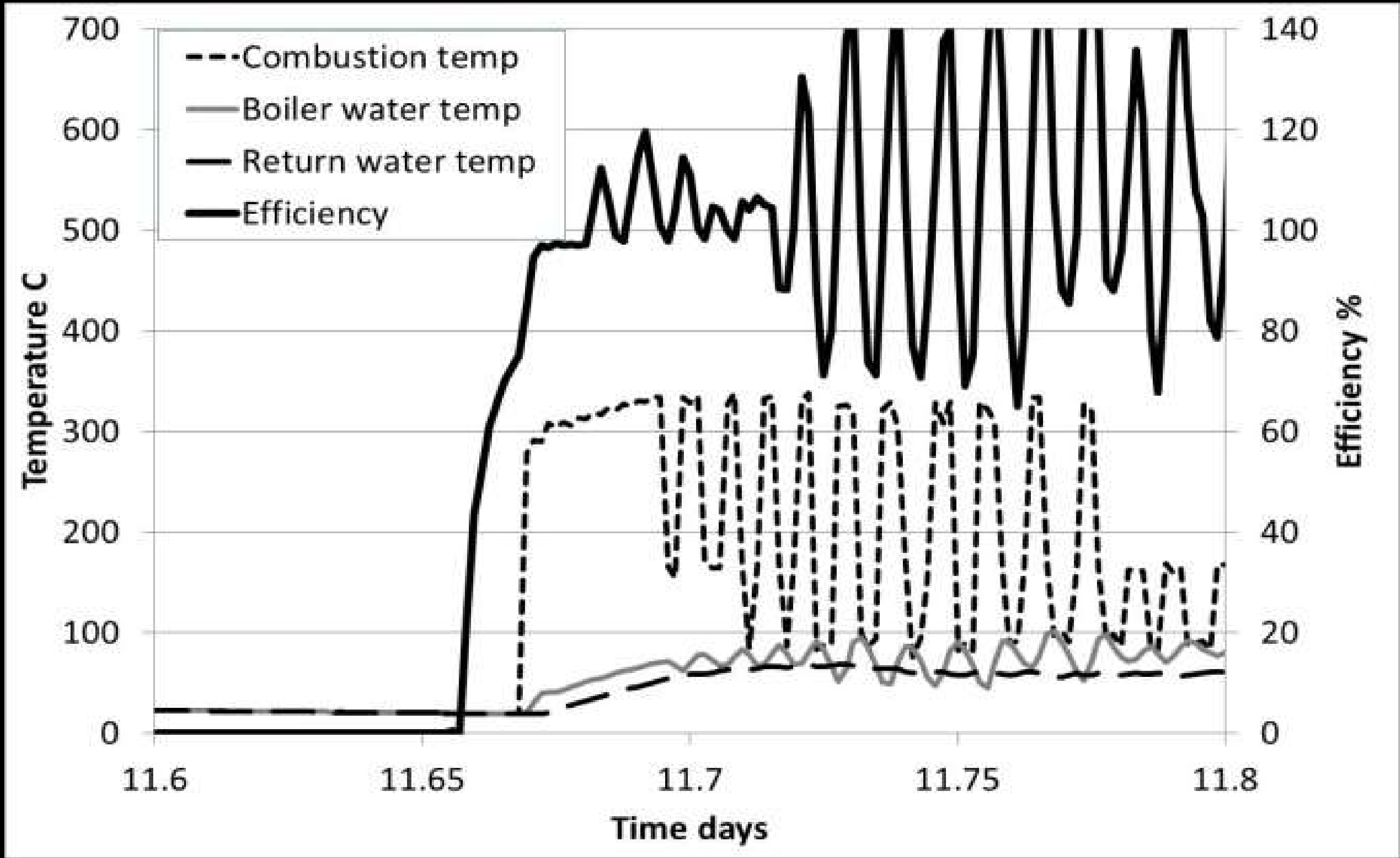
Thermal comfort



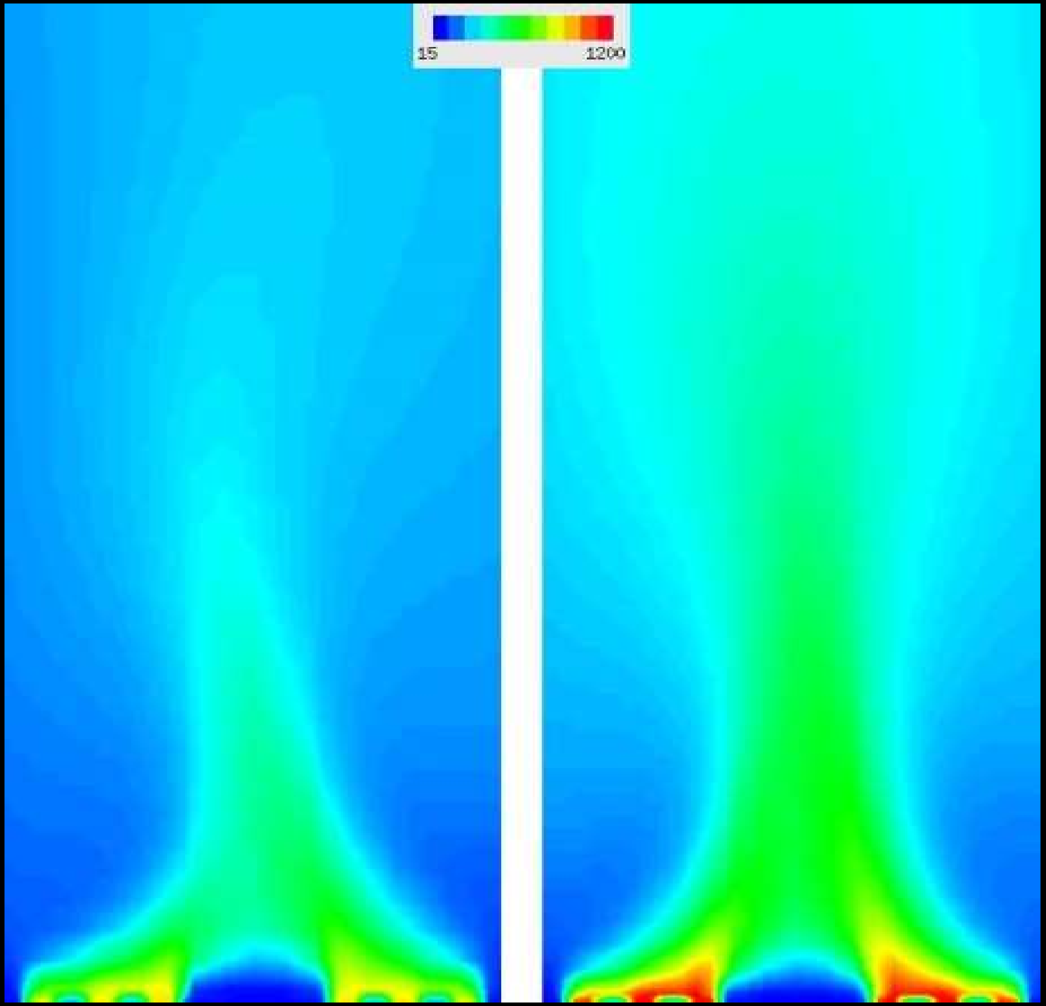
Smoke extract



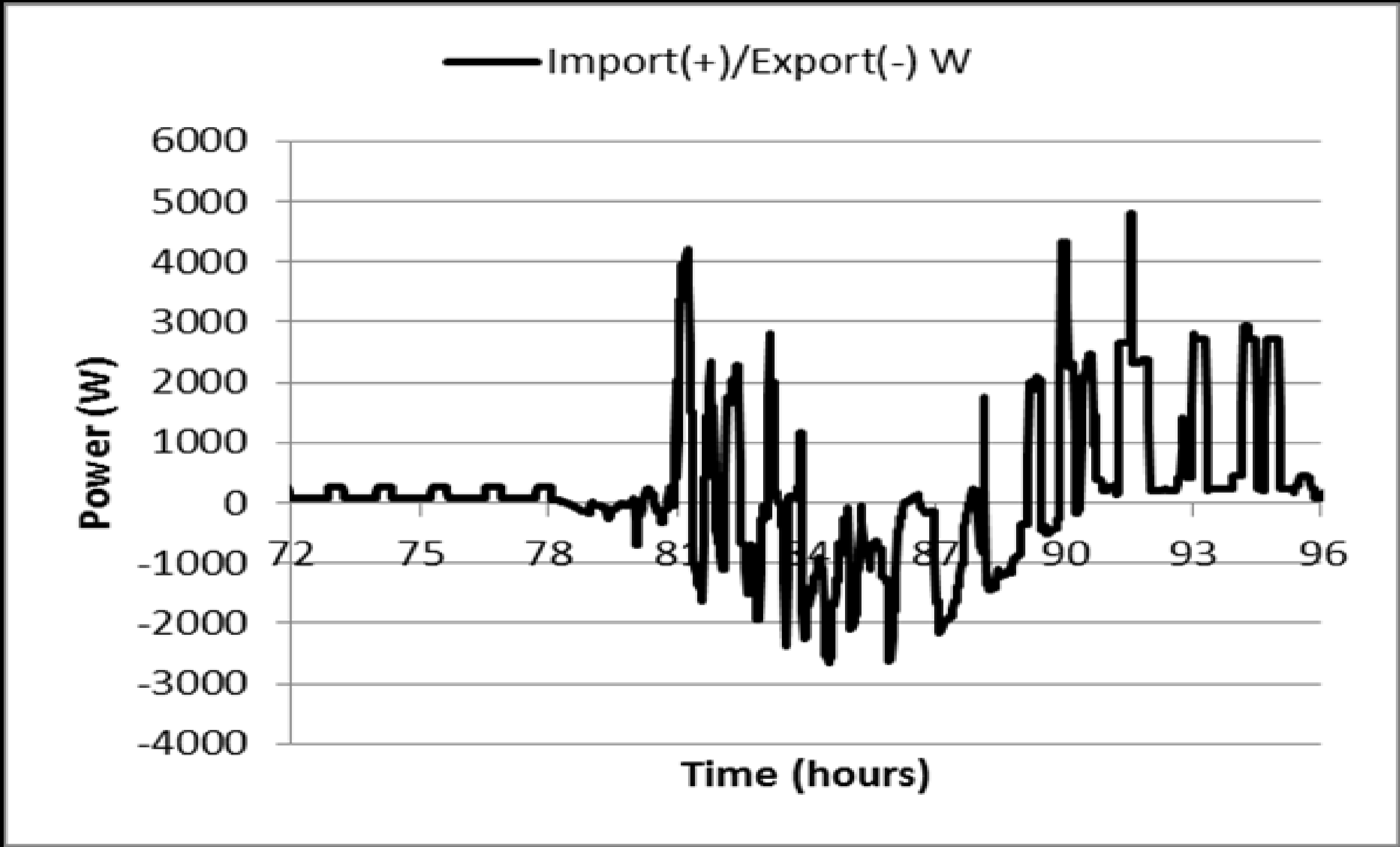
thermal bridging & mould



Boiler efficiency, combustion chamber temperature and boiler flow/return water temperature corresponding to a typical start-up event – water temperature rises from ~20 C to 80 C, followed by on/off cycling.

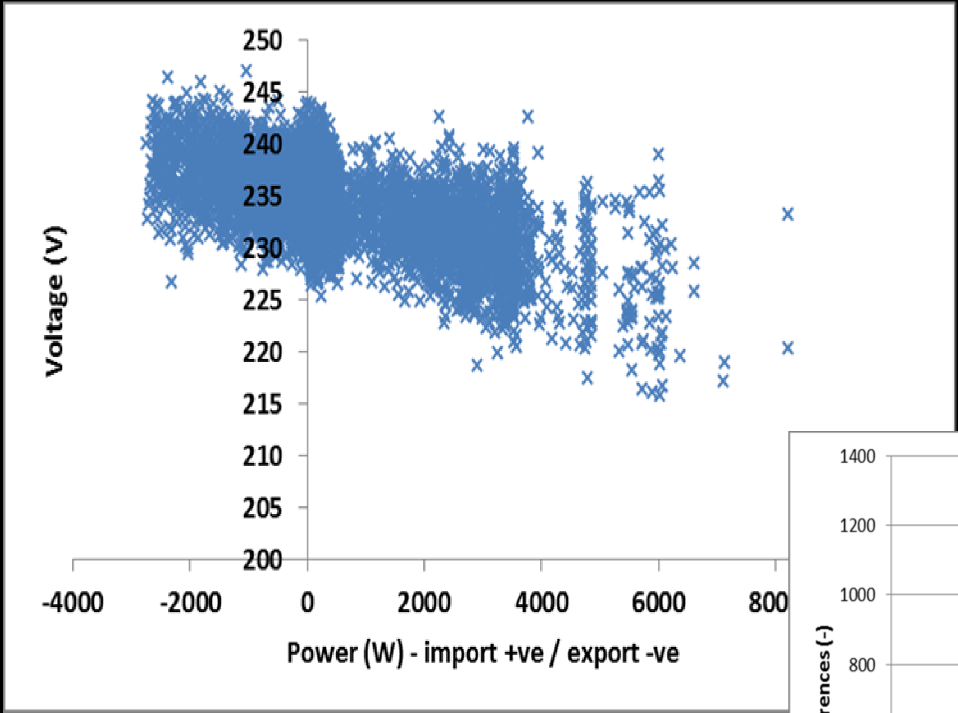


Combustion chamber temperature distribution snapshots corresponding to different levels of stoichiometric excess air.

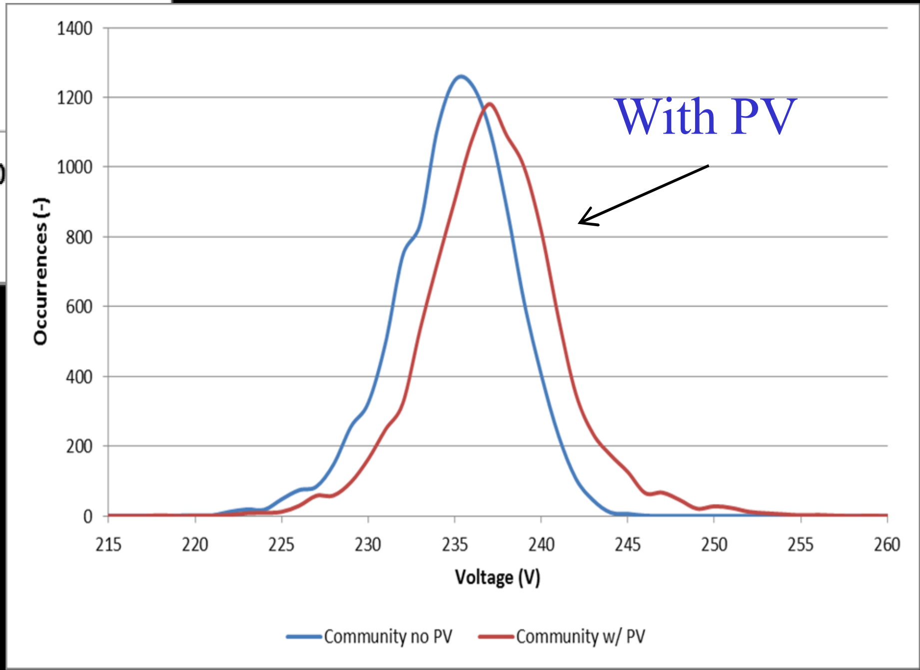


Summer day import/ export for the 4 kW PV array.

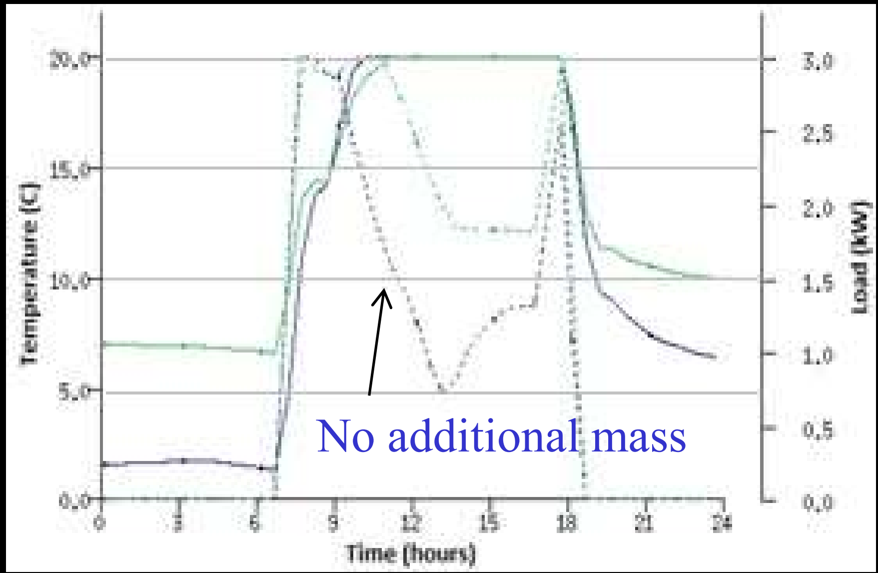
Fluctuation of power between the consumer and LV network and significant power export (-ve power) indicates the need for load control.



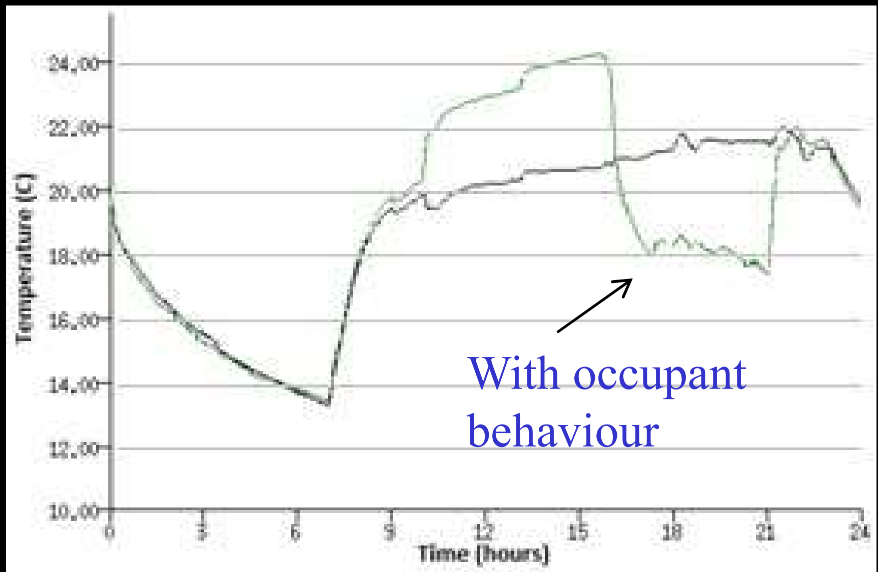
Voltage excursions with power import/ export.



Supply voltage, 200 dwellings.

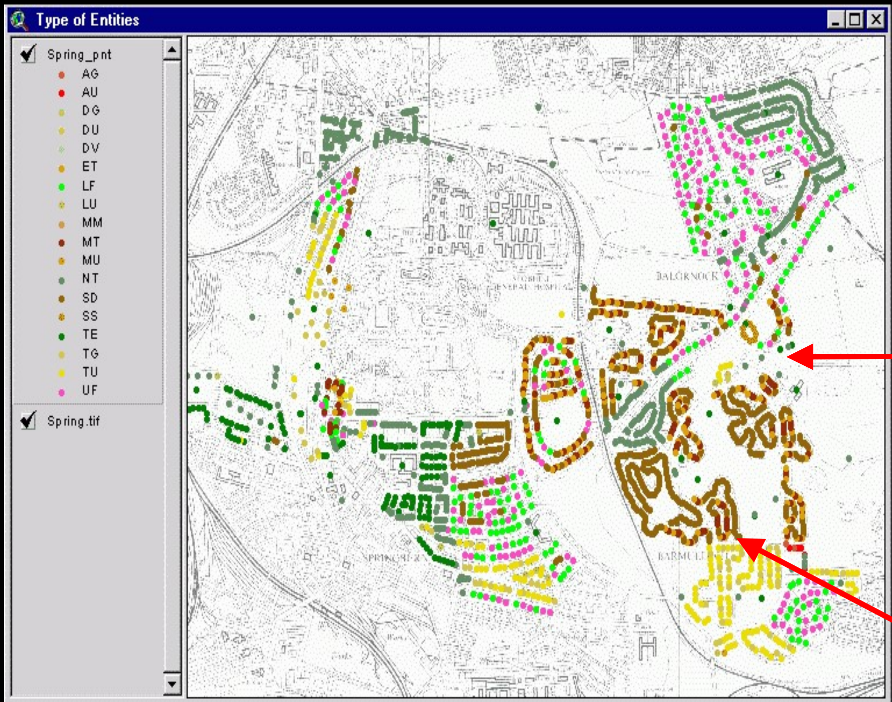


Impact on heating load of additional thermal mass for a given temperature set-point (solid line).



Impact of occupant behaviour on room temperature.

Simulation used for action planning



metered
energy use

database of
actual & future
consumption

interrogations

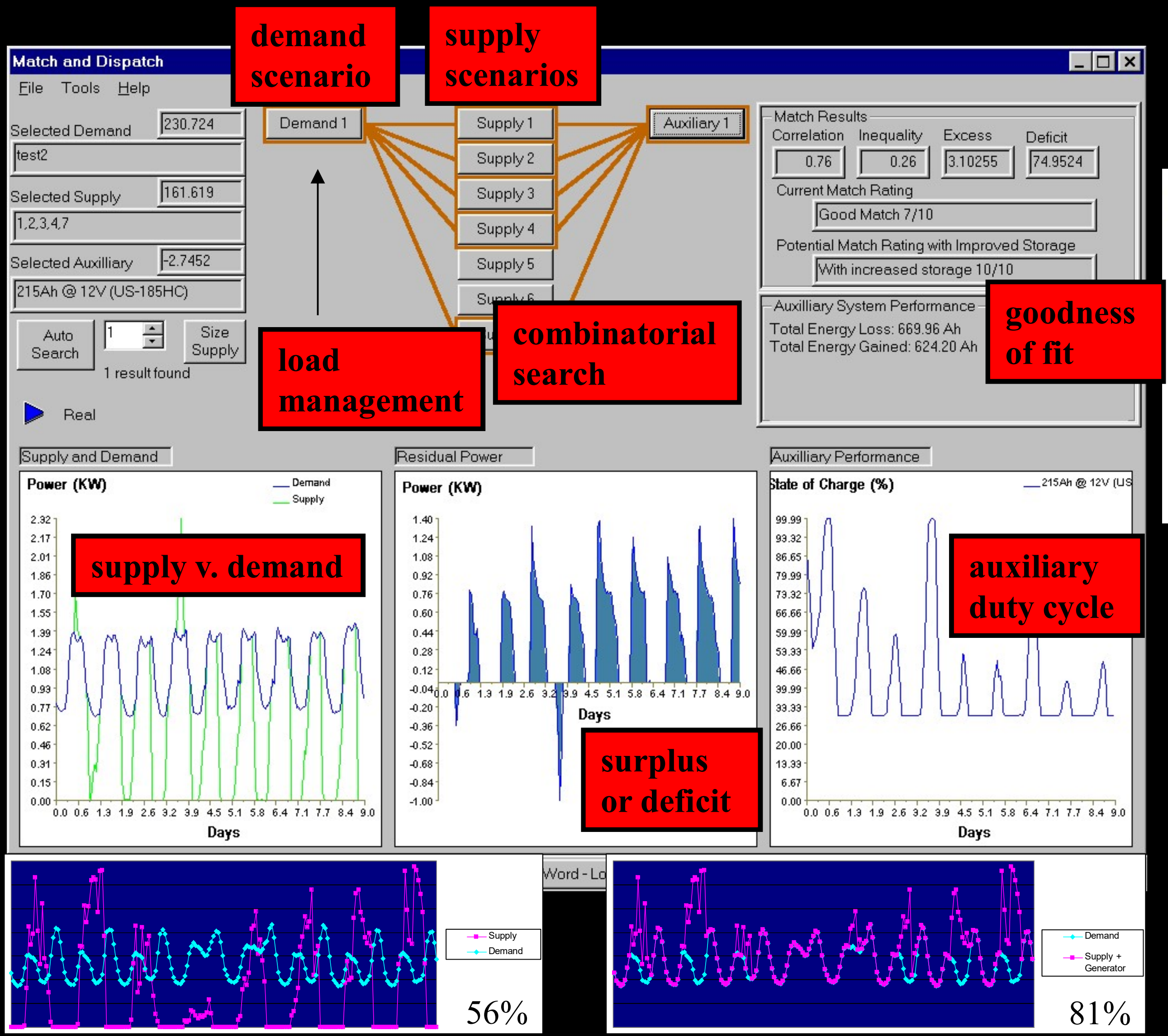
scenario simulations

e-services

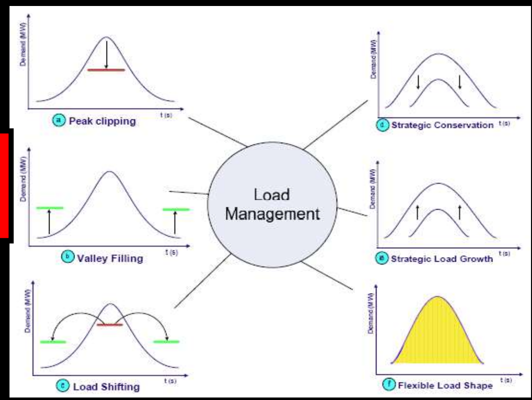
consumption & emissions monitoring;
city profiling & property classification;
trend analysis & action planning

information for government, local authorities, institutions, industry, utilities, designers, planners, citizens and others

Simulation used to match supply to demand



load management approaches:



… and impacts:

Simulation-assisted design

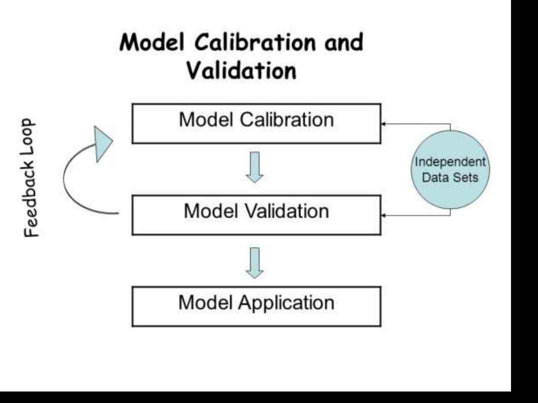
Requires changes to work practices and adherence to standard performance assessment methods (PAMs – action in **blue**, knowledge in yellow):

1. establish initial model for an unconstrained base case design;
2. calibrate model using reliable techniques;
3. assign boundary conditions of appropriate severity;
4. undertake integrated simulations using suitable applications;
5. express multi-domain performance in terms of suitable criteria;
6. identify problem areas as a function of criteria acceptability;
7. analyse results to identify cause of problems;
8. postulate remedies by relating parameters to problem causes;
9. establish revised model to required resolution for each postulate;
10. iterate from step 4 until overall performance is satisfactory;
11. repeat from step 3 to establish design replicability.

Issues: PAMs required for all aspects: comfort, health & productivity; operational & embodied energy, emissions & environmental impact, technology options appraisal, demand management, embedded generation, regulations compliance, hybrid systems control, economics, *etc*.

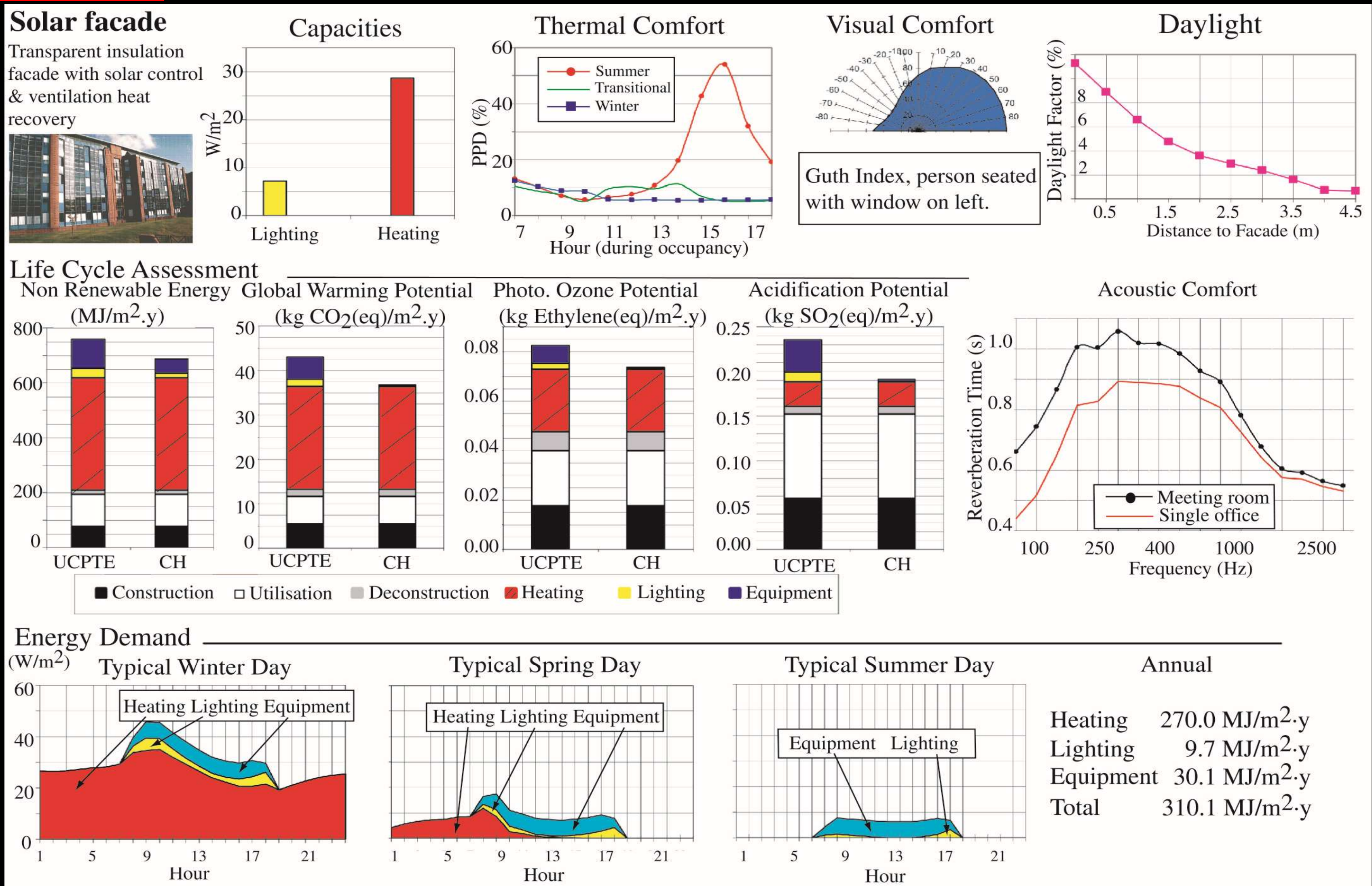
Model calibration

- A systematic adjustment of model parameters to obtain an expected output.
- Input-output pairs for multiple simulation cases are recorded along with corresponding measurements of the outputs and time-matched weather data.
- These data are used to construct a 'meta-model' that emulates the simulation tool being used.
- The meta-model is used to determine the input parameter values that will cause the tool to best reproduce the measured performance.
- The best-fit input parameter values are then imposed on the initial model to yield the calibrated model.

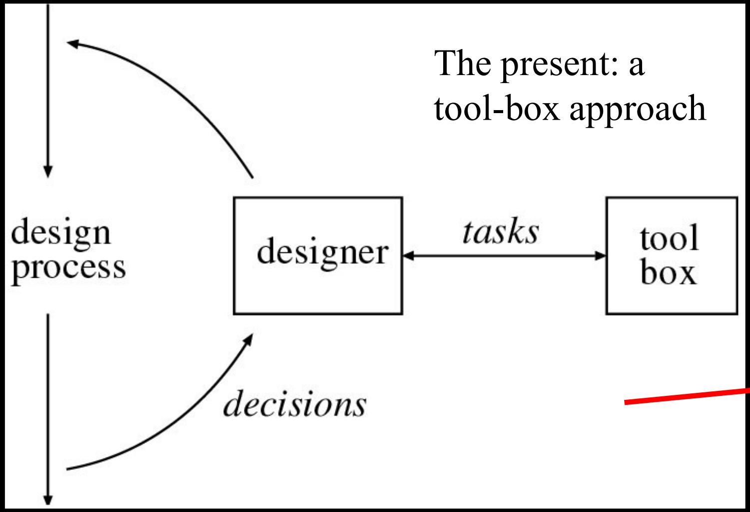


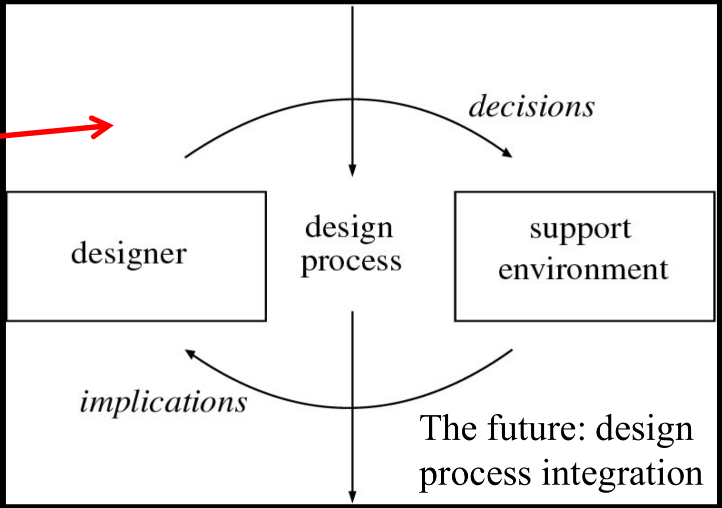
Integrated view of performance

Version 1 | Version 2 | Version 3



Better tool integration necessary

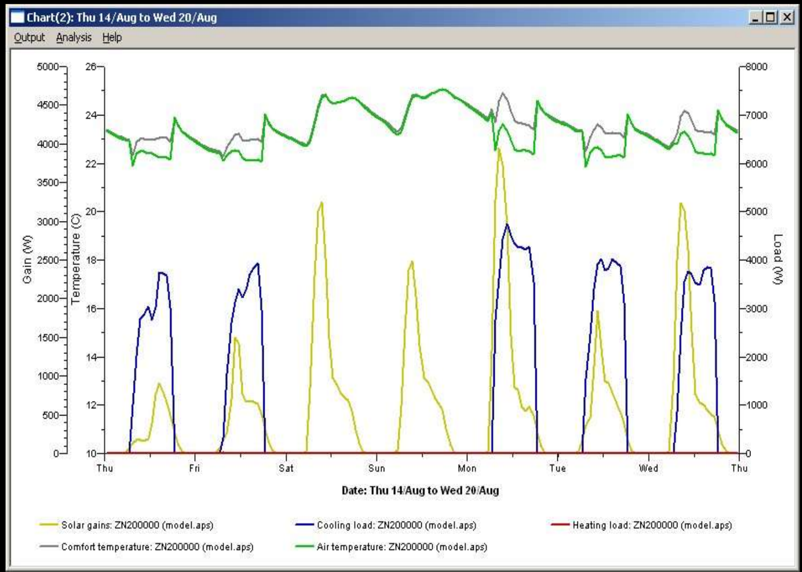


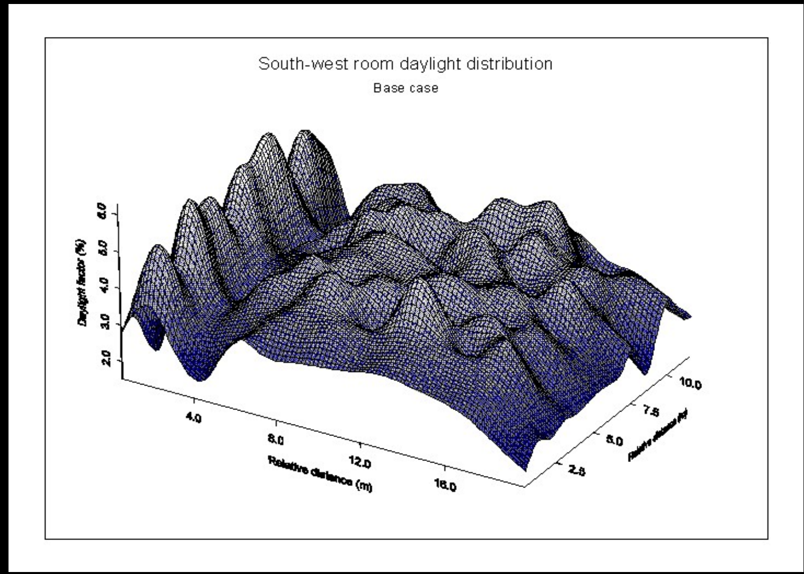


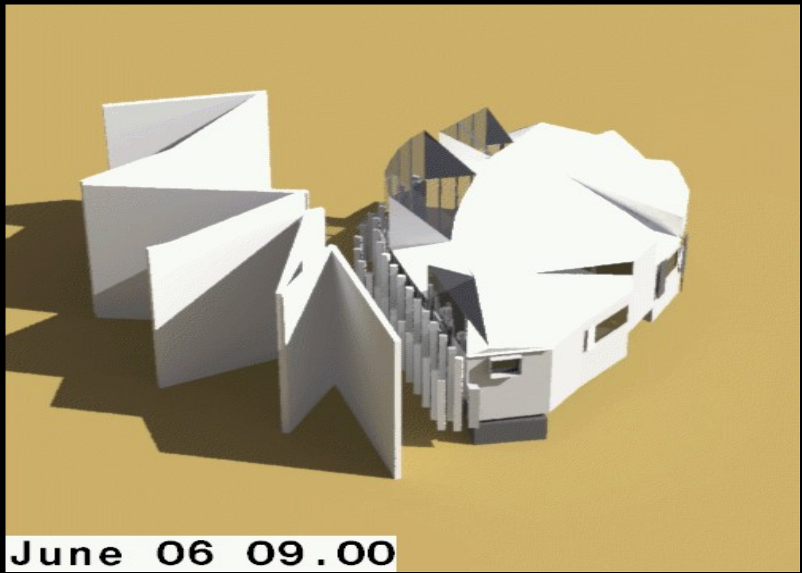
Requires adjustments to design practice:

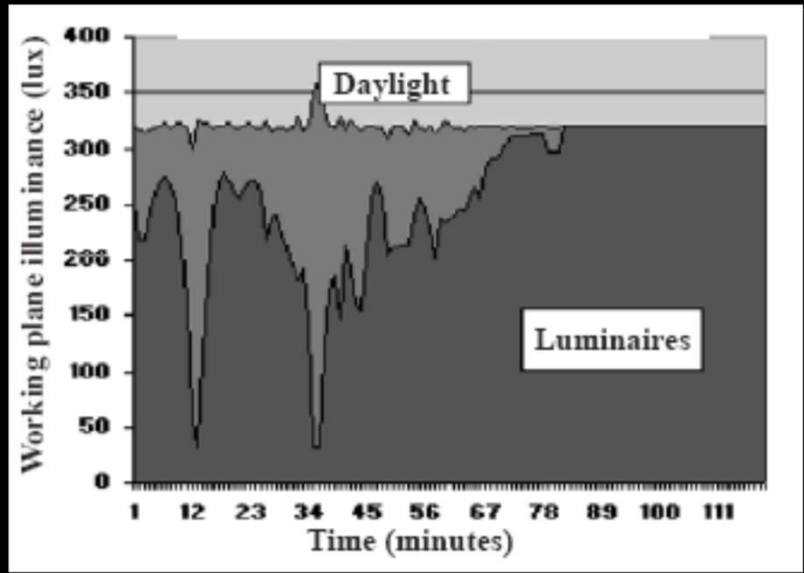
- ❑ Management of the application process (who does what, when and where).
- ❑ Implementation of a performance assessment method whereby each step in the process is demarcated and controlled (model definition and quality assurance, calibration, simulation commissioning, results analysis, mapping to design decisions *etc*.).
- ❑ Formal method to translate simulation outcomes to design modification.

Appropriate data presentation

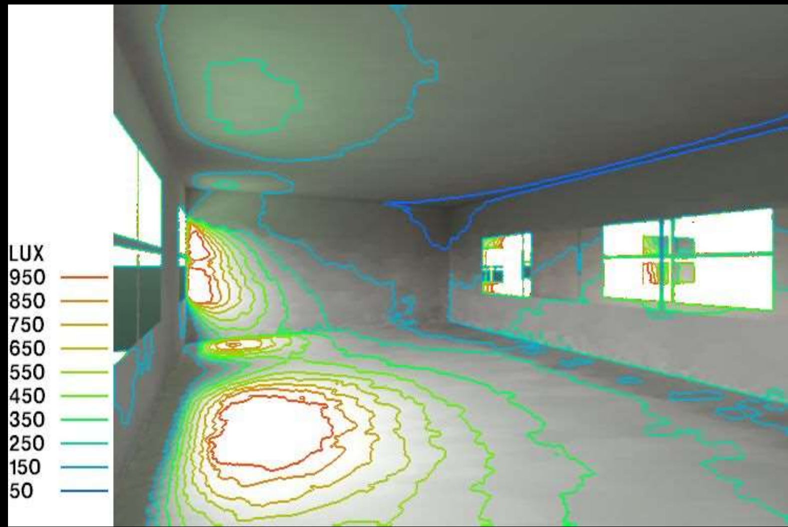




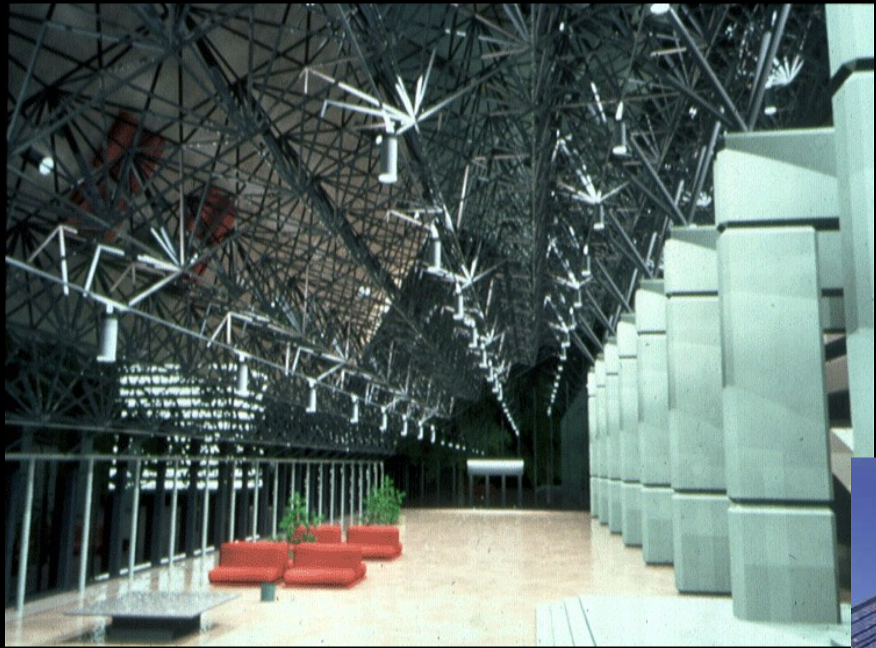




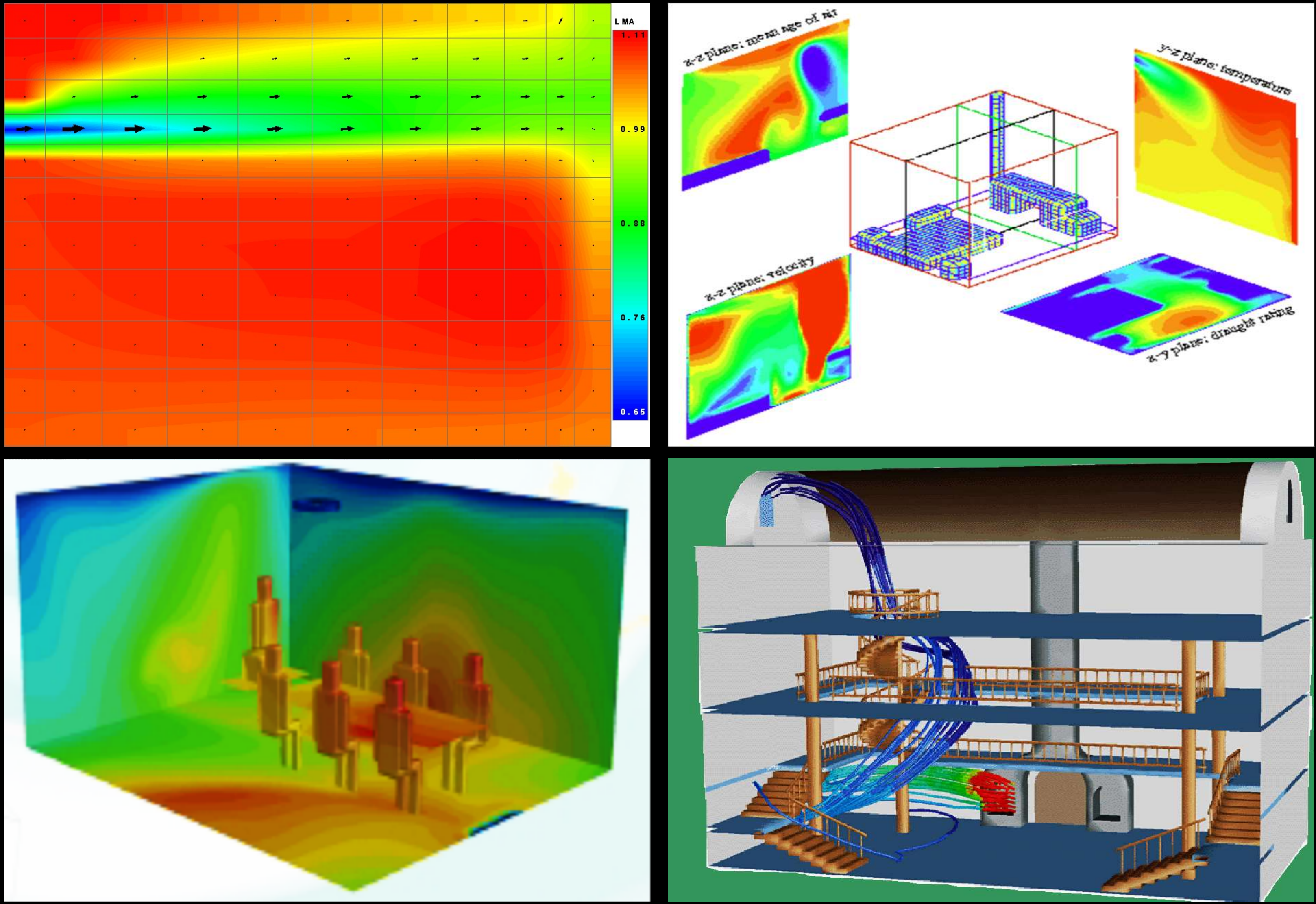
Internal lighting



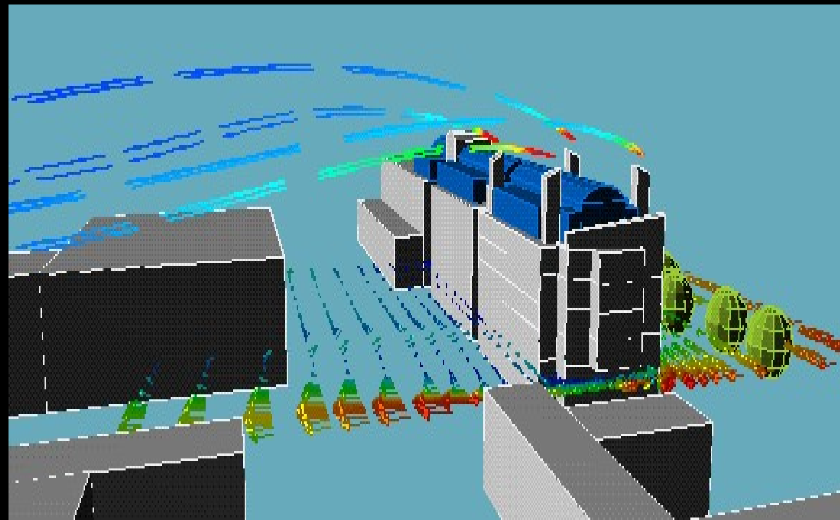
Visualisation

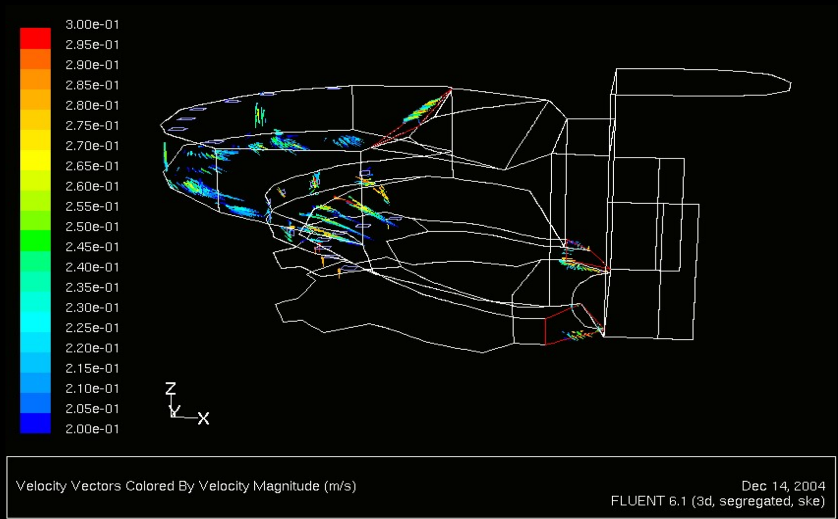


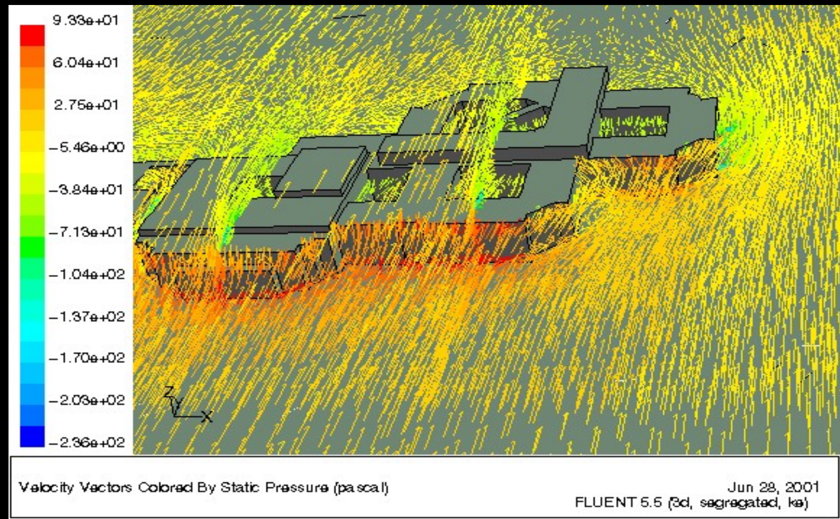
IAQ & comfort


L MA
1.11
0.99
0.88
0.76
0.65
x-z plane: mean age of air
y-z plane: temperature
x-z plane: velocity
x-y plane: draught rating

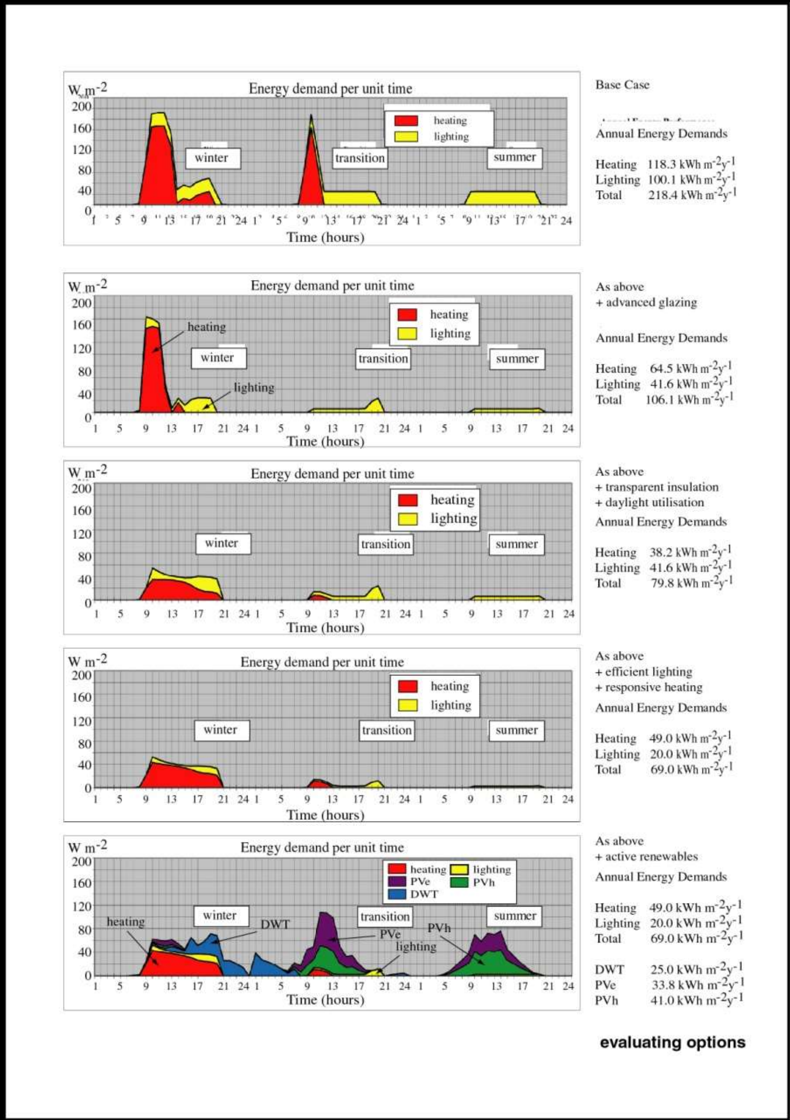
Air flow and emissions



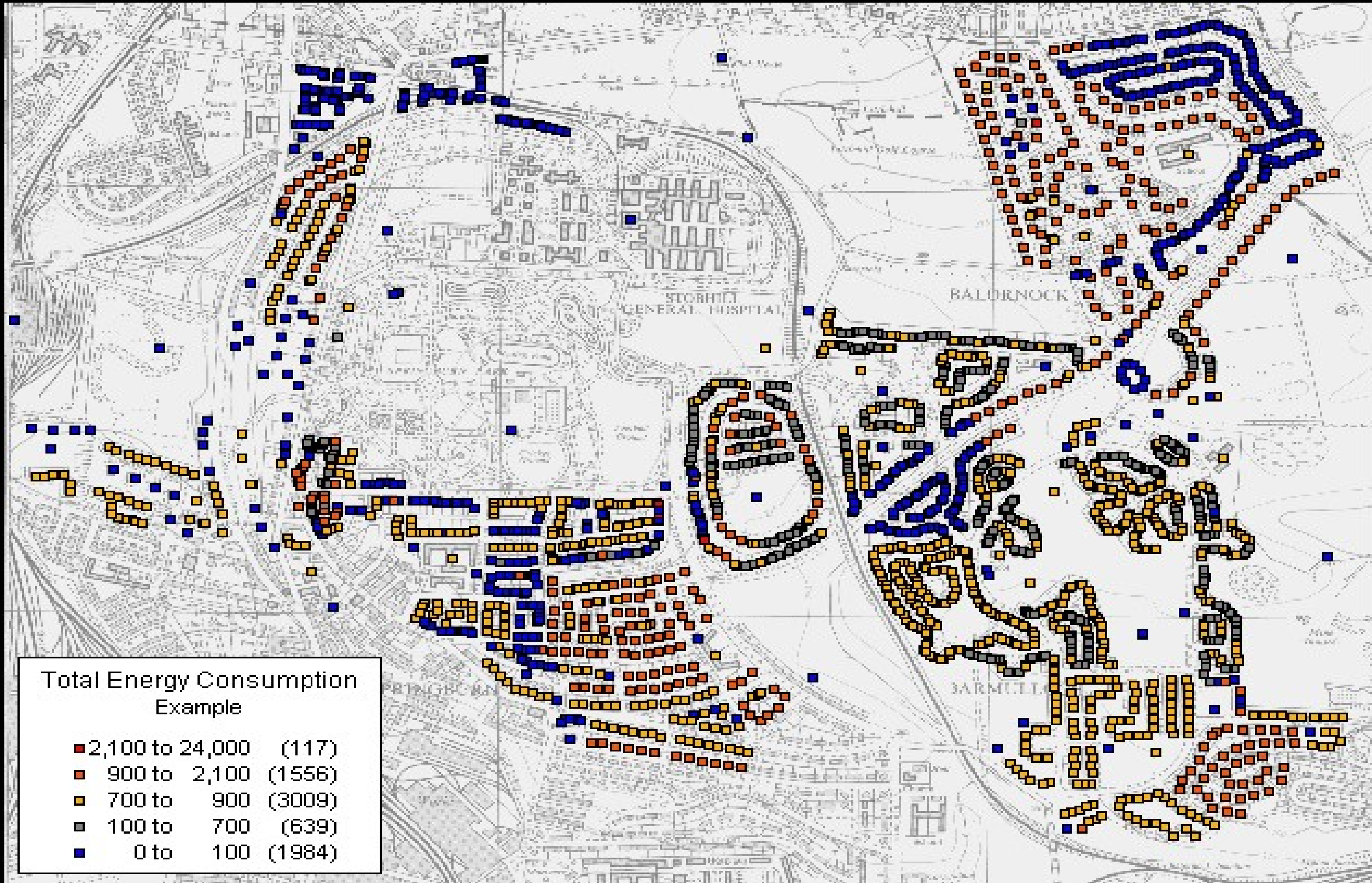




Integrating renewables: the Lighthouse Building



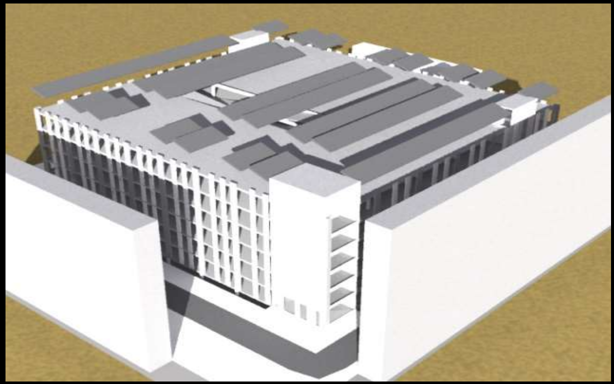
City action planning



Smart street concept

Renewable energy EV charging:

- PV canopy deployed on car park roofs;
- scenario simulations undertaken to assess contribution under progressive charging regimes;
- results used to inform decision on local battery sizing.

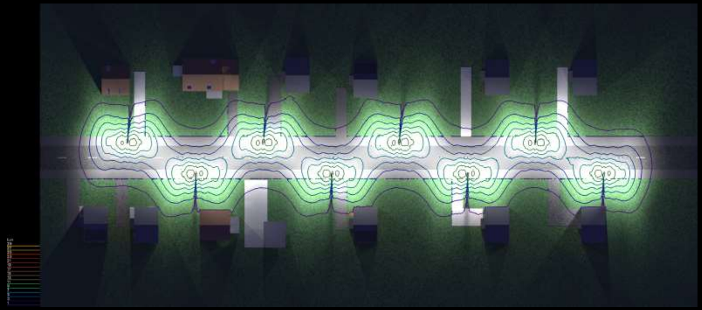


Multi-organisation district heating:

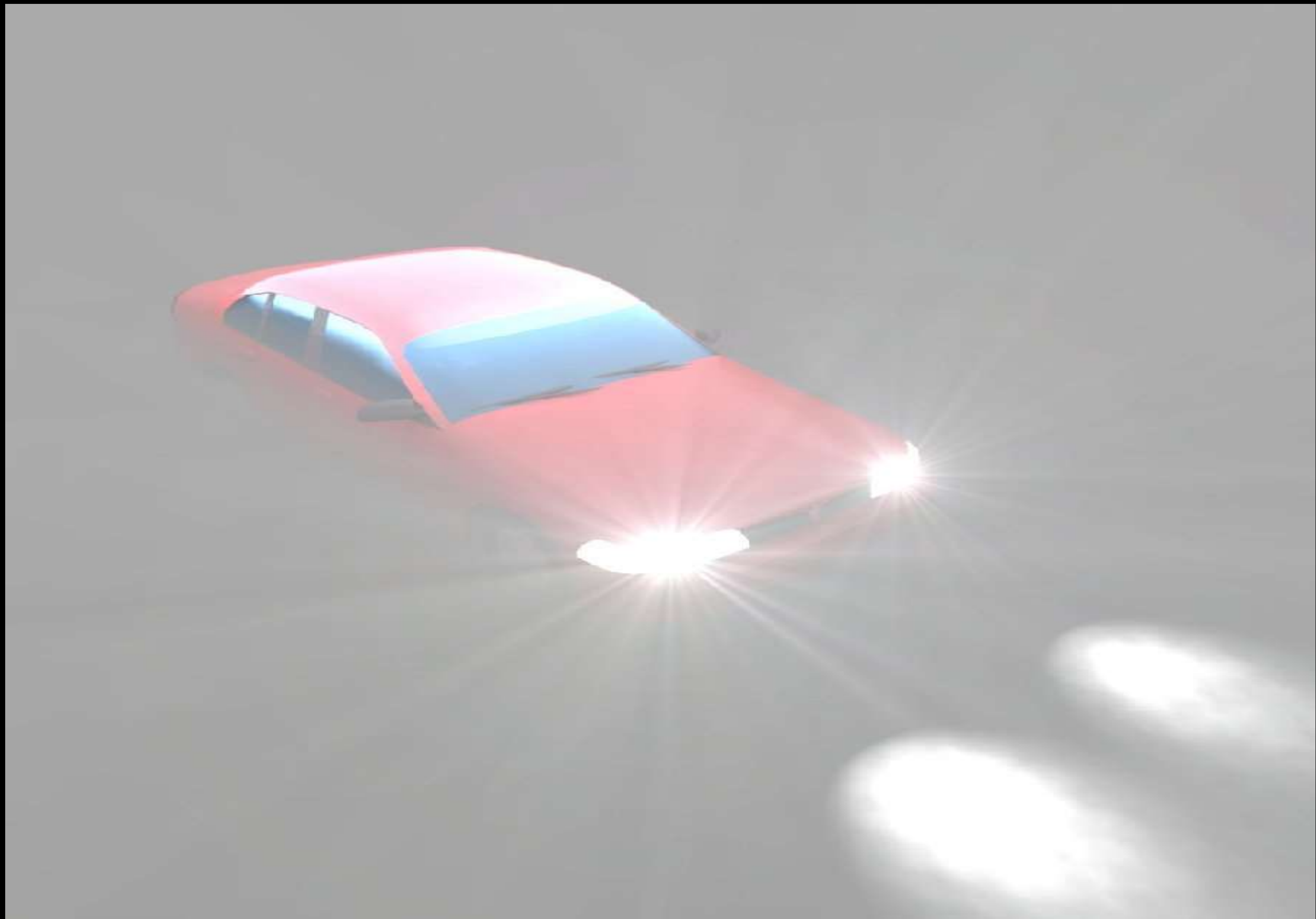
- university's new district heating scheme modelled;
- scenario simulations undertaken to assess system extension to GCC headquarters building;
- results used to assess feasibility of shared DH throughout city.

Demand management:

- Glasgow smart street model constructed;
- scenario simulations undertaken to assess impact of alternative demand control regimes;
- results used to inform deployment of local solutions.



Car safety



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