UC Davis Energy Industry Affiliates Forum

Integrated Energy Solutions

Joe Clarke
(joe@esru.strath.ac.uk)

BRE Centre for Energy Utilisation
hosted by
Energy Systems Research Unit
University of Strathclyde

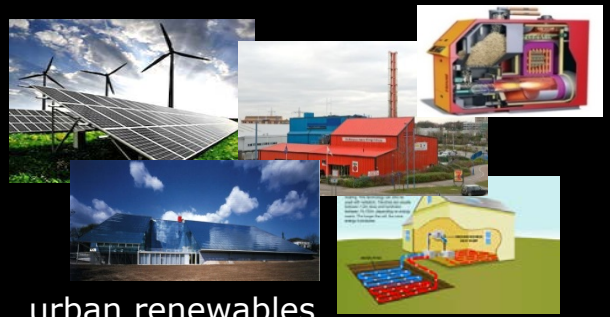
Supply side options

fossil fuels

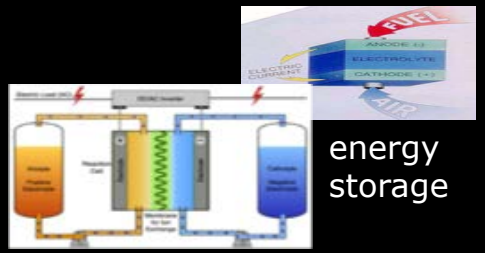
strategic renewables (present)

strategic renewables (future)

nuclear



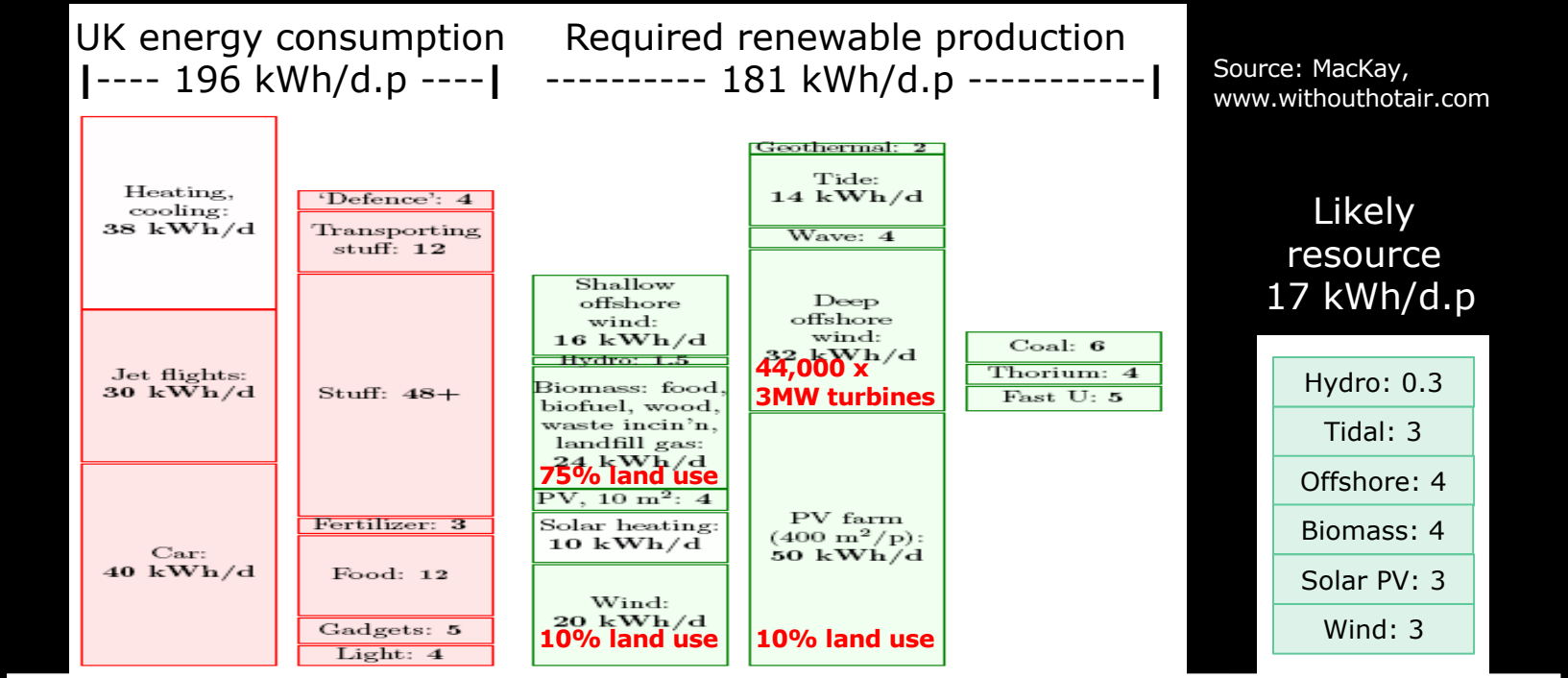
urban renewables



energy storage

Many conflicts between options.

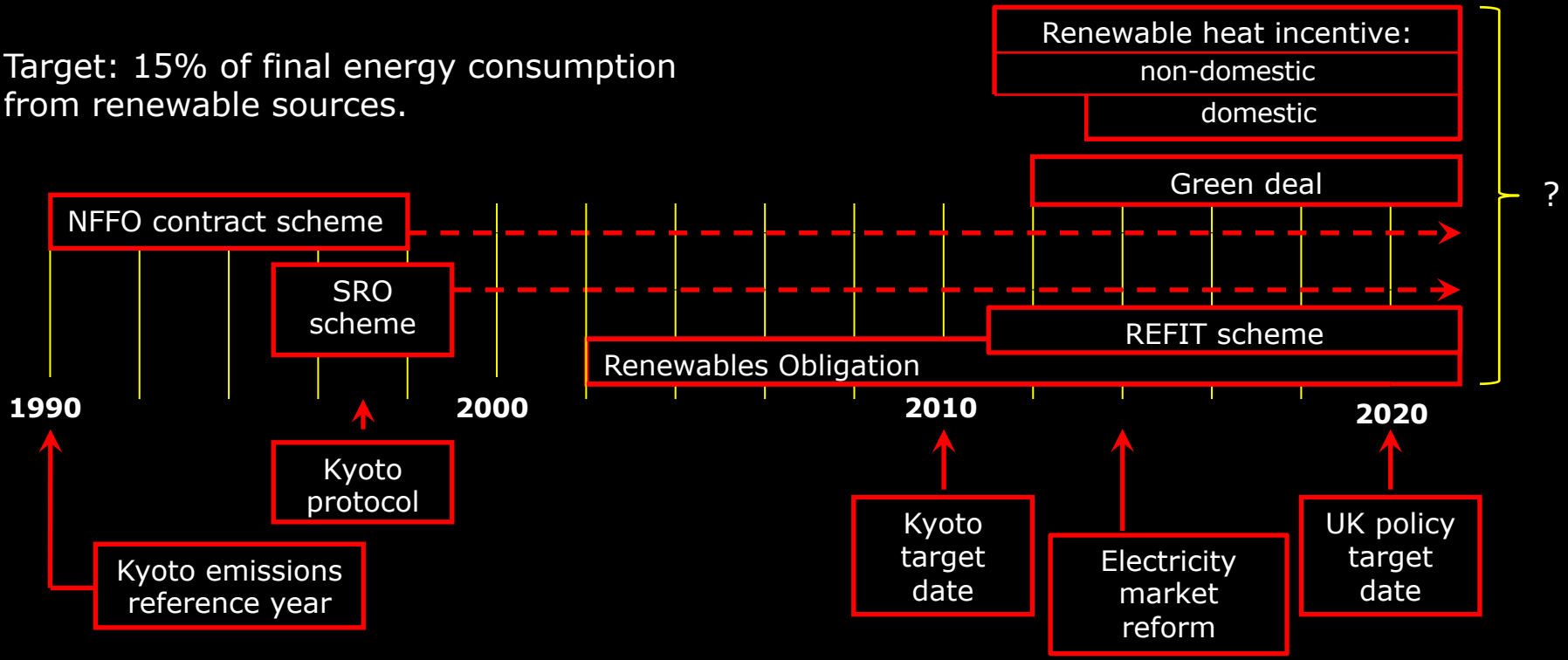
UK renewables - the demand/supply dilemma



Matching requires the industrialisation of the environment on a massive scale.

UK renewables policy framework

Target: 15% of final energy consumption from renewable sources.

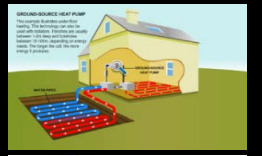


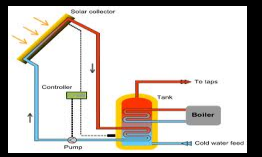
Renewable targets backed by fiscal measures – not technical feasibility.

Demand side options

- daylight utilisation
- adaptive facades
- smart control
- demand management
- passive solar devices
- heat recovery
- SVPH/ MVHR
- switchable glazing
- selective films
- transparent insulation
- moveable devices
- breathable walls
- phase change material
- smart meters & grids
- electric vehicles

- condensing boiler
- heat pumps
- combined heat and power
- tri-generation
- photovoltaics
- desiccant cooling
- evaporative cooling
- electricity to heat
- smart space/water heating
- urban wind power
- biomass/biofuel heating
- embedded RES
- district heating/cooling
- energy storage
- fuel cells and hydrogen



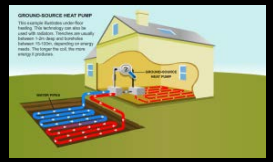


Myriad options with poor understanding of complexity and blending options.

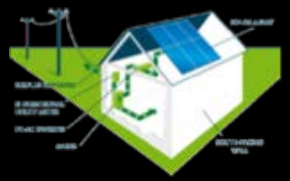
Confounding issues

Cost reduction
Safety
Hybrid systems design
Smart control
Network impacts
Comms resilience
Business models
Unintentional impacts
Stochastic influences
Work practices
Policy conflicts

Electrification of heat



Net-zero energy

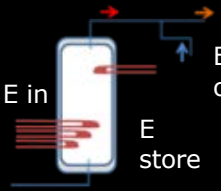


Smart grid

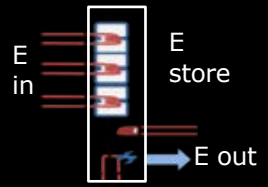
Active Network Controller → Local Interface Controller

Charge controller

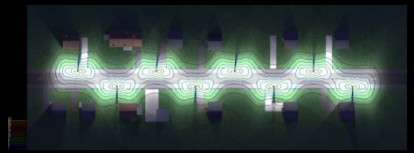
QHWS



QSHS

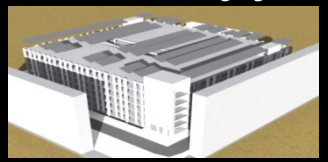


Smart districts

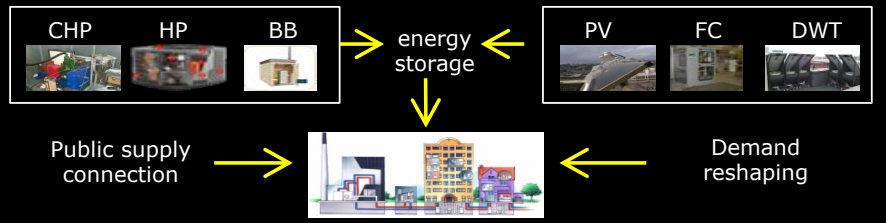


District heating/ power

Electric vehicle charging



Energy service companies



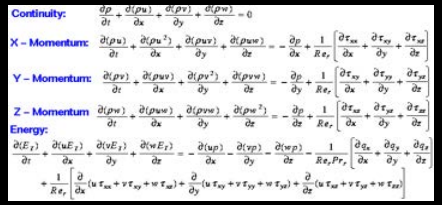
Palpable lack of respect for whole system integrity.

What's the problem?

Actions not predicated on thermodynamic principles

Most decisions are partly-informed

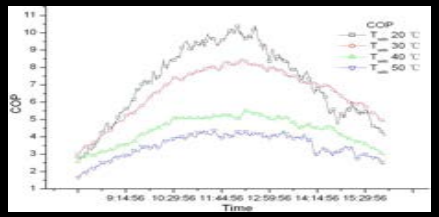
Energy processes are <u>dynamic</u>



Overall system is <u>systemic</u>

Capital/ running/ maintenance cost
Thermal/ visual comfort
Emissions & air quality
Network interaction & power quality
Demand/ supply matching
Adaptability & resilience

Defining data are <u>non-linear</u>



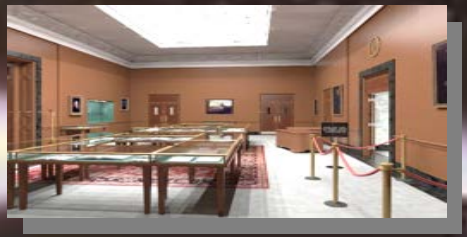
Influences are <u>stochastic</u>

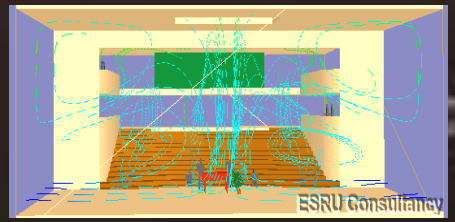
Need to consider energy systems holistically and respect the underlying integrity.

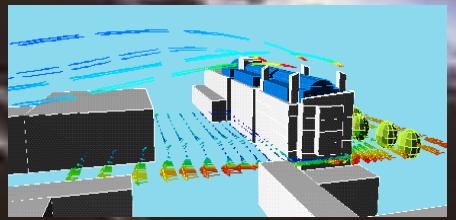
Energy systems modelling and simulation

Aids understanding of the behaviour of complex systems:

- respects complexity;
- integrates all significant issues;
- enables life cycle assessment;
- links systems design to wider issues;
- supports resilience testing;
- is cheaper, quicker and better;
- enables participatory democracy.







IBPSA
International Building Performance Simulation Association

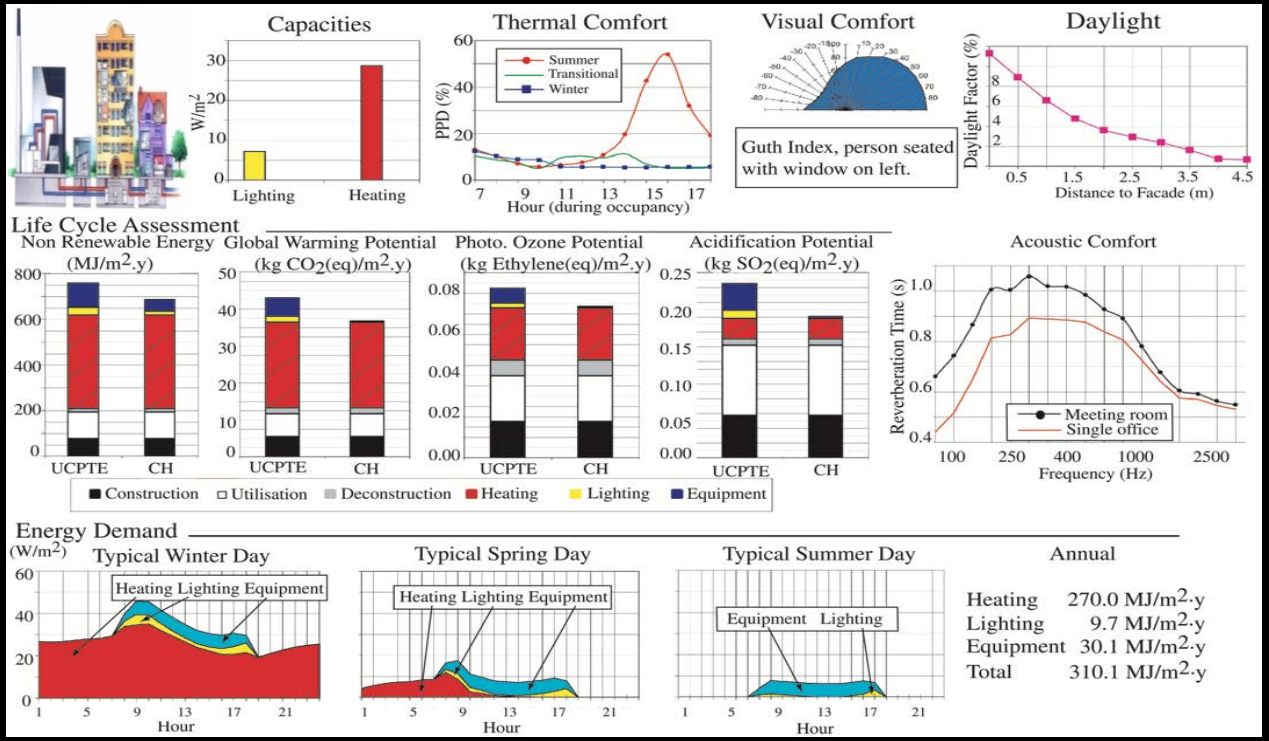
www.ibpsa.org
Founded 1985

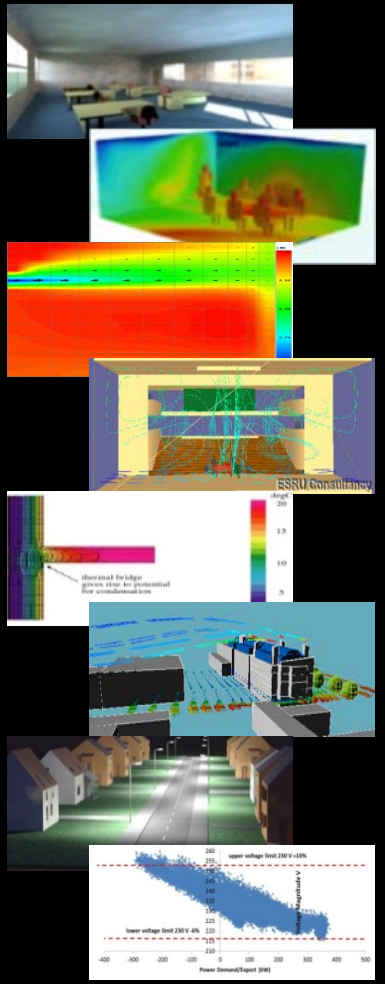
Argentina
Egypt
Japan
Spain
Australasia
England
Korea
Switzerland
Brazil
France
Mexico
Turkey
Canada
Germany
Netherlands + Flanders
Chile
India
Nordic
United Arab Emirates
China
Indonesia
Poland
USA
Czech Republic
Ireland
Scotland
Danube
Italy
Slovakia

IBPSA Fellows

BUILDING SIMULATION 2017

Computational appraisal





Provides an integrated and experiential appraisal of performance.

Defines best practice

Addresses all relevant issues:

- technical feasibility;
- human comfort;
- indoor/outdoor air quality;
- economic impact;
- life cycle economics;
- energy/carbon economics;
- environmental impact;
- controllability assurance;
- hybrid schemes for resilience.

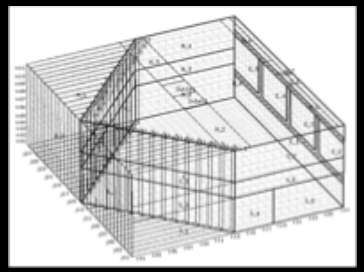
Encapsulates all processes:

- building physics;
- thermo-fluids;
- heat and mass transfer;
- radiation exchange;
- plant and systems processes;
- electrical power flows;
- micro-climate;
- renewables stochasticity;
- control system response.

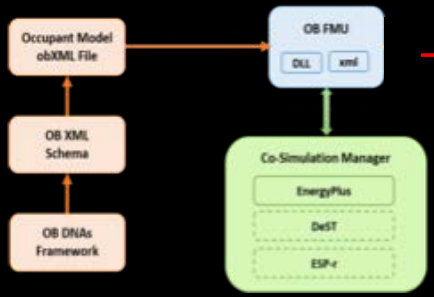
Whole system appraisal including wellness is the new meme.

High resolution modelling

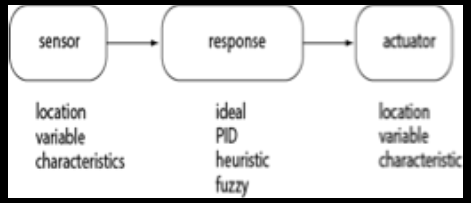
Air flow

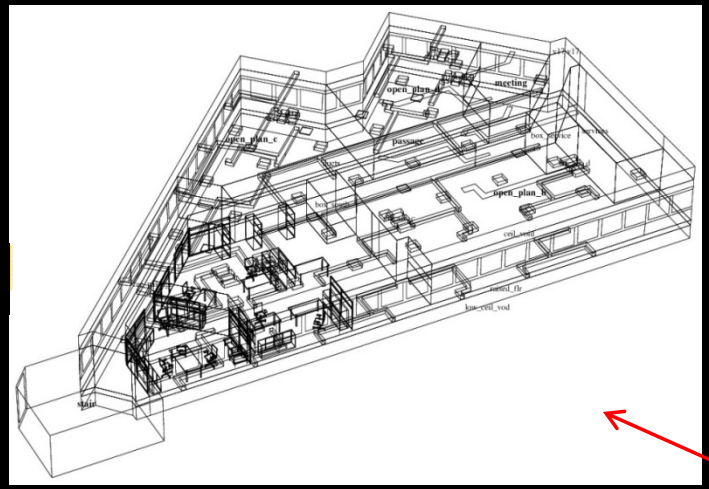


Occupant behaviour



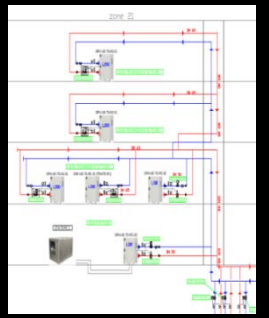
Control



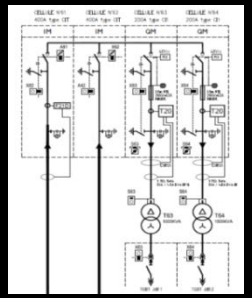


Lighting

HVAC



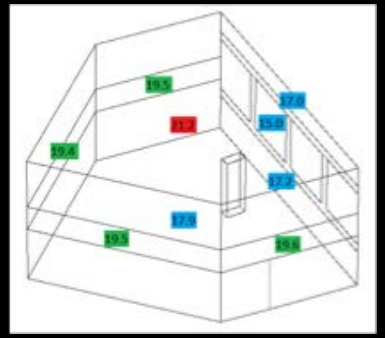
Electrical

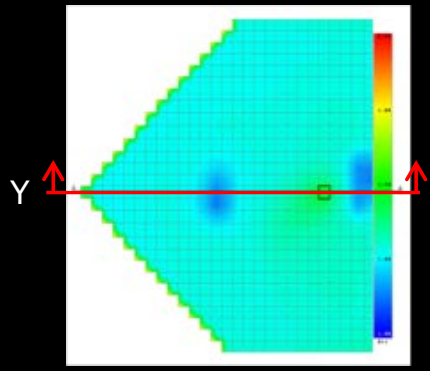


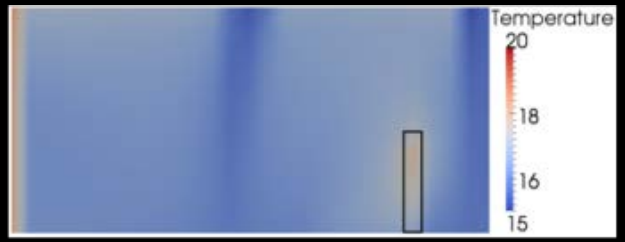
Automated performance assessment

PAM 1: Thermal comfort

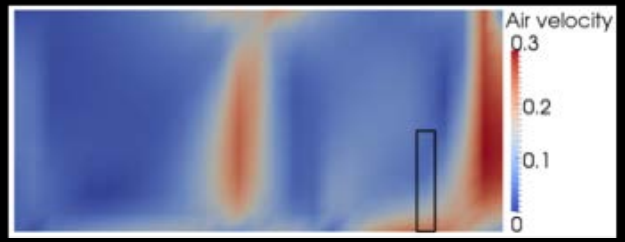
- ISO 7730
- PMV
- draught risk
- vertical air temperature stratification
- floor temperature
- radiant asymmetry







Section YY



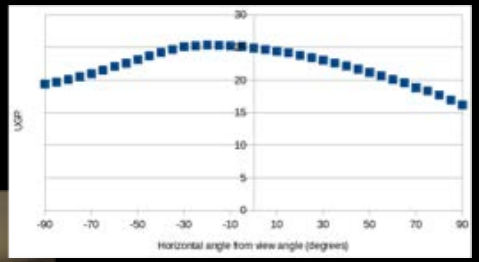
Category	Thermal state of the body as a whole		Local discomfort			
	PPD %	PMV	DR %	PD % caused by vertical air temperature difference	PD % caused by warm or cool floor	PD % caused by radiant asymmetry
A	< 6	− 0,2 < PMV < + 0,2	< 10	< 3	< 10	< 5
B	< 10	− 0,5 < PMV < + 0,5	< 20	< 5	< 10	< 5
C	< 15	− 0,7 < PMV < + 0,7	< 30	< 10	< 15	< 10

Automated performance assessment

PAM 2: Visual comfort

BS EN 12464-1

- glare related to daylight
- unified glare rating
- UGR ≤ 19

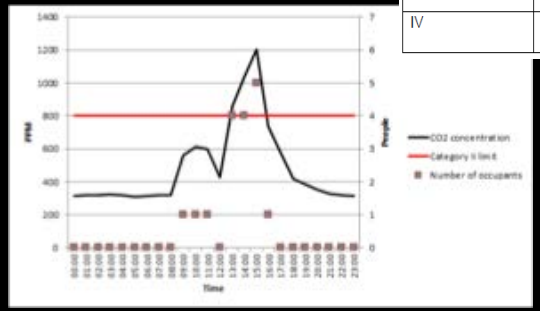


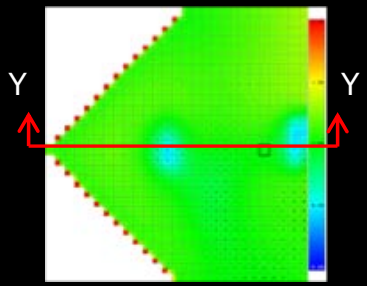
PAM 3: Air quality

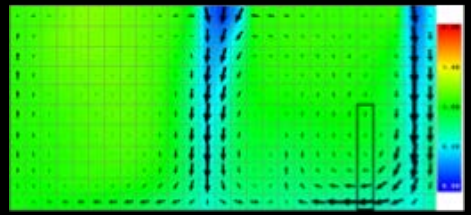
BS EN 15251

- CO_2 concentration

Category	Corresponding CO_2 above outdoors in PPM for energy calculations
I	350
II	500
III	800
IV	< 800

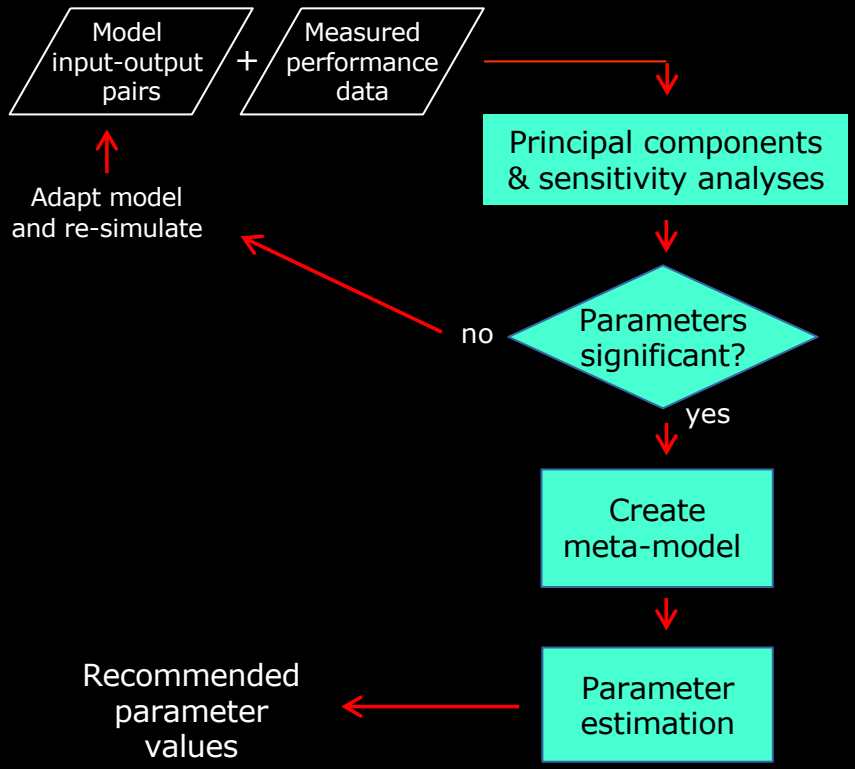




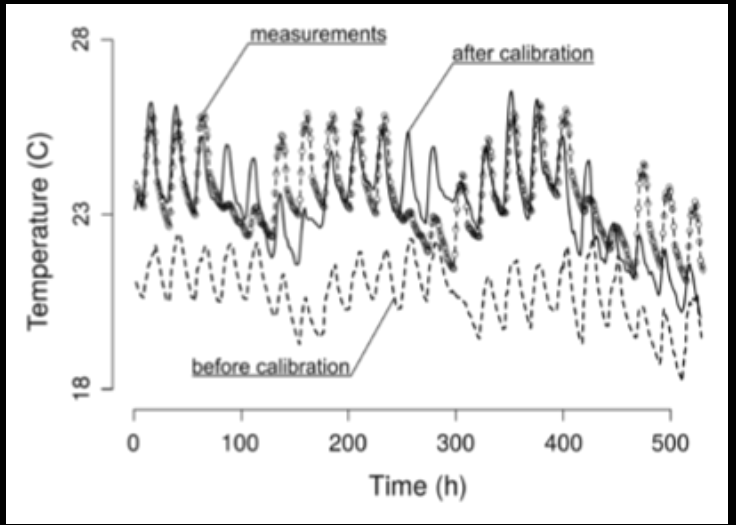


Section YY

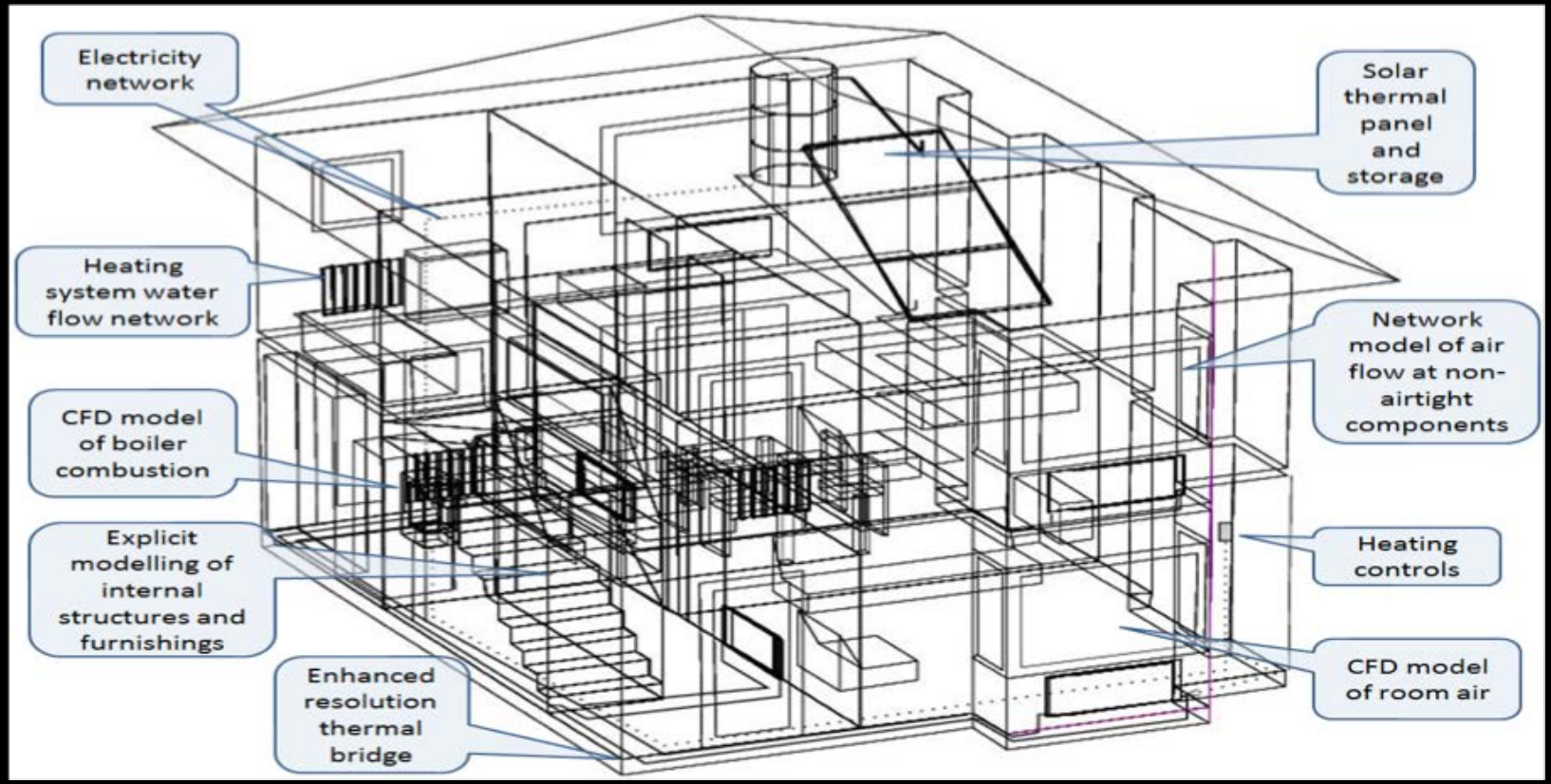
Automated model calibration



- Single parameters: calibrated individually.
- Profile proxy: treated as an ensemble represented by a scaling factor.
- Sub-model proxy: time varying outputs from domain models treated as profiles and the calibrated profile (or its related sub-model) used.
- Group proxy: related parameters combined and represented by a derived parameter.

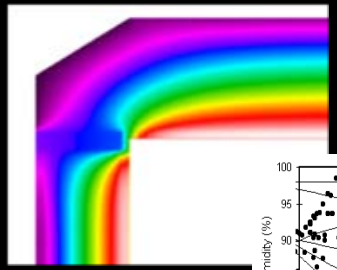


High integrity modelling

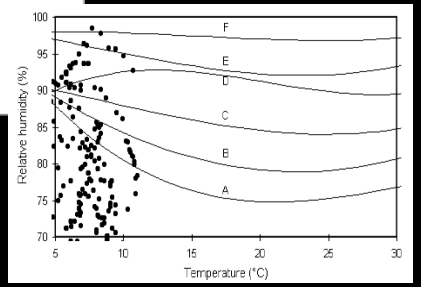


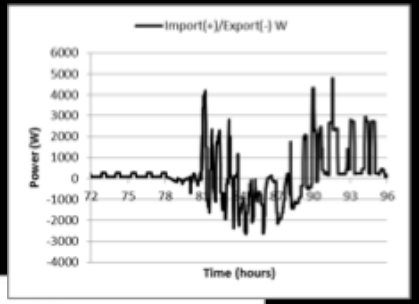
Performance outcomes address real issues

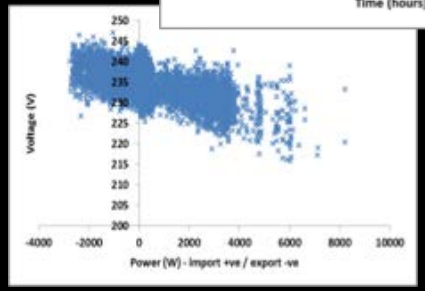
glare and daylight



thermal bridges & mould growth

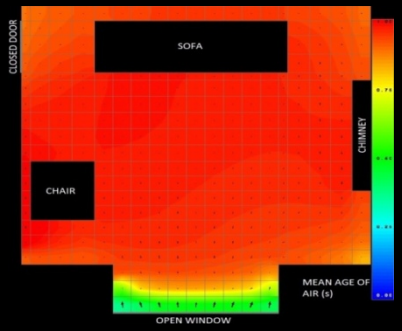




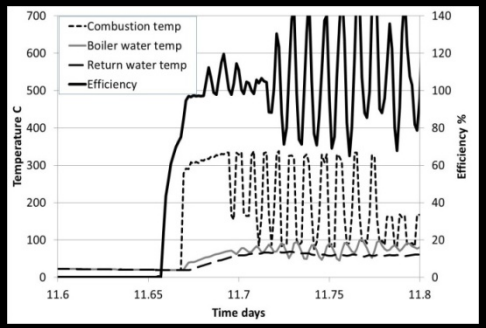


power quality

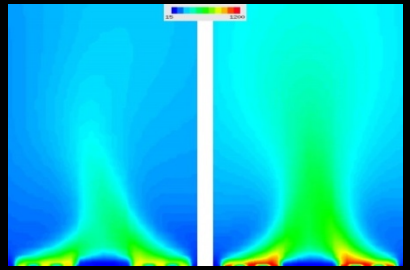
mean age of air



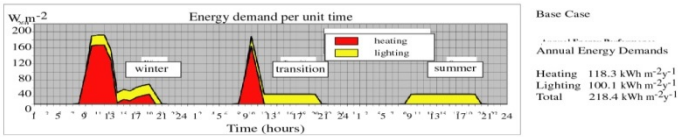
control dynamics



effective combustion



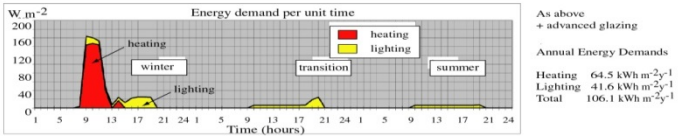
Support for embedded generation



Base Case

Annual Energy Demands

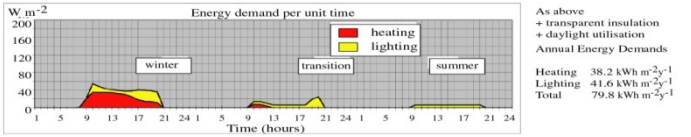
Heating 118.3 kWh m^{-2}y^{-1}
Lighting 100.1 kWh m^{-2}y^{-1}
Total 218.4 kWh m^{-2}y^{-1}



As above
+ advanced glazing

Annual Energy Demands

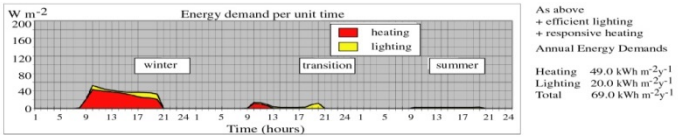
Heating 64.5 kWh m^{-2}y^{-1}
Lighting 41.6 kWh m^{-2}y^{-1}
Total 106.1 kWh m^{-2}y^{-1}



As above
+ transparent insulation
+ daylight utilisation

Annual Energy Demands

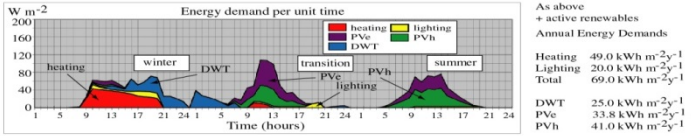
Heating 38.2 kWh m^{-2}y^{-1}
Lighting 41.6 kWh m^{-2}y^{-1}
Total 79.8 kWh m^{-2}y^{-1}



As above
+ efficient lighting
+ responsive heating

Annual Energy Demands

Heating 49.0 kWh m^{-2}y^{-1}
Lighting 20.0 kWh m^{-2}y^{-1}
Total 69.0 kWh m^{-2}y^{-1}



As above
+ active renewables

Annual Energy Demands

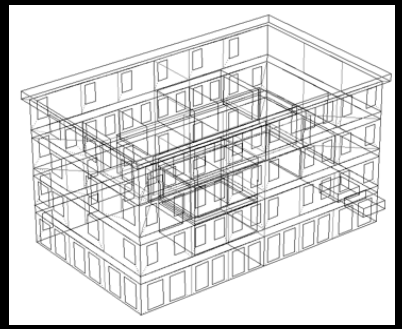
Heating 49.0 kWh m^{-2}y^{-1}
Lighting 20.0 kWh m^{-2}y^{-1}
Total 69.0 kWh m^{-2}y^{-1}

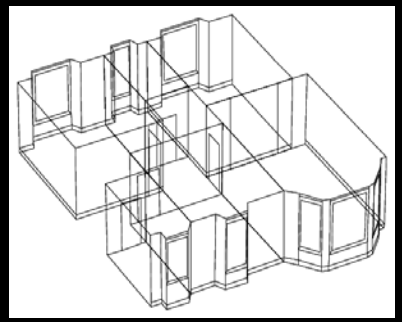
DWT 25.0 kWh m^{-2}y^{-1}
PVe 33.8 kWh m^{-2}y^{-1}
PVh 41.0 kWh m^{-2}y^{-1}

evaluating options

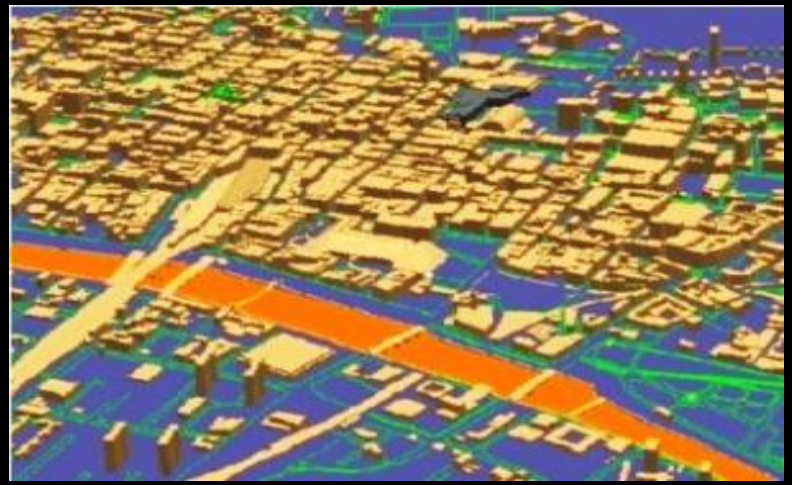
micro power system deployment

Automatic stock model generation





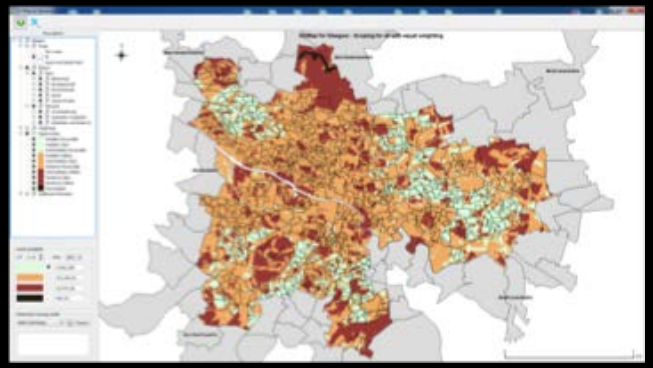
- Diversification of standard archetypes to represent all parameter combinations.
- Virtual 3D models used to extent city cadasters.
- Application potential immense.



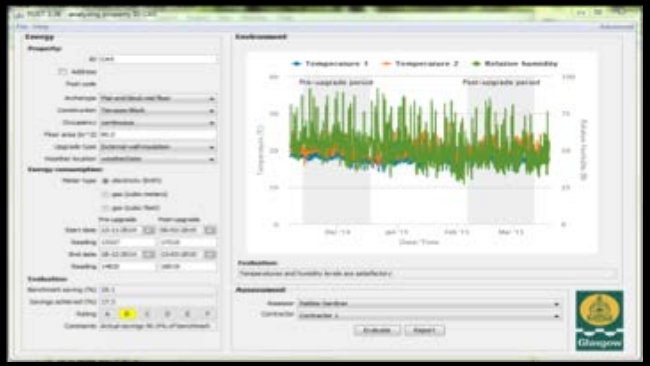
Models available for use by different stakeholders.

Simulation-based simplified tools

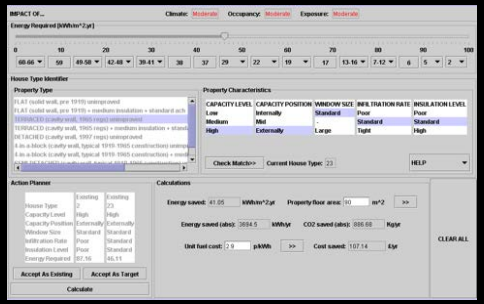
opportunity mapping



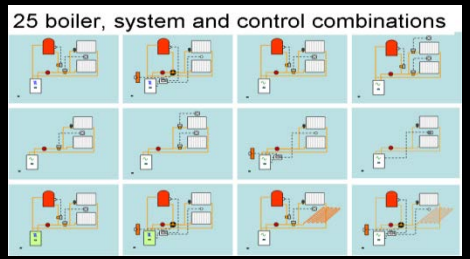
post operation evaluation



stock upgrade planning



control systems



biomass heating

Big data platforms

Urban energy management and action planning

metered data

Actual & future consumption data

scenario predictions

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

government, local authorities, industry, institutions, utilities, citizens

Operational support

People
Presence
Behaviour
Environment

Energy
HVAC
Power
ICT

Environment
Weather
Air quality
GIS

Mash-up Platform

Simulation services

Information services

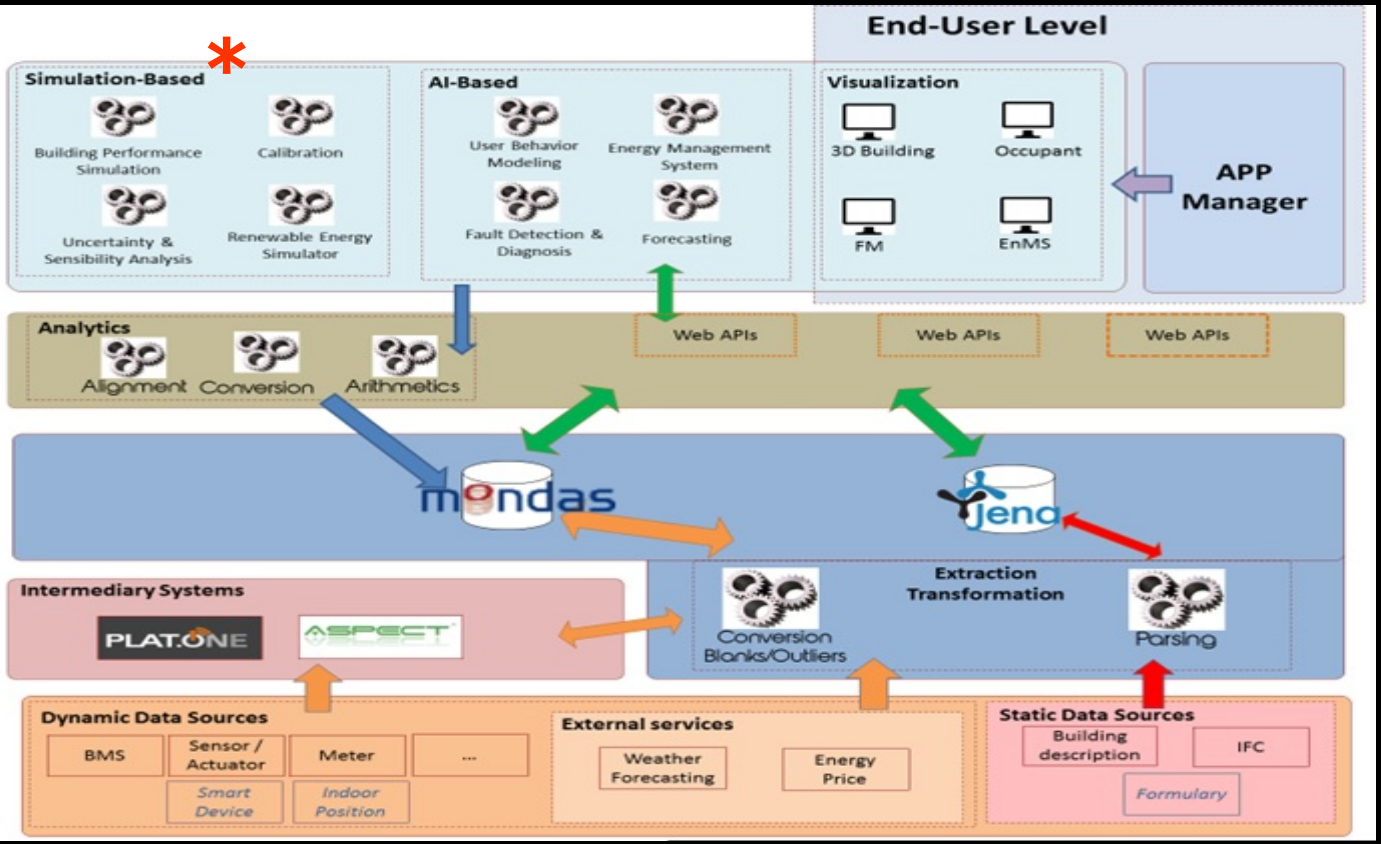
Perceptualisation services

The hit2gap platform

Management level: services that improve operational performance

Core level: data storage, exchange and basic processing (e.g. anonymization)

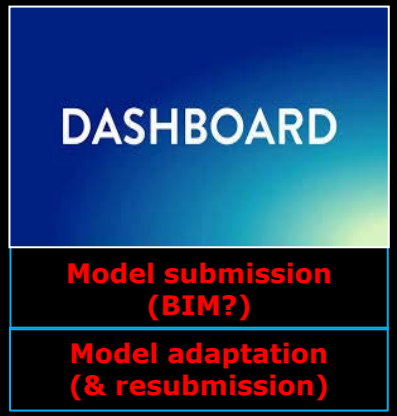
Field level: systems for data acquisition



Problems with performance simulation

- Violation of one or more of the 4 principles resulting in low resolution modelling, especially of technical systems.
- Use of non-harmonised operational assumptions, performance assessments and outcome analyses approaches rendering results opaque and incomparable.
- The hubristic expectation that the future performance of a complex energy system can be predicted in any meaningful way.
- The real destiny of simulation is to test operational resilience in a manner that:
  - is based on high integrity models;
  - does not require users to define performance assessments and interpret results;
  - is standardised across all tool users and problem types; and
  - facilitates proposal intercomparison.

Resilience testing environment



Compliance certificate issued

Open standard application powered by an approved simulation program.

- ❑ Perpetual annual simulations with standard stressors imposed
- ❑ Outcomes assessed via standard performance metrics
- ❑ Process suspended where performance is unacceptable
- ❑ Process terminated on successful test completion

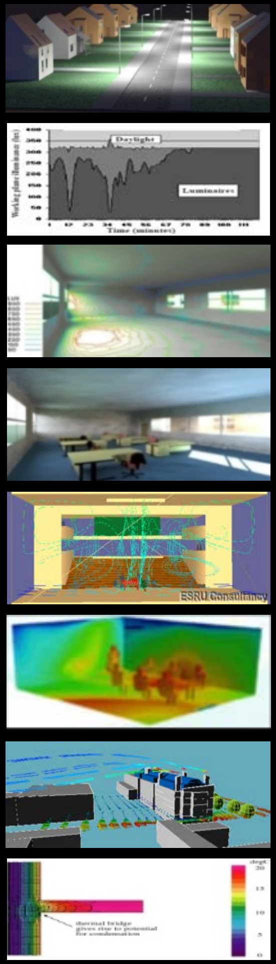
- Thermal comfort
- Visual comfort
- Acoustic comfort
- Running cost
- Air quality
- Emissions
- Control efficacy
- Energy efficiency

RTE assures acceptable performance under a range of conditions and in terms of relevant criteria.

Models can still be used to size system components for peak demand or obtain outputs to legislative compliance.

Effective solutions require whole systems thinking

If you can't simulate it, don't build it because it won't work!



The challenge is to harmonise the application of simulation.