Gary Nixon BE(Hons) MIEI

IES - Integrated Environmental Solutions

Building Capabilities in Complex Environments

CitA BIM GATHERING

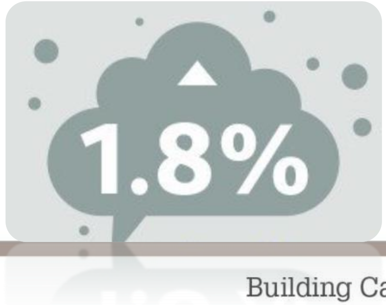
Integration of Performance Analysis across the Building Lifecycle: The latest in Digital Design and Construction

Performance Analysis? What are we referring to?

- Buildings are responsible for 40% of global energy consumption a year

- Most Commercial Buildings waste 25% of their energy

- Over the next 25 years, Co2 emissions from buildings are projected to grow faster than any other sector, with emissions from commercial buildings projected to grow the fastest – 1.8% a year through 2030.



Performance Analysis? What are we referring to?

- We need to be able to design and optimise our buildings so that they operate as efficiently as possible.

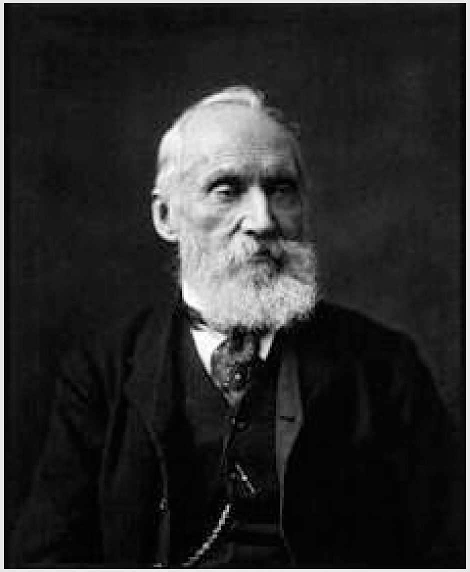
- How can we design buildings that are efficient in terms of their energy without compromising on the occupancy comfort and experience of the building environment?

Performance Analysis? What are we referring to?

- Without advanced tools we could be confident in, we end up oversizing our heating and cooling plant and equipment using tried and tested crude calculations that although approximate the requirements, leads to inefficient buildings that consume a lot of unnecessary energy.

- We needed a tool that we could have confidence in, that will allow us to design closer to the edge of what is an efficient design in terms of energy consumption.

If you can’t measure it you can’t improve it

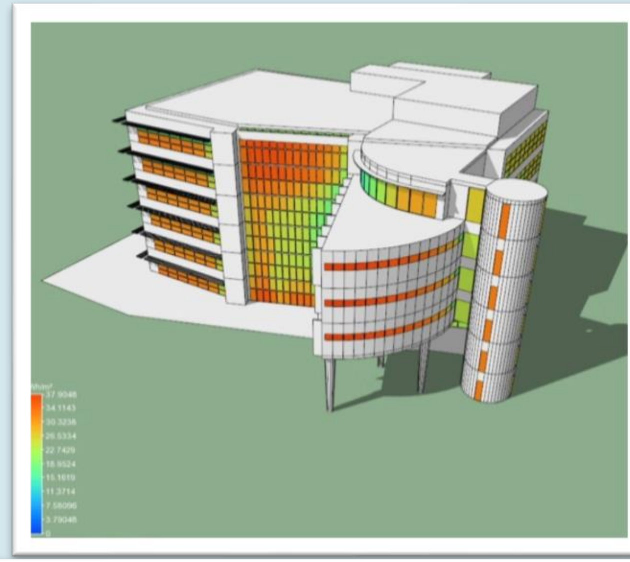


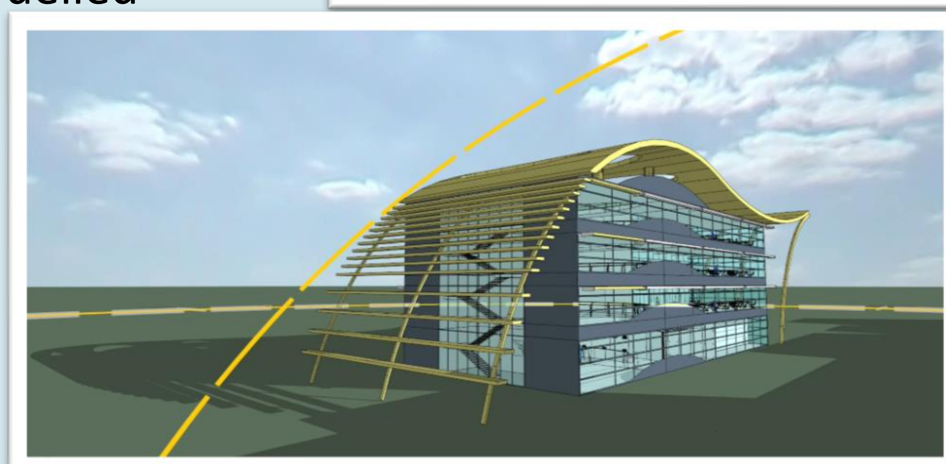
I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the state of Science, whatever the matter may be.

{Lord Kelvin}

Performance Analysis? What are we referring to?

- Enter – Dynamic Thermal Simulation calculations
  - The ability to model complex shapes
  - Calculation time steps as low as one minute
  - Use actual building design data
  - Localised weather files
  - Shading devices included
  - Natural ventilation scenarios modelled
  - Daylight harvesting
- To give an accurate design model.





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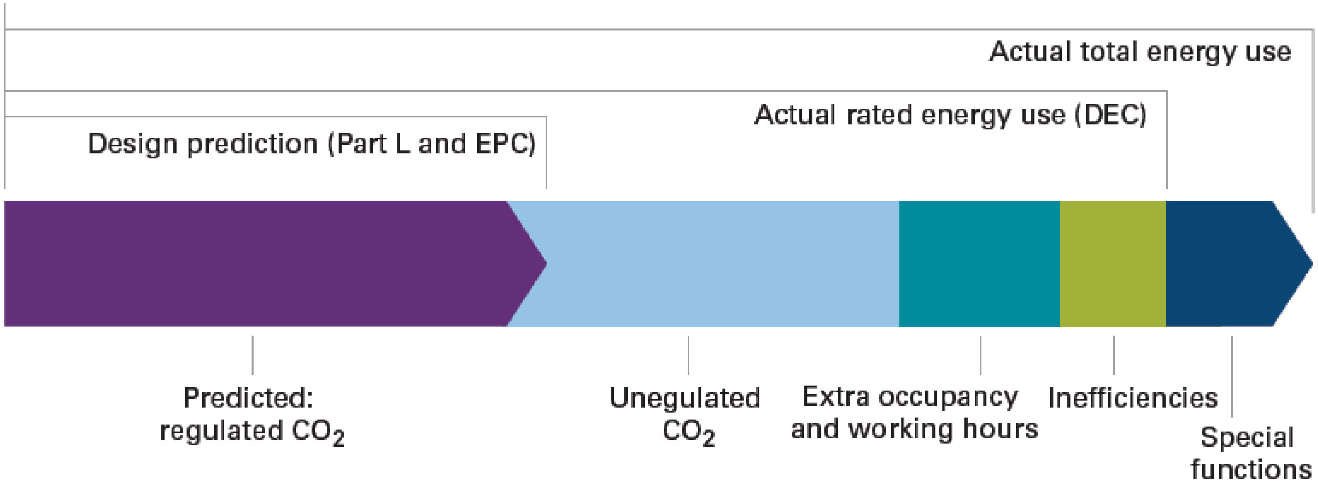
How has Building Performance Analysis changed in the last 5 years?

- Efficient design of new buildings as well as retrofits and refurbishments may predict large theoretical savings on paper but actual performance often proves different once the building is operational.

- There have been many instances where the energy the building is consuming is greatly different to that which was predicted.

Figure 1 Design predictions for regulatory compliance don't account for all energy used in a building (adapted from Carbon Buzz)



- Regulated energy use includes modelled heating, hot water, cooling, ventilation and lighting
- Unregulated energy use includes plugload, server rooms, security, external lighting, lifts, etc
- Extra occupancy and equipment and extra operating hours (e.g. evening/weekend working)
- Inefficiencies from poor control, bad commissioning, bad maintenance, etc
- Special functions (separable energy uses) include trading floors, servers rooms, cafeteria, etc

How has Building Performance Analysis changed in the last 5 years

- The digital transformation taking place in the construction industry is revolutionising assessment of building performance, integrating it across the building lifecycle in order to reduce the energy consumption and environmental impact of our buildings.

- This is something we recognise as a leading technology provider.

IES

Pioneers of Building Simulation

23 years of sustainable design

Located in Glasgow, Dublin, Paris, Atlanta, San Francisco, Vancouver, Pune, Dubai & Melbourne

In over 140+ countries IES are helping…

Architects, Engineers, FMs, Cost Consultants, BREEAM Assessors, LEED Assessors, Developers, ESCOs, Contractors, Local Authorities, Governments & Academia

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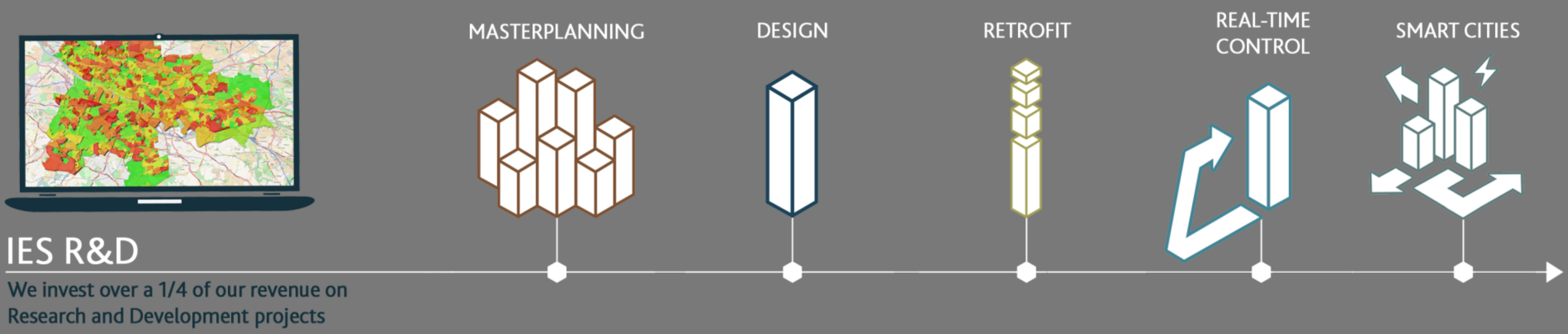
MASTERPLANNING
DESIGN
RETROFIT
REAL-TIME CONTROL
SMART CITIES
IES R&D
We invest over a 1/4 of our revenue on Research and Development projects

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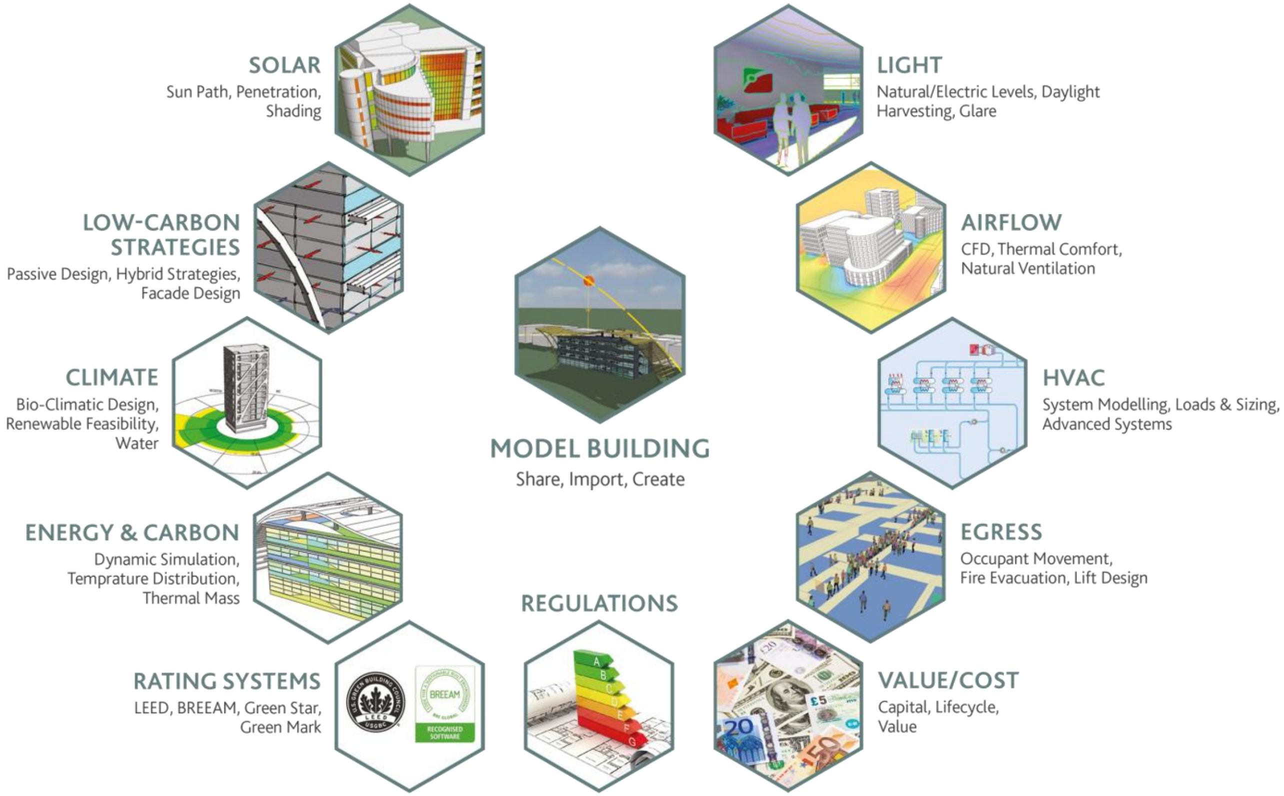
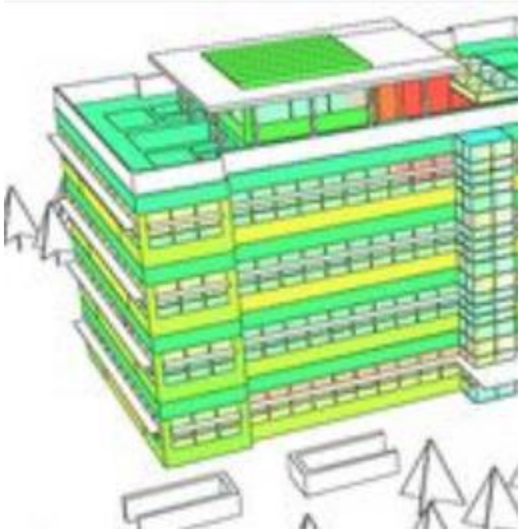
Our Core Technology

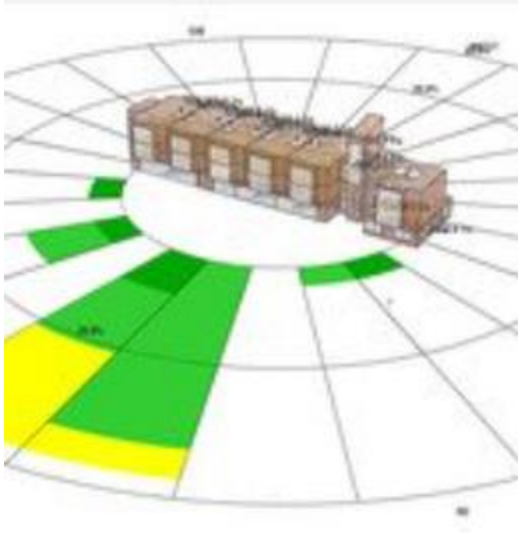
Our core software technology is called the Virtual Environment.

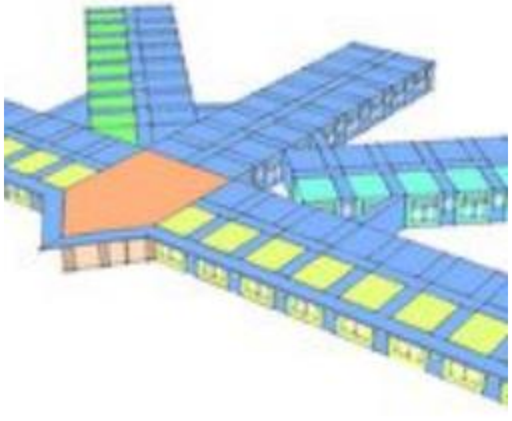


Our Core Technology

Our Dynamic Thermal Simulation Engine called 'ApacheSim' is well respected and used around the world, with many case studies on display on our website which testify to the accuracy of the algorithms used in predicting how a building will perform.
https://www.iesve.com/discoveries/type/casestudy







- The ApacheSim Dynamic Simulation Algorithms have been shown to be robust when compared with real building data results.

Dynamic Simulation Model + Operational Data

Actual Building

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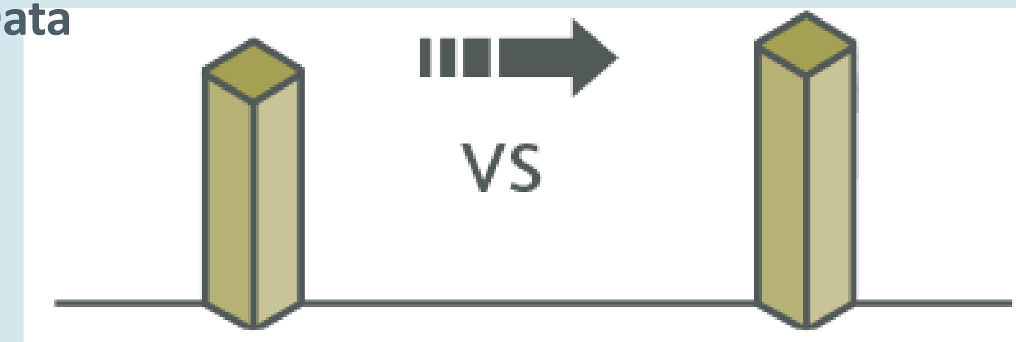

Gap between predicted and actual performance can be closed to 5-10%

- One example of this goes back to as early as the 2000's.

- Walmart in the US was the single biggest private user of electricity in the US with an annual store energy bill in the region of around US$2 billion.

- Walmart wanted to reduce their energy bill as well as play their part in reducing their negative impact on the environment.

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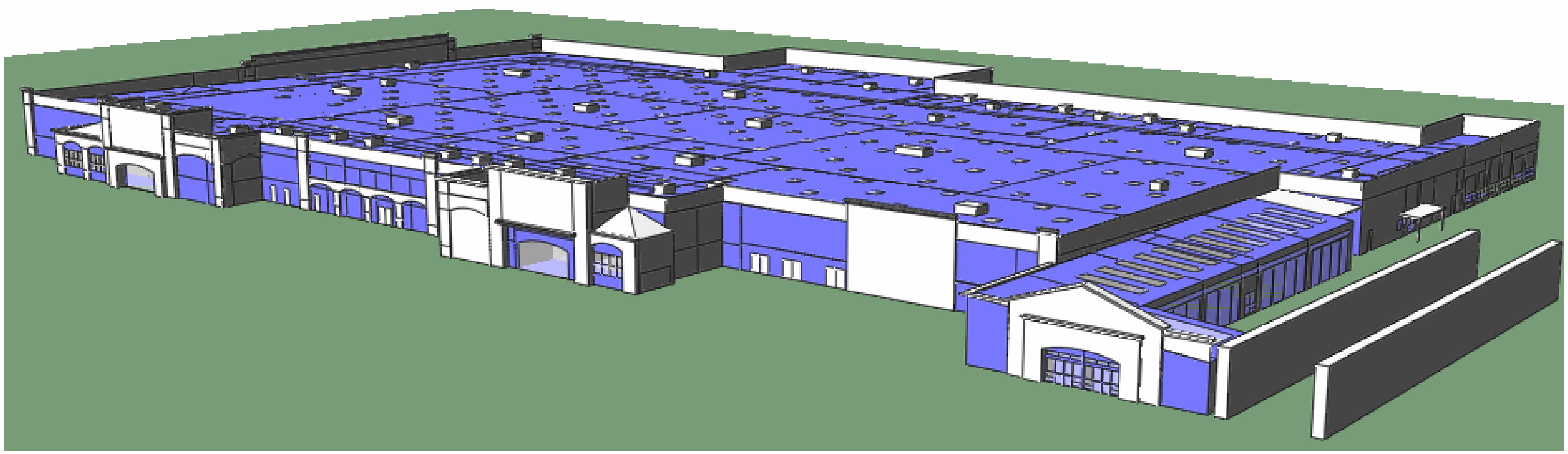
- When the real building data for a number of stores was input into the Virtual Environment and compared with the actual building data taken on site of a number of Walmart stores, the software results were found to deviate from the building actual energy consumption by around 5%.



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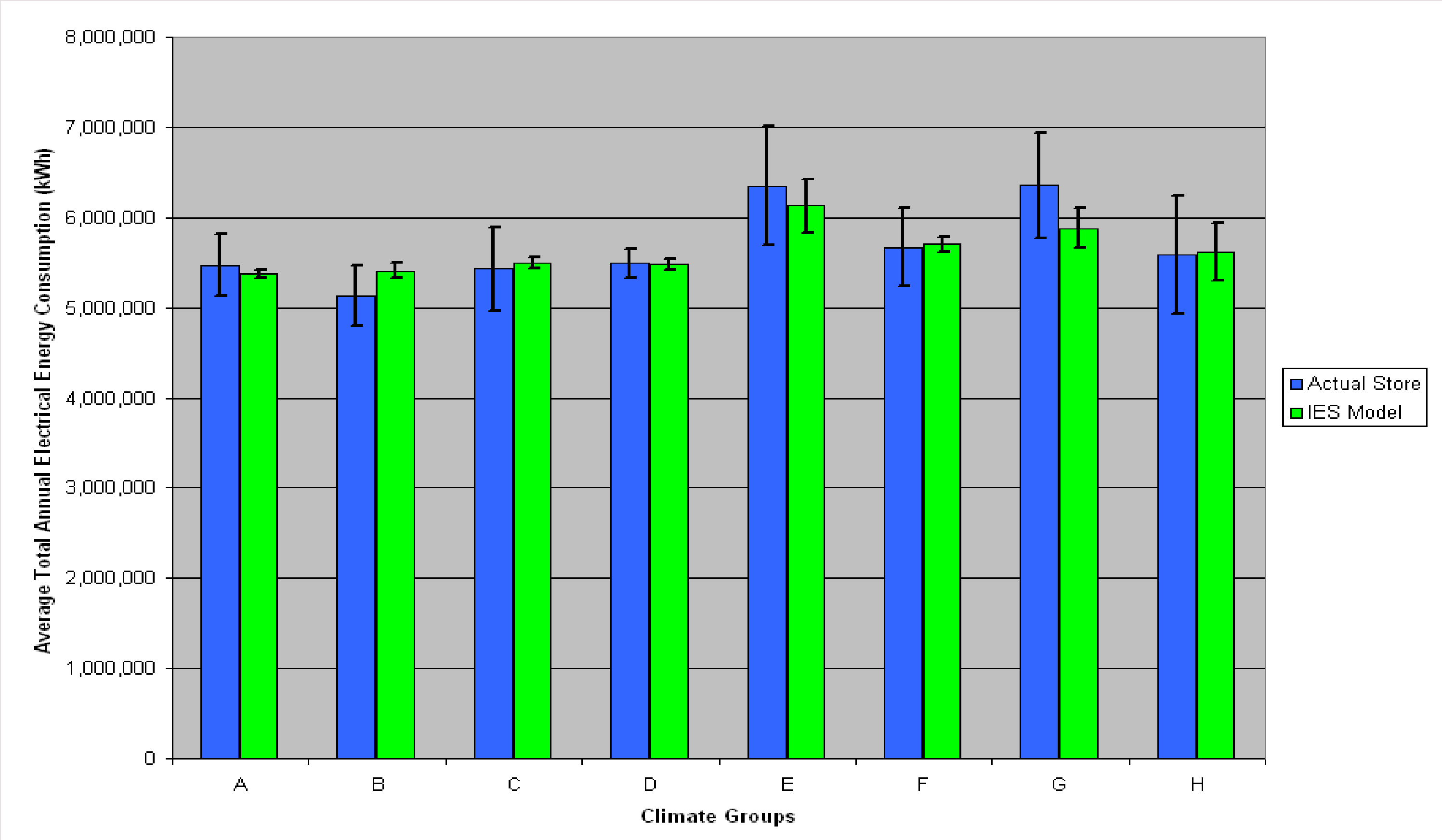


	A		B		C		D		E		F		G		H	
	Actual	Model	Actual	Model	Actual	Model	Actual	Model	Actual	Model	Actual	Model	Actual	Model	Actual	Model
Average	5,468,395	5,375,370	5,130,452	5,411,026	5,428,003	5,497,575	5,490,218	5,480,427	6,350,665	6,127,301	5,666,261	5,701,500	6,353,183	5,878,467	5,585,254	5,618,463
Std. Dev.	6.3%	0.9%	6.6%	1.6%	8.6%	1.1%	3.0%	1.0%	10.3%	4.8%	7.6%	1.4%	9.2%	3.8%	11.6%	5.6%
Range	1.7%		-5.5%		-1.3%		0.2%		3.5%		-0.6%		7.5%		-0.6%	

Who uses our software traditionally and why?

- Users for the last 23 years have been using our dynamic simulation tools to;
  - meet regulatory requirements for analysing their buildings performance in terms of energy consumption, Carbon emissions, overheating analysis, daylight analysis, right to light studies etc.
  - design buildings that have passive technologies incorporated and used the tool to identify which technologies would be most appropriate
  - Use our software to run the calculations associated with voluntary environmental rating systems such as LEED and BREEAM.

The purpose of modelling

Common strategies for improving energy and environmental performance of buildings

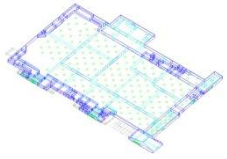
Passive solar design principles

Use of atria & courtyards
Light shelving
Embodied energy of materials
Wind energy
Geo-thermal heat
Ventilated facades
Adaptive comfort criteria
Building orientation
Maximisation of daylight
Solar energy
Beneficial shape and form

High performance building technologies

Chilled beams / ceilings
Cogeneration
Earth shelter roofs
Displacement ventilation
Photo-voltaics
Biofuels
Night sky cooling
High efficiency boilers/chillers
Controls
Solar water heating
Advanced glazing and insulations
Improved air tightness

Use of thermal mass
Underfloor heating/cooling
Natural ventilation
Heat recovery
Night cooling
Heat pumps



Optimum configuration

The <VE> acts as the ‘calculator’ for true energy and environmental performance e.g.:

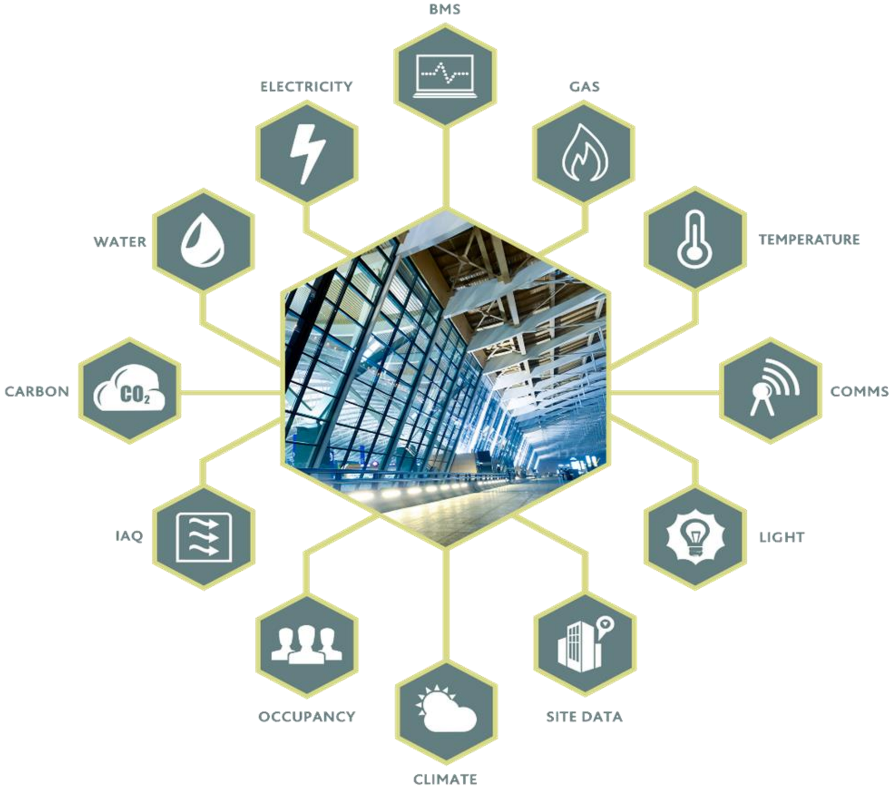
- First cost savings
- Energy consumption
- Running costs
- Carbon emissions

Clients value judgement filters strategies down to identify the optimum configuration e.g.:

- Natural ventilation
- Heat recovery
- Night cooling
- Heat pumps

Where we have moved into in the last 5 years

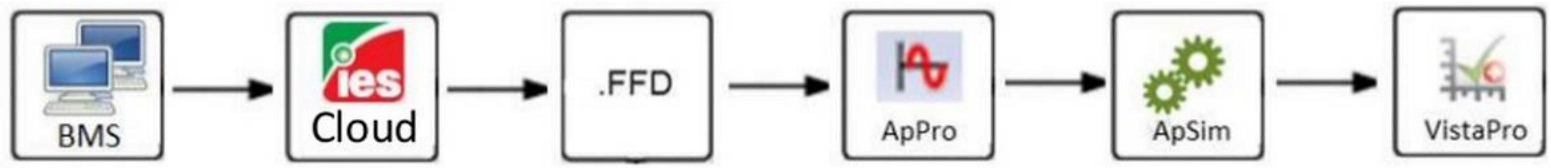
- Data management becomes more and more relevant as focus turns towards building operation and facilities management (FM). At the core, a building must have a robust sub-meter, BMS and sensor set-up, logging and data management strategy.



Where we have moved into in the last 5 years

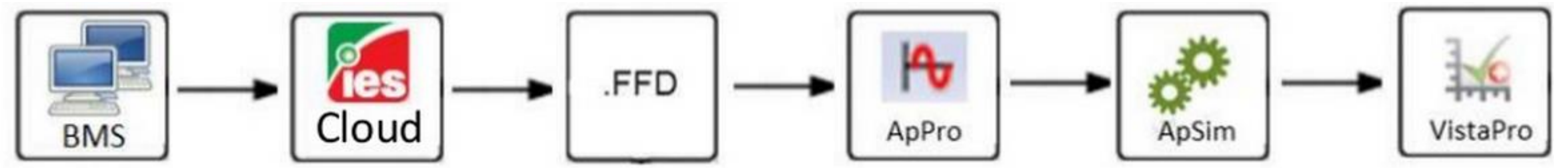
- Combine this with building performance analysis and you can provide appropriate and accurate information that allows Portfolio, Facilities and Energy Managers to understand where inefficiencies are present, and the trade-offs associated with mitigating or eradicating these inefficiencies completely.

IES-ERGON Workflow

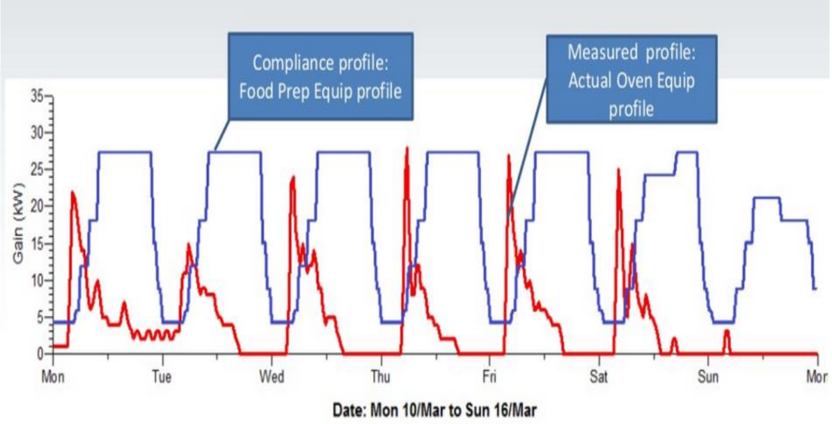


- Collect data from BMS/BAS, BEMS, AMR, Dataloggers, etc.
- Upload data in csv format to IES-ERGON to view the data, check data completeness and create Free Form Data (FFD) profiles

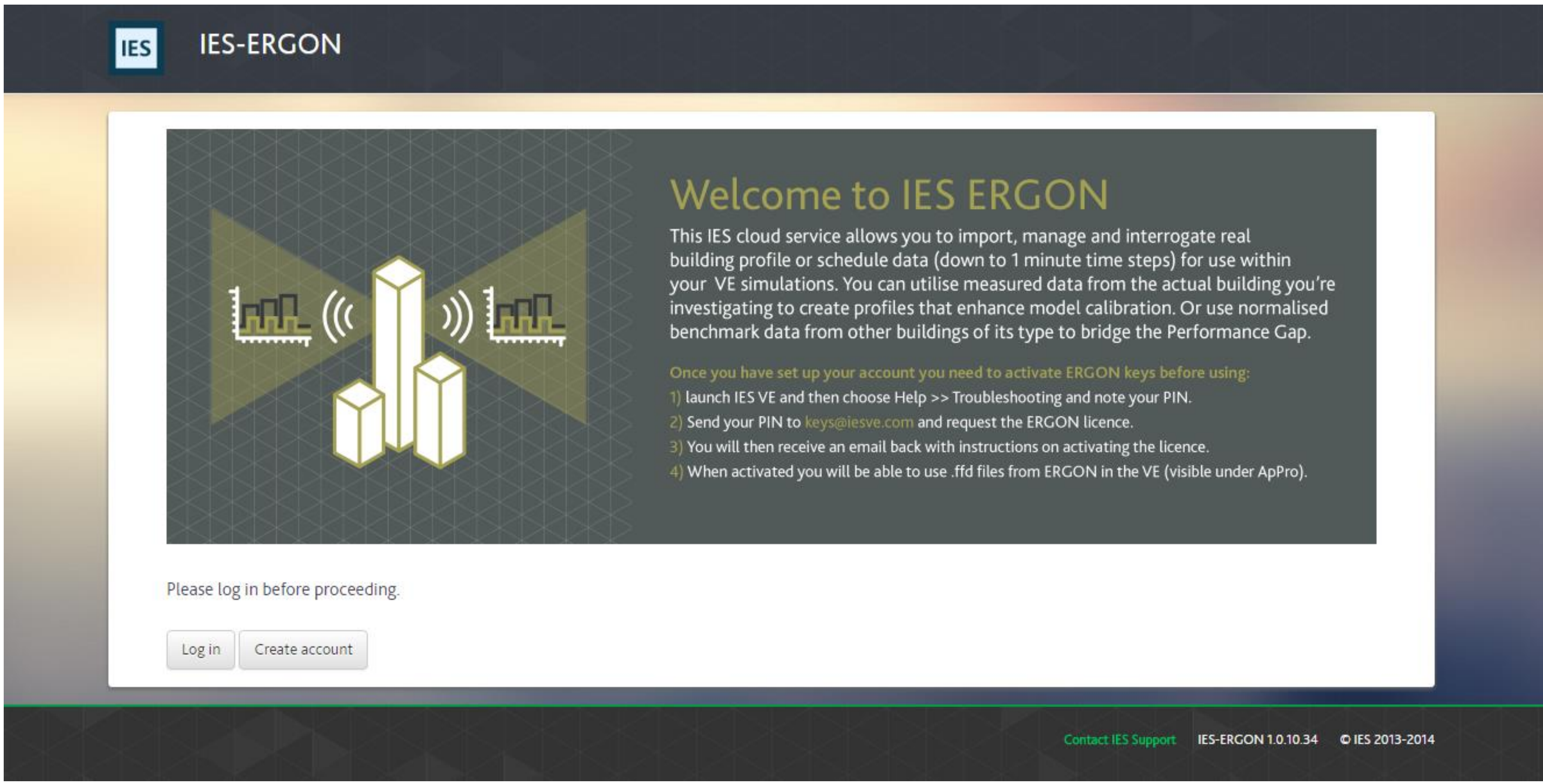
IES-ERGON Workflow



- Assign ffd's to the project VE-Model through ApPro and assign to replace existing profiles
- Simulate model with updated profiles and inputs
- Review the results in VistaPro to understand the building performance



- Sign up at ergon.iesve.com



Where we have moved into in the last 5 years

- Recently IES has focused on how the simulation environment can be exploited to not only intelligently manage the commissioning and handover process, but also to operate and control the building optimally.

- Operational data can not only be analysed on its own to discover faults, control strategy issues and low-cost interventions that improve building operation, but it can also be used to create a calibrated operational model of a building.

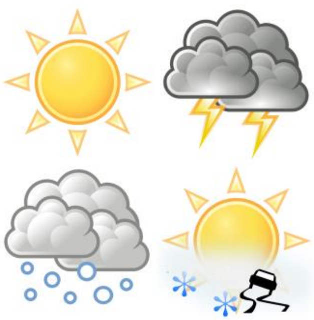
- We do this using two new technologies we now offer on a consultancy basis.

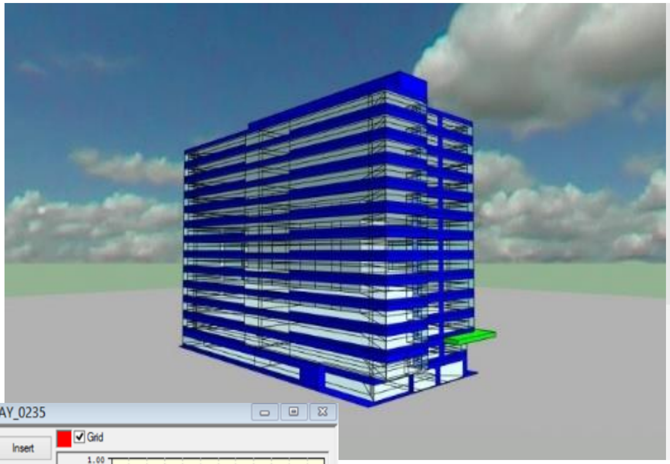
SCAN

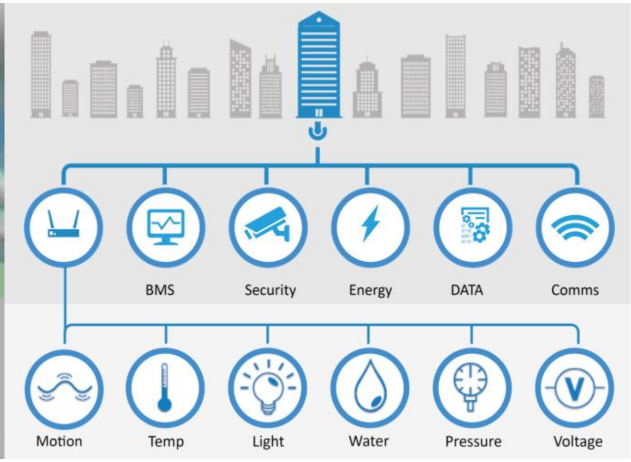
Ci2®

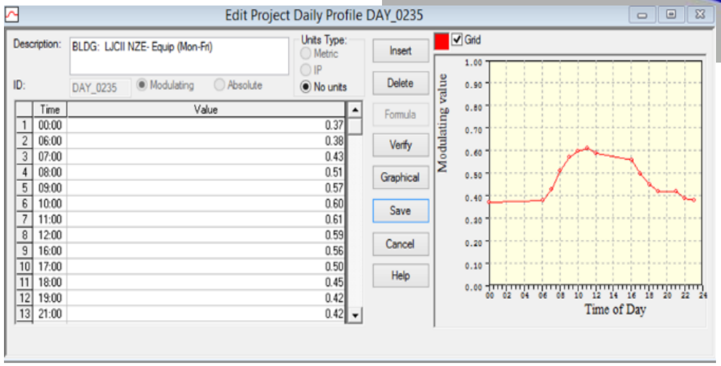
IES

Take Control of Your Data









IES can **integrate** operational building data with 3D performance models & real weather data

Operational Modelling
Using Ci2® and SCAN

Deliver energy/carbon/cost savings and improved internal conditions in buildings during the operation phase

Building data can be used to calibrate enhanced operational models & create virtual benchmarks

IES

SCAN

- Online Platform
- Data Collection & Analysis
- Links to IES VE Software for More Accurate Calibration

"With approximately 80% of a buildings lifecycle energy usage occurring during its operational stage, there has become a much greater need for improved control in building operation. By integrating our performance analysis expertise with the operation of the building and applying predictive simulation combined with optimisation techniques, the basis for better building operation will be established. With this tool we are enabling building owners and managers to participate effectively in optimising building performance."

Don McLean, Managing Director, IES.

IES

IES

With Analysis Data is Powerful

Using Data to build a complete picture




More data captured and managed = clearer picture of your building's performance

IES can deliver a robust data collection and analysis strategy:

- Effective Logging
- Well organised and managed, with clear naming conventions
- Gaps identified & filled using simulation
- Stored for a long time period, in a manner that is easily accessible
- Analysed in depth, to find opportunities and deliver added value

Ci2®

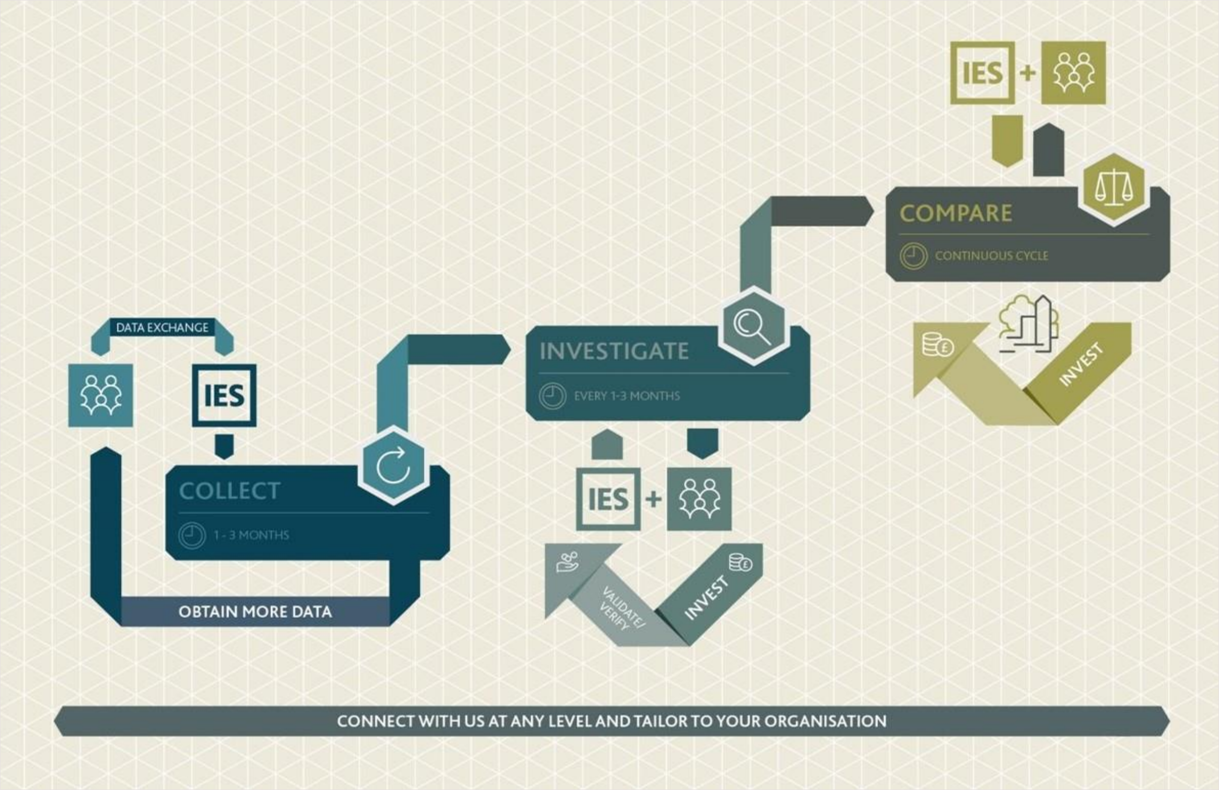
Ci^2 stands for Collect, Investigate, Compare and Invest

- Take Control of Your Building Data
- Uncover Hidden Inefficiencies
- Reduce Energy Costs & CO_2 Emissions
- Improve Control Strategies
- Fix Internal Comfort Issues
- Assess Large Scale Retrofit Options
- Inform Deep Retrofit

*Applicable for both **Single** Buildings and across **Portfolios***

Ci2®

Ci² stands for Collect, Investigate, Compare and Invest



UK Government BIM strategy

PA5 1192 STAGE	STRATEGY	BRIEF	CONCEPT	DEFINITION	DESIGN	BUILD & COMMISSION	HANDOVER	O&M
INFORMATION MODEL	Design (Federated) Model					Construction Model		O&M Model
PRINCIPAL S.L ACTIONS		Briefing		Design Dev		Pre-handover	Initial Aftercare	1-3 Year Aftercare
OUTPUT	Strategies for Electricity, Gas, Water & District Heating and Cooling.	Oriented model to minimise energy, maintenance and replacement costs. Review existing resources	Services, Philosophy, Outline planning, Prelim P&L, BREEAM/CfSH.	Services, layout & zoning Energy, carbon & cost Interim P&L Update BREEAM/CfSH	Coordinated design, site layouts, GA's, Services & controls strategies, cost plan schedules.	As built model, Soft landings, Performance metrics.		Ongoing performance review and feedback.
HOW THE VE FITS	Masterplanning	VE for Architects – Climate – Bioclimate – Water – Renewables (natural resources) – Initial energy & carbon optioneering – Feasibility Studies	VE for Engineers – Compliance – Daylighting – Orientation – Glazing – Shading – Water – LZCT – IMPACT: materials, LCC/ LCA – FAQ – Comfort	VE for Engineers – Energy, carbon, cost – Compliance – Daylighting etc – ApacheHVAC: Autosize main plant components	VE for Engineers – Detailed – Final design – Final P&L & EPC – Final BREEAM – Final LCA/LCC – BREEAM/ CfSH	ERGON Enhanced commissioning & soft landings performance feedback (energy, carbon, cost, visual & thermal comfort controls etc.)		ERGON Feedback loop: capture metered data, compare with the design scenario, feed into subsequent designs.

Ref: Department for Business Innovation & Skills (BIS)
Local Government Model BIM Process Map Cabinet Office

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BIM GATHERING

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www.iesve.com/DiscoverIES

THANK YOU

Case Study - Barts Health NHS: Alex Wing

"Energy costs Barts Health £14 million a year, forecast to increase to £24 million by 2018. We have already achieved a lot towards our 2020 target and are on track to meet our legal targets to reduce energy by 80 percent. Now that many of the 'quick win' and short payback measures have been implemented, the organization now needs to work hard to achieve the 2020 target and seek transformational change in order to achieve the 2050 target."

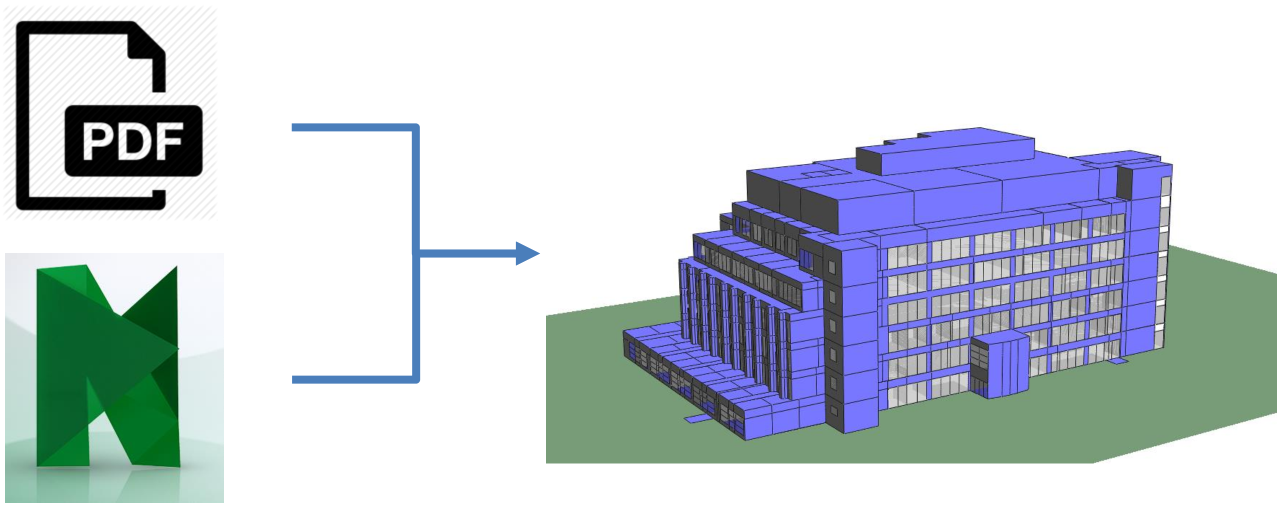
Fiona Daly, Associate Director of Sustainability and Patient Transport

- Live Project: November 2016
- Alex Wing – Within The Royal London Hospital
- Strategic Review of Building Performance Data through IES SCAN web portal
- Calibrated Operational Model
- Delivered in conjunction with Skanska

Case Study - Barts Health NHS: Alex Wing

Initial Model Creation:

1. Model Geometry sourced from Navisworks files
2. Basic Simulation Model Populated with design stage information and data from building log book



Case Study - Barts Health NHS: Alex Wing

Enhancement of Existing Building Performance Data:

- Time-series AMR, BMS and Condition data
- Both Automatic and Manual reads
- Data across Energy, Plant Operation and Internal Environment
- IES SCAN cloud-based platform used to collate data in one location and iron out inconsistencies in format, time-series etc.
- Challenges from malfunctioning meters, data loss and pulsed meter readings
- In depth analysis of energy use breakdown undertaken
- Data gaps filled using simulation to extrapolate sensible estimates
- Hourly weather data sourced to support heating & cooling degree day calculations and building energy simulations

Case Study - Barts Health NHS: Alex Wing

Enhanced Model Creation:

1. Results from Basic Simulation Model compared against real data recorded from site via IES SCAN
2. Differences between the Basic Model and recorded data are identified and corrected to form an Enhanced Model

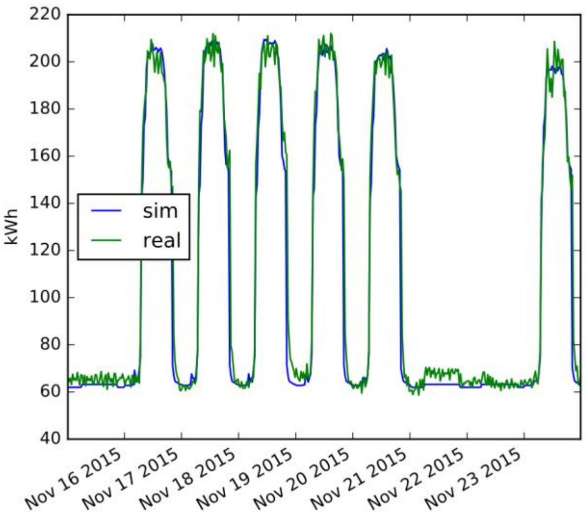
Example opposite shows how run hours of Air Handling Units differ from information in log book. This was corrected in the enhanced model.

Data Plot - Alex Wing - 2015-06-04

Case Study - Barts Health NHS: Alex Wing

3. Measured consumption data compared to results from this initial Enhanced Model
4. Electricity Usage from Motor Control Centres (MCCs) and per floor panels & Half Hourly gas data
5. Simulation parameters in the Enhanced Model were tweaked to provide a close match to measured consumption

Simulated Electrical Consumption against measured electrical consumption – Nov 2015.



Case Study - Barts Health NHS: Alex Wing

Calibrated Benchmark Model Creation:

1. Established by matching simulation data against real data for a benchmark period of April-Dec 2015
2. Real year historical weather data used in simulation
3. Facilitated by extensive sub-metering available on site

Case Study - Barts Health NHS: Alex Wing

Model calibrated to a Monthly level, but IES was also able to calibrate the Electricity to an Hourly level

Alex Wing Benchmark Model Results

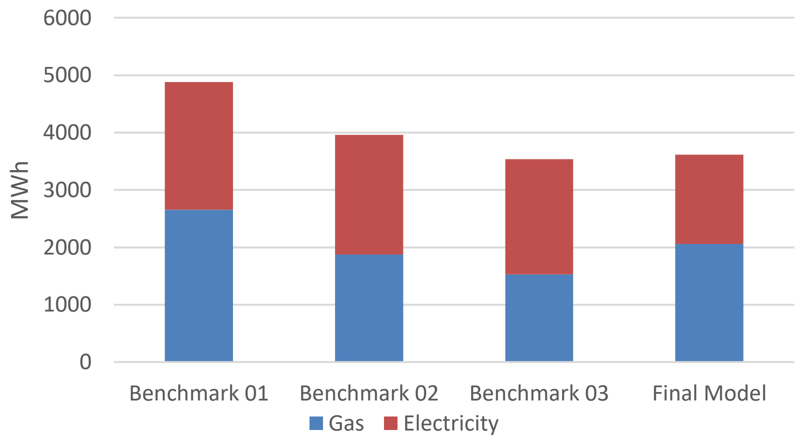
End Use	CVRMSE	NMBE
Electricity (Monthly)	2.1	-0.4
Electricity (Hourly)	14.3	-0.8
Gas (Monthly)	8.6	+0.4
HVAC (Monthly)	6.1	-3.4
Small Power (Monthly)	2.5	+2.2
TARGET	**15**	**± 5%**

ASHRAE Guideline 14: *Model is "calibrated" when the Coefficient of Variance Root Mean Square Error (CVRMSE) is below 15% and Net Mean Bias Error (NMBE) is ± 5% for monthly calibration. If hourly calibration data is used, these requirements shall be 30% and 10% respectively.*

Case Study - Barts Health NHS: Alex Wing

Energy Conservation Measures Reviewed

- Changes to Control Strategies
- Changes to Plant Operation Schedules & Addition of AHU Inverters
- Installation of Solar PV & CHP
- All in combination



Predicted Savings Overall:

- Gas Energy reduced by **22.5%**
- Electricity reduced by **30%**
- Utility cost reduced by **28.2%**
- Carbon emissions reduced by **27.5%**

Case Study - Barts Health NHS: Alex Wing

Not just a Classroom Exercise:

Calibrated Model able to successfully visualise and validate implemented energy savings being achieved by separate commissioning project

- Benchmark 1:
  Changes to Control Strategies

- 29% reduction in Gas Energy Demand
- 6% reduction in Electricity Energy Demand

Case Study - Barts Health NHS: Alex Wing

Energy Conservation Measure (ECM) Evaluation: Operational Improvements

Calibrated Model used to evaluate effectiveness of:

- Benchmark 2:
  Changes to Plant Operation Schedules & Addition of AHU Inverters

- 19% reduction in Gas Energy Demand
- 3.5% reduction in Electricity Energy Demand

Case Study - Barts Health NHS: Alex Wing

Energy Conservation Measure (ECM) Evaluation:

Retrofits

Calibrated Model used to evaluate the effectiveness of

- Photovoltaics
- Thermal CHP

(Benchmark 3)

- 35% increase in Gas Energy Demand
- 23% reduction in Electricity Energy Demand

BUT…

- 13% reduction in Cost
- 9% reduction in CO_2 Emissions

Calibrated Modelling

Potential uses of a good calibrated model:

1. Operational Control Improvements
    - Savings vs Occupant Comfort Predictions
2. Energy Conservation / Retrofit Measures
    - Virtual Testing & Validation
3. Continuous Commissioning
    - Operational Drift Identification
    - Fault Detection