SIMULATION IN THE SERVICE OF DESIGN – ASKING THE RIGHT QUESTIONS

Michael Donn[1], Steve Selkowitz[2], Bill Bordass[3]
[1]Centre for Building Performance Research, Victoria University, New Zealand
[2]Lawrence Berkeley National Laboratory, Berkeley, California
[3]Usable Buildings, UK

ABSTRACT

This paper proposes an approach to the creation of design tools that address the real information needs of designers in the early stages of design of non-residential buildings. Traditional simplified design tools are typically too limited to be of much use, even in conceptual design. The proposal is to provide access to the power of detailed simulation tools, at a stage in design when little is known about the final building, but at a stage also when the freedom to explore options is greatest.

The proposed approach to tool design has been derived from consultation with design analysis teams as part of the COMFEN tool development. The paper explores how tools like COMFEN have been shaped by this consultation and how requests from these teams for real-world relevance might shape such tools in the future, drawing into the simulation process the lessons from Post Occupancy Evaluation (POE) of buildings.

INTRODUCTION – THE ISSUE

In an era where international consensus seems to be settling on a goal of Net Zero Energy Buildings, (IEA NZEBs) there is a great need for building performance analysis and simulation tools that model building performance in all its real-world messiness.

Rules of thumb and generic green design guides are sufficient for small improvements. The feedback from use groups consulted during the development of the COMFEN (Hitchock, 2008) design tool suggests that NZEBs require careful and relevant site specific and end-user focused analysis very early during conceptual design. Unless the design process accurately examines the design goals with design tools that take account of real world data about building operation and maintenance, the likely result is that most countries will miss their Zero Energy goals by a wide margin. The risk is that simulation based design studies create theoretically optimised designs.

Too often, feedback from POE tells us that the performance of advanced design buildings is not as expected, even when simulation has been an integral part of the design process (Short et al, 2009). Designers consulted in the use studies demonstrate awareness of these issues. They seek tools to help them create building designs that work. They want to avoid creating buildings that are so highly tuned that they can only operate at the target performance if occupied by automatons who behave exactly as the computer simulation assumed. POEs suggest a ghastly possibility: highly-specialised buildings that theoretically are Net Zero with dissatisfied and unproductive occupants, where the slightest change in use makes the building more energy intensive than a conventional building.

THE CONTEXT

There seems general agreement within the community of building performance analysts (e.g. Eisenberg, et al. 2002) that design decisions made in the first hours and days of the design process are critical to the successful operation of a building. This has led many researchers to the development of environmental design decision support tools for use early in the design process.

The stereotypical approach to these tools is to run many tens and even hundreds of thousands of runs and to summarise them in charts, tables and even simple digital interfaces. These summaries are presented as design advice or rules of thumb such as Balcomb et al's solar design guide (Balcomb, et al 1992) to the Commercial Windows web site associated with the COMFEN project (commercialwindows.org). This pre-processed information often represents a limited subset of the infinite variety of potential designs.

Figure 1 Commercial Windows web site - design too provides ability to search through pre-processed calcualtions for several thousand scenarios

These summary guidance projects serve an educational purpose and at times assist the development of a design strategy. However, use case feedback from the designers consulted is that these tools do not fit comfortably into a world that needs quantifiable answers to design questions about the specific site and programme that are posed very early during concept design. Design teams need rigorous tools that analyse the specific ideas and issues (http://gaia.lbl.gov/hpbf/design_e1.htm).

In addition, the BuildingSmart Alliance (www.buildingsmart.org) argue for an integrated model approach that permits the design team to spend more time up front in the design process getting the design right. However, the BIM concept (Kensek, 2008) implies performance analysis of a whole building model. The implied design approach is to complete a design and then to calculate performance; next the design is altered on the basis of the calculation. The design approach is modelled on the Karl Popper conjecture/refutation model of scientific analysis. This traditional approach has the designer 'walking backwards into the future' – looking at the performance of the design just completed to sort out the design to be created. But by the time there is sufficient information for a whole building to be modelled, many of the design decisions that most affect performance have been committed – no changes can be made, no matter what the performance analysis reports.

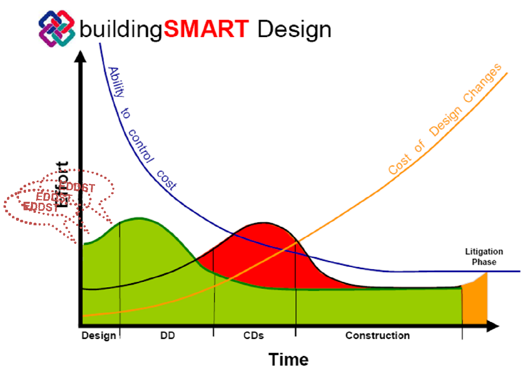

Figure 1 Building Smart (www.buildingsmart.com) graph promoting the advantages of BIM - integrated Information model allows more effort to be spent on early design rather than Construction Documentation (CD) – getting the design right first, avoiding possible litigation later

This backwards to the future approach: a) ensures access for the design team to simulation programs that model building physics rigorously; but b) requires complete models of whole buildings for input to these simulation programs.

However, the mere act of making the first conjecture in this conjecture/refutation pattern commits the design team to a number of stylistic, practical and planning moves that are difficult to reverse through analysis (Donn, 2004) . The design teams consulted report a need for rigorous performance simulation tools that help them explore concepts and ideas that can be used before a whole building design can be completed.

The basic principle applied to the development of COMFEN is that of an analogy with sketch design in architecture. Whenever possible, architects use the best possible drawing tool(s) to create a design sketch. The design analyst needs access to the best possible design analysis tool(s) to create an informative performance sketch.

THE PERFORMANCE SKETCH

The first step to addressing the nature of the performance sketch is removal of the implicit assumption from the traditional and the BuildingSmart processes that comprehensive, detailed digital simulation tools require complete building models as input – completed designs, or worse, incomplete designs of whole buildings with defaulted inputs. That approach requires often slow and careful translation of large 3D computer models from one analysis program (say a CAD program like Revit or Microstation) to another analysis program such as Radiance or AGI32.

The argument for this careful translation is that given the large amount of effort invested in entering data into each performance analysis program, reliable and preferably two-way exchange of the Building Information in each Model is essential for productivity and quality control. Much of the recent research effort in building performance modelling has focused on the issue of translation between domain specific 'views' of buildings. For example, translation between a thermal and a lighting domain requires a change in 'mindset'. A thermal model of a building needs only enough geometrical information to represent mathematically the relevant heat flow paths. The walls, roof, floor and windows can be paper thin with associated thermal properties. Yet, paper-thin walls with potential light leaks are anathema for daylight simulation.

Translation between these different performance 'views' of the building, places a heavy load on the user managing the exchange. This load can discourage rapid or radical design changes.

In user briefings for the LBNL High Performance Building Facade project, and for the Commercial Building Fenestration design tool COMFEN, architects, HVAC engineers and building simulationists contributed definitions of a sketch design decision support tool – a performance sketch.

These briefings have focused on the nature of the environmental performance design information required by design teams. The new paradigm for performance simulation in this context is that conceptual design tools must help design teams answer quantitative questions quickly, early in the design process. Without factual risk, cost, comfort and CO_2 information in the first days of design, the task of achieving a (net) zero emissions building is unlikely to be achievable.

The design teams need a means of 'sketching' the essential properties of their design ideas. In the same manner that an architect isolates a concept or view of the proposed building in a sketch, the performance analyst needs to create simple concept 'sketches' of design ideas. These sketches are richer than can be encapsulated in pre-packaged design rules of thumb. Because they use detailed simulation tools they can be specific to local climate, urban context, building use, site context (solar shadows, wind etc) innovative materials and systems, and crucially, specific to the performance goals for the project.

Design teams report needing the means to create abstractions of design issues in order to explore the performance of their ideas. They need to be able to focus on elegant sketches of building performance; on multiple design variations; and on multiple, parallel design analyses. A performance analysis sketch tool of this type would not just be used during conceptual design. It is likely to be as useful as the architectural sketch at exploring design ideas at all phases of design.

MODELLING THE REAL WORLD

User briefings for COMFEN suggest the following key questions a performance sketch must answer:

1) likely costs of operation; these costs should be energy, demand, CO_2, productivity, maintenance, and should be presented in hourly, daily, weekly and seasonal plots.
2) likely variation of comfort variables in space and time: thermal, lighting, glare, provided just by the building with no energy consuming services, so that the inherent building performance is revealed; and with services in place to reveal the likely interaction of building, people and services.
3) likely risks to comfort and cost of:
    a. poor equipment reliability;
    b. poor/normal installation practice;
    c. poor control performance;
4) likely interaction between equipment and user-operable controls (lights, openable windows, shades);
5) likely impact of climate change in a manner that helps the client to budget properly.

All these criteria require answers that are sufficiently based on models of the building physics and are specific to the building site, climate, likely behaviour and programme that they can be used in later value engineering exercises. Importantly, they also suggest a need for real-world data on user-behaviour, maintenance and building operation.

Post Occupancy Evaluation (POE) studies of buildings are a valuable source of much of this real-world data. At one level, POEs can be viewed as models of building dysfunction due to building occupants not following design parameters. At another, they are analyses of the robustness of the building operation in light of real world variability.

"*…there are some buildings that are doomed from day one to perform poorly. In some cases this is because the basic design is poor, but the problem can also affect buildings that have apparently reasonable design and construction, at least at the macro level. In such cases, the buildings may simulate well, but real-life problems swamp the performance to the extent that the theoretical performance has little chance of ever being achieved.*" (Bannister, 2009)

The goal is to put in the design team's hands tools that help them to model normally observed human behaviour found in real buildings. The impact on performance of these changes in the optimum behaviour are essential design information if buildings are to perform well 'from day one'..

Short et al (2009) state: "*…the persistence of chronic problems may have a nonlinear outcome, the bad effects being out of proportion to the apparent scale of the defect.*"

PRE-REQUISITE: INPUT INFORMATION, NOT INPUT DATA

Building performance simulation is often based upon critical data inputs about building operation that are only weakly based in reality. For example, thermal simulation increasingly takes account of the extent to which daylight can make a difference in electricity use for lighting and for cooling. Coupling thermal simulation to annual light simulation of daylight and glare using programs like Radiance and 3DS Max (Reinhart, 2001) is now feasible. These require careful modelling of user behaviour with respect to blinds for glare, windows for light and the heating and cooling load.

What is crucially missing from the input data to many of these models is anything but the most crude estimates of human factors that are critical influencers of energy performance. For example, models of blind usage are based upon observations of typical users. This is insufficient for design analysis. A robust performance sketch would vary the blind usage within 'reasonable' ranges in order to test the robustness of the simulation under variations that might reasonably be expected in practice.

A major research effort is needed to establish data not only on the name plate and Energy Star ratings of appliances in the workplace but also on their actual in-use energy consumption. Similarly, there is a need to establish real data on use patterns in terms of occupancy rates, user expectations of performance, user interaction with controls, and user preferences for environmental space quality. Typical values are insufficient. Reasonable ranges of low and high values are also needed. One study has begun in this area (BRANZ, 2009), focusing not just on 'typical' or 'average' values, but on the range likely to be encountered in workplaces and on the likely probability of exceedance of average values. The following lists the critical parameters for which real measurements in a representative number of buildings are planned:

1) Behaviour of people: as represented by schedules of appliance, lighting and HVAC system switching based on real world data.
2) Recognition within the modelling regime that there is a need to quantify the risk to building performance of deviation of people's behaviour from the norm: "*In any building the occupants will find ways of operating their parts of it with the least effort, for a reasonable result in terms of comfort, service and convenience, but with little regard for efficiency"*(Bordass, 1995)

2) Loads: represented by schedules of appliance face-plate, in-use and stand-by energy consumption.

What is important is not just to provide typical values. These values should also be associated with diversity factors. For example:

a) Given name plate energy use of xxxW, what is the likely performance in use in a school / office/retail outlet of machine y?
b) What are 95%ile upper and lower bounds – reasonable variations of these numbers? (To examine risk of say overheating because all the machines are contributing at the high end of the range found in practice?
c) What is the likely breakdown amongst the computers and their screens in a building between those running at full energy load, those where the computer is up but the screen is in energy saver mode and those where the whole machine is in energy saver/standby mode?
d) And similarly, what is the likely breakdown amongst 100 people in a building that everyone will at their desks; a significant proportion will be out of the office; a significant proportion will be collected in one room for a meeting.

This data is largely dependent on the type of building that is surveyed. Within building type the range is useful for modelling purposes.

The energy modelling professions need energy use 'norms' based upon real world surveys, which provide the appropriate median, mean and daily patterns of the end uses of the energy consuming services in a building. These assumed 'norms' in terms of equipment use should also be associated with some reasonable picture of the likely service delivery in terms of the adequacy of heat and light.

"Designers sometimes … do not make it clear that many measures require vigilance in use, sometimes more than the measure deserves. …One aspect of this problem has been the over-specification of cooling loads. Frequently these requirements were based on guesstimates and fashions, and did not seem to have been queried rigorously by designers, … We need both more routine availability of good information and contingency planning techniques which can prepare for the worst without over-specifying now.

Another problem has been the intensification of usage of many non-domestic buildings, with longer operating hours and more diverse occupancy patterns. Where the design assumption has been routine occupancy and typical tasks, problems have occurred. Engineering systems have defaulted to ON, with considerably more energy use than anticipated. We need to plan to accommodate more diverse use economically. (Bordass et al, 1997)

DESIGN TOOLS

The range of comprehensive performance analysis tools that might be used during design conceptualisation is increasing. Tools with some features in common with COMFEN include EFEN[i], Primero-Comfort[ii], the US DoE OpenStudio[iii], MIT's Design Advisor[iv] and LightSolve[v], SPOT[vi], Daylight1-2-3[vii], Autodesk's Green Building Studio and Ecotect[viii].

EFEN is a tool for evaluating fenestration options in commercial buildings. It uses EnergyPlus and is designed for quick generation of whole building designs. The focus on whole building models makes the data entry and the simulations more like standard simulations in terms of time and flexibility.

Primero-Comfort is an interface to EnergyPlus and provides an assessment of adaptive thermal comfort and a comparison of the primary energy consumption of different regenerative and conventional cooling systems. Its adaptive thermal comfort assessment follows Dutch ISSO 74 differentiating building types by level of user influence and comfort class.

OpenStudio is a plugin to SketchUp[ix]. The plugin permits buildings 'sketched' in an approved manner in SketchUp to be simulated in EnergyPlus. As of Version 1.0, OpenStudio permits the user also to link to the web-based service of the EnergyPlus example file generator[x]. This service creates an EnergyPlus input file, runs an annual simulation, and then emails the user the results, an EnergyPlus file and associated input files. Further analysis can be completed using SketchUp. While the focus is on whole building analysis, simpler buildings can be modelled easily.

The MIT Design Advisor is targeted at building designers wishing to improve occupant comfort and energy performance during conceptual design. It supports quick building input and annual energy simulation without technical experience. It uses independently developed daylight and thermal simulation modules that have been validated against industry-accepted standards. An optimization module is also included.

Lightsolve provides designers with the means to interrogate and interpret the output of lighting simulation (Andersen, 2008). It uses a radiosity algorithm to provide rapid calculation and interactivity (Cutler, et al, 2008).

SPOT™ (Sensor Placement and Optimization Tool) [xi] assists a designer in quantifying electric lighting and daylighting characteristics within a lighting zone and identifying the optimal photosensor placement for annual performance and energy savings. SPOT™ is targeted at classroom daylighting, but can be used for all types of spaces. It is essentially an interface to the comprehensive light simulation program RADIANCE. SPOT™ , like COMFEN, focuses on single room analysis.

Daylight 1-2-3 predicts the daylighting and energy performance of commercial build fenestration options. It is targeted to design professionals with an interest in climate responsive daylighting design concepts, but without expert knowledge in this area. Daylight 1-2-3 analysis is based on Daysim and Lightswitch for lighting and ESP-r[xii] for energy. Its graphical user interface includes presentations of key daylight performance metrics, monthly charts of energy use and peak load for heating, lighting and cooling. It runs ESP-r on remote servers.

A web-based tool that can be used for analysis of design alternatives is Green Building Studio[xiii]. Users send a gbXML file exported from a CAD program to the web service and receive back an Energy and CO_2 analysis based upon DOE2 simulations. The service accepts simple or complex models. It fundamentally relies on the goodness of fit between the original design concept and the gbXML file. The service could be used to examine quickly many design options because it runs on a computer 'cloud'.

Ecotect is a collection of algorithms that were originally developed for hand calculations of building performance now packaged into a coordinated user interface. Its accepts a wide range of data input formats; it also writes out input files for a large number of full simulation design analysis computer programs; and, it provides powerful data representation tools for exploring the output of these analysis programs. Except for its Radiance Control Panel, Ecotect has no in-built means of controlling the detailed simulation programs with which it can communicate. The user must set up the model in Ecotect, run the simulation(s) in another program and then re-import the simulation information into Ecotect for performance visualisation.

Ultimately, no one program from this patchwork of tools meets the needs of the users consulted during the use case studies. All users were aware of some tools. None were aware of all tools. Some expressed suspicion of a tool that required them to learn another interface (either SketchUp or a CAD-like GUI). This was partly a learning curve issue, and partly a desire to quality assure the simulation input data. Others wanted continuity between their initial concept design models and the models they would use later in the design process – but were impatient with the time required to run their initial design concepts through EnergyPlus, EFEN or Green Building Studio.

Users in these COMFEN use cases wanted firm 'numbers' on design scenario performance instantly. They sought a tool that might help them quickly compare design and running costs during conceptual design. If useful then, they expected it also to be useful during concept design meetings. Meaningful glare, comfort and productivity measures were wanted even when the building form and the window orientation were not yet fixed.

This user feedback generated a further principle for creation of performance sketch tools: users want to be able to create many different sketches of building performance. They want these sketches to be compatible, but do not expect that one sketch or one tool will provide all analyses. For example, compatibility requires that in specifying location, weather data, local energy tariffs and embodied energy and embodied CO_2 should be linked. When comparing design scenarios simulation output would be fed easily to post processing models like the UC Berkeley Comfort model (Zhang, 2005).

Despite negative use case feedback about systems that are biased towards CAD drawings for early concept design, there is a singular integrative power made available by OpenStudio's ability to read as well as write EnergyPlus files. This power is implicit in the next section. It examines the ways in which a COMFEN supported design process might focus on real usability issues for the end-user of a building.

VISUALISING PERFORMANCE: THE CRITERIA

Design performance analysis sketches, like architectural sketches on tracing paper, are made, thrown away, and then completely new ones are made. Translation: file exchange issues are sidelined.

The performance analysis sketch is a model that can be created when no-one quite knows what the actual building will look like. However, it has little or no value unless it can be retained in a filing system (use case: "can we go back to scenario 10?); and it provides real feedback about what the building will be like (use case: "scenario 22 is particularly uncomfortable in summer" but 80% of the people have good views, daylight and openable widows for fresh air – can we drill down to why scenario 22 is hot and scenario 16 is acceptable in summer?")

In a world where Architecture 2030, Energy Performance Building Directives and Green Building Council ratings systems like LEED set particular goals, the performance of each scenario needs to be accounted for in relative terms (against other design options/variations) and in absolute terms (compared to LEED or other ratings).

For a single team, at one moment in time, the sketch could be a model of an internal top-lit atrium, modelled as just the one office with windows facing into the atrium and at the bottom of the atrium. Relevant design questions: is natural ventilation possible – what does POE tell us about similar designs? Is daylighting of a significant portion of the floor area feasible – what does user feedback tell us about the practicality of the design solutions?

At another moment, for the same building project, the sketch examines daylight in an external office on the tenth floor, overshadowed by 20 storey buildings in the street outside. These real design issues are not easily answered by pre-processed design information. Use case study participants suggested that a design analysis tool that calculates the actual performance of a typical room and links that to case studies of similar buildings is likely to be useful.

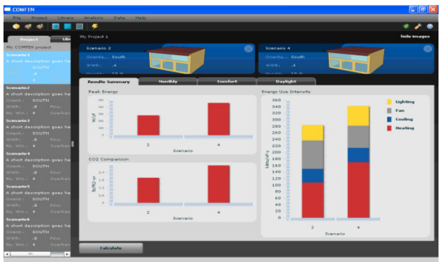

Figure 2 COMFEN scenario browser: scenarios dragged from list on left appear in graphs on right. (Annual energy use shown here is top level information - the starting point ot drill down to detailed data)

Merely graphing performance of a building design scenario is inadequate. Far more important, is building performance reporting tools that allow first a natural grouping of scenarios and then automates report production. Enhancements suggested for the existing COMFEN scenario browser would allow scenarios to be catalogued. The design team should be able to group these scenarios by tag in output reports: switching between views of the data.

The users sought far more flexibility to decide what is graphed. A click of a button might switch between energy, carbon or comfort; or, a report might facilitate linking glare potential in say Lightsolve with the energy scenarios in COMFEN.

Time based performance criteria

One of the most important features provided by simulation programs is the ability to examine the temporal nature of a building's response to climate. A design team that had looked at the climate for their city (say Boston) would find the pattern of global horizontal radiation shown in Figure 3. Simplified calculation techniques render analysis based on this sophisticated and detailed data, impossible. COMFEN is an interface that automates data entry into EnergyPlus for a performance sketch. It has none of the inherent simplifications of a pre-calculated solution.

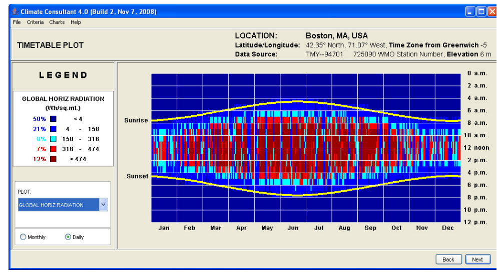

Figure 3 UCLA software Climate Consultant Screen capture of Global Horizontal Illumination variation across all the months (horizontal axis) vs time of day (vertical axis)

The central lighter coloured regions (red and lighter blue) in Figure 3 represent times of the day when global horizontal radiation is greater than a 150 W/m^2 or approximately 25klux. The yellow lines represent sunrise and sunset. There is plenty of illumination available from the unobstructed sky.

Having ascertained the likely availability of light / solar radiation for the local climate, the design team next establish the likely external obstructions to light. The Figure below shows how Ecotect (Marsh, 2006) could be used to derive this data using Radiance to perform the calculations. The calculation might equally have been performed with Radmap[xii] as the interface to Radiance.

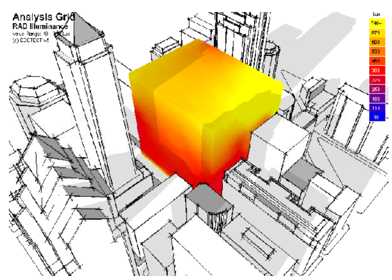

Figure 4 Ecotect 3D grid fed through Radiance and back into Ecotect display - showing incident solar radiation

The next design scenarios are from a simple COMFEN model. The EnergyPlus model that is the heart of the COMFEN analysis at present is imported into SketchUp using OpenStudio. This one room model is then placed into a sketched context (below).

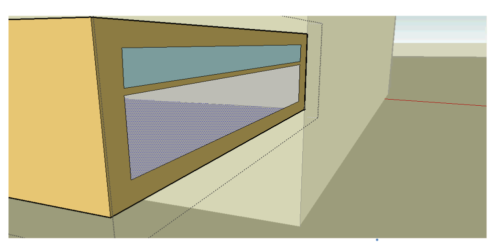

Figure 5 SketchUp (from OpenStudio[xiv]) model of a vision strip plus daylight strip fenestration scenario – assuming a plenum reduced near the perimeter of the building

Once the building is in SketchUp, it can be sent out to Radiance for lighting analysis (Figure 6).

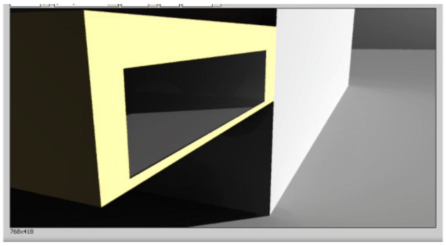

Figure 6 Radiance render of a COMFEN floor to ceiling glass scenario for an office with allowance for a plenum

And, also within SketchUp, tools like the suntool plugin[xiii] for SketchUp can start to explore the need for blinds or sun protection.

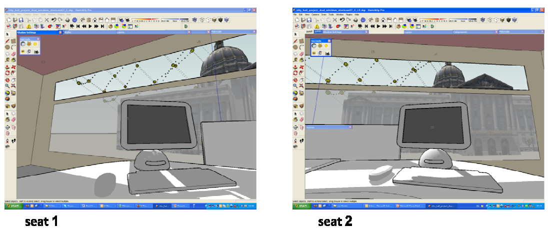

Figure 7 Planning blinds using SUNTOOL plugin for SketchUp - two workstation positions within an office

In the background, having created the EnergyPlus file for these alternative building concepts are the many energy reports produced by the standard COMFEN calculation process.

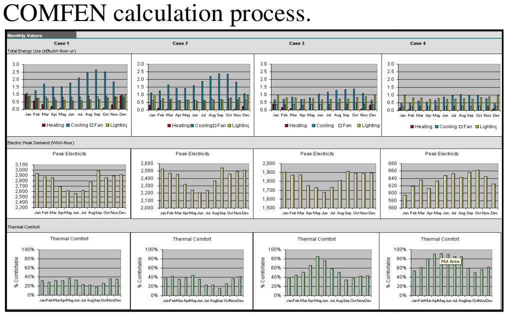

Figure 8 COMFEN Output: Four design scenarios compared in terms of monthly energy use (top row); monthly peak electric demand (middle row); and comfort using monthly PPD scores (bottom row)

The next step for the design team is to start to develop a picture of when in the year there might be problems or performance within the target ranges. The user feedback suggested a need for much greater ability to 'mine' this EnergyPlus data than is currently available. EnergyPlus provides for standard positioning of daylight sensors for electric light. It is therefore possible to produce reports about the light levels due to daylight at these points. However, exploring further requires more comprehensive data analysis. In the following graph, Lightsolve illustrates, over time, how closely an illuminance goal is met in a classroom design (in Sydney, hence the differentiated pattern compared to Figure 3). This could potentially become an externally provided view of the EnergyPlus data.

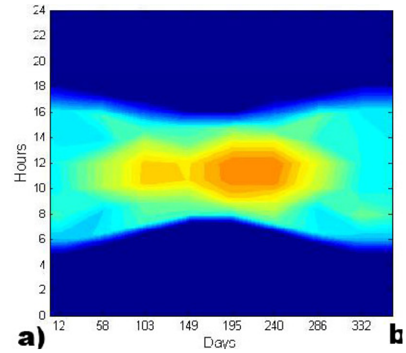

Figure 9 Lightsolve output (source: Kleindienst et al, 2008) showing, for the whole year in Sydney, the percent of the space meeting a target illuminance range.

It is not particularly important what Lightsolve[xv] is representing in this diagram. It could be percentage of space in excess of a 150lux maximum tolerable light level on paintings in a gallery. It could be percentage of space within the Useful Daylight Index (Reinhart et al, 2006) for an office.

For the design, this abstraction of the data gains its fullest value if, the design team can drill down into the data for any time of the day and year, and examine a particular a particular problem area in 3D. If the reports show likely glare or other discomfort issues at particular times, then a 3D analysis can reveal the light flows that lead to the problem.

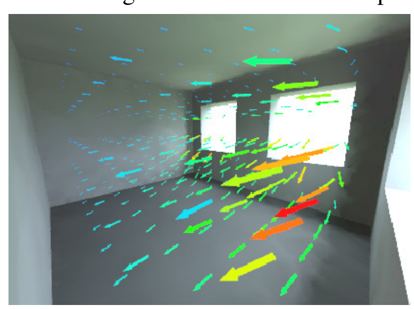

Figure 10 Axel Jacobs: *'The Radiance Cookbook'* Illustration of 3D arrows showing flow of light; colour and size represent amount

This 3D analysis is the type of functionality currently offered simply by Ecotect and Radiance.

The design performance sketch can also be a thermal comfort model like the UC Berkeley Human Comfort Model. This is yet another external data processor that can provide information in 3D of the likely user-response to the design. For example to provide an answer to the question: 'might that area of glass so close to the workstations make those work stations unusable for significant periods of a winter day?"

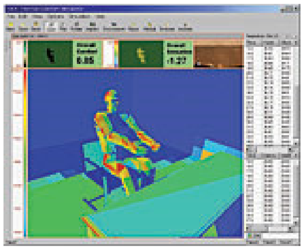

Figure 11 UC Berkeley Human Thermal Comfort Model

The future of this design approach is then to overlay buildings in use experience (Bordass, 1994): *We have found widespread, over-optimistic faith in automatic controls by designers and modellers; …. Often there is no clear analysis of what controls can really do, how they are actually going to work, and how people will operate and look after them. While inadequacies in management have often been identified, designers must recognize that management time is usually much scarcer than, say, money to pay fuel bills, so it is important to design for manageability.*

The final step for the analysis team would not be to edit the SketchUp models, but rather to return to COMFEN and to create a new set of scenarios, now focusing on shading and glazing systems.

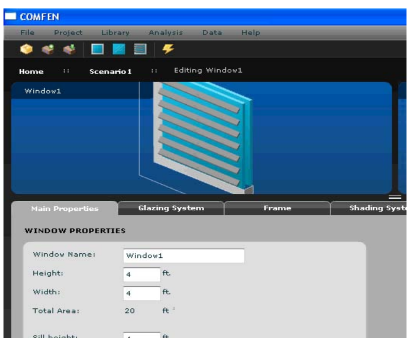

Figure 12 COMFEN window design builder with tabs for Window 6 compatible definition of Glazing system, Frame, Shading system

CONCLUSION

User feedback from people who are using buildings points to a great need for design teams to focus on end user comfort and productivity if buildings are to achieve real Net Zero Energy performance. User feedback from design teams consulted in the development of COMFEN is that they require performance sketch tools that report real consequences and provide detailed energy, comfort, cost and productivity numbers before design has reached the point of a whole / real building. Together these trends suggest a need for interfaces that make the most detailed simulation software available for rapid comparison of many design concepts. Not one, but many tools or interfaces are required.

COMFEN has been used as an example of an approach to this identified need. It focuses primarily on exposing as much of the detailed scenario modelling capabilities of EnergyPlus as is possible. To co-operate with all the other tools likely to be used in conceptual design, it requires also wiki-style sharing of design scenarios, and detailed metrics of performance; access to real PoE data on the likely variability of user behaviour and maintenance; and customisable templates for basic building types.

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