EMBEDDING SIMULATION WITHIN ENERGY SECTOR BUSINESSES

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ABSTRACT

The potential of building energy simulation is now well recognised and the use of the technology by progressive energy sector companies is growing. The success of any building performance assessment hinges on the capabilities of the tool, the collective competences of the team formed to apply it and, most crucially, the rigour of the in-house quality control procedure. Two core issues facing the professions are the management of simulation and the quality assurance of the related models and appraisal results. This paper describes how the Scottish Energy Systems Group (SESG) aims to transfer simulation to energy sector companies and, through specialist staff secondments, to support this transfer in the context of day-to-day work practices. The intention is to demonstrate that simulation-based design can yield results, quicker, cheaper and better than conventional methods. The SESG is a joint Scottish Office, Industry, Scottish Enterprise venture. This paper outlines the aims of the SESG and describes the core elements of its operation.

Keywords: Building Energy Simulation, Use in Practice, Technology Transfer.

BACKGROUND

It is well recognised that efficient energy utilisation and the mitigation of environmental impact are important economic factors. Energy policy objectives are essentially twofold: to eliminate the economic impact of energy profligacy and to develop and exploit new technologies in the energy/environment sector. Energy efficiency and clean technologies (e.g. renewable energy conversion) can be expected to undergo rapid developments in the near future (DETR 1998, EPSRC 1996).

Because the built environment consumes a large portion of delivered energy and is responsible for much of the avoidable carbon-based emissions, many initiatives are focused on this sector (Table 1). However, building energy systems are complex, and in the absence of a means by which the performance benefit of proposed measures can be predicted, such initiatives will fail. The UK has responded to this dilemma in two complementary respects (Clarke and Maver 1991, McElroy et al 1997):

- the development of simulation tools for the integrated appraisal of building energy systems at the design stage;
- and the establishment of the Energy Design Advice Scheme (EDAS) which, in Scotland, has acted to deliver design advice based on these tools.

In recent years EDAS has been acclaimed by its beneficiaries, architectural and engineering practices and client bodies, and by independent government reviewers, who have examined its achievements in relation to energy saved, cost effectiveness and client satisfaction (ETSU 1991, 1998a, 1998b). Now the UK Department of Environment, Transport and the Regions (DETR) has decided to consolidate the EDAS scheme by centralising the delivery of design advice (BRECSU 1999) as a service offered through the UK's Best Practice Programme.

This paper reports on a new venture which aims to foster an in-house simulation capability within design practice. Specifically, the venture seeks to identify the changes required to current work practices in order to support effective business integration.

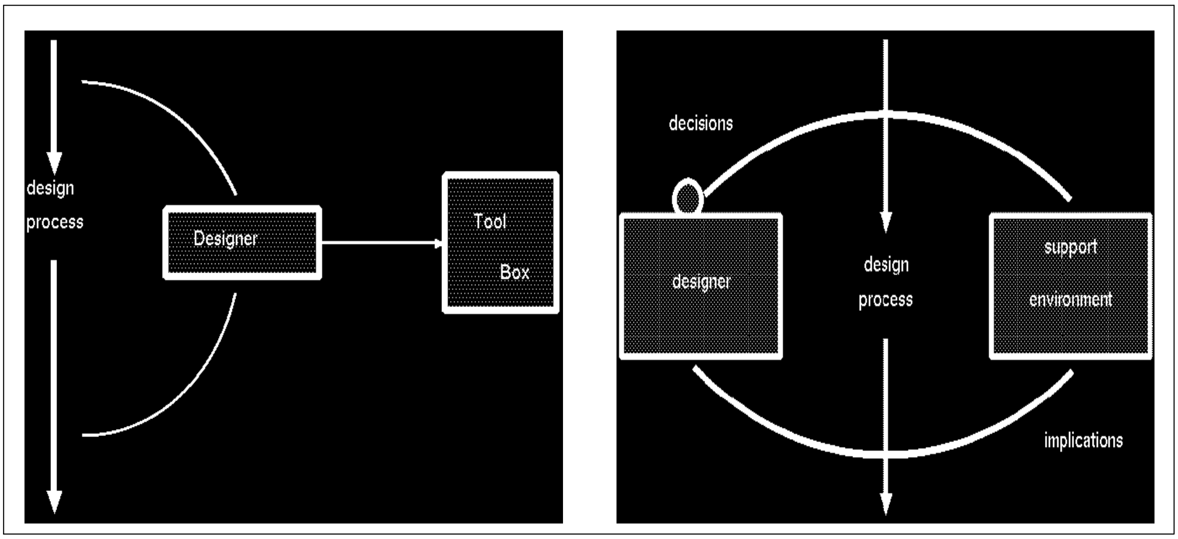

Figure 1: Approaches to tool use; a) decoupled, b) integrated.

Table 1: Energy policy initiatives.

Kyoto Agreement (1997)	Heads of Government commitment to reduce key greenhouse gas emissions in developed countries by at least 5% by 2008-2012 (relative to 1990; EU target set at 8%). This would result in 2010 emission levels that are ˜29% below what would have been in the absence of the protocol.
Local Agenda 21	Commitment to reduce CO_2 emissions at the local level.
UK Home Energy Conservation Act (1995)	Local authorities responsible for preparing practical energy conservation plans to achieve 30% reduction over 10 year period.
UK SAP Ratings Initiative	Introduction to the Building Regulations of a Standard Assessment Procedure (SAP) for domestic buildings.
UK Clean Technologies Programme	Promotion of waste minimisation, sustainable cities and new technologies (e.g. fuel cells, photovoltaics, efficiency measures).
Electricity market deregulation	Open market puts pressure on all sectors to change current practices, especially in relation to complementary demand- and supply-side partnerships.
Energy Action Planning	Requires elaboration of a range of appropriate sustainability indicators.

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The EDAS approach to providing simulation-based advice relied on the services of modelling specialists who remained detached from the design process (Figure 1a). Such an approach gives rise to a delay between the delivery of the simulation results and the evolution of the design hypothesis.

The SESG has been founded on the belief that the industry is now ready to commence the process of adopting a computational approach to energy systems design (Figure 1b) whereby modelling tools are fully integrated within the design process. Table 2 lists the premises underlying the SESG initiative. The aim is to tackle the perceived barriers to the uptake of simulation: steep learning curve, poor ease of use, fear of user error, discontinuity between program capabilities and the

Table 2: Premises underlying the SESG initiative.

1.	That in the context of energy systems design there exists an urgent need to reduce the gap between system specification and life cycle performance assessment.
2.	That existing modelling systems provide a means to bridge this gap and so reduce the design response time.
3.	That the ability to address the complex dynamic interactions, and multi-variate issues inherent in energy systems will enhance product robustness.
4.	That there exists a need to move such analyses towards the early design stage to better support design concept synthesis where the potential impacts are greatest and least costs committed.
5.	That the early design stage activity can be supported through the creation of appropriate computer-based, decision-support environments.
6.	That a critical mass of specialist energy modelling knowledge currently exists in the UK which is in danger of being dissipated with the demise of the regional dimension of EDAS.
7.	That computational tools and facilities required by the industry and the expertise to use them will only be developed through collaboration between the user and developer communities.
8.	That virtual design technologies will enable co-operative working between disparate partners.

scale and complexity of real buildings, demanding resource requirement, credibility of predictions, need for specialist computing equipment and, most importantly, the lack of a supportive network (Howrie 1995).

The SESG was inaugurated in January 1999 and comprises a spectrum of energy sector organisations: architectural and engineering design practices, local authorities, component and system manufacturers, utilities, renewable industries, software vendors and research bodies. The primary objective is not to help practitioners to assess the energy efficiency of specific designs, as achieved previously by EDAS, but to establish a mechanism to bring about the transfer of the necessary computer systems into their businesses. This will allow them to undertake energy and environmental analyses in-house as a matter of routine. Because the SESG will facilitate industry's direct access to the technology, as opposed to providing access via contracted specialists, it may be expected that the savings achieved by EDAS can be substantially improved upon: estimated cumulative energy savings to the year 2008 of £172 million, 285,000 tonnes of displaced CO_2 per annum; and the improved capability of the industry through the provision of explicit performance assessments (ETSU 1998b).

In particular, the intention is that the SESG will assist its members to evolve in three important respects: better design of energy systems through integrated performance assessment; enhanced productivity through reduced design development times; and improved inter-organisational collaboration through technology-centred operation. At the very least the SESG will help its members to develop a better understanding of the development path that organisations should adopt to utilise the new technology. Four devices are being employed to attain these goals:

- the provision of support for routine program use in the context of ongoing commercial activities;
- creation of advocacy groups to explore key issues and elaborate future actions;
- the elaboration of practical quality assurance procedures;
- and the development of integrated performance benchmarks for a range of building types.

SUPPORTED TECHNOLOGY DEPLOYMENTS

Supported Technology Deployments (STDs) are the mechanism by which members are able to obtain in-house support from modelling specialists seconded to the design team. The aim is to allow practitioners to gain risk-free access to simulation in the context of live projects and otherwise normal work practices. This will allow them to identify the financial and human resource barriers to routine tool deployment.

By placing specialists within the design team, the two way flow of information is supported: simulation know-how is thus exported directly to practioners and specialists are directly exposed to real design issues.

Typical examples of an STD include:

- □ the deployment of software within an architectural practice to allow early design stage assessment of energy and environmental issues;
- □ the deployment of compatible thermal and lighting modelling programs within an engineering consultancy;
- □ the deployment of an energy modelling system within a housing association for use, in conjunction with field measurements, to evaluate the impact of proposed upgrading measures;
- □ the deployment, within a utility, of software for co-generation feasibility assessment in the context of high rise housing.

The SESG will document the process in order to highlight and resolve deployment issues, assuming a completely passive role in the process. Of paramount importance is that the specialist is responsive to the design team needs and is not pro-active in the application of modelling.

The following scenario elaborates an STD:

Company A, an architectural practice, is working with company B, a building services practice on a new building design. Both companies wish to explore the potential of adopting a formal modelling approach. The project entails the introduction of several energy conserving measures and the possible use of renewable energy conversion in the form of photovoltaic components integrated within the building facade.

A software tool provider is identified and, along with SESG technical staff, joins the team to install the selected packages and assist with their application in terms of the creation and evolution of computer-based models, the co-ordination of simulations, and the interpretation of the performance outcomes. The SESG director monitors the process in order to identify any bottlenecks and to suggest a technology investment plan to the participating companies and report to the wider SESG membership.

ADVOCACY GROUPS

While the potential of modelling within some sectors of the energy industry is well understood, its deployment within other sectors is not well developed. Advocacy groups allow their members to explore issues together and thereby identify opportunities for, and barriers to, the effective application of simulation in their area. To ensure good user requirements capture and tool options definition, groups are comprised of model developers and users. The views from advocacy groups are disseminated through SESG newsletters and workshops.

Typically, advocacy groups are multi-discipline but focused on the needs of a homogeneous sector:

- □ design practices with an interest in the same modelling package;
- □ local authorities who are required to respond to legislation concerning the energy efficiency of their building stock;
- □ manufacturers wishing to demonstrate the performance enhancing impact of their products;
- □ and utilities concerned to effect procedures for the matching of supply to demand.

To raise the level of knowledge within the groups, the SESG provides a range of member services:

- □ dissemination of information on available modelling systems;
- □ applications software training;
- □ establishment of partnerships between SESG members and technology providers;
- □ seminars/workshops on modelling topics;
- □ and the placement of students possessing modelling skills.

In this way, it is expected that the participants will be able to move forward together.

QUALITY ASSURANCE PROCEDURES

Kaplan (1992) has suggested that, "models are to error as sponges are to water". Accordingly, users are easily frustrated by systems which do not support model creation, documentation, archiving and retrieval practices which are design to trap errors. Hand (1999) has suggested that these practices must be encapsulated within an overall quality assurance procedure. Parand and Bloomfield (1991), and Chapman (1991) have warned of the complexity of this task. The SESG aims to evolve such a procedure by building upon the good practice established previously by EDAS and CIBSE (1998). The envisaged procedure has 8 stages:

1. project initiation;
2. identification of objectives;
3. mapping of objectives to simulation tasks;
4. identification of uncertainties and risks;
5. simulation procedures and maintaining audit trail;
6. translating simulation outcomes to design evolution;
7. client reporting;
8. model archiving and sign-off procedure.

The following sub-sections explain how the SESG aims to consolidate these stages in practice in the context of an active STD.

Project initiation

This stage includes the definition of the project's scope, the selection of the necessary applications software and the establishment of the in-house project team, including the SESG project observer. Arrangements are then made for the delivery of the required application-ready hardware from a computer loan pool and the secondment of specialist staff. It is important to note that it is the company staff who set the appraisal agenda and delivery deadlines; the seconded staff serve only to ensure that the simulation program does not burden the process.

Identification of objectives

At this stage an agreement is drawn up which defines the technical objectives and apportions responsibilities between the organisations involved. The SESG's role is to facilitate access to new simulation packages, ensure that misapplication does not arise from unfamiliarity and determine any barriers to routine use. In this last respect, the SESG observer documents the approach taken, the tools used, the outcomes attained and the (changing) perceptions of the project team.

Mapping of objectives to simulation tasks

Because modelling specialists are not building designers, and building designers are not (yet) proficient modellers, the mapping of design questions to modelling intent is a non-trivial activity. This mapping is the domain of the SESG: within an active STD the SESG observer ensures that planned mappings are subjected to due scrutiny by a matched advocacy group. In this way the SESG will ensure that good practice will evolve over time.

Identification of uncertainties and risks

An important issue facing users of simulation is uncertainty. In the context of innovative design, it is the risk element that must be tested if the boundaries of best practice are to be pushed forward. Only when a parameter's uncertainty is known, can the associated risk be determined (Macdonald et al 1999). Perceived uncertainties and risks will be documented within each STD and debate enabled through the advocacy groups.

Simulation procedures and maintaining audit trail

While vendors may be confident about the validity of the results produced by their program, there is as yet, no mechanism whereby this confidence can be passed to a user. The SESG will serve to raise the level of awareness about predictive accuracy in general, establish procedures for simple model calibration and develop a checklist approach to model/result archiving.

Translating simulation outcomes to design evolution

Simulation allows designers to perceive the future reality at the design stage. This, in turn, gives them an appreciation of the performance impacts of intended design actions. Unfortunately, the mapping of time series performance data to decisions on design hypothesis modification is a non-trivial process. The SESG will seek to raise the level of debate on this issue through its advocacy groups and workshop activities.

Client reporting

The development of a standardised reporting procedure is seen as an essential prerequisite for practitioners. The SESG will develop a standard reporting format based on the model instigated by EDAS (McElroy 1998). Such reports facilitate inter-project comparison and assist with project quality assurance.

Model archiving and sign-off procedures

Good practice simulation dictates that project models be archived for possible future use. Which model to archive will depend on its perceived value within the project. The SESG aims to evolve the industry's views on how this might be done in a manner which supports inter-organisation use.

BENCHMARKING

Understandably, designers are often reluctant to use simulation in cases where they have no concept of what outcome to expect. Benchmarks provide a means to judge the integrated performance of a building against others in the same class (DETR 1994). They also allow users to scrutinise the impacts of new program releases. Using models of specific building designs which typify the range, the SESG will generate performance data, normalised by floor area, weather, etc.

CONCLUSIONS

It is widely accepted that simulation defines a best practice approach to the assessment of design performance (CIBSE 1998). In order to assist energy sector companies to maintain a competitive position, the SESG has been established to support routine, in-house use of energy and environmental simulation packages.

If such a transfer of technology can be achieved, it will help to create a progressive, IT-literate industry which has the potential to respond to the complexities and challenges of sustainable development.

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