Achieving Sustainable Building Results from New Processes and Strategies

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Summary

Sustainable Design of buildings is not an add-on technology. It is a new way of thinking involving a holistic approach. It requires the early establishment of team responsibilities, environmental goals and evaluation criteria together with agreed processes for value management and life-cycle cost analysis. Key advancing technologies and approaches are in the areas of greenhouse gas abatement and indoor comfort conditions. The concept of energy neutral buildings utilising transitional gas-fuelled energy systems combined with renewable energy systems has emerged as an affordable strategy for greenhouse gas abatement. "New age" buildings will not only save energy, they will harvest it. The new CSIRO Energy Centre being constructed near Newcastle NSW illustrates a typical means of achieving sustainable building results.

Introduction

The delivery of more environmentally sustainable buildings requires a reinvention of building design and procurement processes. This is required in order to extend responsibilities and returns to all stakeholders and to incorporate consideration of economic, environmental and social impacts and costs across the life cycle of a building. This reinvention can be applied to both new buildings and the retrofitting of existing buildings. The biggest inhibitors to energy efficiency and other sustainability improvements in building and construction exist at the very inception of a project, in the early decisions that are taken by developers and investors, and as a consequence of traditional cultural attitudes surrounding the current building procurement and delivery process in Australia.

An improved process and a new way of thinking will challenge many prevailing assumptions and building practices. However, the incorporation of environmental criteria, including the sustainable use of resources, energy efficiency and air quality, into the design and procurement process, can deliver better buildings in which traditional criteria of cost, functionality and aesthetics are also met.

A New Way of Thinking

An improved process for design and procurement is required to enable the establishment of common attitudes and approaches. Figure 1 shows a combined team organisation and tasks required. The "improved process" elements are shown shaded. These may be grouped as follows:

- Definition of environmental goals and an environmental rating level sought. These may involve generic items of energy and water efficiency but are more effective if direct reference is made to a specific document and the target rating level. It could mean a simple statement that a building is to achieve a gold medal under a particular rating system or achieve a particular energy rating. Financial goals also need to be included so that sustainability strategies are not eliminated subsequently by financial constraints.
- Value management supported by financial modeling using life-cycle costing and any tax incentives available. Essential to the value management is agreed evaluation criteria and direct involvement of the Client in Value Management Workshops.
- A possible performance contract which provides additional incentive for the design team to meet the environmental goals. This could involve an increase in the overall team fees tied to achieving the required result and a penalty for failure below a defined level. This concept could be extended to cover the demonstrated performance by contractors and suppliers or in the case of a design and construct ownership development, a rent increase incentive for meeting or bettering a defined energy rating for the project. Users and occupants need education as part of this process.
- Inclusion of a "sustainability facilitator" who acts as an ombudsman to guide the sustainability thinking and advancement of initiatives and ensures consistent application of goals and evaluation criteria.
- A true teaming approach where all are considered partners to determine and achieve goals and where integrity, professionalism and appropriate innovation are fostered and rewarded.
- The use of guidelines and tools such as standards and benchmarks, a sustainable specification and computer-based simulation studies.
- Access to new products and materials including developing technologies – **leading edge and not bleeding edge.**

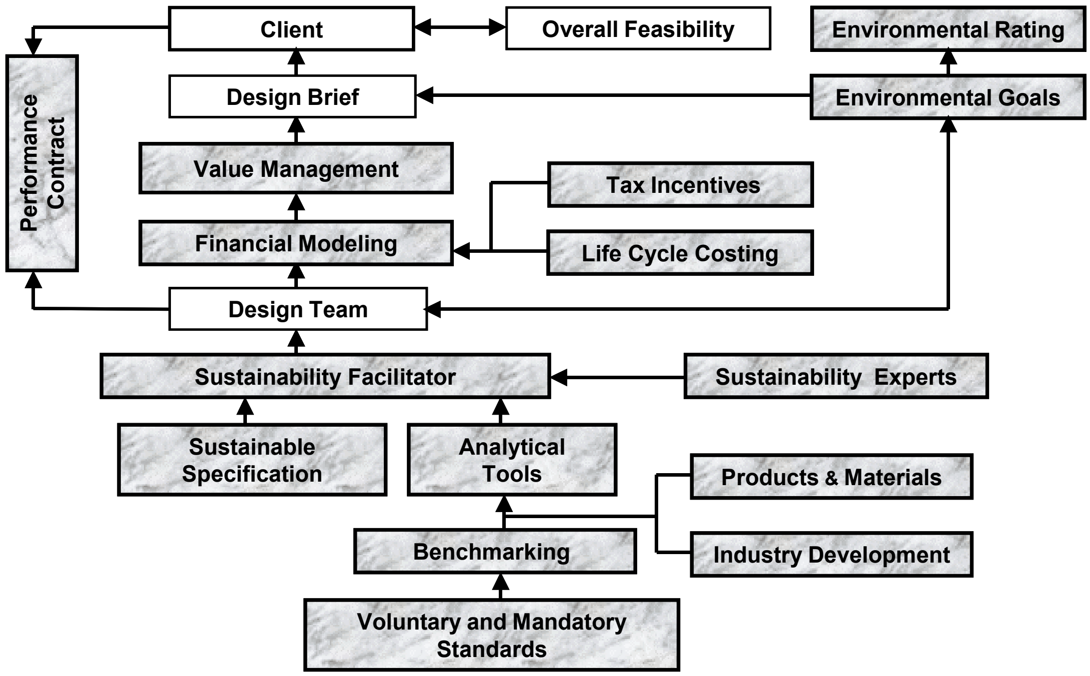

Figure 1. Team Organisation and Tasks for an Improved Process

Life-cycle Costing

Financial modeling approaches and the associated commercial mechanisms need to be integrated as part of the improved building design and procurement processes. Over a 30-year period the total of all expenditures associated with the life of a building, typically include 2 per cent for design and construction, 6 per cent for operations and maintenance and 92 per cent for occupant costs.

In order to optimise the life-cycle building performance and economic return it is necessary to use effective financial modeling and at the same time to ensure that the building project team understands the type and relevance of the inputs to this. A wide range of computer packages has been developed to analyse whole systems and individual components. They typically consider the following factors over the life of a project:

- financing costs
- tax implications
- energy costs
- replacement costs and intervals
- operation and maintenance costs
- opportunity costs for money (discount rates)
- the impact of inflation
- non-energy benefits (such as improved occupant productivity and tenant retention).

The models produce 'bottom-line' economic parameters as well as year-by-year cash flow analysis, including:

- net present value of life cycle costs and savings
- savings to investment ratio
- adjusted internal rate of return
- net cash flow annually
- annual gross profit and annual net income
- project value.

Other factors of importance include:

- productivity improvement rate
- salary costs
- time on the market
- capitalisation rate
- average lease and average occupancy rates.

Because of uncertainties that exist regarding time impacts, some models automatically perform sensitivity analysis to show upper and lower limits of results.

An important outcome of improved financial modeling is the effect that it has on the long term value of buildings. Further research is needed in this area. A major barrier to the inclusion of energy efficiency strategies is the continuing constrained focus on construction cost impacts. Take-up of energy efficient strategies is also limited by a marketplace which does not recognise the financial benefits of an energy efficient building with its consequent improvements in the quality of the workplace and higher occupant productivity. It is important for owners, property consultants and valuers to understand the improved process and to look realistically at building values.

Workplace Comfort Impacts

Productivity studies have been conducted since 1992 on buildings in the United Kingdom [1], Europe and Australia. The studies have been directed at determining a relationship between workplace comfort and productivity. The buildings studied include both "new-age" buildings with sustainable features and conventional buildings built with standards typical in the 1980's. Productivity levels fluctuated up to around 12% above and below a statistical average with "new-age" buildings being generally at the high end of comfort and productivity. Figure 2. shows the typical relationship.

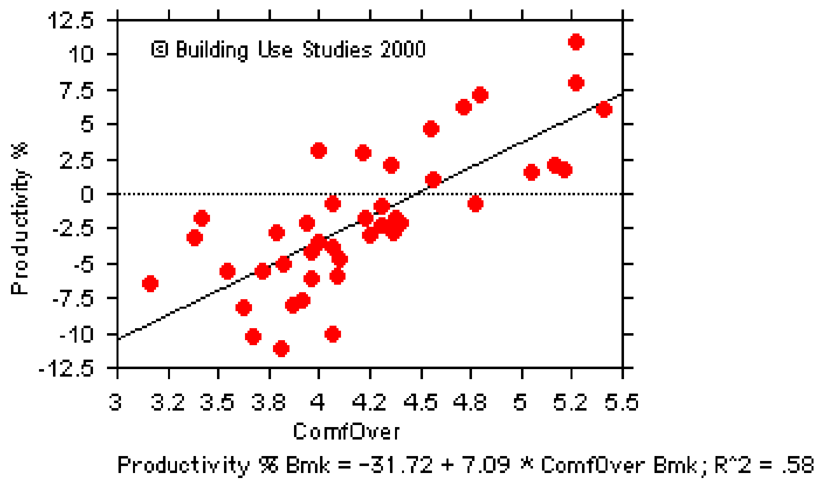

Figure 2. Typical Relationship between Comfort and Productivity.

The indicated productivity increase is consistent with data obtained by BOMA International in studies in the United States [2]. Evaluation factors of image, after-hours access, business location and user location showed high levels of satisfaction whereas factors relating to "comfort" showed significant scope for improvement – 20% for temperature, 13% for indoor air quality and 28% for the opportunity for user intervention with comfort controls.

Extending the comfort/productivity relationship to financial impacts shows an important comparison with energy cost savings. Using a typical effective Australian energy cost of 10 cents per kilowatt hour it is concluded that a 50% reduction in office building energy consumption from 200 kilowatt hours per square metre per annum yields $10 per square metre per annum. By contrast, a conservative 1% productivity increase for an occupant with an annual aggregate salary of $100,000 and occupying a floor space of 20 square metres yields a saving of $50 per square metre per annum. This fivefold improvement becomes a strategy driver for sustainable energy efficiency initiatives.

A comfort analysis is now an essential component of the sustainable design process. Typical elements of such an analysis are:

- criteria for light levels, glare and the appropriate mix of ambient and task lighting
- analysis of daylighting opportunity and applicable ambient light levels
- analysis of façade shading and glazing options
- analysis of the indoor environment including heat transmission and radiant heat from facades and the impacts of air velocity and movement
- analysis of the opportunity for natural ventilation
- determination of occupant intervention opportunities for both visual and thermal comfort systems
- determination of the impacts of intervention on the Building Management System.

The comfort analysis can be supported beneficially by a comfort workshop which could be held with either management or occupants generally or both. The outputs from the comfort analysis can then be used to assist in the establishment of sustainable building initiatives.

Sustainable Building Initiatives

Many individuals and organisations have developed sustainable building strategies. Application of these is dependent on both climate and cost relativities between one location and another. A useful checklist and Technical Manual has been developed by the US Green Building Council [3]. Produced in conjunction with Public Technologies, Inc. and the Department of Energy, this manual provides a blueprint for green buildings from site selection through operations and maintenance. Several companies, state and local governments and federal agencies have used the manual as the basis for their own green building guidelines. Key elements of this include:

- site and landscape strategies for utilising the natural environment, maximising landscaping and vegetation, minimising outdoor water consumption and maximising re-use of stormwater
- transportation strategies which reduce dependence on motor vehicles
- building forms which utilise the natural environment – solar, wind and light
- reduction of building energy demand
- comprehensive waste management strategies
- reduction of lifetime material consumption, sources of indoor pollution and adaptive reuse of materials
- optimisation of all building services, HVAC and electrical systems
- indoor water minimisation and management strategies
- incorporation of appropriate renewable energy systems for both energy and heating
- direct digital controlled Building Management Systems.

All initiatives must be subject to options analysis, evaluation using consistent criteria and value management by all members of the design team including the Client and if possible, future building facilities managers and occupants. The final test for agreed initiatives should be an informal or formal environmental rating using one of the acknowledged schemes.

Environmental Rating Schemes

Numerous schemes for environmental and/or sustainability rating have been devised and adopted around the World. Environment Australia is currently developing the National Australian Building Environment Rating Scheme (NABERS). The US Green Building Council has developed its scheme referred to as Leadership in Energy and Environmental Design (LEED). The Green Building Rating System Version 2.0 [4] was published in March 2000 and has received extensive support both in the United States and around the World. The strength of LEED is that it is supported by the US Green Building Council which has over 1,500 members. LEED is relatively simple and direct and requires accreditation by assessors. Its key elements are shown in Figure 3. The two elements of Energy and Atmosphere and Indoor Environmental Quality constitute 46.5% of the total, stressing the importance of initiatives in site energy generation and basic building services of HVAC and lighting.

Key Elements	% of Total Rating
Sustainable Site	20.3
Water Efficiency	7.2
Energy and Atmosphere	**24.7**
Materials and Resources	18.8
Indoor Environmental Quality	**21.8**
Innovation and Process	7.2
TOTAL	**100.0**

Figure 3. LEED Green Building Rating Scheme Integrated Design Process

There is also a LEED for Existing Buildings which was issued for pilot criteria testing in January 2002. It provides a set of performance standards for the sustainable operation of existing buildings. The criteria cover building operations and systems upgrades or retrofitting in existing buildings where the majority of interior or exterior surfaces remain unchanged. A LEED Rating Scheme for Residential Buildings is also under development.

The Challenge of the Energy Neutral Building

The concept of energy neutral buildings has emerged as an affordable strategy for greenhouse gas abatement in both new buildings and retrofitting of existing buildings. It is proposed that the **"new age" buildings will not only save energy, they will harvest it.** Furthermore, the cost of energy neutral buildings is a relatively small part of the overall developed cost of buildings. The Institution of Engineers Australia in its recent publication "Sustainable Energy Innovation in the Commercial Buildings Sector" [5] proposes a move to energy neutral buildings as an achievable strategy to meet the challenge of greenhouse gas emission reduction.

Step 1 involves using international best practice and delivery methods to reduce energy consumption by up to 70% compared to traditional buildings.

Step 2 involves the introduction of low greenhouse gas fuels for embedded energy systems such as microturbines and fuel cells.

Step 3 involves matching the greenhouse gas emissions with the introduction of renewable energy systems such as photovoltaic cells and wind turbines.

Step 4 is to maintain the indoor environmental quality of air, lighting and noise transmission together with visual appeal of the building and its finishes.

Step 5 is to introduce direct digital controlled energy management systems and to provide for biennial energy performance audits.

Embodied energy is to be considered but treated separately from the **operational energy strategies.**

CSIRO Energy Centre – Energy Neutral Building Case Study

The new CSIRO Energy Centre currently under construction at the Steel River eco-industrial Park near Newcastle, NSW will be an outstanding demonstration of passive and active energy initiatives uniquely integrated into the building fabric of this research facility. The Centre comprises a range of building types, offices, laboratories, process bays, auditorium and plant areas, each one specifically designed to respond to the user's functional requirements and the most appropriate and effective energy saving and energy generating systems. The total building area is approximately 9,500 square meters. The significant features of the Centre are:

1. It is thought to be the first facility in Australia which may be described as "energy neutral" – that is after reducing energy demand by around 40% it provides "transitional energy systems" fuelled by natural gas and compensates for the Greenhouse Gas Emissions produced by utilising an equivalent amount of true Green Energy in the form of solar and wind technologies. Overall CO2 emission reduction (excluding the impact of Process Bays and their process equipment) is about 70% compared to a conventional building development. See Figure 4. below.
2. The project incorporates a custom designed Energy Management System which enables multiple sources of site generated energy to be exported to the Grid. The System is linked to the Building Management System enabling total building management of power and heating needs to be related to site energy generation and with localised public display and world-wide web enabling access.
3. The project utilises three photovoltaic cell technologies (each readily available from Australian suppliers) to demonstrate the efficiency and behaviour on various orientations and tilt angles. Total installed capacity will be 90 kW generating around 220,000 kWh per year.
4. The project will utilise a mixture of small and medium sized wind turbines which will demonstrate energy production from a relatively low-capture site and with the turbines forming part of the building area where minimising turbulence effects has been a major consideration. Turbines will have relatively low levels of noise from the latest designs of rotor blades. Total installed capacity will be 160 kW generating around 180,000 kWh per year.
5. Microturbines using natural gas as a fuel are utilised as the first component of the transitional energy systems with heat recovered and used for domestic hot water and building heating. Total installed capacity will be 150 kW generating 500,000 kWh of electricity per year.
6. Provision has been made for incorporating small hydrogen-fired fuel cells as part of the site energy generation system. These should be available by the completion of the building construction stage. They will use natural gas as the initial fuel and will demonstrate the next generation of transitional energy systems which are also being utilised in new-age motor vehicles. Total future installed capacity will be 100 kW generating around 850,000 kWh per year.
7. The total capacity of site generated energy will be 400 kW increasing to 500 kW after fuel cells are installed. Annual generated electricity will be 900,000 kWh per year excluding the fuel cells.

8. CSIRO will also utilise its own storage battery technologies with around 1,000 kWh of energy storage connected to the site generation system.
9. The buildings also feature many energy conservation initiatives such as natural daylighting from façade-integrated light shelves, opportunity for natural ventilation of offices and stair wells, a healthy and energy-efficient underfloor air-conditioning system for the offices, energy-efficient light fittings and lighting controls.

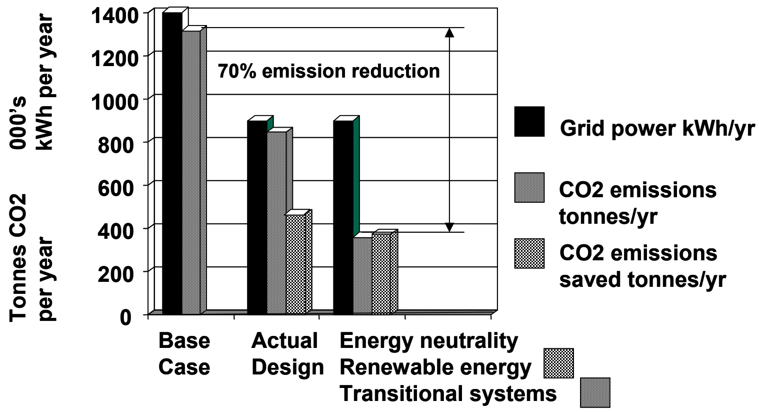

Figure 4. CSIRO Energy Centre Newcastle. Energy Neutrality excluding Fuel Cells.

Conclusions and Recommendations

1. Sustainable building can be achieved when using a new way of thinking and an improved process for design and management which involves early team formation, definition of team responsibilities, holistic design, establishment of goals and evaluation criteria and use of life-cycle costing and value management.
2. In order to optimise the life cycle building performance and economic return it is necessary to use effective financial modeling and at the same time to ensure that the building project team understands the type and relevance of the inputs to this.
3. Comfort analysis is an imperative part of design since thermal and visual comfort can be improved significantly by adopting energy efficiency strategies. The real benefit then is increased productivity as a by-product of energy efficient design.
4. Sustainable design initiatives can be considered methodically by reference to one or other of the "checklists" and Rating Schemes which are available. The US Green Building Council provides a useful checklist and LEED Rating System for both new and existing buildings.
5. The Institution of Engineers Australia recommends a move towards "energy neutral" buildings to meet the serious pressure for reduction in greenhouse gas emissions. Transitional energy systems using natural gas as a fuel are an important strategy in achieving energy neutrality.
6. The Institution of Engineers Australia and its members should support the formation of an Australian Green Building Council which will provide a well-informed and comprehensive focus on processes and strategies for achieving the delivery of sustainable buildings.

Acknowledgement

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