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A PARTICIPATORY APPROACH TO ENERGY EFFICIENT DESIGN

David Oppenheim

This note, DES 1, originally published in May 1995, was reviewed by David Oppenheim in August 2000. The information herein is considered contemporary and relevant.

SUMMARY OF

ACTIONS TOWARDS SUSTAINABLE OUTCOMES

Environmental Issues/Principal Impacts

- Very early decisions in the design process often have the greatest impact on the reduction of greenhouse gases.
- Energy issues need to be treated as often, and evaluated in the same way, as monetary issues, to minimise overall costs and energy use.

Basic Strategies

In many design situations, boundaries and constraints limit the application of cutting EDGe actions. In these circumstances, designers should at least consider the following:

To maximise the benefits of a participatory approach to energy efficient design, five key strategies should be followed:

- inclusion of energy adviser in the design team
- use of participatory design approach
- use of life cycle energy and monetary analysis
- project team consisting of all stakeholders; and
- use of energy targets.

Cutting EDGe Strategies

- Use zero resources charette at beginning of project.
- Energy adviser, and advice, would cost in the region of $2,000 for smaller jobs and between $10,000 - $15,000 for larger projects, and typically less than 1% of the cost of the works.
- Whenever a cost or budget decision is required, an energy decision is also required.

Synergies and References

- *BDP Environment Design Guide*: GEN 2; GEN 23; DES 2; DES 5; DES 7; DES 34; PRO 2; PRO 3
- Brown, AM, Fricker, JM and McKenzie, AR, 1986, *Reasonable Targets for Low Energy Building Design and Operation*, Australian Institute of Refrigeration, Air Conditioning and Heating, Sydney
- Property Council of Australia, 1994, *The 1994 BOMA Energy Guidelines*, PCA
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A PARTICIPATORY APPROACH TO ENERGY EFFICIENT DESIGN

David Oppenheim

A small 1500 m² net lettable area two storey energy efficient office building was designed using a Participatory Design Approach. Ecologically sustainable design is a multi-disciplinary task at all stages, and this design strategy was chosen because it best suited the problem to be solved, and ensured that energy efficiency was integrated from the beginning of the project. This case study describes this design method, the project team, the use of energy targets and computer modelling.

1.0 INTRODUCTION

Appropriately creating and managing the project team can contribute to the energy efficiency of a building. Building design involves many competing issues, and the process detailed below gives an example of how these competing issues can be resolved to maximise the energy efficiency for a building. The following four elements are central to this approach:

- *an energy specialist* (i.e. architect or engineer) is required on the project team to provide energy advice, computer modelling skills for energy, and up-to-date knowledge of energy efficient plant and equipment (this advice may be provided by an in-house team member);
- a *Participatory Design Approach* (see section 3.0) is used so that competing issues can be successfully and quickly resolved;
- *Life cycle energy and monetary analysis* is essential so that embodied energy, operating energy, capital monetary cost and the energy cost of operation for various design options can be properly evaluated; and
- the *project team* should consist of all stakeholders, including the client, the architect, consulting engineers (structural, mechanical, electrical, civil, hydraulic, etc.), cost consultant, energy specialists, letting agents, builders, etc.; and, design decisions should involve the whole project team (final recommendations are made by the architect and these are then presented to the client for approval).

1.1 Building Types

While this Note refers to a non-residential project, the same principles can be applied to residential projects. The team will be smaller, and will probably consist of the client(s), the architect, the builder, and the energy specialist if the architect does not have those skills. The Participatory Design Approach process will also be simpler due to the smaller number of issues to be considered.

1.2 Sole Practitioners

This participatory design approach can be applied to a practice of any size, including the sole practitioner. The time involvement may be increased because of the need for meetings involving the whole project team, but this time increase may be offset by decisions being made more quickly, and not being rescinded at a later date.

1.3 Type of Client

Clients may well be unaware of this team approach, and the benefits it brings. It does require more involvement by the client, and should be discussed with them. The approach, however, is suitable for all types of clients ranging from individuals to large corporations. It is essential that the client or the client's representative has the authority to make decisions, and that they can be involved throughout the process of design, documentation and construction.

1.4 The Team Approach

The Participatory Design Approach described here was chosen because it emphasises a co-operative design strategy rather than an adversarial one. Ecologically sustainable design is a multi-disciplinary task at all stages, and this design strategy was chosen because it best suited the problems to be solved.

2.0 PROJECT TEAM

2.1 Establishing the Project Team

The project team was established at the very beginning of the project, before any design work was done. It consisted of all members of the team, not just those who appeared to be appropriate at the beginning (see section 2.2). This was necessary to ensure that there were no preconceived design decisions that could adversely affect the energy performance of the building. The form of the building was not known before the first team meeting, and developed as a result of the team's discussions.

2.2 Members of the Project Team

The project team consisted of all the stakeholders in the process. In addition to traditional members (client, architect, structural engineer, services engineers, quantity surveyor, end user/tenant - who was the client), non-traditional members

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were also included (limited in this case to the energy specialist). It would have been preferable to have the developer, builder and letting agent involved, but these were not known at this stage. However, the range of team members ensured the decisions were informed by a diverse range of pertinent ideas.

The architect was responsible for the overall vision for the project and chaired the meetings, setting the agenda and directing the team. Minutes were kept of these meetings.

2.3 Fees

For this project, consultants charged their standard fees with no additional costs except for travel. The only exceptional fee was that of the energy specialist, who is not normally included in the project team. The fee for this service was less than 1% of the cost of the works. The annual energy operating costs of a normal project of this size may be in the order of 8-10% of the capital cost. As the energy specialist's involvement may result in savings to the energy operating costs of up to 50%, the simple payback period for this fee may be as little as 3 months.

2.4 Effective Communication Between Members of the Project Team

The communication used in the design process was an *inclusive* rather than an *exclusive* process. Instead of project team members defending their specialist territory, the decision making process was an open one where all considerations were respected and aired. This was achieved in several ways. The attitude of the client and the architect established the tone of the communication. The architect was aware of the interactions between the project team members, and ensured that an open form of communication was maintained.

2.5 Written Statements on Goals and Decisions of the Project Team

Note taking and production of minutes was essential to record decisions and the events leading up to them. Energy goals were set and recorded. This ensured that previous work was not revisited unnecessarily, and that commitment to a goal or decision was recorded by all members of the project team.

3.0 DESIGN PROCESS

The use of a *Participatory Design Approach* was central to establishing an effective design process. For this project, the *Participatory Design Approach* meeting occurred twice over about half a day each, and all members of the project team were present. The various stages of the approach used are outlined below.

3.1 Gathering Data

The data gathered at the beginning of the project was the usual material (site information, site services, client brief, etc.), as well as a new set of data (energy tariffs, energy rebates if available, energy efficient design approaches, recent case studies of low-energy buildings, acceptable payback periods for capital investment used to reduce running costs, etc.). Generally, service engineers, energy specialists and quantity surveyors will have access to this latter data.

3.2 Energy Auditing

An energy audit of the existing premises occupied by the client was conducted and revealed energy patterns that could be addressed in the design process for the new building. The cost of the audit was approximately 5% of the annual energy bill, and this is typical.

If a project is a refurbishment of an existing building, an energy audit will be useful to determine current energy patterns and to make recommendations that can be included in the refurbishment. Recommendations usually fall into two categories. Firstly, for *immediate or short term payback periods* that have paybacks usually of less than one year, strategies include calibration of controls, reducing excessive light levels, changing tariffs and reducing equipment running hours. Secondly, for *medium/long term payback periods* that involve capital expenditure, strategies include energy recovery equipment, solar film on windows, upgrading control systems, etc.

3.3 Defining a Base Case Building

A *base case building* was identified and used as a basis for comparison throughout the design process. A *base case building* is a hypothetical building of the same use as the proposed building. From existing data, a profile of the energy used in the sample building is derived and applied as a basis of comparison with the required energy performance of the proposed building. This energy use is broken down into various components. It can be modified by an energy audit of existing premises (if applicable), or other circumstances, as recommended by the energy specialist. The table below shows typical values of a base case office building for Melbourne. Values for other building types are given in section 4.0.

Table 1: Energy consumption for a Melbourne office building with energy efficient elements

	MJ/m^2.year
Air-conditioning	
Fans	40-60
Refrigeration	35-60
Heating	100-300
Hot water service	5-10
Lifts	25-40
Public lighting and general power	25-70
Office lighting	125-175
Office power	20-100

Source: Energy Victoria 1994, *Energy Efficient Commercial Buildings - Design Guidelines and Case Studies*, Energy Victoria, Melbourne, p. 50.

3.4 Selecting a Computer Model to Evaluate Design Options

The energy specialist recommended a computer model that was used to evaluate the operating energy aspects of the building design. The computer model used was BUNYIP. Computer models for thermal simulations currently available in Australia include BUNYIP, Cheetah, DOE 2, ESPII, CARRIER E20, and TRACE 600. There are no combined lighting and thermal programs available, though these are being developed. Typically, for a 5,000m^2 office building the cost for using such an energy model is about $5,000. This cost is made up of two parts. Firstly, about half the cost is involved in inputting the data that describes the building. The remaining cost is taken up by computer runs that evaluate options. Each run typically costs about $200 - $400, depending on the variations required to the original building. These costs either can be deducted from the mechanical and electrical consulting fees, or paid for by the client, or an arrangement that falls between these two options.

3.5 Meeting 1: Establish Initial Design

The first meeting in the Participatory Design Approach occurred before any design work was done. Participants were required to come to the meeting having completed the necessary research for their particular discipline (i.e. architect to have client brief, site details, etc.; energy specialist to have energy targets; mechanical engineer to have energy efficient design options; etc.).

Prior to the meeting, an agenda was circulated with an attachment of notes prepared by each team member relevant to the project.

This meeting lasted for a little over half a day and was attended by the whole project team. The members of the team consisted of those people who were actually working on the project (i.e. where a partner of a firm attended and then handed the work over to an employee, this employee also attended). Interruptions and outside communication were avoided.

The aim of this first meeting was to design a 'zero fossil fuel energy building' - to move the design approach to the far end of acceptable wisdom, and evaluate previously untrialled, and unknown, solutions.

The design of this 'zero fossil fuel energy building' evolved from the input of all team members. Building fabric capital and running costs were balanced against service design capital and running costs. The building footprint was balanced against lettability of the resultant space. Window/ wall ratios were evaluated against client perceptions of image. Some of this work was done in an outline form at the meeting, and refined over time after the meeting.

This meeting ended when a preliminary schematic design was arrived at, along with an attachment called *Outstanding Issues*, which listed items that required evaluation and costing in greater detail.

The minutes taken of this meeting, along with the preliminary schematic design and the *Outstanding Issues*, were circulated to each team member for further work as noted in the minutes.

3.6 Evaluating Energy Decisions in *Outstanding Issues*

The list of items identified in the *Outstanding Issues* were processed by the team members and a corresponding list of solutions developed. The energy specialist undertook evaluations of the various options. The quantity surveyor costed them. The combined analysis of these evaluations and costings resulted in the development of payback periods for the various options. These results were then minuted and circulated to all team members.

3.7 Meeting 2: Confirm Revised Design

The second meeting evaluated the options, developed by the energy specialist (see section 3.6), and set out to design the lowest energy use building that would be acceptable to the marketplace. The project team arrived at a preferred design using the most appropriate option. The client was present at the meeting and therefore confirmed the preferred design. If the client had required additional time to confirm the design, this could have been given. However, it is preferred that confirmation is given at the meeting.

3.8 Documenting the Preferred Design

The architect and associated engineers then documented this preferred design, with details of both capital cost and running cost prepared by the quantity surveyor and the energy specialist respectively.

The cost details will form the basis of the energy part of the schematic design report to the client. Signing off of the energy part of the schematic report can be done at this stage.

3.9 Reviewing Energy Decisions Throughout Documentation and Construction

Throughout the design development, documentation and construction process, the findings documented in the schematic design report were adhered to, thus ensuring that the energy efficiency of the original design was not compromised. If major redesign were necessary, it should be evaluated by both the energy specialist and the quantity surveyor to ensure that the correct energy decision is made.

3.10 Commissioning

Particular attention was paid to the commissioning of plant and equipment. Commissioning is often done in a hurry at the end of a project, in order to facilitate the occupation of the building at the earliest possible time. Energy audits have revealed that poor energy performance can be directly related to incorrect commissioning. It is important that effective commissioning be undertaken by the mechanical subcontractor, under the contract administration of the mechanical engineer. The contractual responsibility rests with the mechanical subcontractor. However, it may well be prudent to employ the energy specialist to act as an energy 'clerk of works' on behalf of the proprietor to ensure that commissioning has been correctly completed. If deficiencies exist, these can be brought to the attention of the mechanical engineer who would then instruct the mechanical contractor.

3.11 User Manual

The project team prepared a user manual that describes, among other items, the energy efficient features of the building, and how to maintain them.

3.12 On-Going Monitoring During Life of Building

The services design and control system that was chosen has the ability to monitor the on-going energy performance of the building. The energy performance of the equipment is being fed back to a PC that can display the energy used by each part of the system. This will quickly reveal degrading and inappropriate performance of any plant item.

This monitoring can be done in two ways. Firstly, by an in-house services engineer who is employed on the site to maintain and service the plant and equipment. Secondly, by a remote person using a modem connected to a PC. Such a remote person can be a maintenance firm or an energy specialist.

The purchase and installation of the monitoring equipment will form part of the capital cost of the building, and the ongoing cost of monitoring will form part of a maintenance agreement with the appropriately appointed person.

This ongoing energy assessment can be coupled with a Post Occupancy Evaluation to assess qualitative factors in energy use.

4.0 ENERGY AND BUILDING TYPES

Examples of energy targets are contained in both *The 1994 BOMA Energy Guidelines*, and in tables produced in 1986 by The Australian Institute of Refrigeration Air Conditioning and Heating (AIRAH).

4.1 BOMA Energy Targets

The Building Owners and Managers Association (BOMA) guidelines set out a planning process for energy management, as well as energy targets for office buildings in the eight capital cities. Figures from the BOMA table for Sydney are shown below. For full explanatory notes on the understanding and use of these targets refer to *The 1994 BOMA Energy Guidelines*.

Table 2: Typical design targets for offices, Sydney (BOMA)

	ELECTRICITY MJ/m^2.year			GAS MJ/m^2.year
Office equipment (5W/m^2)	43			
Lighting (14W/m^2)	130			
Lifts	25			
Ventilation and pumping	50			
Cooling	58			
Sub-total	306			
Heating Type	Direct	Heat Pump	Gas	
Space heating	40	11	0	53
Hot water service	7	4	0	7
TOTALS	353	321	306	60
Typical Total costs $/m^2.year	$12-$20	$11-$18	$10-$17	$0.5-$0.7
			Total	**$11-$18**

Note: 'Heating Type' refers respectively to direct resistance electric, air-to-air heat pump and heating with gas (no electric). Other systems such as water-to-air heat pumps and thermal storage require specific calculations.

Source: Building Owners and Managers Association 1994, Victorian Division, *The 1994 BOMA Energy Guidelines*, BOMA, Victoria.

Table 3: AIRAH energy targets, 1986 (all figures are MJ/m².year)

Building type	Cooling	Heating	HWS	Interior Lighting	Lifts	Ventilation and pumping
Offices	200	100	5	130	25	50
Schools	150	90	20	60		40
Hospitals	750	250	180	280	60	200
Barracks	130	150	100	80		40
Stores	150	75	10	60		30
Workshops	150	75	20	100		50
Laboratories	300	130	40	140	20	100

4.2 AIRAH Figures for Various Building Types

The AIRAH tables give a series of different energy targets for various building types for heating, cooling, hot water service, interior lighting, lifts and mechanical ventilation and pumping, and a summary is shown below. These figures need to be revised to reflect the advances made in energy efficient design since 1986, and a correlation with the 1994 BOMA figures by an energy specialist will allow this to be done.

A compilation of these figures is shown in Table 3.

5.0 SUMMARY

A team-based approach is an essential element of energy efficient design, and this approach should involve all stakeholders from the very beginning of the project. It is important to set energy targets and make the best use of computer modelling. Finally, monitoring equipment should be installed for energy consumption to be evaluated during occupation, to ensure that energy levels sought by the design team are maintained.

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FURTHER READING

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BIOGRAPHY

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