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AN INTRODUCTION TO ENERGY EFFICIENCY IN AIR CONDITIONED TROPICAL BUILDINGS

Vin Keneally

This note GEN 14, originally published in August 1997, was reviewed by Vin Keneally in June 2002. The information herein is considered contemporary and relevant.

SUMMARY OF

ACTIONS TOWARDS SUSTAINABLE OUTCOMES

Environmental Issues/Principal Impacts

- Air conditioned systems in wet tropics consume up to 70% of total energy demand.
- An increasing number of clients are briefing design teams to provide air conditioning in buildings and in many cases it is a functional or regulatory necessity.
- Energy efficient air conditioning can result in direct and in-direct greenhouse gas reductions.
- Designing for tropical regions involves additional pressures on project delivery which compete with energy efficiency objectives.

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:

- Commence strategies to improve energy efficiency at the very beginning of the design process.
- The entire building should be regarded as a system in which passive and active features interact.
- Appreciate the tropics as a unique climatic zone requiring unique design solutions.
- Key factors to consider are listed in the document.

Cutting EDGe Strategies

- Closely integrate active and passive systems to recapture control of the processes.
- Invest in improving architects understanding of technology and building science.
- Understand the application of whole of life concepts.
- Understand life cycle costs and financial parameters which affect investment in energy efficiency.

Synergies and References

- Close coordination with mechanical and electrical engineering disciplines at the commencement of the architectural design process is crucial for success
- Key information sources include government agencies in each of the main tropical cities, universities in Brisbane, Townsville and Darwin.
- *BDP Environment Design Guide* CAS 9, CAS 21, DES 36, DES 42, TEC 2, TEC 7.

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ENVIRONMENT DESIGN GUIDE

AN INTRODUCTION TO ENERGY EFFICIENCY IN AIR-CONDITIONED TROPICAL BUILDINGS

Vin Keneally

Many air-conditioned buildings in the wet tropical regions are consuming excessive amounts of high-cost electrical energy to operate mechanical cooling systems. These systems are compromised by inadequate passive building design or by inherent system inefficiencies. This Note provides a broad overview of the key factors to be considered by architects to improve the energy performance of air-conditioned tropical buildings.

1.0 INTRODUCTION

Notwithstanding the preference for naturally ventilated buildings amongst the long term acclimatised locals, the reality of architectural practice is that an increasing number of clients are briefing design teams to provide air-conditioning to meet their requirements. Government agencies occupy a significant number of buildings in tropical Australia, and many specify air-conditioning as a pre-requisite for leased offices, retail outlets, hospitals and other public buildings.

It is estimated that air-conditioning systems in the wet tropics consume up to 70% of total energy demand, due to the need to control high humidity as well as temperature. There are a number of initiatives that architects can adopt to reduce this level of energy consumption, thereby reducing the whole of life-cycle cost as well as greenhouse gas emissions.

2.0 ARCHITECTURAL PRACTICE AND ENERGY

Most architects will acknowledge a decline in the architect's role in the management and control of building design and delivery processes. There has been an emergence of specialists in almost every area of practice including Project Managers, Design Managers, Risk Managers and Value Managers. Engineering disciplines are also becoming more specialised. Despite the plethora of management and technical specialists, building projects have not become easier to design, document or administer, or the processes made more fluid. Arguably, the standards have indeed declined.

These problems are compounded in the tropical regions where demands on cost control and project delivery are underscored by lack of resources, high cost, remote location and severe climatic impact on materials availability, durability and performance. Against this background, energy efficiency often rates very low in the priority list. In the tropics, where the production and reticulation cost of electrical energy is high, the end result is usually inefficient buildings.

Understanding the client's financial objectives and desired outcomes is a critical first step towards improving energy efficiency. There is a need to gain a better appreciation of the fundamental importance (to the client) of achieving value for money, often through a formal building valuation process. Financial value is not the same as cost. For architects to make a positive contribution to the achievement of value, the financial processes involved must be clearly understood. For instance, processes such as capitalisation of income, reversionary interest, discount rates and whole of life cycle analysis. For clients (and their financiers) these are a crucial issues.

In addition, there is a need to improve technical skills in the areas of building science and services technology. The tropics are a unique climatic zone requiring unique design solutions. Education and training are critical to success.

3.0 WHEN TO CONSIDER ENERGY?

Strategies to improve energy efficiency should commence at the very beginning of the design process and continue throughout the design, construction and operation phases. Most effective results are achieved very early in the concept design phase when critical decisions (for instance, about building shape, orientation, materials, window/wall ratios and sun-shading) are being considered within the context of the functional requirements and the budget.

4.0 WHOLE OF LIFE CYCLE

Whole of life cycle (WOL) analysis is usually only applied to discrete service elements on a stand-alone basis (such as mechanical or electrical systems). It is critical that the entire building be regarded as a system in which passive and active features interact. A comprehensive understanding of WOL concepts and application is essential in order to utilise the technique as a design tool and as a means of *selling* the benefits to clients. It should be noted that there are many impediments to this approach, particularly amongst short term developers and design/construct contractors.

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5.0 KEY FACTORS TO CONSIDER

5.1 Building orientation

The impact of orientation on energy consumption needs to be considered. The building's optimum orientation is often overlooked due to competing forces, including the orientation of the land, the street frontage, optimising floor to wall ratios, views and aspect. In the tropics rectangular buildings with long elevations facing north and south are preferred so as to minimise solar heat gain.

5.2 Building shape

There is a dynamic relationship between shape and orientation. The most efficient plan shape to enclose the maximum floor area is a square, whereas a rectangle is preferred for solar control.

5.3 Windows

Windows should be designed to admit daylight, but exclude heat. The solar characteristics of the glass, such as transmittance, absorption and reflectance, should be carefully considered. Refer to DES 6.

The thermal transfer properties of the window frame and glazing systems should be verified. For instance, aluminium framing fitted with thermal bridging can assist in reducing heat transfer.

5.4 Core position

The position of service cores in multi-storey office buildings should be carefully considered as a device to minimise cooling loads on air-conditioning systems.

5.5 Sun control

In the tropics it is imperative to minimise solar access and heat gain all year round, particularly through windows, but also through facades. The preparation of a sun path analysis should be a mandatory component of the design process.

Architects should not simply rely on high performance glazing systems to achieve appropriate solar control - all windows should be shaded with the shading system carefully designed and checked for effectiveness. Care is required on *south* facing glass to exclude solar access.

It is critical to develop window/wall ratios (WWR) which respond to climate. In the wet tropics, ratios should be less than 50%.

5.6 Reflectivity and colour

As a general principle highly reflective and light coloured materials for facades and roofs are more effective than darker colours. Specialist coatings are available to improve the thermal performance of the base materials and these should be considered.

5.7 Building envelope

Thermal transfer

The building envelope needs to be considered as a total system. Care should be taken to achieve an Overall Thermal Transfer Value (OTTV) of about 45 watts/m^2 of external face area.

Insulation

Insulation of the building envelope is critical to thermal performance. The optimum level of bulk thermal insulation if R3. Facade and roof materials with inherently good insulating characteristics are preferred. Refer to PRO 8.

Vapour barrier

The vapour barrier is an important element of an air-conditioned building. The correct design, detailing and installation of a complete vapour barrier is critical to prevent condensation and damage. Long term integrity and effectiveness of the barrier are also critical.

Great care is required in detailing adequate sealing, backing supports and treatment of penetrations. Even greater care is needed to ensure that the on-site installation is complete and in accordance with the design. Paint is not an appropriate vapour barrier.

Air infiltration

Building envelope elements which are difficult to adequately seal, or rely on rubber gaskets, or which are porous should be avoided. Despite the claims of some manufacturers, many silicons, polysulphides and rubber based products deteriorate rapidly in the tropics.

6.0 MECHANICAL SERVICES

6.1 Thermal comfort conditions

There is some conjecture amongst researchers and engineers about the optimum thermal comfort conditions for tropical air-conditioning. There is a general consensus that suitable design set point conditions for wet tropical buildings are 24° + 1°C and 55 + 10% relative humidity. Refer to DES 12.

6.2 System controls

The management, control and zoning of the air-conditioning system are critical to minimise energy consumption. A flexible zoned control system to manage perimeter zones and changes in partitioning layouts is preferred.

A modern Building Management System incorporating a computer based graphical user interface can provide tight control of indoor conditions, avoid costly over-cooling, as well as log system performance and energy consumption. Optimum start and time switch controls are important.

6.3 Outdoor air

Compliance with AS 1668 imposes potentially costly requirements for outdoor air which in the wet tropics is high-temperature, high-humidity air. Careful consideration should be given to modulate outdoor air dampers to optimise energy consumption. High quality return air filtration can enable a reduction in outdoor air requirements and should be considered.

6.4 Innovative systems

Architects need to be aware that innovative systems which fall outside the mainstream of engineering design practice are being developed and applied. There is much resistance to such systems, but nevertheless innovation is constantly improving energy performance.

7.0 CONCLUSION

In many instances greater energy efficiency gains can be achieved. In order to achieve these gains there needs to be a change to the accepted way of doing things. There is a need to:

- improve architects understanding of technology and building science,
- more closely integrate active and passive systems to recapture control of the processes, and
- comprehensively upgrade skills in whole of life cycle costs and financial analysis.

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BIOGRAPHY

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