

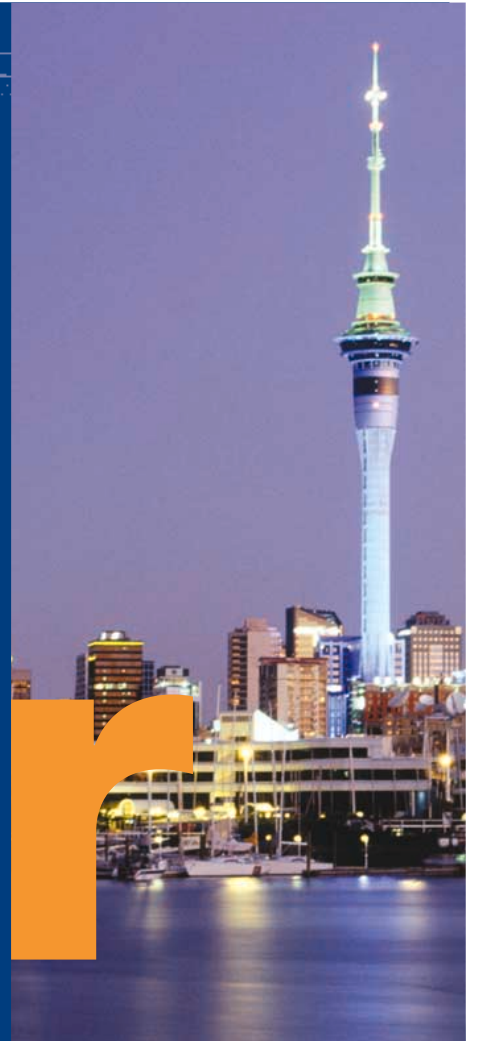
ENERGY  WISE

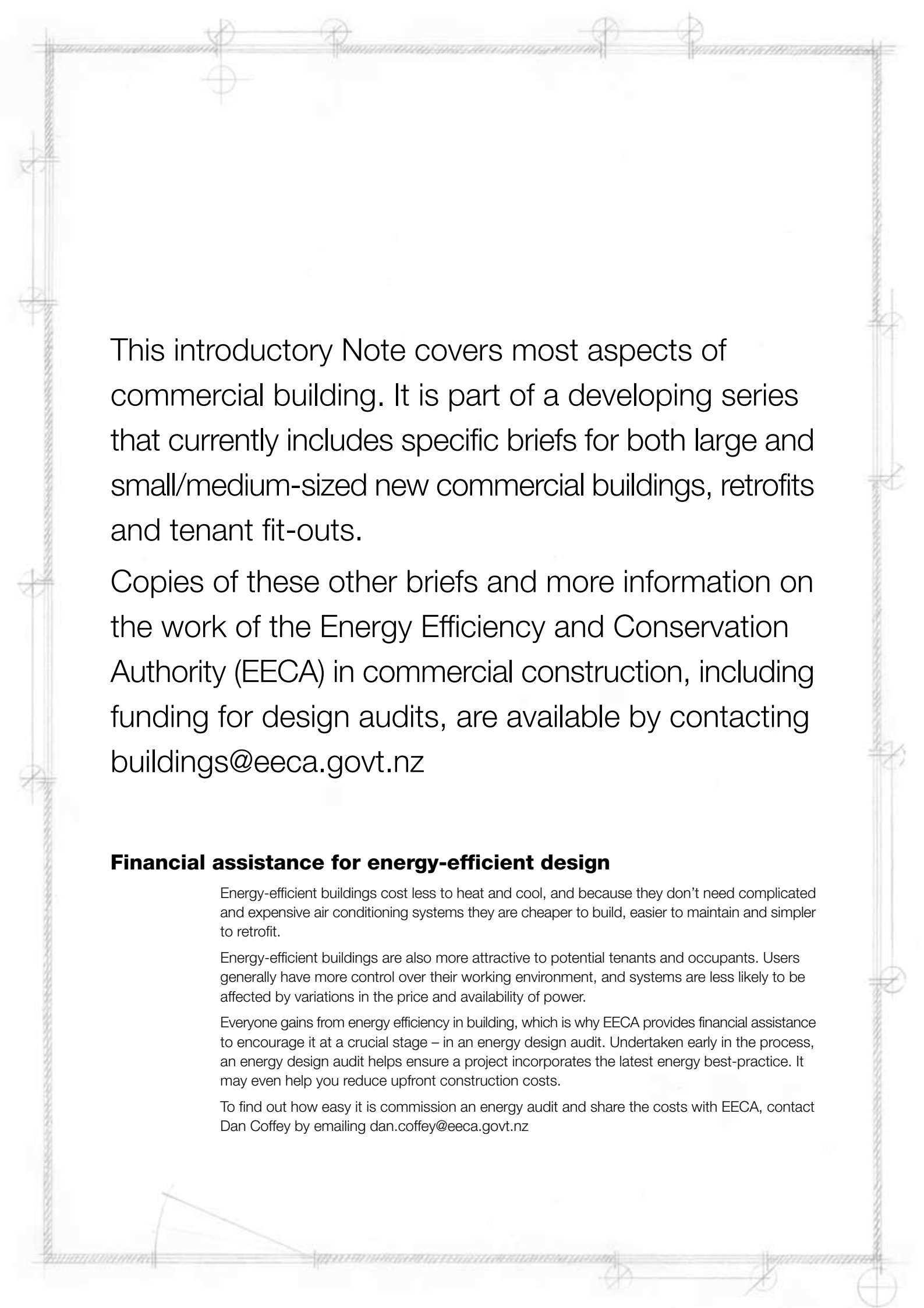
BEFORE  
THE FIRST

# pour

Energy-efficient design for commercial buildings

An introduction



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This introductory Note covers most aspects of commercial building. It is part of a developing series that currently includes specific briefs for both large and small/medium-sized new commercial buildings, retrofits and tenant fit-outs.

Copies of these other briefs and more information on the work of the Energy Efficiency and Conservation Authority (EECA) in commercial construction, including funding for design audits, are available by contacting [buildings@eeeca.govt.nz](mailto:buildings@eeeca.govt.nz)

### **Financial assistance for energy-efficient design**

Energy-efficient buildings cost less to heat and cool, and because they don't need complicated and expensive air conditioning systems they are cheaper to build, easier to maintain and simpler to retrofit.

Energy-efficient buildings are also more attractive to potential tenants and occupants. Users generally have more control over their working environment, and systems are less likely to be affected by variations in the price and availability of power.

Everyone gains from energy efficiency in building, which is why EECA provides financial assistance to encourage it at a crucial stage – in an energy design audit. Undertaken early in the process, an energy design audit helps ensure a project incorporates the latest energy best-practice. It may even help you reduce upfront construction costs.

To find out how easy it is commission an energy audit and share the costs with EECA, contact Dan Coffey by emailing [dan.coffey@eeeca.govt.nz](mailto:dan.coffey@eeeca.govt.nz)

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## Summary

# Overview

## A new context for building design

Without significant energy efficiency improvements, New Zealand's energy consumption is forecast to rise by 33% between 2001 and 2012. The costs to the economy and the impact on our rivers and lakes to resource of such an increase would be enormous.

Global warming from CO<sub>2</sub> emissions is another major issue. It has the potential to dramatically change our temperature, wind and rainfall patterns, affecting agriculture and lifestyle, and significantly raising sea levels – by up to 17cm in 2025, and up to 35cm by 2050.

These are real threats and unlike the oil shocks of the 1970's, they are permanent changes.

Efficiency is a key part of the solution. If it is not embraced voluntarily by the construction industry, further regulation is the inevitable prospect, particularly if the Government is to meet its Kyoto Protocol commitments.

Ignoring energy efficiency effectively disenfranchises the wider community and future generations from opportunities which may shape a better world.

## Energy efficiency. The new imperative

Commercial and industrial buildings account for around 8% of New Zealand's total energy consumption a year, and 5% of total CO<sub>2</sub> emissions.

Field studies have shown that energy consumption in similar buildings can vary enormously - by a factor of up to 10. They also show that construction-related issues are the single biggest contributor to the differences – as detailed in the next section.

Clearly, there is plenty of scope to significantly reduce consumption through energy-aware design. Given the issues that face our country, energy efficiency is therefore going to be a key criterion in future commercial developments.

## Construction is the key

There are three main contributors to the huge variations in building energy performance:

	<b>People</b> (use and misuse, operating and maintenance etc.)		<b>Systems</b> (lighting, air conditioning, equipment etc.)		<b>Construction</b> (orientation, form, fabric etc.)	
<b>Factor</b>	2	x	2	x	2.5	= 10

Of the three, construction is the most important factor to get right.

- The discretionary energy use of people in a building can be influenced over its lifetime by training, education and incentives
- Systems-related energy use can also be influenced by proper testing and commissioning at the start of the equipment's life, proper operation and maintenance and eventual upgrading
- However, construction related energy use tends to be embedded within the building and is difficult to influence once construction is complete

In practice it's important to consider, optimise and monitor the influence of all three factors in a holistic way.

In the past, systems design has received too much attention, with very little integration of people or construction issues. Similarly there has not been an ongoing commitment to the building and its users post-completion. This has often led to under-performance and user dissatisfaction, even on high profile building projects.

## Efficiency optimises lifetime costs

Designing energy-efficient buildings makes sense on all sorts of levels – not the least of which is the overall economics.

### Costs relative to initial construction costs over the life of a typical building

Environmental consultant fees	0.03
Professional fees	0.10
Construction costs	1.00
Energy, operating and maintenance costs	3.00
Business costs (salaries, rental/space)	200.00

As the table shows, even taken together the design fees and costs of construction are only a tiny portion of total lifetime costs of a building. Focusing on these initial costs alone will almost certainly result in a project that does not optimise its lifetime costs.

The extra cost of letting the architects and engineers think through the design thoroughly and arrive at an energy-efficient solution is an investment that will repay itself many times over the life of the building.

Business costs are by far the most significant lifetime cost of a project, and to influence them, the effect of a building on the productivity and health of its users must be taken into account.

There is a growing body of research and case history which suggests demonstrable productivity and satisfaction gains can be realised by providing better built environments.

Based on measured and anecdotal evidence, the potential gains in productivity and reduced absenteeism could be between 5-15%.

It has also been estimated that a 3% improvement in productivity could pay the full cost of a new building.

Energy-efficient design has a significant role in providing healthier, more productive environments. For example:

- External shading to lower peak cooling loads in summer also cuts down uncomfortable direct radiant gain for building occupants. Shading also means users don't need to use their blinds as much, making them feel less cut off and more in contact with the exterior environment
- Energy-efficient lighting provides better colour rendering and eliminates headache-producing flicker
- Making better use of thermal mass lowers peak cooling loads and energy requirements, and also gives occupants more and more comfortable radiant cooling.

These are just a few of the ways an energy-efficient building can improve productivity.

## Efficiency adds value

All stakeholders in the building stand to gain from more energy-efficient design.

Owners/occupiers and tenants enjoy lower operating costs, greater operational flexibility and an environment that encourages greater productivity.

These attributes all help to make the building a more marketable commodity for developers, helping them attract a suitable margin with less risk. The benefits also add to the long-term value of the asset for owners and portfolio holders.

Initially, the demand for energy efficiency will be driven by tenants and owner occupiers, who will in turn influence real estate agents, owners and developers over time.

The benefits of energy efficiency will become more obvious and more valuable as energy costs rise, employees' pressure for healthier environments increases, regulation becomes a more distinct possibility and overall environmental awareness improves.

## Before the first pour

The greatest gains in energy efficiency come from integrated building design early in the project's development – well before work on the ground begins.

Design considerations must include the building, its systems and the people that will use it.

Integrating these issues involves team work between all the design disciplines. It also requires a commitment to minimising life cycle costs for the whole building – not just minimising the capital costs for an individual component.

Integrated energy-aware design progresses from the macro to the micro, including:

- Site selection to provide favourable micro climates
- Orientation and massing to maximise the potential for natural ventilation and light while controlling summer exposure
- Internal planning to locate areas that need daylight and natural ventilation near the perimeter
- High performance facades that control summer solar gains, allow good penetration and distribution of daylight and insulate against temperature extremes
- High efficiency lighting to take advantage of lighting technology advances that now allow internal lighting loads to be dropped below 10W/m<sup>2</sup> in offices. Combined with good daylight controls this means it is possible to achieve lighting power densities of 5-7m<sup>2</sup>
- High efficiency mechanical services. Optimising external and internal loads means a much smaller - and less expensive - mechanical plant is required. This in turn frees up capital that can be used for the more expensive facades and lighting systems.

## A continuing process

Realising and maintaining energy efficiency doesn't end when construction is complete. Energy efficiency is a process of continuous improvement throughout the recurring cycle of construction, use and renewal.

## Ensuring a team focus

Designing a building project usually involves a large and diverse team. It is important to adopt a multi-disciplinary approach, integrating architectural energy efficiency aspects with systems (mechanical, electrical and hydraulic), all within the cost and project management framework of the project.

This type of approach is often constrained by the structure of the team and the influence, responsibilities and fees for each discipline.

As a result, energy efficiency opportunities are often not considered systematically and may be lost. In default, the status quo and prescriptive solutions often prevail.

Similarly, cost and time constraints often conspire against considering energy efficiency opportunities, meaning short-term needs prevail over long term benefits

One solution is to appoint a dedicated energy advisor, or to at least incorporate the role into the responsibilities of a member of the design team. Either way, it demonstrates the client's commitment to energy efficiency and ensures its systematic consideration in the building design and construction.

Assigning specific energy responsibility is particularly appropriate in large new building or retrofit projects. The appointee's responsibilities would include:

- Developing a project-specific energy brief, ideally based on one of the design briefs in this series
- Providing energy efficiency advice and promoting energy efficiency opportunities throughout the design process
- Auditing the design for energy efficiency throughout the design process. For more complex projects, this might include energy modelling and simulation

- Reviewing testing, commissioning and hand-over procedures
- Carrying out post-occupancy reviews of energy and environmental performance.

## **Involving tenants and users**

Tenants and users have relatively little say in what is provided for them in a new commercial building. Their needs are normally distilled into a basic specification and brief that represents hypothetical needs of a generic population. Tenant and end users needs should be considered more deeply to provide more healthy, productive and energy-efficient environments.

## **Committing to energy efficiency**

A start has been made with the introduction in 2000 of Approved Document, H1 – Energy Efficiency of the Building Code and the associated NZS 4243.

However, its scope is limited. It prescribes minimum standards of energy efficiency for large/commercial buildings. Simply satisfying the Code does not create an energy-efficient building. There are many other significant and financially attractive saving opportunities.

The Design Briefs in this and companion documents will provide owners, designers, tenants, project managers and developers with ideas and tools to create truly energy-efficient buildings that make sound economic sense and are attractive in the marketplace.

## **Allowances and incentives**

A tangible way to encourage energy efficiency in the design and construction of a building is to make a dedicated proportion of the budget available for cost-effective energy efficiency measures. For instance, this might be 1% of the construction cost for measures which demonstrate a payback less than four years for new build projects and 2% of the construction cost for fit-out or retrofit projects.

Another option is to incentivise – for example, to link an element of the consultants' fees to energy performance

## **Scope of Briefs**

The Design Briefs in this series cover large and small/medium new buildings, fit-outs and retrofits. In each situation, the scope for introducing energy efficiency opportunities will vary. Each project should set its own agenda and path towards energy efficiency through the process of good design.

New buildings can incorporate the full range of energy efficiency measures including buildings, systems, and people orientated opportunities.

Fit-outs and to a lesser extent retrofits can usually only incorporate more limited measures including systems and people orientated opportunities. They usually also have more limited budgets and aspirations and more extensive constraints than new build projects.

The Briefs attempt not to be too prescriptive and to view energy efficiency as just one of the outputs that should be achieved by a variety of means in a well considered new building, fit-out or retrofit design.

Attached to each brief is a specific checklist brought together from the measures in the accompanying Design Guidance Notes. Items on this list should be considered, evaluated and implemented as part of the overall design process.

The Design Briefs generally consider the following elements:

- User needs
- Energy targets
- A range of appropriate technologies and innovative design ideas
- Maximised passive environmental control, minimised complex HVAC and electric services

- Energy efficiency considered at all stages from concept to completion
- Optimising comfort and health standards
- Commissioning to appropriately specified criteria
- Training building occupiers in the correct operation of the environmental systems that have been installed.

## Setting performance targets

Establishing energy targets at the briefing stage enables the design of the building and its systems to be directed in terms of its ultimate performance and provides a basis of comparison when the building is brought into use.

Targets should be supported with regular monitoring to ensure systems perform satisfactorily, to identify options for improvement and increased efficiency and to guide maintenance in a process of continual commissioning and improvement.

Targets should be used as follows:

- Establish energy targets for the building at the design stage. Refer to existing exemplars, aiming to better their recommendations and set new standards wherever practicable. Carry out estimates or modelling of the building to assess compliance with the targets
- Consider installing the systems necessary for ongoing energy monitoring when the building is brought to use
- Monitor actual energy usage against targets and identify any anomalies and sources of excessive consumption. Take action as required.

Energy costs are generally not used as a target as they vary depending upon availability of energy sources, the providers, location and with time.

Targets will vary depending on the climatic location of the building. The zones identified in NZS 4243 provide a useful marker for the climatic variable.

Energy efficiency targets should be set higher than benchmarks achieved by existing buildings so the standard will rise over time.

The energy targets included in Section 4.5 of NZS 4220:1982 remain useful goals to aim for. As NZS 4220 notes, the limitations of an existing building restrict the energy measures that can be applied.

For fit-out targets should be limited to the on-floor services including lighting, small power, local boost air conditioning and local domestic hot water supply.

## Embodied energy

The energy content of building materials - ie. the energy used for their production, transportation, maintenance, repair, decoration and their expected life - has not been considered by any of the Design Briefs at this stage.

There is no generally accepted methodology for calculating the embodied energy of building products, so at present any values of embodied energy need to be viewed within caution. In the wider context it should be remembered that embodied energy is unlikely to be the most significant environmental effect associated with a building product.

## Incorporating energy efficiency at each stage

There are various opportunities for promoting and implementing energy efficiency measures at each stage of a project. Our Design Briefs are structured to cover these various project stages.

### Inception/pre-design

*Formulation of brief* – can include energy efficiency objectives.

*Appointment of design consultants* – could be based on energy briefs.

*Surveys and needs assessment* – can include energy efficiency.

*Business case and preliminary budgets for CAPEX (capital expenditure) and OPEX (operating expenditure)* – can include energy-efficient measures.

*Project financing* – can factor in energy-efficient measures.

## **Design**

An integrated approach to the building, its systems, design and associated operational aspects will consider various energy efficiency options against the total life cycle assessment.

By combining their ideas and using their imagination, the client and design team can become 'market makers' and leaders in creating energy-efficient buildings.

## **Guarding efficiency through the tender**

Contractors often offer cost saving options to make their tender more attractive. Energy saving initiatives are particularly vulnerable at this stage, as they're often seen by contractors as opportunities to cut capital costs.

Unless the project is significantly over-budget, energy-aware owners, developers, designers and advisors should be aware of this tendency and resist it as a short term expedient which will detract from the ultimate value of the building.

Monitoring efficiency implementation

Construction should be inspected regularly to ensure that approved energy-saving measures are being implemented and are not being prejudiced by poor construction practices.

As a guideline, the IPENZ/ACENZ documents specify appropriate levels of inspection in relation to building size and complexity.

## **Testing, commissioning and hand-over**

Proper testing and commissioning is always important in ensuring energy-efficient buildings, particularly in larger projects where there are likely to be more advanced services and relatively complex building management systems (BMS). Testing and commissioning should be carried out by suitably trained personnel, fully documented and certified as being correctly completed.

Providing proper Operating and Maintenance (O&M) instructions along with Record Drawings of the building is also important. The Contractor should supply these for the users or tenants with simple instructions for energy-efficient day-to-day operation.

## **Maintaining efficiency in tuning**

Design assumptions and control settings of energy efficiency systems will need to be fine tuned for the realities of users/tenants and climate.

After-hours or weekend inspections are a good idea, to ensure that services start and stop when required, that security and cleaning arrangements aren't affecting efficiency and that users and tenants are being responsible in terms of switching off lights and computers and setting up power saving routines.

Tenants and users will need to be educated in how to use the building's systems correctly for energy efficiency. They also need to know how to deal with problems promptly, or the systems may revert to a default setting which may not be efficient. All this should preferably involve some structured training.

In the first year's operation, energy use should be checked against targets and budgets at least monthly.

## **Defects and hand-over: the final opportunity to check**

At the end of defects/final hand-over, there should be a final inspection to identify any defective works and residual issues. A full year's operating costs should be reviewed and anomalies against targets and budgets examined and corrected.

# Energy-efficient Design Guidance Notes

These notes provide general guidance on a range of energy efficiency issues and opportunities, including:

- Siting, orientation, building form and planning
- Internal environment
- Infiltration, ventilation and air conditioning
- Lighting and daylight
- Building fabric
- Controls
- Energy sources
- Hot water supply.

Obviously, some issues apply only to new constructions, however many also apply to retrofits and fit-outs. Specific notes are available in separate Guides on large new commercial buildings, small/medium commercial buildings, retrofits and fit-outs.

The recommendations and considerations are generalised for all climate commercial office types. Obviously their application to a specific building with particular constraints may be limited.

## **Siting, orientation, building form and planning**

Climate conditions will vary from site to site. It is important to establish the local factors which may influence decision making. The client should expect this examination to include seasonal temperatures, prevalent wind direction and strength, rainfall levels and sun paths.

Clearly, on many sites and for retrofits and fit-outs, there are no options for significant repositioning of the building. However, these factors will nevertheless have an influence. Consider the following:

- Choose siting and orientation for the building to minimise energy use. Consider the effect of adjacent building and the influence of the new building on its neighbours
- Ensure positioning on site takes maximum advantage of unobstructed daylight in occupied spaces
- Consider accessibility of building to meet demands of business and staff
- Give shelter to points of entry to the building
- Consider availability of transport and energy supply services
- Consider local factors such as noise or other environmental pollutants.

At its simplest level, a building merely protects its occupants from rain and wind. At its most sophisticated, a building creates its own specific internal climate and may well alter the climate in its vicinity. Consider the following:

- Where opportunities exist, influence the local microclimate by modelling the building or the ground form or by introducing planting to give shelter from wind and driving rain
- Consider reducing solar gain by minimising reflective surfaces adjacent to buildings.

The form of the building is a significant determinant of the amount of energy used in its occupation and use. While the shape and size of any building will principally be determined by its function, the form and internal planning should be considered with a view to reducing the overall energy consumed. Decisions on built form and internal planning will revolve around ensuring that the principal occupied spaces are positioned to take advantage of daylight, natural ventilation and useful solar gain. Consider the following:

- If possible, give preference to shallower plan buildings – these have the most potential for energy efficiency. Improve deeper plan buildings with light wells, roof lights, atria or courtyards to assist in natural ventilation and lighting

- Plan glazing and sun shading to reduce overheating/cooling in summer and to reduce heating loads in winter
- Use the form of the building to modify external environment extremes. Provide protection from excessive solar gain, or from wetting by rainfall which can 'chill' the building fabric
- Minimise energy losses by planning energy sources near load centres
- Where possible allow sufficient space for relatively generous duct sizes and minimise their length by grouping similar environments.

## Internal environment

In conjunction with the Design Team the Client should determine the environmental conditions which are to be achieved in the building. The choice of temperature or lighting standards can have a significant influence on the overall energy consumption. Consider the following:

- Select appropriate temperature levels for the activity in the space
- Design naturally ventilated buildings not to exceed a dry resultant temperature of 28°C for more than 1% of the year and 25°C for more than 5% of the year. Air movement may be used to offset higher dry bulb temperatures, but the air velocity should not exceed 0.8m/s. If the moving air is cooler than the bulk air conditioned supply, air movement should be limited to 0.2m/s. For winter, design the building so it is not less than 20°C for more than 1% of the year
- Design air conditioned buildings for 22°C ± 2°C. Leave humidity uncontrolled provided it generally lies within the range 40-70% or unless dictated by a particular building process
- Establish minimum requirements for ventilation appropriate to the proposed activity. Refer to NZS 4503
- Choose appropriate lighting levels to optimise the energy required in achieving the desired visual standards. Use AS/NZS 1680 for guidance
- Determine periods when the building will only be in partial use. Ensure plant and system operation have flexibility to accommodate these
- Identify any particular activities or processes which will require specific environmental conditions, particularly cleanliness or humidity control.

## Infiltration, ventilation and air conditioning

An adequate supply of fresh air is essential for our wellbeing. Its provision is governed by the NZ Building Code Approved Document G4 and an increasing awareness of indoor air quality.

However, in the heating and cooling seasons the temperature or the ventilation air must be raised or lowered to ensure comfort. In a well insulated building the energy lost through ventilation can account for over half the total consumption. Consider the following:

- Keep ventilation rates to the minimum required to provide satisfactory environment for the occupants while removing excess moisture or pollutants. Consider partial re-circulation as appropriate, unless 'free cooling' is available and required for comfort control
- Construct a 'tight' building envelope to reduce uncontrolled infiltration losses. Detailing must ensure satisfactory fit of components while allowing for movement
- Provide adequate seals for windows and doors to minimise heat losses/gains due to uncontrolled air filtration. Locate doors in sheltered positions and provide lobbies. Alternatively, use revolving or automatic doors. Provide essential large traffic openings into the building with draught lobbies, air curtains or rapid action shutters.

Out of the heating season and particularly in summer, sufficient ventilation is required to maintain a comfortable environment and to avoid over-heating. Outside air temperatures are on the whole adequate to provide comfort conditions without the need for air conditioning, except where specific activities, processes or equipment produce an additional heat input.

Using natural ventilation to limit over-heating in summer and thus avoiding air-conditioning can give savings of initial capital, energy and maintenance costs and in certain situations, reduce the need for additional services spaces, suspended ceilings and the like.

However where air conditioning is an essential of the brief, consider the following:

- Ventilate locally to cool specific heat emitting equipment or processes to keep overall mechanical ventilation and cooling requirements to a minimum.
- Base the design on realistic criteria and avoid over-provisioning
- Minimise perimeter loads by appropriate shading and glass selection
- Zone the system for differing user requirements (eg. low occupancy, variable occupancy, out of hours use, areas of high solar radiation) and generally minimise the need for reheating the building
- Minimise lighting and small power loads by specifying energy-efficient equipment
- Choose air conditioning systems for energy efficiency and free cooling potential. 'All air' air conditioning systems offer the maximum potential for free cooling
- Consider using high thermal mass to minimise peak loads
- Base the design on realistic design criteria and avoid over-provision
- Consider using 'energy recovery' between the outside air and exhaust air streams
- Avoid using CFCs and HCFCs.

## Lighting and daylight

The energy consumed by lighting is becoming increasingly significant as other loads are reducing. Lighting is both a direct electrical load and potentially an indirect load on any air conditioning system provided. Daylight can satisfy a considerable part of the lighting demand and is generally found to be more liked by building users. Consider the following:

- Where appropriate, provide adequate glazed areas to give maximum utilisation of daylight whilst controlling unwanted solar gain
- Light landlocked areas such as internal corridors with borrowed light introduced from adjoining spaces or rooms with access to natural light
- Consider introducing light shelves, roof lights and atria to improve natural light distribution within the building
- Design lighting layouts and switching arrangements to take advantage of the available daylight without using artificial sources. Switch lighting in rows parallel to corridors. Where appropriate use local lighting in preference to overall illumination
- Consider using automatic controls for artificial lighting to reduce electricity consumption as levels of daylight rise. Alternatively arrange manual switching to achieve the same aim. Consider size of zone/group controlled by one switch and provide separate switches for individual offices
- Use internal finishes with higher surface reflectiveness to reinforce the lighting system
- Carefully consider design illuminance/uniformity and how it is achieved
- Consider high efficiency and alternative light sources with high light output ratios and high frequency or low loss control gear to achieve a lighting installation with an average power density of 12W/m<sup>2</sup>
- Label all light switches clearly. Locate them where they intuitively relate to the zone switched to minimise the likelihood of switching on non-required areas by mistake
- Use occupancy sensors in areas of infrequent use like meeting/conference rooms, storerooms, toilets etc.
- Consider locally-initiated after hours overrides and circuit lighting to provide separate levels for cleaning and after hours security

## Building fabric

Increasing the overall levels of insulation and carefully considering window wall ratios in the construction of a building are probably two of the simplest ways of reducing energy consumption. Increased insulation can also give a more even distribution of heat and cooling throughout the building and therefore better utilisation of the space. Consider the following:

- Select a structure appropriate for the intended use (thermally lightweight for intermittent use, thermally heavyweight for continuous use and air conditioned buildings)
- Exceed Building Code minimum insulation requirements. Consider insulation giving 'R' values of 3.5 for roofs, 2.0 for external walls and 2.0 for suspended/exterior floors
- Raise insulation levels evenly throughout the fabric of the building to avoid comparatively cold areas which could create local condensation problems
- In cold climates pay particular attention to the detailed assembly of components at junctions to avoid poorly insulated construction (so-called 'cold bridges'), which result in heat being rapidly lost through the fabric
- In cold climates check the build up of components and positioning of insulation in the external envelope so that it does not give rise to condensation within the fabric
- Ensure that all insulation products specified in the building are manufactured without using CFCs or HCFCs
- Avoid heat gains from, or losses to, cavities through uninsulated panels, suspended ceilings etc.
- Prevent excess infiltration and allow for thermal expansion, deterioration and distortion when detailing external joints. Where practicable, avoid materials susceptible to weathering changes
- Minimise air infiltration further by sealing off internal skins including suspended ceilings, shafts, ducts etc.
- Where practical optimise window wall ratios (WWRs). As a general guide aim for the following maximum WWRs:

North	40%
South	50%
East	30%
West	30%

- Consider double glazing for windows, particularly for continuously operated buildings, those with high WWRs and those located in cold climates
- Consider shading and high performance glazing to minimise air conditioning requirements.

## Controls

Installing adequate control systems is essential to ensure that the internal environment closely matches the client's requirements in terms of temperatures, lighting levels, ventilation and periods of occupation. Consider the following:

- Fit good thermostatic and time controls to ensure spaces are not overheated or overcooled. Enable systems to allow for fortuitous gains from people, equipment, lighting or sun penetration through areas of glazing
- Allow for a wider control band than the conventional  $\pm 1^{\circ}\text{C}$
- Install controls to allow individual occupied areas to achieve the required environmental conditions. In certain situations, consider local manual control for personnel, particularly where large spaces and low occupancy is a requirement
- Consider zoning environmental conditions to reflect different activities or orientation. Allow for current and future changes in occupancy pattern or function

- Ensure controls minimise simultaneous heating and cooling
- Control lighting to take advantage of day-lighting levels and to reflect occupancy patterns. Photoelectric controls and activity sensors are now widely available
- Organise switching to encourage lights to be turned off when not required
- Consider terminal-based demand control strategies for variable volume circuits
- Locate sensors in representative places - not in sunlight, draughts or above local sources of heat
- Use cool night air to flush or pre-purge the building on hot summer days
- Match outdoor ventilation rate to occupancy by using CO<sub>2</sub> or air quality sensing, unless free cooling benefits overall energy consumption
- Design systems to be capable of 100% recirculation during pre-occupancy periods
- Avoid dew point control
- Allow for free cooling economiser cycle (enthalpy control) where RH control is not important
- Wherever possible, link control systems to a building management system (BMS) which can automatically determine optimum control regimes for maximum energy efficiency and provide metering and monitoring of the building and its services.

## Energy sources and distribution

Efficient conversion and distribution of energy within a building is particularly important. Alternative technologies also offer the potential to use renewable sources of energy although the costs for these sources are still relatively prohibitive. Consider the following:

- Choose plant and systems which are matched to the building and that convert supplied energy to useful energy with minimum losses
- Where boilers are to be provided consider modulating burners, condensing boilers and flue gas heat recovery
- Where function or specific processes produce a surplus of heat, consider recovery systems to further reduce demand for supplied energy
- Consider use of renewable energy sources including wind, solar water heating, photovoltaics and geothermal heating/cooling. Bear in mind the capital cost of some of these may be prohibitive and others, including geothermal heating/cooling, will require resource consent for use
- Locate plant close to the centre of load
- Minimise losses from idle plant
- Match plant capacity to the range of load to maintain a high operating efficiency range. Avoid using a hot gas bypass for refrigeration compressor capacity control
- On large systems, adjust flows to match loads
- Provide sufficient instrumentation to be able to monitor operational efficiency
- Site transformer sub-stations as near to load centres as possible
- Apply diversity to the whole installation
- Design power factor to be greater than 0.95
- Where possible, arrange for load shedding to minimise maximum demands
- Minimise energy losses on long runs by laying out distribution systems by the shortest route within the building, subject to zone and control requirements. Consider variable speed motors for fans and pumps and high efficiency motor section
- Insulate pipe and duct work to AS 4508 or better.

## Domestic hot water services

Consideration of the domestic hot water services should include the following issues:

- Consider centralised versus localised hot water storage and distribution systems. Carefully consider heating/storage capacity relationship for particular usage
- Ensure local storage units are appropriately insulated to reduce standing losses and generally in accordance with NZS 4305. Units to be time-clock controlled
- Consider installing solar water heating. Refer to NZS 4614
- Minimise dead legs
- Fully insulate distribution pipework
- Consider use of low-flow fixtures, water flow restrictors and pressure reducing valves as appropriate to limit hot water demand
- Specify low-energy boiling water units, time controlled to limit hours of operation.

## Summary

Considering these issues in the early stages of a project's development is taking the first steps to an energy-efficient project which will offer a number of benefits:

- A reduction in actual running costs. The potential energy savings can be assessed using various calculation methods. Increasingly, computer modelling allows building's performance to be assessed against performance targets at the various design stages
- Improved internal environment. A reduction in heat loss/gain through the fabric of the building and fewer draughts and hot/cold spots will give fuller, more comfortable utilisation of the spaces. Maximising the use of natural daylight and ventilation provides a healthier, more acceptable visual and physical environment for the building occupants, creating a healthier and more productive working environment
- Improving building quality. Constructing energy-efficient building is demanding. Careful control of site operations and a consistent approach to quality and its management are required to meet specified requirements and ensure the building is well insulated and air tight.

Our knowledge of the way we utilise energy is constantly expanding, accelerated by the need to reduce costs and our concern for the environment. These Guidance Notes can only hope to reflect the current situation. They should be updated on a regular basis to become a living document that reflects new developments and legislation.

The issues and ideas in this document are by no means definitive. Design possibilities are limited only by our imagination.

*The 'Before the First Pour' series has been developed from design briefs produced for EECA by Roger Feasey of Opus International Ltd. and David Fullbrook of Ove Arup & Partners New Zealand Ltd.*