ENERGY WISE

BEFORE THE FIRST pour

Design guide for energy-efficient small to medium commercial buildings

These Notes bring together the knowledge of professionals in various disciplines of design and construction. You can use the text in full as a complete and self-contained design brief, or as a guide in developing your own brief.

This document on small and medium new commercial buildings is from a developing series that currently includes introductory notes and specific briefs on large 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@eeca.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@eeca.govt.nz

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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_2 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.

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_2 emissions.

Field studies have shown there can be a ten-fold difference in energy consumption between similar buildings and that construction-related issues are the single biggest contributor to the differences.

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.

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 and utilisation
- Orientation and massing
- Efficient facades
- Internal planning
- High efficiency lighting and electrical services
- High efficiency mechanical services
- Alternative energy sources.

After the hand-over

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

Large opportunities in small-medium buildings

Small to medium new commercial buildings provide considerable opportunities for introducing energy efficiency. This is because they are more likely to:

- Single or at most 2 storey
- Have a single or limited number of tenants, or be occupied by an owner/occupier
- Be outside the central business district of a large city avoiding problems of inherent market needs, noise, pollution, and site planning requirements
- Be less restricted to conformity to current institutional standards
- Be of a size and plan form which inherently encourages passive design and maximises the potential for natural ventilation and lighting
- Have greater flexibility in design terms
- Have mixed uses, eg. retail, office, residential.

Ensuring everyone is briefed

A construction project demands the skills of professionals from many disciplines. All of them should receive a Design Brief and Guidelines like those presented in this document. This will ensure they're aware of the client's desire for energy efficiency and the need to incorporate that in their offer of service.

They should be aware of the implications and how they may relate to:

- Input into capital expenditure (CAPEX) and operating expenditure (OPEX)
- Design
- Construction monitoring
- Testing and hand-over
- Building tuning
- End of defects/hand-over.

Including efficiency in the budget

Budgets for the project will need to allow for energy efficiency measures. The figures should cover design costs, capital costs and recurrent costs of energy efficiency measures, such as those identified in the Design Guidance notes and Checklist included in this brief.

Budget figures should be reviewed in term of the investment criteria set by the owner or developer, including CAPEX ceilings, and take into account the discount or interest rate for the project and any financial incentives for energy efficiency measures.

Taking opportunities in the design phase

As discussed above, there are significant opportunities to achieve energy efficiency in small to medium-sized commercial buildings. The Guidance Notes and Checklist in this brief offer some appropriate opportunities the design team should consider.

If a Design Features report is going to be prepared during the design stage, it should confirm the arrangements for energy efficiency and their economics. Alternatively, you can use the Checklist in this document to confirm which measures are to be implemented.

In bigger projects a dedicated energy advisor is appointed, or a design team member designated to champion and analyse energy efficiency opportunities as the project progresses. This may not be appropriate for a small-to-medium sized project, but you cold consider giving someone part time responsibility for the task.

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. 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 are key to achieving an energy efficient building. They 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.

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.

Design Brief Briefing Checklist

To be completed by Designer/Project manager

Building type: Large new building

Location (climatic zone):		
Energy target:		kWh/m²
Energy efficiency incentive:	☐ Yes	☐ No

Investment criteria:		
Max capital cost	$	
Max operating cost p.a.	$	
Energy	$	
Operation and maintenance	$	
Max payback period for energy efficiency measures		yrs
Discount rate to be applied		%

Design Brief Guidance Notes

The designers shall take the following considerations into account in designing the building. Any initial design report is to comment on the degree of compliance with these guidelines.

Siting, orientation, building form and planning

Key issues

- 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
- Where possible, 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
- 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.

Internal environment

Key issues

- 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 200C 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

Key issues

- 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 n sheltered positions and provide lobbies
- Ventilate locally to cool specific heat emitting equipment or processes to keep overall mechanical ventilation and cooling requirements to a minimum.

Where air conditioning is an essential part of the brief consider the following:

- 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

Key issues

- 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
- 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/m²

- 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

Key issues

- 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 or 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 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

Key issues

- Fit good thermostatic and time controls to ensure spaces are not overheated or over-cooled. 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 ± 1°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
- Design systems to be capable of 100% recirculation during pre-occupancy periods
- Allow for free cooling economiser cycle (enthalpy control) where RH control is not important.

Energy sources

Key issues

- Choose plant and systems which are matched to the building and that convert supplied energy to useful energy with minimum losses
- 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
- 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
- Provide sufficient instrumentation to be able to monitor operational efficiency
- Apply diversity to the whole installation
- Design power factor to be greater than 0.95
- Where possible, arrange for load shedding to reduce 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 motors
- Insulate pipe and duct work to AS 4508 or better.

Hot water supply

Key issues

- Review use of centralised versus localised hot water storage systems and carefully consider heating/storage capacity relationship for particular usage
- Ensure storage units are appropriately insulated to reduce standing losses and generally in accordance with NZS 4305. Units to be time-clock controlled. Electrically heated storage units should also be controlled to minimise maximum demand changes
- 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.

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.

Notes