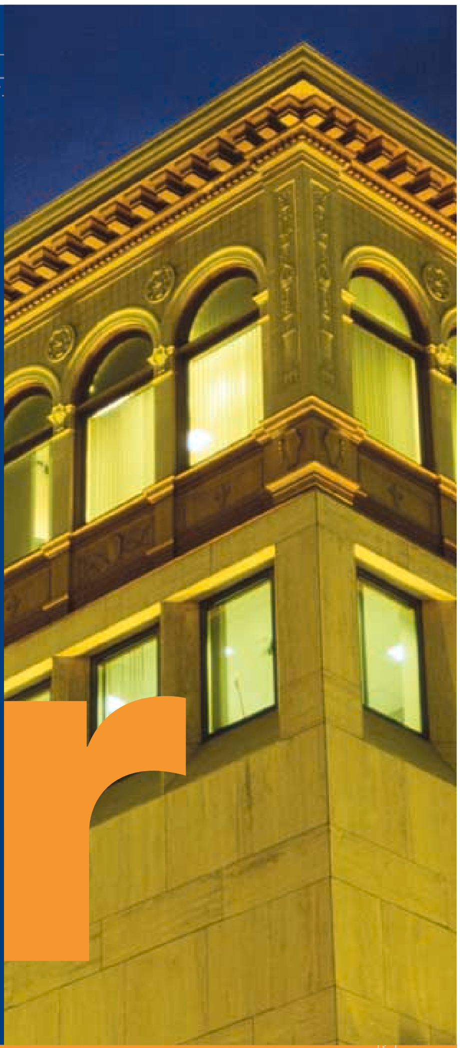
ENERGY WISE



BEFORE THE FIRST pour

Design guide for energy-efficient commercial building retrofits

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 retrofits is from a developing series that currently includes introductory notes and specific briefs on large new commercial buildings, small and medium new commercial buildings 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

Retrofitting vs. fit-outs

A retrofitting cycle usually starts with the tenanted spaces – often triggered by tenants moving in or out – then leads to central plant and equipment and ultimately to the building fabric itself. This Guide concentrates on the two latter stages. The more limited retrofitting of individual spaces has more in common with a fit-out, for which there is a separate Guide.

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.

Efficiency opportunities with retrofits

Retrofitting or modifying an existing building which has become outdated, inefficient, unreliable or out of step with market demands, is inherently energy efficient. It reuses an existing resource which has an energy component embodied, and any upgrading should offer a higher level of energy efficiency than before.

Ensuring everyone is briefed

A retrofit may involve the skill 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 owner'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:

- Surveying the building to be retrofitted
- Input into capital expenditure (CAPEX) and operating expenditure (OPEX)
- Design
- Retrofit monitoring
- Testing, commissioning and hand-over
- Building tuning
- End of defects/hand-over.

An initial survey

A detailed survey is necessary before a retrofit, covering all the building elements or particular elements, depending on the task. The survey should include:

- Record documentation including O&M documents and record drawings to obtain an overview of the building's provisions
- A physical survey of the building and of particular elements as appropriate
- Maintenance arrangements including any deferred maintenance and costs.
- The age and condition of building elements and current/future serviceability
- The currency of the building's technology
- The environment within building and comparison with appropriate benchmarks.
- Energy use and cost trends.
- The flexibility and adaptability of building and suitability to current/future market needs.

Based on the findings a survey report should be prepared based offering options for the following:

- Capabilities and limitations of existing building in relation to present/future market needs
- Extent of retrofitting required, any associated programme and staging
- Cost estimates for the works broken down into capital, operation and maintenance and energy costs together with any associated cash flow
- Indicative returns on investment as a result of the retrofitting
- Other benefits in terms of the retrofitting, eg: marketing, flexibility, improved internal environment etc.

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 developer or owner, including length of the proposed tenancy and CAPEX ceilings, and take into account their discount or interest rate and any financial incentives for energy efficiency measures.

Taking opportunities in the design stage

Energy efficiency opportunities may be more constrained for a retrofit than for a new building. However with some imagination from the client and the design team, many opportunities should be achievable and the building can be updated to become competitive again with similar but new properties.

However, the Guidance Notes and Checklist in this brief offer suggest some 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.

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 tenants 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

The retrofit 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 is always important in ensuring energy-efficient buildings. It should be carried out by suitably trained personnel, fully documented and certified as being correctly completed.

On larger retrofits a building management system (BMS) may be provided. Full point-to-point testing for correct operation and calibration, witnessed by the client's consultants, is recommended.

Providing proper Operating and Maintenance 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 occupancy.

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 staff are being responsible in terms of switching off lights and computers and setting up power saving routines.

Tenants and their staff 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, direct metered energy use and operating charges associated with the base building 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)

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		%

Energy advisors:	☐ Yes	☐ No
Scope (if required):		
Develop project specific energy brief	☐ Yes	☐ No
Provide energy efficiency advice and promote energy efficiency measures throughout the design process	☐ Yes	☐ No
Audit the design for energy efficiency throughout the design process	☐ Yes	☐ No
Provide energy modelling and simulation of the building	☐ Yes	☐ No
Review testing and commissioning, hand-over procedures and results	☐ Yes	☐ No
Carry out post-occupancy review of energy and environmental performance	☐ Yes	☐ No

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

- If not already provided give shelter to points of entry to the building
- 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

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 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

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
- 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 'energy recovery' between the outside air and exhaust air streams
- Avoid using CFCs and HCFCs.

Lighting and daylight

Key issues

- Light landlocked areas such as internal corridors with borrowed light introduced from adjoining spaces or rooms with access to natural light
- 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/m^2
- 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

- 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.
- Consider double glazing for windows, particularly for continuously operated buildings, those with high WWRs and those located in cold climates
- Where the façade is being upgraded, 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 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 ± 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
- Match outdoor ventilation rate to occupancy by using CO_2 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
- Where possible, link control systems to a building management system (BMS) which can automatically determine optimum control regimes for maximum energy efficiency and provide for metering and monitoring of the building and its services.

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
- Where new or refurbished boilers are to be provided consider modulating burners, condensing boilers and flue gas heat recovery
- 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 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 motor section
- Insulate pipe and duct work to AS 4508 or better.

Hot water supply

Key issues

- Review use of centralised versus localised hot water storage and distribution systems and 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. Electrically heated storage units should also be controlled to reduce 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.

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