ENERGY SYSTEMS, APPLIANCES AND EQUIPMENT

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SUMMARY OF

ACTIONS TOWARDS SUSTAINABLE OUTCOMES

Environmental Issues/Principal Impacts

- Systems, appliances and equipment are responsible for up to 90% of energy consumption in buildings.
- Systems and equipment interact with the building envelope and renewable energy sources (including daylight). These interactions influence comfort and amenity, energy costs and greenhouse gas emissions.
- Most systems, appliances and equipment are very inefficient, and operate at between 1 and 50% of maximum efficiency - so there are large potential savings.
- If Australia is to meet its Kyoto greenhouse obligations, selection of optimum efficiency systems, appliances and equipment for new buildings, refurbishments and replacements is extremely important.

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:

- Minimise energy supply losses and greenhouse gas emissions by sourcing electricity from co-generation, renewables or other low greenhouse impact sources, and using other fuels at maximum efficiency.
- Minimise standby energy losses, which can comprise 20 to 95% of total energy use.
- Maximise operational energy efficiency by:
  - Ensuring equipment is designed to operate efficiently at part load;
  - Ensuring all elements in each system are optimised to work together efficiently; and
  - Ensuring equipment is easily maintained and that a maintenance strategy is included in purchase, design and installation contracts.
- Clearly define the task to be carried out and estimate the minimum amount of energy needed to achieve that outcome.
- Although embodied energy is not usually the dominant factor in equipment life cycle energy use, try to minimise it through purchase of equipment with high recycled content and low embodied energy materials, and plan for re-use, recovery and recycling.
- Where equipment uses large quantities of consumable materials, such as paper, water or detergent, during operation, aim to minimise the quantities of consumables (and hence embodied energy) used.

Cutting EDGe Strategies

- Use of high efficiency equipment within energy efficient building envelopes can allow radically different, often cheaper, solutions to be found. For example, using water-efficient taps and showers allows downsizing of pipe sizes. Because efficient systems work differently from traditional ones, there are also traps for beginners, so care is essential.
- Financial analysis of energy efficient systems and equipment should take into account the indirect benefits, ranging from down-sizing of equipment to improved amenity. System packages should be evaluated for overall cost-effectiveness, as analysis of each increment of improvement leads to sub-optimal outcomes.
- Contractual arrangements should not involve payment based on a percentage of the cost of equipment, but should focus on performance. Contracts should include time for analysis, finding new products, and liaison between team members, as well as provision for monitoring outcomes.

Synergies and References

- To maximise system efficiency requires cooperative work from several fields of expertise, so look for consultants who have shown they can work well with other people, have good communication skills and are keen to learn from every experience.
- For energy efficiency, the devil *is* in the detail. While selection of appropriate technologies and systems is critical, success can be undermined by seemingly minor factors such as thermal bridging or one inefficient component.
- *BDP Environment Design Guide*: GEN 13; GEN 22; DES 7; DES 35; DES 36; DES 37; DES 38; DES 39.
- *Factor 4: Doubling wealth - halving resource use* (von Weizsacker, Lovins and Lovins, 1997) provides good examples of a systems approach to energy efficiency.

ENVIRONMENT DESIGN GUIDE

ENERGY SYSTEMS, APPLIANCES AND EQUIPMENT

Alan Pears

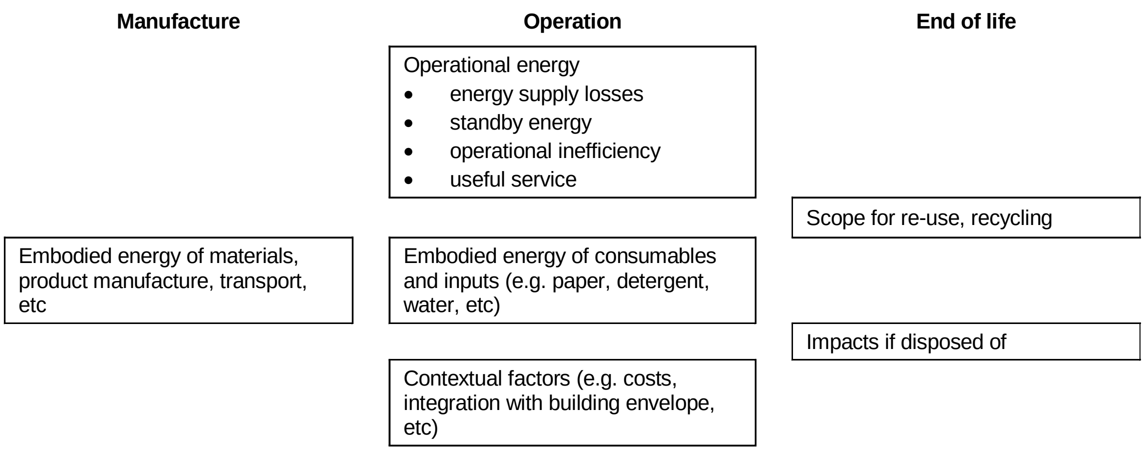
To minimise the energy use and greenhouse gas emissions from energy systems, appliances and equipment involves application of a holistic perspective that includes consideration of life cycle impacts, the context within which equipment operates, and a systems approach to optimisation of efficiency. For a building designer or project manager, achieving effective results may involve careful selection of contractors, facilitation of communication and cooperation within the project team, structuring contracts to reward smart design and improved life cycle performance, and inclusion of monitoring of performance outcomes. Attention to detail is extremely important, as a system is only as efficient and effective as its weakest link, and efficient systems often work differently from traditional systems.

1.0 INTRODUCTION

The selection and design of energy systems, appliances and equipment for buildings has a major impact on energy bills, greenhouse gas emissions, quality of service and maintainability. The basic characteristics of equipment determine, to a great extent, its energy use.

However, most designers and specifiers fail to capture the full saving potential, because they fail to apply a global perspective to the situation they face. Figure 1 shows some of the key factors that should be considered in developing solutions for tasks that involve use of appliances, equipment or systems. The following sections expand on these.

Figure 1. Major factors to be considered in developing low greenhouse impact solutions involving appliances and equipment



2.0 EMBODIED ENERGY OF EQUIPMENT

For energy-consuming appliances and equipment, embodied energy is usually less significant than operational energy, but it may dominate when equipment is energy efficient. Each kilogram of sophisticated equipment has an embodied energy content equivalent to 5 to 20 kilograms of carbon dioxide-equivalent, depending upon the mix of materials and their sources. This is equivalent to 5-20 kilowatt-hours of electricity or 0.1 to 0.3 gigajoules of natural gas. So a 40 kilogram hot water service might have an embodied energy of around 6 GJ. Typically, such an appliance would use around 20 GJ per year to provide domestic hot water. A 15 kilogram computer and monitor that uses 120 watts when operating would use the equivalent of its embodied energy in less than a year, if it operated during office hours.

On this basis, it can generally be concluded that embodied energy is not, at present, a dominant consideration in selection of appliances and equipment. Nevertheless, as equipment becomes more energy-efficient, and it utilises renewable energy for operation, the relative significance of embodied energy will increase. Useful quantities of embodied energy can be recovered if equipment is re-used or recycled, as discussed later.

Another potentially significant aspect of embodied energy, when considering energy efficiency improvement, is the potential scope for embodied energy trade-offs. For example, installation of double glazing will increase the embodied energy of a building. However, its impact on peak energy flows will allow heating and cooling equipment capacity to be reduced, thus reducing the amount of energy embodied in that equipment. In this case, the energy embodied in the double glazing is offset by reductions in the embodied energy of the HVAC equipment, as well as ongoing savings in operational energy use. It is possible to analyse the net impact of the alternative. Life cycle analysis can be used to estimate the overall impact on both operational and embodied energy of adopting different equipment options and building envelope solutions. This is discussed in more detail in DES 35.

3.0 OPERATIONAL ENERGY

Appliances and equipment are chosen to perform one or more useful functions. However, much of the energy they consume is usually wasted. The combination of various types of losses means that most systems operate within a range of 1 to 50% of their potential efficiency. So there are very large savings opportunities.

This waste occurs in four main ways:

3.1 Energy supply losses

These losses mostly occur on the supplier's side of the meter or pump. In Australia, electricity supply usually involves loss of at least two-thirds of the energy in input fuels (mostly coal) through energy losses at the power station or in transmission and distribution. Losses in supply of gas or oil are usually in the range of 5 to 15%.

Building designers and equipment specifiers can reduce energy supply losses and associated greenhouse gas emissions by:

- installing co-generation (equipment that generates electricity and utilises the waste heat for other purposes, so that overall efficiency of energy use is 60 to 80%);
- arranging to purchase electricity and/or heat from a nearby co-generation system that has excess capacity;
- using high efficiency natural gas in preference to resistive electric heating technologies. Note that electric heat pump and microwave technologies may have greenhouse gas emissions comparable to natural gas. Also, refer to the discussion later in this Note on water heating options;
- negotiating electricity supply from a retailer that purchases electricity from high efficiency suppliers, such as co-generation, hydroelectricity or combined cycle gas power stations; and
- buying *Green Power* from new, environmentally acceptable renewable electricity generators.

3.2 Standby energy losses

When equipment is not carrying out its main function, it may still use significant amounts of energy. For example, a storage hot water service that maintains a supply of hot water ready for use loses heat from its tank. An electrical appliance may consume electricity to run digital displays and keep electronic circuitry functional, even though it is not being used. Standby energy losses can exceed energy use during service delivery, especially when equipment is used infrequently.

Some manufacturers are beginning to pay more attention to standby energy losses. For example, new electric hot water services over 80 litres capacity have 30% lower heat losses due to Minimum Energy Performance Standards introduced in 1999, while some gas hot water services now have electronic ignition, instead of wasteful pilot lights. Some electronic appliances now have standby power consumption of less than one watt, compared with 5 to 50 watts for older equipment.

When specifying equipment, it is important to seek information on standby energy consumption from suppliers, especially when it may be a significant proportion of total consumption. It is possible to calculate the significance of standby energy fairly easily. For example, consider a small electric hot water service to be installed in a kitchenette. Its standby losses are estimated at 2 kilowatt-hours per day by the manufacturer. Each litre of hot water requires 0.06 kWh to heat it. So, standby losses are equivalent to using 33 litres of hot water per day - unless extra insulation is wrapped around the tank and pipework, or a unit with lower standby losses is specified.

If equipment is to be selected by contractors or sub-consultants, specify in contracts that they should investigate the levels of standby losses, and optimise the losses with other energy factors, based on likely usage patterns. It will probably be necessary to consult manufacturers to gain this information and, even then, it may not be available. But, unless people start asking for it, it will never become available!

3.3 Operational inefficiencies

Most equipment falls far short of ideal efficiency when operating, due to a myriad of factors including heat and combustion losses, inefficient motors and power supplies, unnecessary or excessive operation of fans or other components, resistance to flow of electricity, air or liquids, failure to utilise natural energy flows, etc. Common operational inefficiencies include:

- Inefficient operation at part load. Most systems are designed to operate efficiently at peak loads, such as on very hot days or at full building occupancy. However, they spend most of their time running at moderate loads. Under these conditions, motors, chillers and other components may operate at well below optimum efficiency, or excessive quantities of outside air may be supplied, wasting large amounts of energy.
- Specification of inefficient equipment. Inadequate insulation of ducts and pipes, low efficiency gas combustion, inefficient motors and use of resistive electric heating instead of heat pump technologies are common examples of inefficiencies.
- System inefficiencies. A system is only as efficient as its weakest element. A high efficiency hot water service with a water-guzzling showerhead and high flowrate taps will still lead to unnecessarily high use of energy. A central heating system with inadequately insulated ducts or water circulation pipes could waste more energy through duct or

pipe losses than is delivered to the building. A lighting system operating in a room painted with very dark colours will provide less useful illumination on the work plane. In addition, thermal bridges, such as steel framing penetrating insulation or metal window frames without thermal breaks, can seriously undermine the effectiveness of insulation or double glazing.

- Poor equipment management or maintenance. Efficient equipment that runs for longer than it is needed is still wasting energy, so effective control systems and management of equipment operation are key factors. Poor maintenance is common practice in Australia. Often, equipment is maintained only after failure or frequent complaints from clients.

While many aspects of system design are the responsibility of sub-consultants, contractors or equipment suppliers, it is the responsibility of the designers and project managers to incorporate appropriate energy efficiency guidelines and, preferably, performance benchmarks in project briefs. For example, it is often feasible to calculate the approximate energy requirements for a process if it were carried out efficiently, and to compare this to the claimed energy consumption of real products or systems. There may also be technologies better suited to the application – e.g. inverter/DC air conditioners follow variable loads more efficiently than those with conventional AC motors.

Ongoing management and maintenance are not usually the direct responsibilities of most designers. However, there are opportunities at the design and construction stage to ensure that the equipment selected is easily managed and maintained; monitoring systems provide feedback when performance is deviating from optimum; and appropriate manuals and instructions are written and located in prominent and appropriate places.

It is also important to ensure that sub-consultants apply appropriate financial analysis to evaluate the cost-effectiveness of energy efficient options (see below).

3.4 Poor definition of the task to be carried out

In many cases, creative strategies can eliminate the need for a task, combine it with some other activity, or satisfy it in some other way. For example, use of daylighting or lighting of working surfaces, rather than a whole room lit to levels appropriate for office work, can save large amounts of lighting energy.

In some cases, the scale or nature of the service to be delivered may require unexpected solutions. For example, when only small quantities of hot water are required in kitchenettes throughout a building, use of well insulated electric HWS units running on a *Green Power* tariff may be a cost-effective and low greenhouse impact solution. In this case, there may not be a convenient location for the flue of a gas HWS, and the low level of water usage may mean that it is cheaper on a life cycle basis to pay for more expensive electricity (and *Green Power)* than it is to invest more capital in a gas HWS. Also, the relatively high standby losses of a gas storage HWS may mean it is quite inefficient for this application. However, where large quantities of hot water are needed, an efficient gas instantaneous HWS, a gas-boosted solar HWS or an electric heat pump HWS using *Green Power* may be a better solution.

4.0 EMBODIED ENERGY OF CONSUMABLES AND OTHER INPUTS

For some appliances and equipment, the consumables (such as detergent for washing machines) or other inputs (such as water) may involve significant financial and energy costs. For example, with 'user pays' water pricing, the cost of using a litre of water in a shower is now comparable with the cost of heating the water to a comfortable temperature using natural gas or off peak electricity. The cost of detergent for clothes washing usually far exceeds the cost of energy and water used.

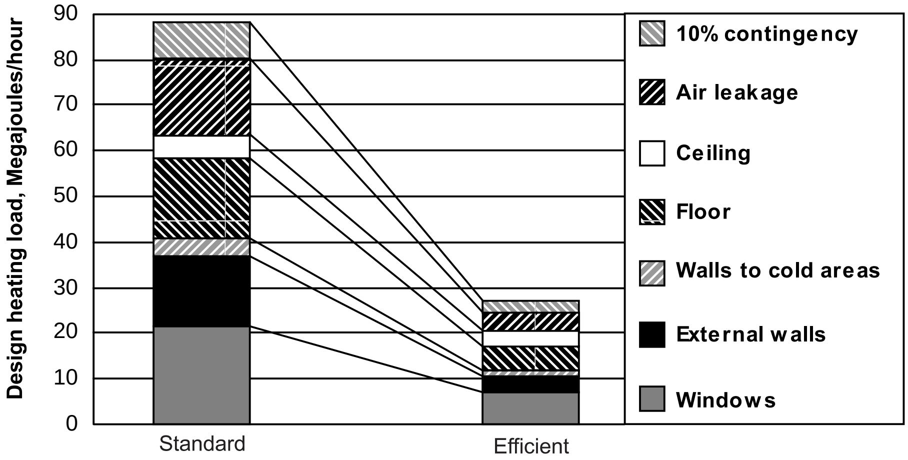
Where the consumables have a high energy requirement for their manufacture, their embodied energy can be significant. For example, a study by Greene (1992) found that the amount of energy used to manufacture clothes washing detergent and its packaging was significantly greater than the amount of energy used to run the washing machine on cold wash, although it was less than the energy used for a warm wash. Switching to a front loading washing machine, which uses less detergent as well as less water, saved both operational energy and energy for detergent manufacture.

Data on these factors are not well-documented so, at this stage, the best that a designer can usually do is use the financial cost of consumables and other inputs as a surrogate for environmental impact.

5.0 CONTEXTUAL FACTORS

Appliances and equipment operate within human and technological systems. If they mesh well with those systems, and those systems are designed to minimise their requirement for energy, synergies can be achieved. For example, a 90 MJ/hour gas central heating system is required for a typical Melbourne house. However, a heating system with a capacity of less than 30 MJ/hour would be needed by an energy-efficient house. This would involve distribution of much smaller amounts of heated air creating the opportunity to dramatically reduce duct and fan sizes. For commercial buildings, where HVAC costs often comprise 20% or more of total building cost, the use of energy efficient lighting, equipment and building envelope mean that significant reductions in plant capacity - and capital cost - can be achieved. However, this requires teamwork between engineer, architect and client. In particular, it may require allocation of more funds for design and consultation. If fees are linked to the capital cost of the equipment, consultants will face a conflict of interest between maximising their fees and reducing the size and cost of the plant.

Figure 2. Breakdown of design heating loads for example house in AG - 706 (Australian Gas Association [1994] AG-706, Design Manual 4) for Melbourne. *Standard house* has ceiling insulation only and two airchanges/hour air infiltration. *Efficient house* has upgraded ceiling and wall insulation, low-e double glazing, concrete slab-on-ground, with edge insulation and 0.5 airchanges/hour air infiltration. Efficiency of furnace is assumed to be 75%.



Energy-efficient systems often work differently from standard solutions. For example, if water-efficient taps are used, there will be a longer delay in delivery of hot water if pipes from the hot water service are long. This can be remedied by using smaller diameter pipes. The lower flow rate means that the pressure drop along smaller pipes need be no worse than for a larger flow through a bigger pipe. Insulated walls and double glazed windows have surface temperatures closer to room temperature, so people located near the building perimeter should feel more comfortable. It is important to understand the subtleties of energy-efficient equipment, so that its performance can be optimised and potential user complaints avoided.

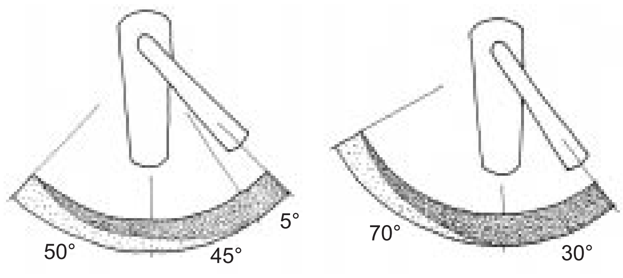


Figure 3.

5.1 The costs and benefits of greenhouse emission reducing measures

It is very important to carry out thorough and fair financial analysis of energy-efficient and low greenhouse impact options.

When considering energy costs, it is important to note that, increasingly, energy suppliers are placing a price on the peak demand for energy, either by charging specific fees linked to peak demand, or by charging a higher unit price at times of high demand. Peak demand determines the amount of investment required in energy supply infrastructure, so it is not surprising that energy suppliers reflect this in their pricing. However, this means designers and specifiers need to pay increased attention to limiting peak demand. This may mean some design features that are not cost-effective, if analysed using average energy costs or annual energy cost savings, may become attractive when peak demand costs are considered in more detail. For example, insulation and double glazing of commercial buildings work best at times of peak demand (that is, when it's hottest or coldest), and are financially more attractive when peak demand costs are included in analysis.

Fair financial analysis should:

- consider all savings and benefits. These may include reduced heating or airconditioning plant capital cost, reduced noise, reduced flicker for office lighting with electronic ballasts which can reduce absenteeism, improved comfort near windows, improved public image, etc. While some of these factors are difficult to cost accurately, they should be listed and a rough estimate of their value made, so they are at least acknowledged. For example, since staff salary cost per square metre of an office building may exceed $2,000 per annum, even a 0.5% reduction in absenteeism through installation of high efficiency lighting (as found by Wilkins et al, 1989) would be worth $10 per square metre per annum, comparable with the value of the lighting energy saved - which, of itself, makes high efficiency lighting cost-effective in many situations.
- use reasonable payback periods for cost-effectiveness calculation. It is common to apply a one or two year payback requirement on energy efficiency measures, when comparable investments in power supply systems are based on 10, 20 or 30 year payback periods. This is economically irrational from both a life cycle and societal perspective, yet it is common practice because designers and builders are rarely responsible for ongoing energy costs. Schemes such as the SEDA

Commercial Building Greenhouse Rating Scheme and the *Nationwide House Energy Rating Scheme*, as well as increasing tenant and householder concern about global warming, energy costs and the quality of their indoor environment, are driving an increase in client awareness of the importance of energy efficiency. There are indications that this is beginning to flow through to property values. As this situation develops, it will be easier for designers to place greater emphasis on energy efficiency. In the meantime, it is possible to use mechanisms such as Energy Performance Contracting (where an energy performance contractor installs the energy efficient systems using their own capital, then recovers the capital from a share of the energy savings) to finance extra costs associated with installation of energy efficient features.

- evaluate system 'packages' rather than each increment of efficiency separately - and aim for the most efficient overall solution, that still meets financial criteria (refer to DES 36). By evaluating each increment of efficiency separately, a much tougher financial threshold is being applied, as the benefits of the highly cost-effective elements are not able to 'cross-subsidise' less cost-effective elements within the overall package. This fragmented approach not only delivers smaller energy savings, but it ignores the important synergies that can be gained from combining a range of measures.

The lead designer should require sub-consultants to demonstrate that they have used up-to-date prices and product information, and should cross-check their estimates. For example, in one project, the quantity surveyor estimated the cost of double glazing at $400 per square metre. A check with a specialist supplier of double glazing produced an estimate of $120 per square metre, including a low-emissivity coating!

In considering how much it is reasonable to invest in energy efficiency, it is worth looking at some other investment decisions that often take precedence, and questioning the rationales applied. For example, in many new medium density developments, expensive stainless steel kitchen fittings and granite benchtops are considered 'essential'. Yet these items do not deliver an ongoing financial return or comfort benefit. Sometimes, decisions on finishes and fittings for parts of buildings are made almost regardless of cost. In contrast, energy efficiency investments must meet absurdly rigorous cost-effectiveness criteria! This is not to ignore the reality that aesthetic features are important for sales. But it may be that offering 'trade-off' options and highlighting to potential clients the life cycle benefits of energy efficiency investments may lead to greater consumer acceptance. If the assumptions and preconceptions are not challenged, then change will not occur. In addition, a lack of improvement in energy efficiency will increase the likelihood of government intervention, on the grounds that the market has failed to deliver cost-effective and environmentally important outcomes.

6.0 SCOPE FOR RE-USE OR RECYCLING, AND IMPACTS IF DISPOSED OF

These issues have significant implications for the net embodied energy of materials incorporated in equipment and appliances. They are discussed in detail in DES 35.

When considering the option of refurbishment or replacement of a building, analysis could usefully extend beyond building issues. For example, replacement of a building that is well-located with a higher density development may increase use of public transport, or allow more households to live lifestyles less dependent on car use. These energy savings may strengthen the argument for replacement over refurbishing.

There may also be potential to use some wastes to produce useful energy, if they cannot be re-used or recycled. These opportunities should be utilised if at all possible.

7.0 GREENHOUSE GAS EMISSION REDUCTION THROUGH APPLIANCE AND EQUIPMENT DESIGN AND SPECIFICATION

For information on greenhouse gas emission reduction opportunities in design of residential space heating and cooling, water heating and lighting, the reader is referred to GEN 13.

Heating, cooling and air handling systems, along with lighting, are the dominant aspects of energy use in the commercial sector. However, other activities are important in some subsectors. For example, cooking and refrigeration require appliances that are major energy uses in the retail sector.

It is not possible in this Note to address all the major energy-consuming activities, but the example of refrigeration is now considered as an illustration of the issues that should be considered.

7.1 Domestic refrigerators

The appliance Energy Rating Label provides useful information to assist in the selection of a low greenhouse impact domestic refrigerator. However, care is needed in interpreting the label. The star rating indicates the energy consumption per litre of storage capacity, and the number on the label indicates the annual energy consumption under standard test conditions. While the star rating is useful for appliances of the same size, the consumption number is an objective measure of consumption. This number is reasonably representative of consumption in climates such as Sydney, but understates consumption in hotter regions and overstates consumption (by up to 20% or so) in colder areas. Each star rating is roughly equivalent to a 15% improvement in energy efficiency.

A revised Energy Rating Label is being introduced in 2000. It will still work the same way, but what was a 5-star appliance will now rate around 3 stars. Details are available at www.energyrating.gov.au.

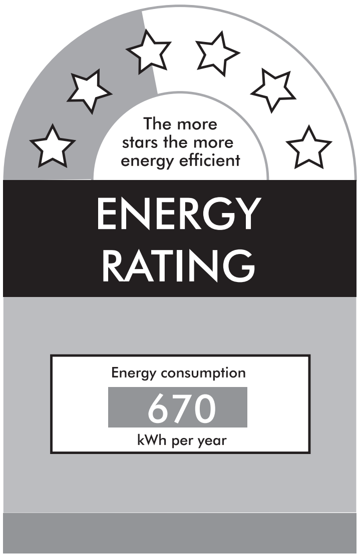


Figure 4. Energy Rating label

Specifying and buying a high efficiency model is the single most effective emission reduction (and operating cost reduction) action to be taken with refrigerators. However, it is also important to ensure that:

- there is a clear airpath *above* the rear of the refrigerator and sufficient space between the appliance and the surrounding cabinets to allow air movement around the cabinet - usually 25 to 60mm is recommended by the manufacturer, and more space is better than less. Modern 'clean back' refrigerators have heat transfer coils attached to the back *and* sides of the appliance - the coils are integrated with the wall of the cabinet, so they are not visible. It is particularly important that these types of appliance have good ventilation around their sides as well as their back, or their performance may be adversely affected and their energy consumption may increase by up to 15% due to the temperature increase around the appliance.
- the wall behind the appliance is shielded from heat from the rear. If the wall behind the appliance is an external one, or belongs to a room that may be hot for significant periods, ensure that it is very well insulated. For each degree that the average temperature of the space behind the appliance increases, its consumption will increase by up to 2%.
- direct sun does not fall on the door of the appliance for long periods: each degree by which the surface temperature of the door is increased, increases energy consumption by about 1%.

While it may seem like a good idea to incorporate a vent to draw cool under-floor air up around the refrigerator, this can increase heating and cooling bills by more than it reduces the running cost of the appliance, unless this outside air is effectively isolated from the indoor air. Odours from underfloor areas can also be a problem.

7.2 Small refrigerators in commercial premises

For hotel rooms, it may seem like good value to buy cheap refrigerators for use in suites. But an extra 100 kilowatt-hours per year can increase life cycle running costs by $150, and also add to air conditioning loads. As for full-size refrigerators, it is extremely important to provide effective ventilation for built-in bar fridges. Poor ventilation can increase running costs by 30%, and increase motor running time (to the annoyance of hotel guests) as well as adversely affecting the ability of low cost models to maintain specified internal temperatures.

7.3 Commercial refrigeration equipment

Commercial refrigeration equipment, such as small coldrooms or modular cabinets, is often very inefficient. This results from a combination of faults which often include:

- Serious thermal bridges at doorways and sometimes corners: these may be responsible for up to 40% of heat flow through the cabinet, and can be avoided by careful design detailing. These bridges also promote mould growth by causing condensation, so they should be avoided for health reasons, anyway.
- Use of inefficient fans both inside the cabinets and attached to the condenser. High efficiency DC fans and careful design of ductwork can save up to 80% of fan energy. When fans use less energy inside the refrigerator, a double benefit is gained: a direct saving from reduced fan energy consumption, and an indirect saving from reduction of cooling energy consumption (and peak demand).
- Inadequate insulation: 100mm of polyurethane foam is desirable for a coldroom and 175mm thickness for a freezer (NSW TAFE, 1993).
- Location of the doorway near hot cookers or other equipment.

An efficient coldroom operating in ambient temperature of 25°C under steady-state conditions (i.e. no door openings and no transient food load effects) should consume 0.3 to 0.5 watt-hours per day per litre of volume - with small rooms (say 5 cubic metres) at the high end, and larger rooms (10 cubic metres) at the lower end. Poor performers could use twice or three times as much energy. At 20°C, they should consume around 25% less energy. Units with glass doors will consume more; use of advanced glazing systems and avoidance of thermal bridging around door openings should limit the increase to 25-30%. Lighting within refrigeration units, or for associated display lighting, can also be a significant contributor to energy use. Careful placement and selection of high efficiency systems can cut this waste.

Since designers usually order commercial refrigeration equipment from specialist suppliers, it is important to specify an energy performance criterion in the contract. There should be a financial penalty if actual performance, when installed, exceeds the specified limit.

8.0 CONCLUSION

Selection of energy-efficient appliances and equipment, and design of efficient systems are critically important aspects of successful design for energy efficiency. Indeed, many good efforts at energy-efficient design fail ,,because of lack of attention to these details.

In many cases, the designer is not directly responsible for the design or selection of appliances and equipment, or the detail design of systems. This places even more importance on ensuring that:

- Contractual arrangements encourage efforts by sub-contractors to select more efficient solutions and communicate with other contractors, where system design has implications for other elements of the project.
- Processes encourage liaison and consultation within the project team.
- Requirements are carefully specified, including performance benchmarks and penalties for failure to perform - as well as incentives to do better.
- Outcomes are monitored, so that everyone is accountable.

Remember, the devil *is* in the detail. For an energy-efficient commercial building consuming, say, 125 kWh/square metre per annum, the average electricity demand is only 14 watts/square metre on a continuous basis, or 42 watts/square metre over a 3,000 hour/year operating period. An energy loss that adds even 1 watt/square metre on a continuous basis is a 7% increase in total energy consumption.

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BIOGRAPHY

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