POTENTIAL FOR REPLACING HAZELWOOD WITH ALTERNATIVES, PARTICULARLY ENERGY EFFICIENCY

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Alan Pears originally trained as an engineer and educator. He was worked in the sustainable energy area since the late 1970s. During the 1980s, he worked for the Victorian government, implementing appliance energy labelling and dwelling insulation regulations, among many projects. Since 1991 he has been a consultant, and has been involved across the spectrum of energy efficiency issues, from designing energy efficient appliances and buildings (eg the Dishlex Global series dishwasher and EcoVend drink vending machine, and the 60L Green Building) to developing and implementing leading energy efficiency programs (including the Australian Building Greenhouse Rating Scheme for office buildings and the Energy Efficiency Best Practice Program for industry), as well as policy analysis and research for various governments and sustainable energy associations. Since 2001, Alan has taught part-time at RMIT University in the environment program, and has been recognised through his appointment as an Adjunct Professor. In 2000 he received an award for his lifetime contribution to sustainable energy from the Sustainable Energy Industry Association of Australia and, in 2003, he received a Centenary Medal for his contribution to climate change and environment policy.

Summary

- Victoria's load profile has been distorted over many decades by the State Electricity Commission's efforts to increase base load to facilitate maximum use of inflexible brown coal fired power stations, including through use of extremely low off-peak electricity prices. This has led to load shifting and wasteful use of energy in off-peak periods. This means the potential for energy efficiency improvement to reduce base load is very large
- Partly because of the above distortion, there is at least 1,600 MW of base load demand in the residential and commercial sectors, as well as large potential in industry
- Cost effective electricity efficiency potential in Victoria would reduce commercial and residential electricity consumption by around two-thirds, and industrial consumption by at least 40%, saving more than twice as much electricity as is now supplied by the Hazelwood power station. The cost of these measures varies from negative (i.e. cheaper up-front) to around the same as investment in power supply. Demand side measures would also reduce peak demand problems and avoid large investments in transmission and distribution networks, further enhancing their economic benefit
- The timeframe for capture of the energy efficiency potential identified in this project is very dependent on the effectiveness of policies and programs. Much could be captured within five years, although some of the savings rely on limited amounts of technology development and some measures are best integrated with refurbishment, equipment replacement and new investments to optimise cost-effectiveness
- A comprehensive strategy that includes energy efficiency (including cogeneration), fuel switching at point of use and renewable energy has the potential to reduce Victoria's conventional electricity use in absolute terms, and avoid the need to operate Hazelwood. However, to achieve this would require strong and effective policies that target both existing and new equipment and buildings, and further reform of the electricity market to provide appropriate price signals to both electricity suppliers and consumers
- Early action to avoid the ongoing need for Hazelwood would provide more flexibility for the balanced management of coal resources and development of alternatives. Deferment of expansion of the coal resource would also reduce the risk of creating a 'stranded asset' in the form of the developed coalfield.

Introduction

Hazelwood power station is a brown coal fired plant consisting of eight 200 MW generators commissioned between 1964 and 1971. There are proposals to increase its output to 1730 MW. If utilised at 85% of full capacity, and allowing for 15% of output to be 'lost' through power station usage and transmission and distribution losses, this would mean that replacement by point of use demand side activity would involve avoiding or replacing approximately 10,000-11,000 GWh of electricity usage each year, around a quarter of Victoria's existing electricity consumption.

In practice, an effective strategy to replace Hazelwood would not focus on one option, but would involve a combination of strategies phased over a period of time, including:

- Energy efficiency improvement combined with improved customer load management (commonly called Demand Side Management or DSM)
- Fuel switching at point of use (to gas and renewable energy)
- Cogeneration in industry and commerce: it should be noted that there is rapid technological development in this field, and cogeneration is increasingly being applied to commercial sector sites where it is being used to produce cooling as well as heat and electricity. CSIRO's micro-cogeneration demonstration project at Hornsby library illustrates the possibilities.
- Imports of electricity from interstate, possibly involving further upgrades to transmission capacity, or a reduction in net exports (which, in 1999, comprised almost 9,000 GWh) which could involve significant load management to facilitate local utilisation of generation capacity
- Modifications to existing brown coal-fired power stations such as 'gas boosting' where a gas turbine is added to a power station, and its waste heat is used to produce steam that replaces steam produced by coal. Effectively this is an extremely efficient form of cogeneration, as most of the energy in the gas is utilised either to generate electricity directly, or to produce steam used by the power station. This could be applied to Hazelwood as a way of extending the life of existing coal resources. Similarly, there is potential to co-fire biomass with coal.
- Expansion of renewable electricity generation

The earlier a strategy to phase out Hazelwood is implemented, the more flexibility there will be, as the remaining coal resource could be better managed to mesh with introduction of alternatives. At the same time, an effective short to medium term strategy could reduce the risk of investment in expansion of the coal resource becoming a 'stranded asset'. It is Victorian Government policy to introduce carbon pricing, and this will impact more on Hazelwood pricing than other, more modern brown coal and black coal power stations because of its higher greenhouse intensity. For example, at a carbon dioxide price of $20/tonne, Hazelwood would have to pay approximately $30/MWh while a black coal plant would pay under $20/MWh.

An effective strategy with the above elements could offer a very useful mechanism to defer investment in opening new coal resources until uncertainties regarding carbon prices and directions in energy policy are reduced, thus reducing risk for both the owners of Hazelwood and the Victorian community.

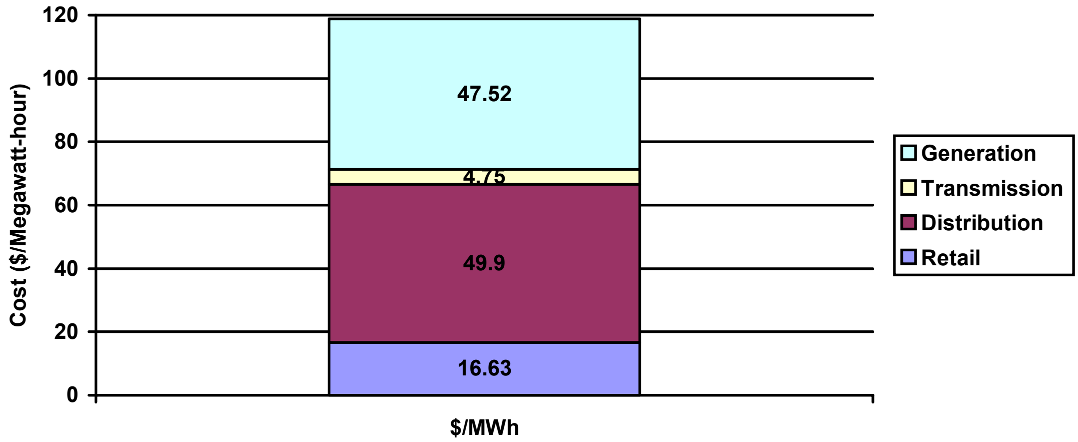
Clarification of some myths

When looking at options that differ from existing solutions, it is easy to make assumptions that make the alternatives look less viable while reinforcing the status quo. Some key issues relevant to energy efficiency include:

- The present Victorian electricity load profile is the outcome of decades of distortion through pricing and policies intended to artificially increase off-peak demand, so that utilisation of inflexible coal-fired plant and transmission and distribution infrastructure could be optimised. If we wish to look at alternatives that do not necessarily involve base load capacity, we need to understand how much flexibility we have to change load profiles and manage demand. For example, low off peak electricity pricing has traditionally driven high usage of off-peak electric hot water and overnight irrigation pumping. Further, low off peak prices have meant that many commercial and industrial sites use off peak power wastefully, because it has been so cheap. Recent large increases in off peak prices, especially in rural areas, will lead to significant changes in off peak demand over time. These changes will reduce off peak demand and place pressure on inflexible base load generation plant.

- Efforts to flatten total state demand to suit the characteristics of base load power stations can lead to situations where off-peak power demand creates regional and local peak transmission and distribution demand, particularly in rural and regional areas, creating pressure to upgrade network infrastructure. Shifting load can also lead to energy waste at point of use, such as losses from large off-peak electric hot water services. So over-investment in base load generation can lead to energy waste and additional costs for other energy market participants.
- Residential and commercial sector electricity demand comprises a surprisingly large proportion of total and base load electricity consumption, and therefore offers much more potential for reduction in base load electricity demand than is widely recognised.
- Demand-side action, including energy efficiency, demand management, cogeneration and on-site renewables actually competes with electricity retail contract prices, not the cost of generation at the power station. So demand-side measures can be cost-effective at much higher prices than centralised energy supply alternatives. Figure 1 shows that the average cost of Victorian electricity at the customer's meter is approximately $120/MWh, of which only $47.50 is generation cost. Demand side action avoids the cost of investment in all elements of the electricity supply system.
- Demand side action can also avoid investment in networks by reducing peak demand as well as base load. NSW studies have shown that the network cost potentially avoided in the 25 hours per year of highest demand can be of the order of $3.80 per kilowatt-hour, making energy efficiency improvement very financially attractive – if full supply costs are considered. Further, avoiding expansion of networks reduces pressure to grow demand at other times to increase utilisation of infrastructure – see Attachment B.

Figure 1. Total cost of Victorian electricity (DNRE, 2002).



- Demand side action is typically expected to meet much higher rate of return criteria than investment in conventional generation. Typically supply-side investment will be pursued if it delivers 8-15% pa rate of return, while energy efficiency will be rejected if it fails to meet a 30-50% pa rate of return. A recent report by the Allen Consulting Group (2004) for the Business Council for Sustainable Energy, Insulation Council of Australia and New Zealand, and Australasian Energy Performance Contractors Association goes into extensive detail regarding the economic distortions and market imperfections that lead to under-investment in energy efficiency relative to supply capacity. This means there is large energy efficiency potential not presently captured, but available at financially attractive returns. It also means that effective and sustained government policy will be critical to capture of energy efficiency potential, and that energy market signals must provide a strong incentive to the supply industry to invest in demand side action as an alternative to supply capacity. This creates a major challenge to the architects of energy markets. The COAG Review of energy market reform has acknowledged the importance of ensuring that the demand side of the market is made to work.

- Delivery of energy services via energy efficiency improvement offers higher employment and higher rates of overall economic activity than does investment in conventional centralised electricity supply. This is because energy efficiency involves employment-intensive but low capital cost services and light manufacturing activity, and generally delivers a higher rate of return than does investment in conventional electricity supply. This is reflected in, for example, the outcomes of modelling by the Allen Consulting Group for Victoria's Five Star energy rating regulations (AGC, 2002).

Potential for Energy Efficiency to reduce base load electricity consumption

Figure 2 shows a breakdown of Victorian electricity consumption by end-use sector since 1973-74. It is dominated by the residential sector, metal products industry (mainly aluminium) and the commercial sector. Electricity use by the electricity industry itself is also substantial. In Figure 2, losses in transmission and distribution networks are included, along with coal mining and other usage, as consumption by the electricity industry. Point of use energy efficiency measures reduce these losses.

Figure 2. Trends in Victorian electricity usage by end use sector in Gigawatt-hours per year (GWh), 1973-74 to 2000-01 (ABARE, 2004)

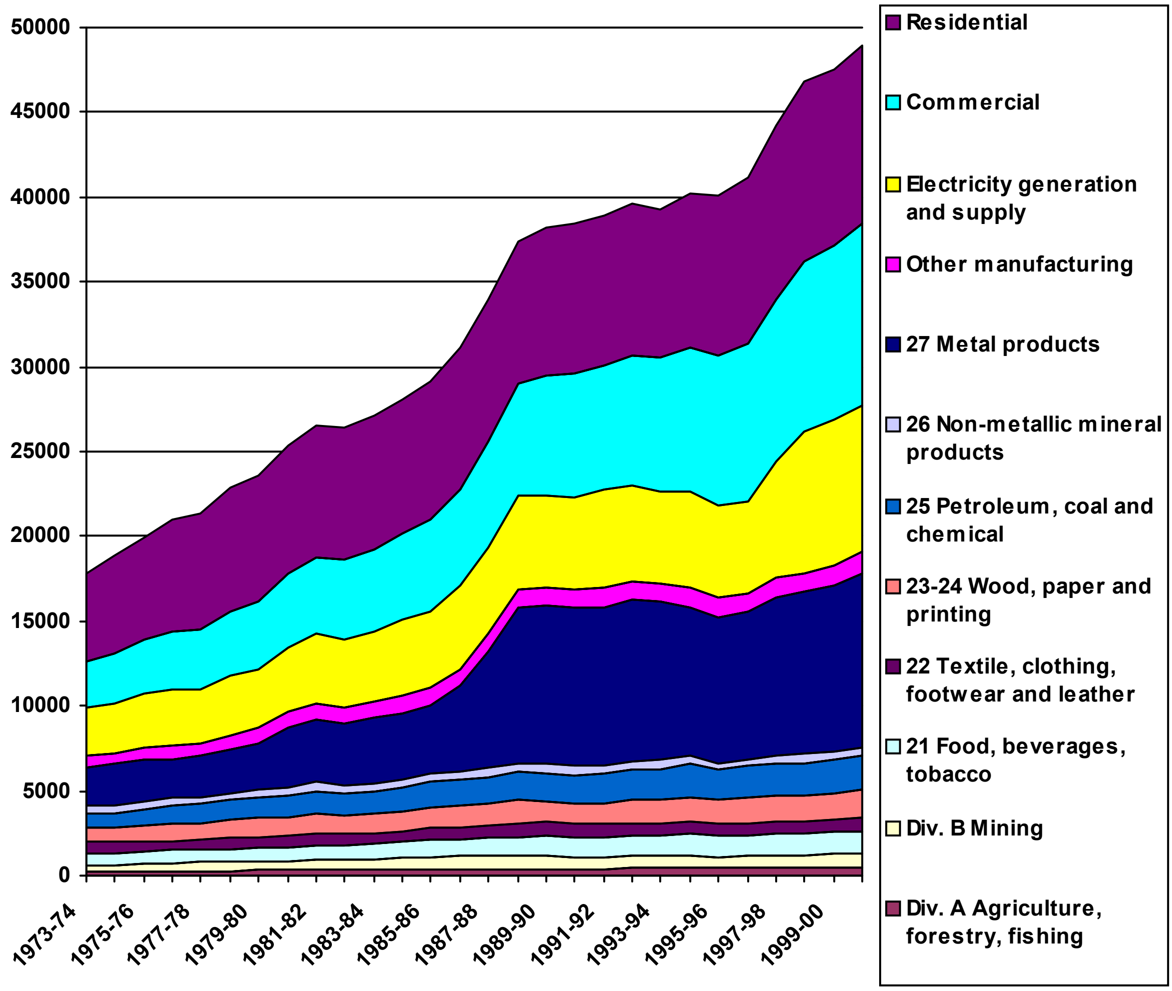


Figure 3a. Victorian electricity load-duration curve (McLennan Magasanik Associates, 2004) Note that the vertical scale starts at 2,000 MW: this over-emphasises the peakiness of the demand.

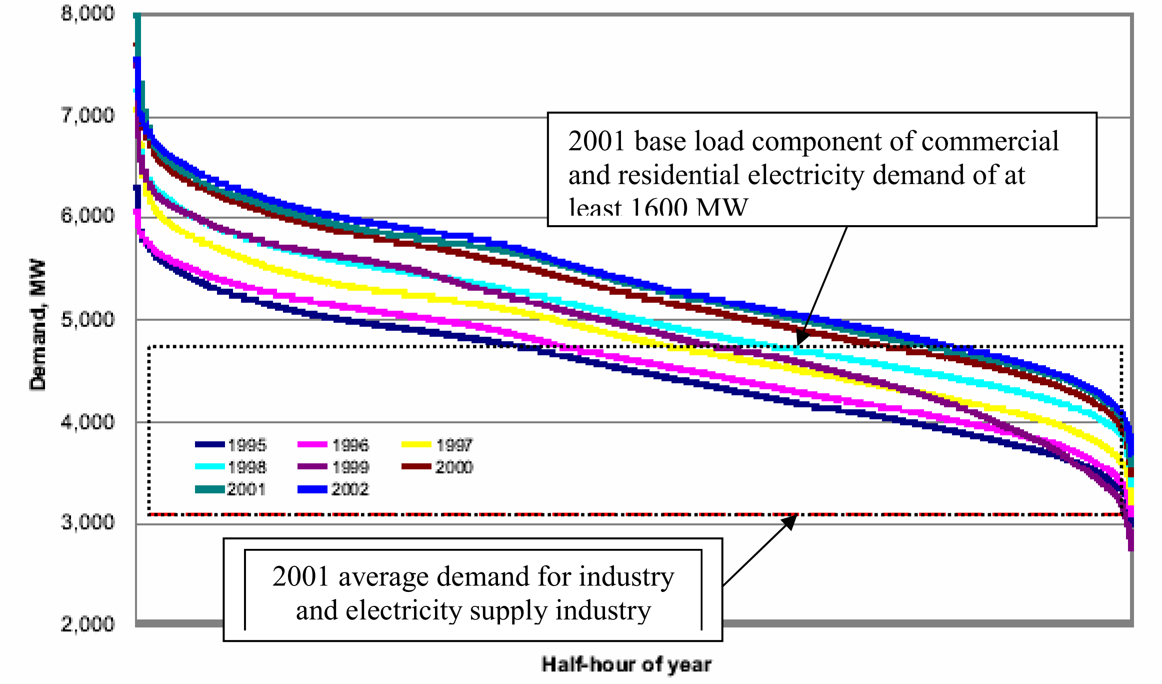


Figure 3b. Victorian electricity load-duration curve relative to base load generation capacity without Hazelwood (McLennan Magasanik Associates, 2004)

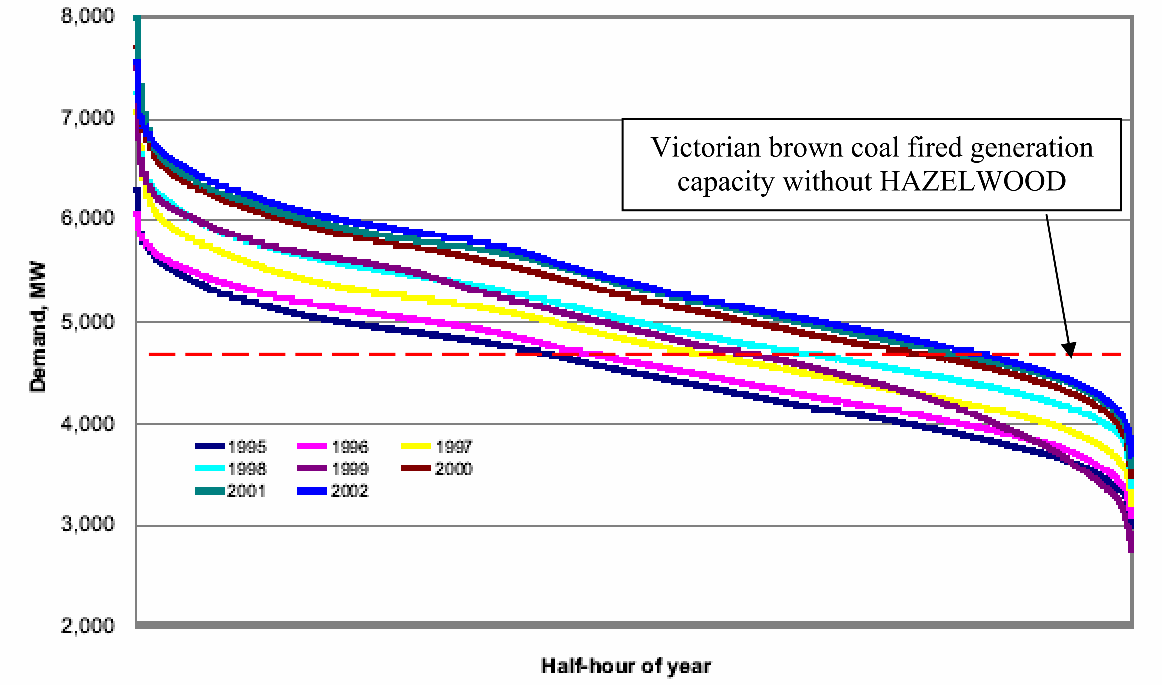


Figure 3a shows load-duration curves for Victoria in recent years. While such curves are usually used to highlight the peakiness of demand, they can also tell us a lot about other aspects of demand. For example, from ABARE data it is possible to estimate the average demand for all agriculture, mining and industry at 2180 MW and average demand for the electricity supply industry is 980 MW for 2001. So, if it is assumed that all industrial activity and electricity industry usage were pure base load (an extremely conservative scenario), these sectors would comprise 3,160 MW of base load demand. It can then be inferred that more than two-thirds of average commercial and residential annual load of 2420 MW, that is over 1,600 MW, exists for more than 80% of the time, and could be described as base load. It is likely that, in reality, at least 200 MW of industrial load is peak-intermediate, so that commercial-residential base load is at least 1,800 MW.

The key point from this analysis is that energy efficiency measures and point of use fuel switching in both the residential and commercial sectors offer substantial potential for reducing base load electricity demand, beyond the substantial potential that also exists in industry, agriculture and mining.

Base load generation capacity other than Hazelwood in Victoria as of 1999 was 4770 MW (ESAA, 2000), of which the bulk was provided by Loy Yang A and B, and Yallourn. In 2002, this meant that, for 15% of the time, Victoria's base load power stations would either have had to reduce output, export power or carry out maintenance if Hazelwood had not existed, as shown in Figure 3b.

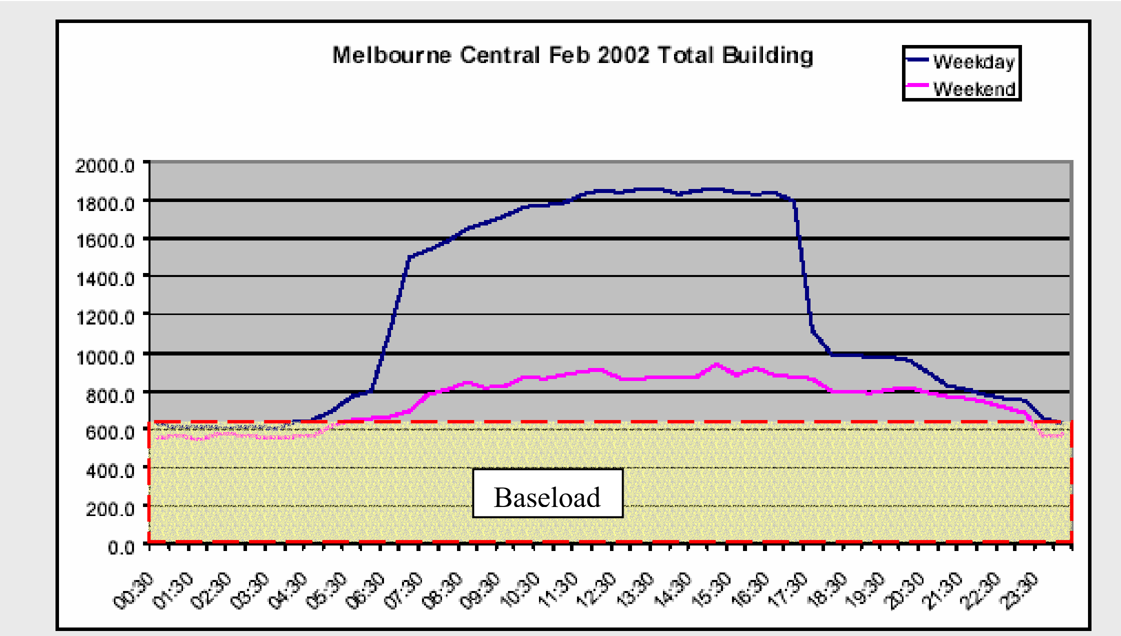
While it is certainly true that peak load growth is more rapid than base load growth, both components of load have been growing, as shown by Figure 3. However, data for recent years seems to indicate slowing of load growth after a spurt linked to the early years of energy market operation (see Figure 2). Growth can be avoided by effective energy efficiency measures, fuel switching and other measures. This raises questions about the economic sense of maintaining excess base load capacity – unless base load demand continues to grow strongly.

The following sections review the potential for electricity efficiency improvement in the major sectors of the economy, as shown in Figure 2.

Commercial Electricity

The residential and commercial sectors are typically seen as peaky loads, and it is therefore assumed by many analysts that they contribute little to base load demand. However, this is simply not the case. The foregoing analysis has shown that substantial proportion of commercial and residential sector demand is, in fact, base load.

Figure 4. Daily load profiles for Melbourne Central, a large office building, in February – note that weekend energy consumption is almost half of weekday daytime demand, even though most of the building is unoccupied. (From Ostoja, 2003). Note that average daily demand would be significantly lower than shown in the graph, which is for February, Melbourne's hottest month.

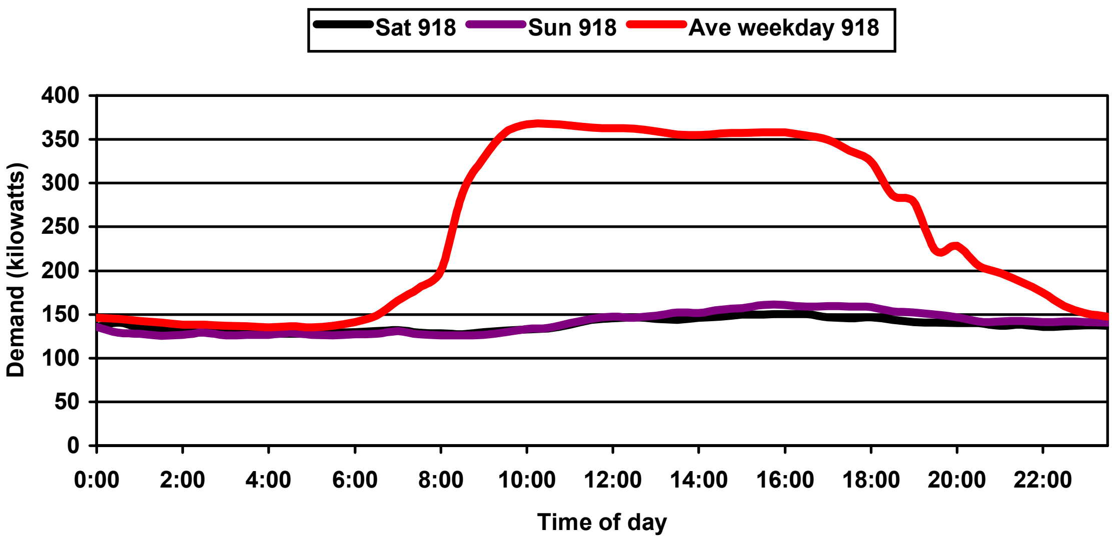


A study of NSW commercial sector electricity demand in 1996 (NSW DoE) found that commercial sector electricity base load demand was more than half of its annual average demand. A specific example of a large Melbourne office building, shown in Figure 4, illustrates the high proportion of base load. Indeed, in this case, the base load consumption of over 600 kW for 168 hours per week comprises around two-thirds of the total consumption, as most of the additional daytime demand occurs for only 55 hours per week.

Figure 5 shows an example of a large office tenancy in Canberra: in this case, only 28% of total electricity consumed for lighting and general power is for additional activities carried out during working hours. These examples demonstrate clearly the large potential for commercial sector energy management to reduce base load electricity demand.

Different loads within the commercial sector have different demand profiles. For example, data centres are typically large base loads, while desktop computers (when properly power managed) mainly operate during weekday working hours. Air-conditioning demand is linked to climate, although a significant proportion is a fixed overhead associated with factors such as poorly managed fans and pumps. So the priority placed on managing energy use by different activities will depend upon the objective(s).

Figure 5. Electricity consumption profiles for electricity used for tenant light and general power in a Canberra office tenancy (previously unpublished data)



Given the importance of managing peak demand (to limit pressure for investment in additional transmission, distribution and peak generation capacity – see Attachment B), the need to reduce greenhouse gas emissions, and the concerns about the adequacy of base load, it seems that there is a reasonable case to pursue all practicable and cost-effective energy efficiency measures in the commercial sector, rather than targeting specific activities with certain demand profiles.

Wilkenfeld (2002) has prepared estimates of electricity use by activity for the Victorian commercial sector, as shown in Figure 6a. It should be noted that these estimates are based on very limited data. For comparison, data from the State Electricity Commission of Victoria's demand management program in 1994 are shown in Figure 6b: although dated, these are potentially more accurate, as they are based on field work. The main differences between the two estimates relate to lighting, cooling and air handling/electric drive shares. It should be noted that energy use by lighting and other equipment contributes a significant proportion of the cooling load – which is one of the reasons why commercial cooling demand is not as temperature sensitive as might be expected. This also means that efforts to reduce lighting and other equipment energy use will have multiplier benefits by reducing cooling.

Figure 7 shows Victorian electricity use by commercial sub-sector. This highlights the relative roles of different sub-sectors in electricity consumption, as well as the growth trends in each sector.

Figure 6a. Breakdown of Victorian commercial sector electricity usage by activity, 1999 (Wilkenfeld, 2002).

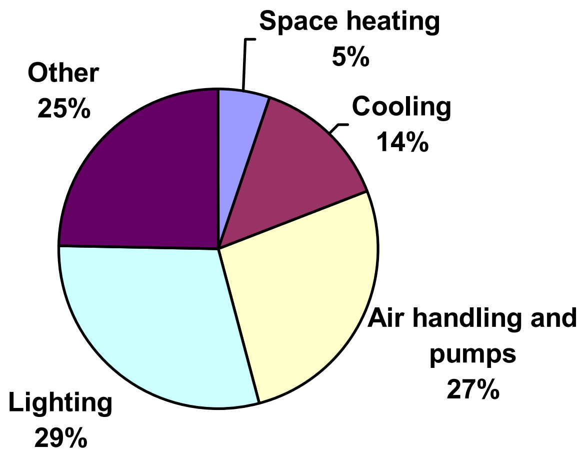
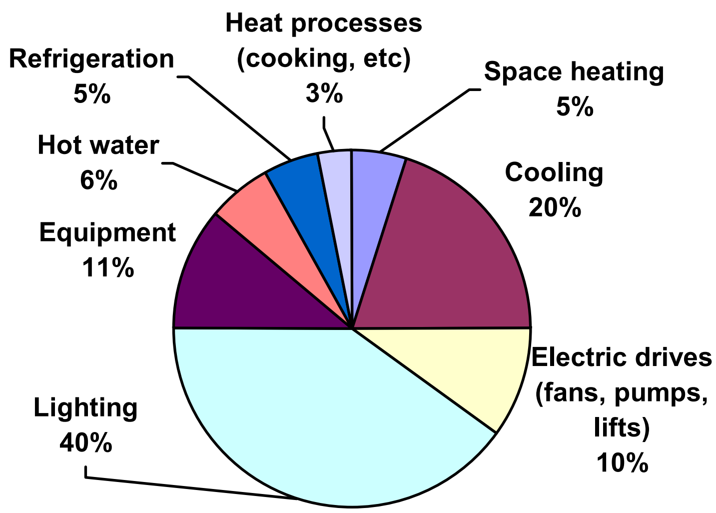


Figure 6b. Breakdown of Victorian commercial sector electricity usage by activity, 1993-94 (Electricity Services Victoria, 1994).



The potential for energy efficiency improvement in the commercial sector is very large. For example, the average Melbourne office building consumes around 275 kilowatt-hours per square metre per year, compared with 77 kWh/sqm for the 60L Green Building in Carlton (Mailer, 2004) – which can be further reduced quite easily.

The retail sector is a very large electricity user, comprising 36% of commercial sector electricity consumption, yet there have been no significant programs targeting energy savings to date. This means the opportunities are enormous. A pilot project by the Commonwealth Government's Energy Efficiency Best Practice program was able to cut energy use by 32% and greenhouse gas emissions by 48% in a hot bread shop (DITR, 2003), and the scope for additional savings was only limited by the lack of availability of high efficiency equipment. EEBP has also worked with a supermarket chain to improve energy efficiency, and a proposed new supermarket in Gisborne is expected to achieve substantial electricity savings through a range of strategies.

Figure 7. Trends in Victorian electricity use within the commercial sector (ABARE, 2004)

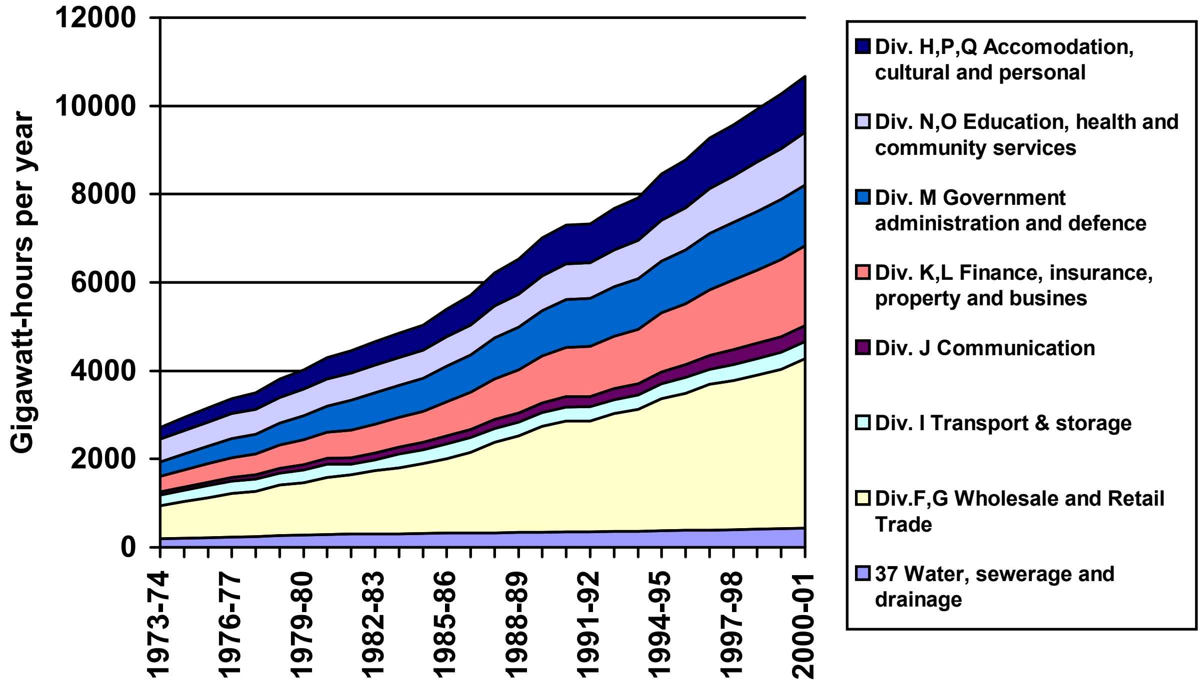


Figure 8 shows that, for a supermarket, off-peak electricity usage is comparable to that during peak periods throughout the year, so around 80% of total electricity usage is base load. This reflects the high refrigeration load and long opening hours. So efficiency improvements, particularly in refrigeration systems, offer potential for substantial base load energy savings. One US study (Faramarzi, 1999) has shown that simply adding glass doors to open refrigerators reduces electricity consumption by70% - but this would probably need to be mandated via MEPS, as open cabinets are seen as a key marketing strategy by retailers. Figure 8 also shows a surprising lack of sensitivity of electricity demand to ambient temperatures, which reinforces the view that there is much energy waste that could be saved.

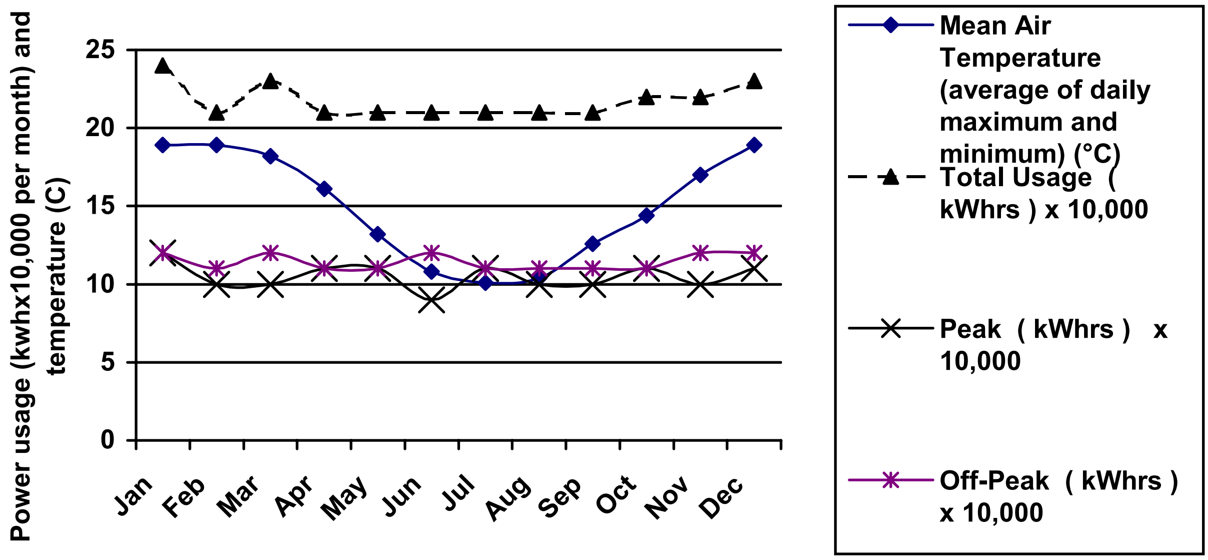
A project conducted by RMIT's Centre for Design in the mid 1990s, in which this author was involved, showed that it was possible to reduce electricity consumption of drink vending machines from over 10 kWh/day to 4.3 kWh/day through cost-effective improvements. Application of more modern technology could further reduce this to less than 3 kWh/day. Victoria has tens of thousands of these vending machines. Since vending machines are refurbished every few years, and improvements could be easily retrofitted, there is scope to upgrade performance relatively quickly.

The cost-effective potential for lighting energy efficiency in the commercial sector is very large, with cost-effective savings of up to 85% being achievable using high efficiency lamps and fittings, and movement and daylight sensors. Potential reductions in electricity use of 20-30% of total sector consumption are feasible from lighting alone. While most commercial lighting is intermediate load, there are many off-peak lighting loads with potential for large reductions, including:

- street and outdoor lighting (street lighting uses around 230 GWh pa, of which half can be saved)
- outdoor display lighting (billboards and signage) which can be switched off or dimmed at night

- aesthetic lighting of buildings, which could be switched off at, say midnight or, in many cases, eliminated. This load was actively promoted by the SECV in the late 1980s as a way of increasing overnight load to keep coal-fired plant running
- security lighting, which can be reduced by use of movement sensors to switch on lighting for short periods when intruders are sensed, rather than widespread continuous lighting that effectively provides sufficient light for intruders to operate
- safety lighting in buildings, such as Exit signs: these commonly use 12-17 watts but can be replaced by units using less than 3 watts
- overnight lighting in shops and offices

Figure 8. Example of monthly electricity usage for a typical Victorian supermarket (previously unpublished data)



Cogeneration is a form of energy efficiency improvement, as it involves on-site utilisation of energy in a way that reduces full cycle energy losses by capturing waste heat that would otherwise have been lost at a centralised power station. In the commercial sector, the potential for cogeneration is significant and increasing, as technologies improve. Commercial sector cogeneration opportunities include:

- aquatic centres, where waste heat can be used to heat pools and domestic hot water
- hospitals and health care facilities that require large quantities of heat for domestic hot water and laundry
- office buildings, supermarkets, shopping centres, where waste heat from cogeneration can provide part or all of the cooling requirements via absorption or desiccant cooling

Technologies such as microturbines, fuel cells and increasingly cost-effective gas-fired engines can be used for the above cogeneration systems, and part of the capital cost can be offset by avoiding the need to invest in back-up generation plant. A key challenge here is to provide fair offsets for the value of avoided transmission and distribution infrastructure and losses, as well as provision of long-term reasonably priced natural gas supply. The most practicable and cost-effective option for commercial sector cogeneration could well be for the plant to be owned by gas suppliers (who can source natural gas at wholesale prices, sell electricity, heat and 'coolth' to the host and nearby clients, and spread risk across a number of projects). As for other energy efficiency measures, the requirement for a high rate of return relative to that considered adequate for investment in centralised electricity supply seriously disadvantages cogeneration.

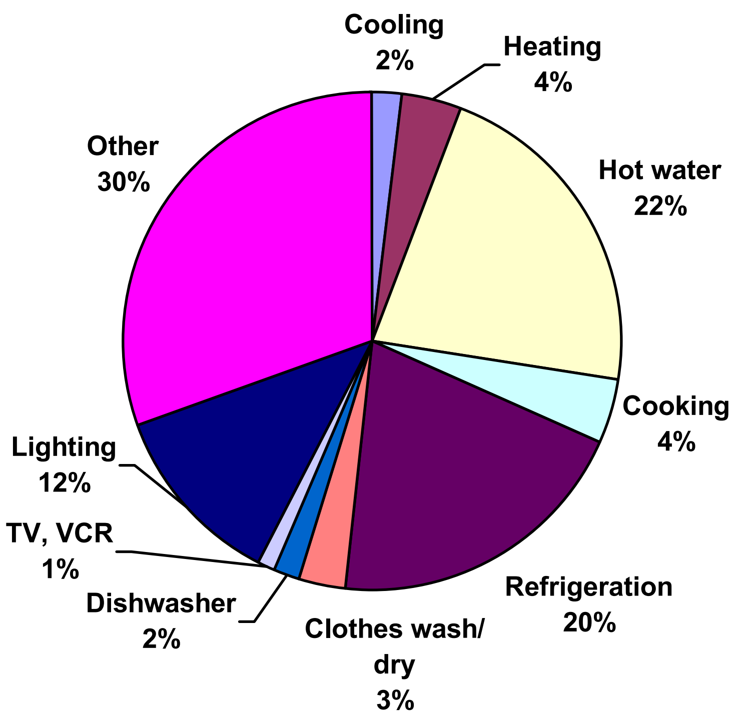
A key element of any effective commercial sector strategy is to target existing buildings and equipment, not just new ones. There is wide variation in energy intensity of seemingly similar facilities, with the differences often due to faulty or poorly commissioned equipment or poor management. Electricity retailers have billing data that would allow them to identify facilities with unusually high peak and base load demand. However, at present, they have no incentive to help these energy wasters save energy. It is critical that the energy market be modified so that electricity retailers make more money and can expand their businesses more by helping customers to save energy than by allowing them to continue wasting it. It is also important to develop databases of high efficiency products and systems that can be applied under specific circumstances.

Lastly, it is critical that a number of market intermediaries be given strong incentives to incorporate energy efficiency. These include shopfitters, air-conditioning contractors, maintenance contractors, equipment (refrigeration, catering equipment, etc) designers and salespeople for lighting and equipment suppliers. These market intermediaries play critical roles, yet often have a financial incentive to incorporate energy wasteful rather than energy saving features.

Residential

Victorian residential electricity use is unusual relative to the rest of Australia, as most Victorian households have access to natural gas, which dominates provision of space heating, hot water and cooking energy use. Despite its low penetration compared with the rest of Australia, Victorian off-peak electricity use, mainly for hot water, comprises around 1,400 GWh per year, of which about 30% is heat losses from storage tanks (Wilkenfeld, 2002).

Figure 9. Victorian residential sector electricity consumption, 1999 (Wilkenfeld, 2002). Standby energy use is approx 10% of the total.



Around three-quarters of Victorian electricity used for hot water could be replaced by gas, solar or heat pump electric HWS units. MEPS requirements for improved insulation of electric storage tanks will reduce total water heating electricity requirements by around 10% - but this will be reduced to the extent that other energy sources replace electricity.

Standby electricity usage, power used by many appliances when they are energised but not doing useful tasks, comprises around 10% of Victorian household electricity: this is pure base load. Most of this could be eliminated by appropriate product design. There is a national '1-watt' standby program, however, this is relatively ineffective in that it is not a mandatory requirement for most products.

Refrigeration is a significant load, and is largely a base load. Recent work by the Moreland Energy Foundation has found that a significant proportion of refrigerators are wasting energy due to undiagnosed faults. New Zealand research by BRANZ (Isaacs, 2004) has indicated that 18% of all NZ refrigerators are using 50-100% more power than they should, due to faults. Identification and replacement of faulty refrigeration appliances therefore offers potential for substantial electricity savings. Further, since modern refrigerators use 70% less electricity than properly operating refrigerators of the mid-1980s (Marker, 2004), so replacement of old refrigerators, including faulty units, could cut household electricity usage by 5-10%.

Residential lighting contributes significantly to the late afternoon-evening peak, and is a significant part of evening electricity usage. Recent trends to installation of large numbers of low voltage halogen lamps has increased lighting energy use: indeed, New Zealand (BRANZ) field studies suggest that Wilkenfeld's estimate of lighting electricity usage may be conservative (Isaacs, 2004). A range of strategies can be applied, ranging from replacing 50 watt lamps with 35 and 20 watt units (for existing installations) to replacement by much more energy-efficient lighting such as micro- and compact fluorescent lamps. In the short term, 50% savings are achievable, while long term savings of 80% are feasible.

Almost a third of Victorian household electricity usage is by miscellaneous equipment, including home computers, TV, VCRs, stereos, swimming pool pumps and chlorinators, and other equipment, although this part of Wilkenfeld's estimate may also include some lighting and other activities, due to the lack of detailed data on which to base analysis.

Very little attention has been paid to development of programs that address these areas of electricity usage, and virtually no information on energy efficient options is publicly available. Yet the savings potential is large. The most efficient 68 cm TVs on the market use less than half as much electricity as some other models, and consume less than some 34 cm TVs (Sustainable Solutions, 2003). High efficiency pumps and motors could halve energy use for pool filtration. And so on.

If reductions in residential electricity consumption are to be achieved, it will be critical to address existing wastage, rather than just focusing on efficiency of new equipment and buildings. Around 5% of residential electricity customers consume 15% of household electricity (Pears, 1998): this group is an obvious target for electricity efficiency programs. As in the commercial sector, electricity retailers have billing data that would allow them to identify unusually high residential electricity consumers, and to target them with cost-effective programs to reduce their consumption. Yet no such programs have been implemented.

Recently, Victorian water retailers have introduced benchmarking information on water bills, so that households can identify whether they are above or below average for their household type. This is a useful model for electricity retailers. If the structure of the electricity market cannot be changed to provide effective incentives for electricity retailers to aggressively pursue energy efficiency opportunities in the residential sector, then government must step in and require provision of information such as benchmarking on billing, then offer attractive financial incentives and promotional campaigns to encourage (or require) high electricity users to capture their savings potential.

For new homes, a broader scheme similar to the NSW BASIX system (www.basix.nsw.gov.au) would provide a mechanism to reduce electricity consumption for space conditioning, hot water, lighting, cooking and other major activities. BASIX is web-based, and is designed to streamline the whole regulatory process, thus reducing costs and time for development.

Industry

There is little recent public data on industrial energy use by activity for Victoria. Figure 11 shows a 1994 estimate for Victorian industrial electricity use by activity. Motors and drives comprise around 7,500 GWh per annum of industrial consumption, and dominate industrial electricity usage other than aluminium smelting. The potential for savings in electricity use by motors and drives does not just arise from improving motor efficiency and drive efficiency, but also results from reduction in distribution losses and mechanical task requirements. This potential is discussed in more detail later in this paper.

Figure 10. Victorian industrial electricity use, 2001 (ABARE, 2004)

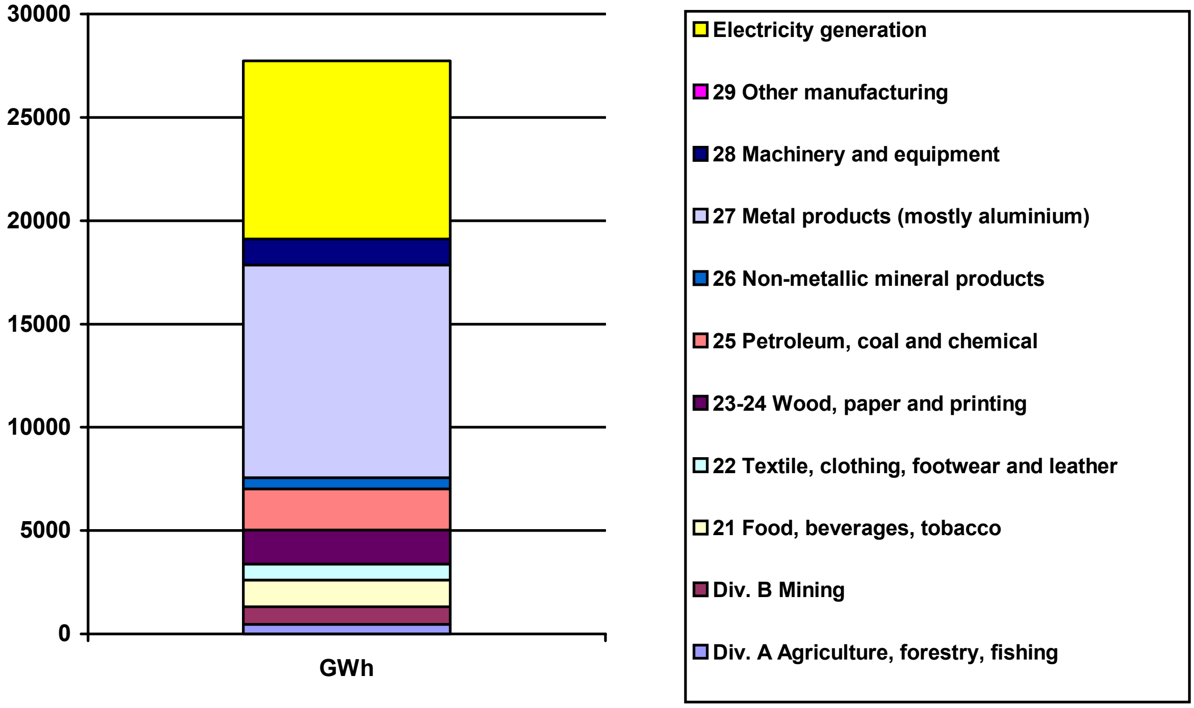
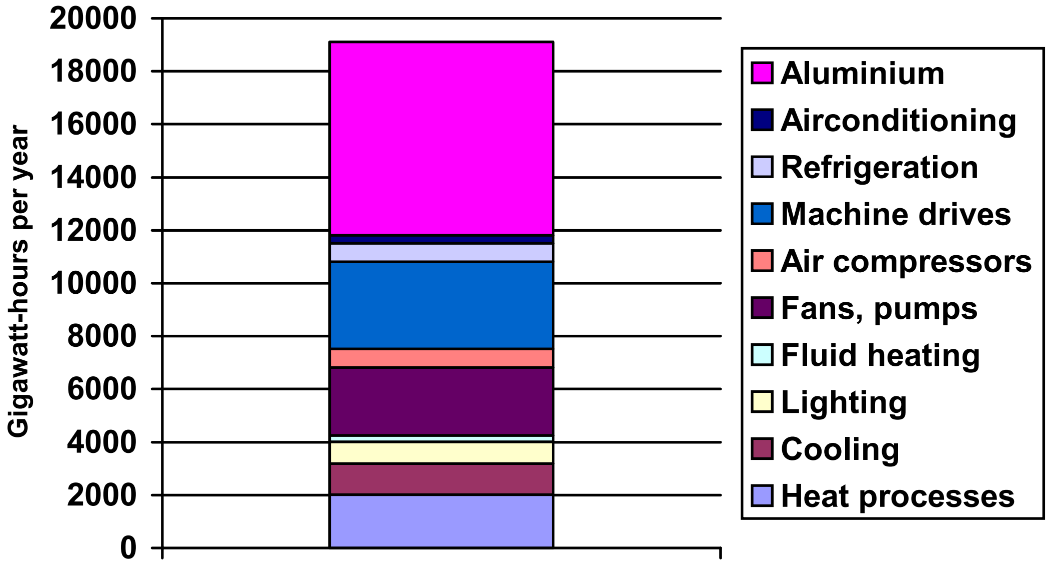


Figure 11. Victorian industrial electricity usage by activity, 2001, based on 1994 data (ESV, 1994)



The following discussion relates to the large sub-sectors of industrial electricity usage. The reader is also referred to a recent study by Energetics (2004) for the National Framework on Energy Efficiency, which reviews the potential for energy efficiency improvement across many parts of the industrial sector. Energetics estimates that 18% electricity savings could be achieved across Australia's industrial sector with an average 4-year simple payback. If a less stringent financial return requirement were applied, comparable with that applied to investment in power stations, significantly larger savings could be achieved.

It is also critically important to recognise that much of the potential for reduction in energy use in industry comes from measures beyond the plants themselves, through improving efficiency of material usage, switching to less energy intensive materials, and recovery and recycling of materials. For example, dilution of cement with 65% blast furnace slag and fly ash effectively reduces the amount of pure cement required for a given task by two-thirds. At present, these cement extenders comprise 15-20% of cement content, so driving higher use of extenders could still almost halve cement production energy (including electricity) requirements at no extra cost to customers.

<u>Electricity generation and supply</u>

Victoria's electricity generation and supply industry uses a lot of electricity, much of it for mining brown coal. Energy efficiency improvement at point of use avoids transmission and distribution losses. So using energy efficiency improvement to shut down Hazelwood will therefore reduce electricity use by the electricity sector by as much as 25%. A reduction in exports of Victorian electricity to other states and a shift towards cogeneration, gas-fired and renewable electricity sources would also reduce the electricity consumption of the Victorian electricity industry.

The Victorian EPA greenhouse regulations, national Electricity Generation Standards and other programs are focusing attention on the potential for efficiency improvement in this sector, but the application of a three-year payback criterion by the EPA means that much efficiency improvement that is cost-effective over the life of a power station is still being ignored. A requirement that the electricity industry should invest in energy efficiency to the same rate of return threshold as it applies to supply-side investment would lead to identification and capture of significantly more efficiency potential.

<u>Metal products</u>

This sector is dominated by aluminium smelting, but includes substantial activities such as steel production from an electric arc furnace.

Best practice electric arc furnace energy usage is around 7 GJ/tonne, with potential to reduce to 3.5 GJ/tonne (Worrell, 2004), but it is unlikely that the Victorian plant is close to this: future upgrades could therefore achieve savings. Further, given the need for both heat (to melt steel) and electricity for smelting, there is potential for cogeneration. Indeed, there is potential to develop an energy park in Laverton where cogeneration is used to provide heat and power to a number of industries.

With regard to aluminium production, questions must be asked about the future of Victorian facilities beyond 2016, when some large existing very cheap contracts expire. If the private electricity market requires the Portland smelter to pay for transmission costs, as well as covering long run generation costs and a carbon price, Portland's electricity price could triple. This could have significant implications for its future.

If the above possibility is ignored, a number of technologies are being developed that offer significant potential for energy efficiency improvement in smelting. These include drained cathodes (20% saving) and inert anodes. Further, US research is developing methods of capturing the large amounts of high temperature heat released from smelting: this can be used for cogeneration or sale of heat to neighbouring industries. Traditionally, the aluminium industry has ignored the potential for waste heat recovery because it pays so little for electricity. However, if the electricity generated were to be sold to the grid, or to neighbouring customers, it could be sold at a price significantly higher than would be avoided by using the power on-site.

The aluminium industry also offers some potential for cost-effective electricity savings in ancillary equipment. For example, the installation of variable speed drives to fume fans on one potline at the Tomago smelter in NSW is cost-effectively saving 7 GWh of electricity each year, 14% of the previous consumption of the fans (IPART, 2004).

Non-metallic minerals

This sub-sector is dominated by the glass, bricks and cement industries. Energy use in these industries is dominated by sources of heat, although electricity comprises between 5-20% of energy use. As noted earlier, the potential to replace virgin material with recycled material, and to switch to less energy-intensive materials, is significant. For example, around two-thirds of Australian glass production is for containers: a shift to plastics could significantly reduce energy (and electricity) requirements in the glass industry. Increased use of cement extenders, as well as shifts to less energy intensive alternatives such as magnesium-based cements and geopolymers (Hes and Bates, 2004) offers potential for more than 50% savings in cement production.

These industries have potential to reduce electricity consumption through use of high efficiency motors, variable speed motor drives, improvement in efficiency of grinding (which is very low), optimisation of electricity use, and so on. Significant electricity usage could be avoided by replacing large electric motors with gas engines for some processes. These industries also offer significant potential to export electricity from cogeneration. As in other industries, this cogeneration potential has been largely ignored because of the failure of energy markets to provide appropriate signals.

Petroleum, coal and chemical

These sectors offer significant potential for cogeneration. Although some cogeneration is already installed in these industries, past strategies have been aimed at limiting the scale of cogeneration to match internal plant requirements, rather than to maximise electricity generation. This has been a response to the disincentives created by the electricity supply industry to exports of cogenerated power.

Australia's chemicals industry is also undergoing significant change. There are moves towards larger, internationally focused plants, and it's not clear what the future of some local plants will be. At the other end of the scale, 'green' chemistry, improving end-use technologies and recycling are creating alternative, less energy intensive sources of supply, and are reducing the need for chemicals in some processes.

Wood, paper and printing

This industry sub-sector has substantial potential for cogeneration using a variety of renewable sources and wastes. Again, lack of price signals from the electricity industry has meant that much of this potential has not been captured. For example, the waste gasification plant installed at Visy's Coolaroo plant is being used to produce heat, rather than for cogeneration. The Maryvale mill is considered to be a significant potential cogeneration opportunity – subject to appropriate price signals and financial evaluation criteria.

Recent US research (Worrell, 2004) proposes that a combination of maximum efficiency and gasification could allow Kraft process paper and pulp plants to be energy neutral or even export electricity.

Food, beverages and tobacco

This industry uses large amounts of heat and significant amounts of electricity. Again, there is substantial cogeneration potential, in many cases using wastes or renewable energy, as well as scope for efficiency improvement in motors, drives, maintenance and process management. Gas driven engines could replace electric motors for some activities, where the waste heat can be utilised in processes.

Mining

Mining uses significant amounts of electricity for grinding and crushing and transport of material. Gas driven engines can replace electric motors. Research by CSIRO and others is leading to improvement in the efficiency of crushing and grinding which, at present, is very poor. At the same time, overall energy use is sensitive to ore quality and other factors, so it is difficult to estimate long-term trends in efficiency.

Agriculture

Dairy farms use large amounts of electricity for water heating, pumping and chilling of product. Switching to alternative heat sources, use of waste heat, heat (and 'coolth') recovery and process optimisation all offer the potential for large energy savings in this industry. Given the large powerline losses in many rural areas, end-use electricity savings in this industry will be amplified significantly by accompanying reductions in line losses.

Irrigation pumping is also a significant use for electricity in agriculture. Trends towards water conservation, including use of drip irrigation offer potential for electricity savings. Further, high efficiency pumps and motors offer further savings potential, as well as appropriate sizing and correct management (see below). The solar pumping industry has pioneered development of high efficiency pumps, which can be more widely applied.

Cogeneration

Views on the potential for cogeneration vary widely. A recent study by NIEIR (2004) for VenCorp suggests a few hundred megawatts of potential. In contrast, a 1984 study for the Victorian government (Greene, 1984) estimated the technical potential in 1999 at up to 3165 MW and the achievable potential for that year at 910 MW. A study by Redding Energy Management for the Sustainable Energy Authority of Victoria identified potential for over 1,000 MW of cogeneration in Victoria (AEA, 2001).

Present Victorian cogeneration capacity is less than 400 MW. Given technological developments regarding gas turbine efficiency, micro-turbines and other components of cogeneration systems, the medium to long term potential is likely to be greater, not less, than that identified in the above studies.

Motors

Worrell (2004) estimates that motors use 60% of US industrial electricity. Given the major role of aluminium smelting in Victoria, it would be a smaller proportion here, probably around 30%. This is consistent with data from Electricity Services Victoria (1994), the most recent public data available to the author (see Figure 11).

Oversizing motors has a significant impact on both efficiency and Power factor of even large motors, with 20% loss of efficiency for a motor running at 25% of full load. It is routine to oversize motors as a 'safety measure'. High efficiency motors lose less efficiency when oversized (CIBSE 2002). Variable speed drives can make significant savings where equipment is oversized.

Reducing peak flow rates and using larger diameter pipes can have a disproportionate impact on pumping energy requirements because of the non-linear relationship between flow rate and pipe losses. For example, using a variable speed drive to reduce flow by 20% typically reduces energy requirements by 40% (CIBSE 2002) Optimisation of pump operation is also important, as pump efficiency can easily fall from 80% to 40% with a relatively small change in operating conditions. Small irregularities inside pipes and poor maintenance can have serious impacts on pumping energy use: one Australian case study showed a motor was using 84% more electricity than it should to pump fluid (AGO, 2003).

Worrell (2004) reports that 16% of motor energy is used for compressed air systems, and that they are often less than 10% efficient. Apart from system efficiency improvements, the development of compact electric motor-driven equipment and other strategies can reduce the need for compressed air in a plant.

Overview of Industry Issues

Within the limited time available for preparation of this paper, it has not been possible to quantify much of the savings potential in industry. However, the above discussion highlights that there is large untapped potential. Further, for many industries, cogeneration and renewable energy can be combined with efficiency improvements to deliver even larger savings. Changes in markets for materials (eg cement extenders, switching materials, dematerialisation, etc) also offer significant additional potential for electricity savings in industry.

Three key issues constrain capture of these opportunities. First, the electricity market discourages industrial energy efficiency and cogeneration. Second, tough investment thresholds are applied to investment in energy efficiency and cogeneration. Third, there is a lack of market intermediaries and equipment available to assist industry to save electricity.

There is a case to review transmission and distribution losses and consider emerging needs for replacement or upgrading of transmission and distribution infrastructure as a basis for setting priorities for investment in energy efficiency. This will allow cost-effectiveness of investment in energy efficiency and cogeneration to be optimised.

Overall Electricity Saving Potential

Table 1 summarises the potential for electricity savings in the sectors discussed.

It can be seen from Table 1 that the total potential savings from application of known cost-effective (but not necessarily yet widely available) energy efficiency measures is of the order of 21,000 GWh, close to double the savings required to offset closure of Hazelwood. Savings resulting from a reduction in coal-fired electricity generation are additional to this, and are also substantial, potentially over 2,000 GWh. Of course, growth in population and the economy must also be considered, but effective policies mean that the energy requirements of new equipment, buildings and industrial plant can be much lower than present technologies. Other measures such as introduction of renewables, gas-fired power generation and other options listed early in this paper will also make substantial contributions.

The dynamic nature of energy efficiency improvement potential, which increases as technology development occurs, means that additional electricity savings potential will emerge over time to offset the impact of economic and population growth – if appropriate policies are in place.

Costs of Energy Efficiency Measures

The costs of the energy efficiency measures outlined in this paper vary from negative to simple payback periods of around ten years – real rates of return varying from more than 100% per annum down to around 10%. In some cases, non-energy benefits such as productivity improvements, comfort, product quality and equipment reliability are also gained. In comparison, investments in regulated network upgrades are guaranteed real rates of return of around 8% pa, and investors in power generation also have to accept quite low rates of return and high risk. So, overall, the measures outlined here are cheaper and much less risky than further investment in electricity supply. They also generally involve creation of more jobs and greater economic activity throughout the economy because of the structural changes and flow-on effects. Incorporation of carbon prices would further improve the economics.

It is stressed that many of the measures involve stepping outside traditional boundaries for savings: for example reducing electricity use for cement production by diluting cement with other materials. They also involve systems thinking, as almost all energy use occurs in systems with multiple components that interact, so that a saving at one point in the system can multiply in both scale of energy savings and avoidance of capital investment. Significant proportions of the savings require development of improved products, upgrading of trade and professional skills, and new ways of analysing energy use. None of these things involves rocket science, but they will involve strong policies, and they will encounter opposition from vested interest groups. Government has an important role to play.

Table 1. Estimates of cost-effective potential electricity efficiency improvement for Victoria.

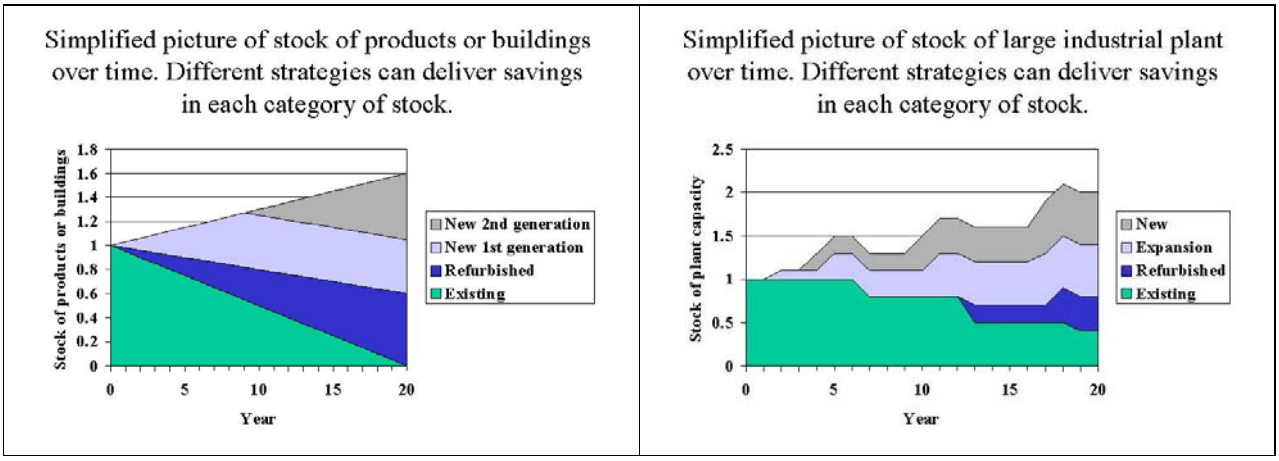
COMMERCIAL SECTOR (10,700 GWh)		
	ACTIVITY (% total commercial electricity)	POTENTIAL SAVINGS (% of total commercial usage)
	Lights (40%)	30
	Cooling + fans, pumps, lifts (30%)	20
	Heating (5%)	3
	Equipment (11%)	7
	Hot water (6%)	4
	Refrigeration (5%)	3
	Cooking (4%)	2
	TOTAL	69% (7,380 GWh)
RESIDENTIAL (10,500 GWh)		
	ACTIVITY (% total residential electricity)	POTENTIAL SAVINGS (% of total residential usage)
	Hot water (22%)	17
	Refrigeration (20%)	15
	Lights (12%)	9
	Other (30%)	20
	Major appliances (5%)	1
	Cooking (4%)	2
	Heating (4%)	3
	Cooling (2%)	0
	TOTAL	67% (7,035 GWh)
INDUSTRY (19,100 GWh)		
		POTENTIAL SAVINGS (% of total industrial usage)
	Energetics estimate	18
	Further savings (see text)	20+
	TOTAL	38% (7,260 GWh)
ELECTRICITY SUPPLY INDUSTRY (8606 GWh)		
	Reduced coal-fired generation due to Hazelwood closure and reduced T&D losses	Say 25% (2,150 GWh)

<u>Timeframe for Capture of Energy Efficiency Potential</u>

To a great extent, the timeframe over which the energy efficiency potential identified in this paper can be captured depends on the effectiveness of policies and programs, and the level of political will and community empowerment. The reality is that the beneficiaries of energy efficiency are dispersed and relatively ignorant of the potential benefits. Further, energy is a relatively minor issue in their lives or business activities. In contrast, the beneficiaries of the existing, who include many market intermediaries and product manufacturers, as well as the electricity supply industry, are well-organised and politically powerful.

Much of the identified potential could be captured over a five year period, if effective targeting, incentives and programs were used. Much of this would involve simply identifying waste and reducing it. However, it makes sense to integrate energy efficiency investment into investment cycles and, in some cases, to delay action until high performance technologies are available, so it is more likely that the full potential would only be captured over the next two decades – unless there were important reasons (such as climate change) to further accelerate efficiency improvement. It is important to recognise that, to achieve actual reductions in total electricity consumption in the short to medium term, it is essential that effective programs target existing energy use and waste. Focusing on new equipment and buildings will just slow growth until the new equipment becomes dominant in the stock – a process that can take decades. This situation is illustrated in Figure 12.

Figure 12. Indicative graphs of the shares of stock of existing, refurbished and new equipment or plant over time



It should also be noted that the potential for energy efficiency improvement will increase over time, as technology develops and appropriate packaging of measures makes it easier to build them into existing and new energy-consuming systems.

At the same time, the objective of this paper is not to argue that energy efficiency alone will avoid the need to continue operating the Hazelwood power station. Its objective is to show that energy efficiency has the potential to do this. As noted in the introduction, it is much more likely that an integrated strategy involving a number of components, including aggressive energy efficiency, would be pursued.

<u>Where to from here?</u>

The proportion of the identified cost-effective savings potential that can be captured over the next decade, during which the phase-out of Hazelwood might be implemented, is more than enough for energy efficiency to play a major role in replacing Hazelwood. It will be necessary to ensure all new investment involves best practice electricity efficiency, while capturing around half of the potential identified in this paper in existing buildings, plant and equipment. It will be even more critical to focus strong programs on existing energy use, with careful targeting to ensure that the most cost-effective opportunities are captured.

This is certainly feasible, but it would require some fundamental changes in key areas, including:

- Modification of electricity markets so that it is financially and strategically preferable for decision makers at all levels within electricity retailers, network providers and generators to invest in energy efficiency in preference to growing demand. While governments and regulators have signalled a desire to facilitate more effective operation of the demand side, much stronger

actions than are generally envisaged will be required to overcome cultural and 'sunk capital' factors.
- Electricity customers will need to be actively engaged through provision of feedback on their usage relative to benchmarks, and effective programs to assist (and in some cases require) customers to save electricity
- Market intermediaries, from supermarkets that sell replacement light globes to shopfitters and installers of equipment, must be given adequate incentives or required to ensure they deliver electricity-efficient outcomes.
- Equipment in all sectors needs to be equipped with self-diagnostic capability, so that when its energy performance shifts outside a specified range, it warns the user that it requires repair. For example, faulty household refrigerators are probably adding 200 GWh to annual electricity consumption. A simple module that compared compressor running time and ambient temperature averaged over each week to a predicted level of performance could avoid much of this waste.
- Improved equipment must also be developed and commercialised, and relevant market intermediaries and users informed and educated about its benefits.

It is often argued that raising the price of electricity will provide an appropriate stimulus to drive energy efficiency. Conversely, it is often argued that raising the price of electricity would seriously damage the Victorian economy. The reality is that electricity is not a major cost factor for most business, and electricity usage is not very sensitive to price – which is why economic modelling projects that attempt to use a carbon price to drive changes in behaviour require very high carbon prices before they see emission reductions.

To illustrate the situation, ABS data (ABS 2002) shows that, on average, non-transport energy (gas and electricity) comprises around 1.5% of total input costs for Australian business overall, and around 0.5% for the commercial sector. This reflects the reality that, while some industries are very energy intensive, most aren't. For households, non-transport energy on average comprises about 2.5% of household expenditure.

Further, as shown in Figure 1, the wholesale price of electricity is only a small component of the total price paid by most customers. Typically, households and commercial customers pay around $120/MWh and, for small customers, supply charges can comprise a large proportion of the total bill. For example, in the author's case, supply charges comprise almost 30% of annual electricity costs, even though a premium is paid for Green Power – average cost per kilowatt-hour including all costs is 26 cents ($260/MWh), of which 5.5 cents is for Green Power and 7.7 cents is the fixed supply charges. Larger customers may pay around $60/MWh, and only very large industries would pay much less.

So, for example, a 20% increase in wholesale electricity price, equivalent to, say $6/MWh, would have less than a 5% impact on electricity price for households and much of the commercial sector, and 10% impact on most other business. Given the small contribution of energy to input costs and expenses, this wholesale price increase would increase household expenses by 0.125%. For typical commercial businesses, it would increase input costs by 0.025%. For a reasonably large industrial customer with energy as 2.5% of input costs, the impact would be a 0.25% increase in input costs. These are not numbers that seem likely to inspire significant change in behaviour. Strong and effective policy response is likely to be more effective, and is less likely to provoke opposition from traditional large industry lobbyists.

There is an urgent need for collection of detailed end-use data and the construction of a comprehensive bottom-up model of electricity use in Victoria by sector, activity, time (of day, week and year) and activity that can be used to identify priorities and to benchmark performance. This should be developed on an area basis so that demand side opportunities in areas where infrastructure capacity is tight could be targeted.

For business sectors, independent assessments of the factors that may affect future economic and technological development, particularly in energy intensive industries, need to be made on an ongoing basis, so that realistic estimates of future demand trends and the options for efficiency improvement

References

ABARE (2004) Energy data downloaded from www.abare.gov.au Jan 2004

Allen Consulting Group (2002) *Cost Benefit Analysis of New Housing Energy Performance Regulations* Report for Sustainable Energy Authority Victoria and Building Commission, Melbourne

Allen Consulting Group (2004) *The Energy Efficiency Gap* included as part of Australian Business Council for Sustainable Energy submission to Productivity Commission Inquiry into Energy Efficiency, available at www.pc.gov.au

Australian Bureau of Statistics (2002) *Business Operations and Industry Performance 2000-01Australia* Cat No 8140.0

Australian Ecogeneration Association (2001) *Sustainable Energy on Bracks' Agenda* **Ecogeneration** Issue 5 April/May p.10, (now Business Council for Sustainable Energy)

Australian Greenhouse Office (2003) www.motors-online.gov.au

CIBSE (2002) *Energy Efficiency in Buildings: CIBSE Guide* London

Department of Industry Tourism and Resources (2003) *Case Study: Achieving Results in the Bread Baking Sector* Energy Efficiency Best Practice Case Study, Canberra

Department of Natural Resources and Environment (2002) *Energy for Victoria* Melbourne

Electricity Supply Association of Australia (2000) *Electricity Australia 2000* Melbourne

Electricity Services Victoria (1994) *Demand Management Action Plan: Final Report* Melbourne

Energetics (2004) *NFEE: Energy Efficiency Improvement Potential Case Studies – Industrial Sector* Report for Sustainable Energy Authority Victoria, Melbourne

Faramarzi, Ramin (1999) *Efficient Display Case Refrigeration* ASHRAE Practical Guide: Refrigeration

Greene D (1984) *Cogeneration in Victoria* Report to State Electricity Commission of Victoria and Victorian Government, Melbourne

Hes D and Bates M (2003) *Concrete and Sustainability- Supporting environmentally responsible decision making* PRO 31 in **BDP Environment Design Guide** Royal Australian Institute of Architects, Melbourne

Isaacs N (2004) *Supply Requires Demand – where does all of New Zealand's energy go?* Paper for Royal Society Conference **People and energy – how do we use it?** Christchurch

Mailer A (2004) pers comm. Project Manager 60L Green Building, Carlton

Marker Dr A (2004) *Minimum Energy Performance Standards* Presentation on behalf of Australian Greenhouse Office at ACRE Energy Efficiency Workshop, UNSW March 2004

McLennan Magasanik Associates (2004) *New Generation Technology Review* Appendix D in Allen Consulting Group report *The Greenhouse Challenge for Energy* Report to Victorian Department of Infrastructure and Department of Sustainability and Environment

National Institute for Economic and Industry Research and GreenWorld Energy (2004) *Projections of Cogeneration and Renewable Energy Generation in the National Electricity Market* Report for NEMMCO, Clifton Hill

NSW Department of Energy (1996) *Energy Use in the NSW Commercial Sector* Sydney

Ostoja A (2003) *Existing Buildings: 360 Elizabeth Street, Melbourne* Australian Building Greenhouse Rating Second National Case Study Seminar, Sustainable Energy Development Authority, Sydney

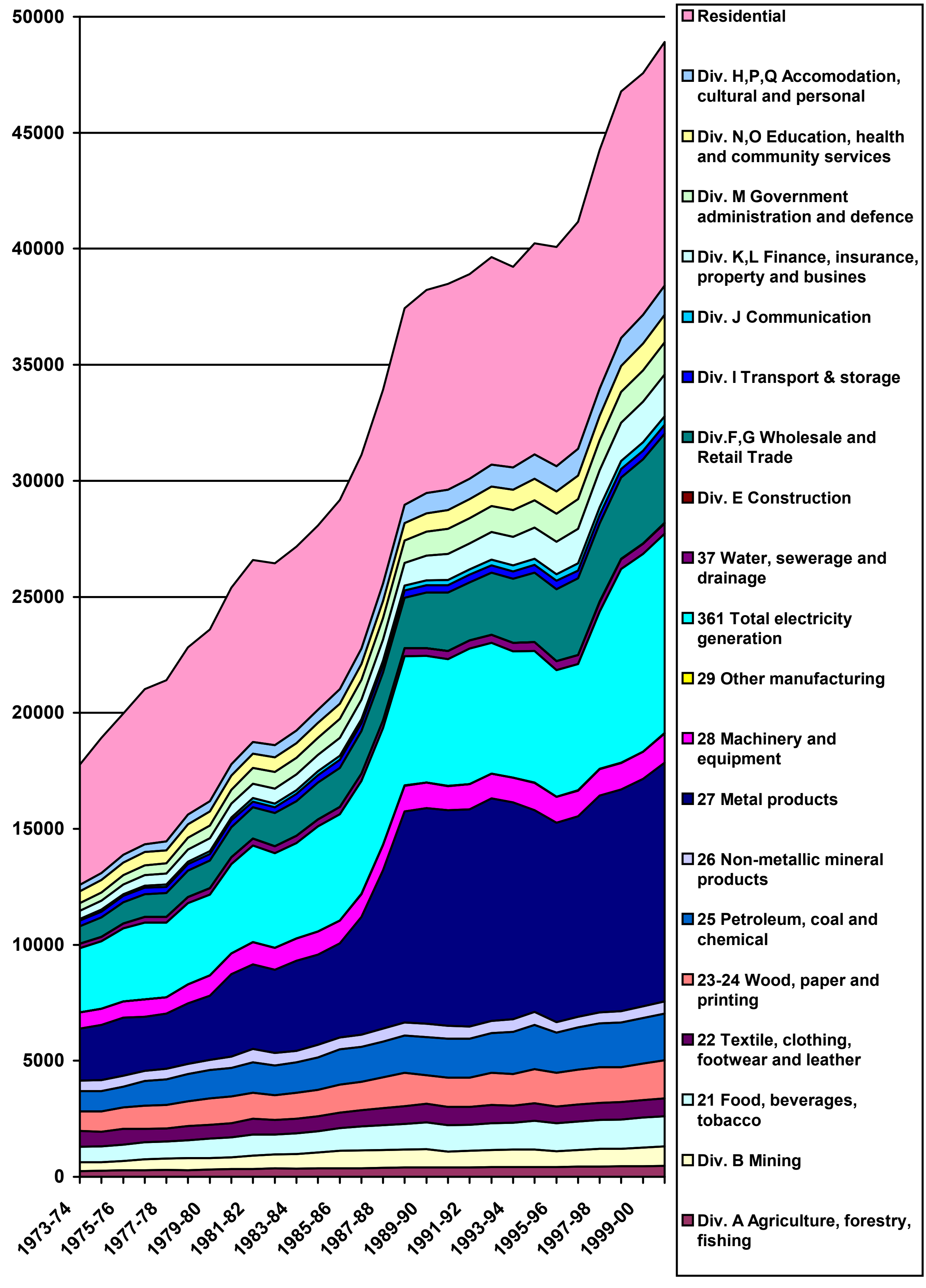
Pears A (1998) *Strategic Study of Household Energy and Greenhouse Issues* Report for Environment Australia (now Australian Greenhouse Office), Canberra www.energyrating.gov.au

State Electricity Commission of Victoria/Dept of Industry, Technology and Resources (1989) *Demand Management Development Project: 3 year Demand Management Action Plan Information paper no. 5* Melbourne

Sustainable Solutions (2003) *A Study of Home Entertainment Equipment Operational Energy Issues* Report for National Appliance and Equipment Energy Efficiency Program, Australian Greenhouse Office Canberra

Worrell E (2004) *Industrial Energy Use, Status and Trends* **Encyclopedia of Energy** Vol 3, Elsevier

Attachment A. Full breakdown of Victorian electricity usage by end-use sector, 1973-74 to 2000-01



ATTACHMENT B

MEGAWATTS OR NEGAWATTS – DISTRIBUTED AND DEMAND-SIDE ALTERNATIVES TO NEW GENERATION REQUIREMENTS

Alan Pears, Adjunct Professor, RMIT University and Director, Sustainable Solutions Pty Ltd

Presented at *Energy in NSW 2004: A Strategic Review*
Australian Institute of Energy Symposium May 20 2004, Australian Technology Park, Redfern NSW

Introduction

The main focus for electricity supply at present is on summer peak demand, which is growing rapidly. This is driving investment in additional generation, transmission and distribution capacity.

There's nothing like the threat of blackouts and spiralling electricity prices to focus public and political attention on electricity supply – and encourage the media to create a sense of crisis. But this is not a situation conducive to rational consideration of long-term solutions.

For those of us who have been involved in the energy sector for more than a decade, the hysteria driven by the recent realisation that peak load issues need to be managed was predictable. It is an outcome of the failure of the reformed energy sector to come to terms with many of the subtleties of energy supply and demand, as technical issues were swamped by marketing mantras and economic ideology. Lets hope we can be voices of reason in a volatile situation.

In this paper, I intend to step back and look at:

What are – or should be, our objectives in addressing peak electricity demand
What other options are available to achieve our objectives, and
What are some strategies that might deliver such options

Objectives of addressing peak demand

Table 1 lists a number of possible objectives related to peak electricity demand, and some of the outcomes that might be linked to each objective.

Unfortunately, the focus of recent debate seems to have been mostly on the first two objectives, at the expense of the others. Indeed, some involved in the debate seem to simply dismiss energy efficiency as irrelevant to efforts to manage peak demand. For example, a study for VenCorp in Victoria (CRA and Gallaugher & Associates, 2001) described the problem as one of "sharp needle peaks caused by periods of hot weather and/or unforeseen loss of generation capacity". They then decided to exclude energy efficiency from their definition of demand response strategies on the grounds that:

> "Although these [energy efficiency] measures are valuable in their own right – they offer (a) attractive financial returns to users when compared to the operating costs of less efficient stock and equipment, (b) better environmental outcomes for society through reduced greenhouse gas emissions, and (c) greater economic efficiency for the State overall – they will neither (*i*) significantly reduce the magnitude of the difference between average load and peak load, nor (*ii*) change the duration or cause of the needle peaks. As a result, energy efficiency will not improve the functioning of the NEM during times of needle peak demand (which are forecast to characterize Victoria's load profile for the foreseeable future), and we have therefore omitted consideration of energy efficiency from the set of actions included in the term "demand response" for the purpose of this study."

Indeed, a more recent paper by some of the same authors (CRA, 2003) lists as the potential response options to peak demand problems:

- Cost-reflective price signalling
- Efficient price signals by networks
- Tariff options – existing metrology
- Tariff options – interval metering metrology

There seems to be no reference at all to the role of energy efficiency or distributed generation: presumably it is assumed that some of the demand side response driven by the above strategies may include energy efficiency, but this is not obvious. The paper also seems to make the assumption that a distributor will not be directly involved in delivery of demand-side energy efficiency, but will rely on price signals to drive response.

Table 1. Some possible objectives when addressing summer peak demand issues

Possible Objective	Possible Response
Minimise costs for and increase profitability of the existing electricity supply industry	‘Leave it to the market to sort out’, probably by using pricing, interruptibility mechanisms, load shifting and cycling while allowing ongoing growth in consumption
Protect incumbent politicians’ jobs	Avoid blackouts at any cost and ensure ‘swinging voters’ do not experience rapid price increases: the obvious response is to increase supply capacity but smear the costs across all users
Minimise total energy costs for society	Working within a market context, provide incentives and/or regulate electricity industry to overcome market imperfections and deliver ‘least societal cost’ outcomes rather than ‘best for individual distributor/retailer’ outcomes Drive public policy and programs to target those who influence electricity use but are not influenced by electricity prices and policy (eg equipment manufacturers, designers, installers and other market intermediaries)
Minimise total costs of energy services (including environmental and social costs) for society	As above plus include environmental and social costs in prices and ensure all agents (on both demand and supply side) apply similar low discount rates to investments in sustainable energy solutions
Cut greenhouse gas emissions by 60-80% ASAP	As above, but apply more aggressive policy measures
All of the above	What balance? Who decides? Who participates?

Lets look more closely at the claims about energy efficiency in the VenCorp report.

First, it is claimed that energy efficiency will not “significantly reduce the magnitude of the difference between average load and peak load…”. The outcome actually depends on the daily and seasonal demand profile of the activity to which efficiency measures are applied, and the detailed characteristics of the actual efficiency measures implemented. For example, installing lighting controls can cut peak (or at least hot weather) demand by more than its impact on average load. On the other hand, improving building envelope thermal efficiency can make this ratio worse. Although such measures can dramatically reduce peak cooling (and heating demand), they may also reduce heating and cooling requirements at other times, and shorten the periods during which heating and cooling is required.

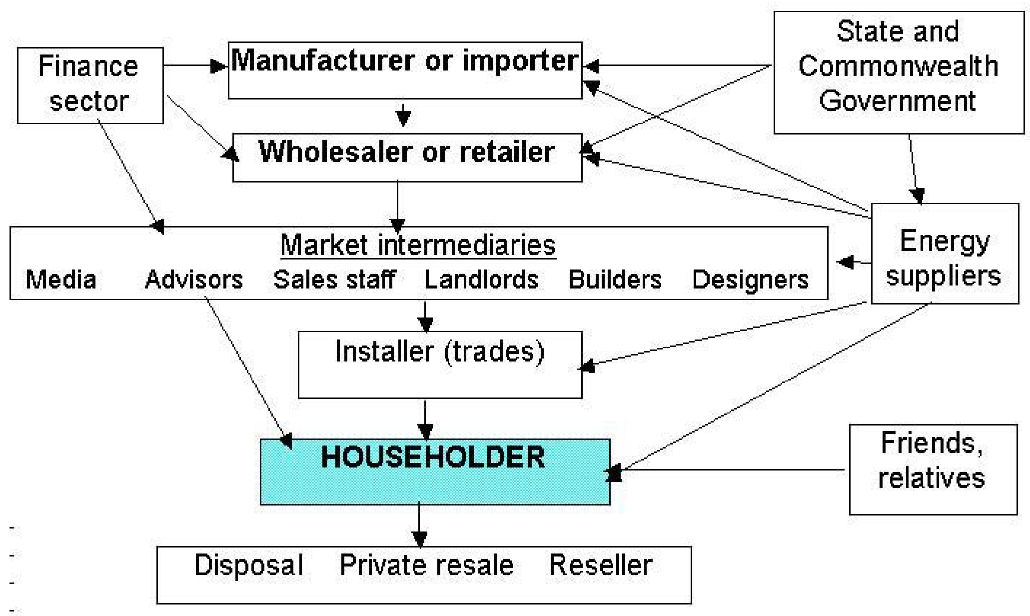
But an important question to consider is why the ratio between peak and average demand matters. It certainly helps the electricity supply industry improve utilisation of its assets. But if this is at the expense of larger savings in greenhouse gas emissions and energy costs for customers from energy efficiency measures that cut peak demand but don't necessarily improve utilisation of electricity assets, why should this objective take priority?

Second, it is argued that energy efficiency will not "change the duration or cause of the needle peaks". This just seems plain wrong. When the peaks are being caused by increasing use of air-conditioning in thermally poor buildings, it follows logically that addressing those issues will reduce the peak problem. Indeed, a thermally-efficient building with high efficiency air-conditioning and photovoltaic cells could well be a net supplier of electricity to the grid at times of summer peak demand. And a well-insulated refrigerator will disproportionately reduce consumption in hot weather.

We should also keep in mind that efforts to achieve flat load profiles reflect the nature of the present infrastructure, not a fundamental issue. At present, the bulk of generation capacity is coal-fired (and hence fairly inflexible and high in capital cost) and, being centralised, relies upon transmission and distribution infrastructure to deliver the electricity to users. But summer peak demand occurs when some forms of renewable energy are at their most bountiful. And if we utilised distributed generation while using energy efficiently, optimisation of investment in transmission and distribution infrastructure would also be less of an issue. And how does achieving flat demand profiles impact on greenhouse gas emissions if it encourages construction of coal-fired power stations?

Lastly, we should look at investment in energy supply infrastructure in context. Australian households spend over $8 billion each year on energy-consuming appliances and equipment, and tens of billions of dollars on new dwellings and major renovations. These drivers of electricity demand – or energy efficiency potential, involve much more investment than expansion of energy supply infrastructure.

Figure 1. Participants in the household appliance market (Pears, 1998)



Overview of household appliance market system – each link in the chain of decisions must be considered

The billions of dollars of investment in energy consuming equipment and buildings occurs largely outside the influence of energy markets. Figure 1 shows a model of the system that delivers appliances to households. Few of the participants perceive that they have any significant link to energy markets or even energy demand. In fact, many of them have vested interests in selling equipment that uses more energy – not because they are necessarily deliberately encouraging energy waste, but because the nature of the markets within which they work often provides strong signals to encourage energy waste, for example:

- many salespeople, plumbers, heating and cooling contractors and other market intermediaries encourage buyers to select larger capacity products, ‘so they won’t run out of hot water’, or ‘so they will be able to heat or cool the house on the hottest day’. Typically larger products have higher standby losses (eg heat loss from storage tanks) and operate less efficiently at part load for much of the time. This approach maximises the profit from each sale or installation and reduces the risk of complaint about inadequate capacity – often at the expense of performance under other circumstances.
- in order to cut up-front costs of these larger units, salespeople and advisers then often encourage buyers to select cheaper, less efficient models from the range in that size, in order to secure a sale
- often the range of inefficient products available is much wider, and it is easier to find attractive solutions for a buyer. For example, in lighting shops the range of fittings is dominated by those suited to inefficient halogens and incandescent lamps, and few are designed for compact fluorescent lamps
- few market intermediaries are knowledgeable and place a high priority on energy efficiency. The widespread belief among lighting salespeople and designers that low voltage halogens are efficient – because low voltage must mean less electricity (when it is actually the watts of lighting that matter) is an example, but many plumbers seem to believe that plastic pipes are good insulators that do not need additional insulation, and there are many other incorrect myths.
- Some sales people actually try to undermine the credibility of energy labelling schemes or advice from energy efficiency experts if it complicates their sales pitch

These points highlight the need to look at the bigger picture. If trying to ‘solve’ the summer peak demand problem distorts outcomes of broader significance, and distracts us from focusing on other important issues, this may not be the best pathway. On the other hand, if we can find solutions to summer peak demand problems that support achievement of other important societal goals, they will be preferable.

In this context, it is important to recognise that the potential for energy efficiency to help to avoid the need for additional investment in energy supply infrastructure is very large. In my view, we could satisfy the energy service requirements of our growing economy using less than half as much electricity as we now use. We do not need to build more conventional power stations or upgrade transmission and distribution infrastructure, except where urban expansion is occurring. But to avoid the need to expand conventional energy infrastructure requires strong action, well beyond what we have seen to date.

Managing Summer Peak Electricity Demand

There has been a re-emergence of the realisation that distribution costs are driven by local demand, which may be dominated by residential, commercial or industrial demand – or combinations of them. Transmission infrastructure capacity is linked to aggregated regional demand, and so is not so sensitive to each sector’s demand profile. And generation requirements relate to regional, state or even multi-state demand. So the drivers for investment in distribution, transmission and generation vary. To manage summer demand, we must understand its characteristics and the characteristics of the options available.

In Sydney in summer, residential sector demand peaks in the late afternoon and early evening, while commercial load peaks from early to late afternoon and industrial demand is fairly stable over the day (CRA, 2003). Lets look at some of the issues relating to electricity demand for these different sectors.

Residential Demand

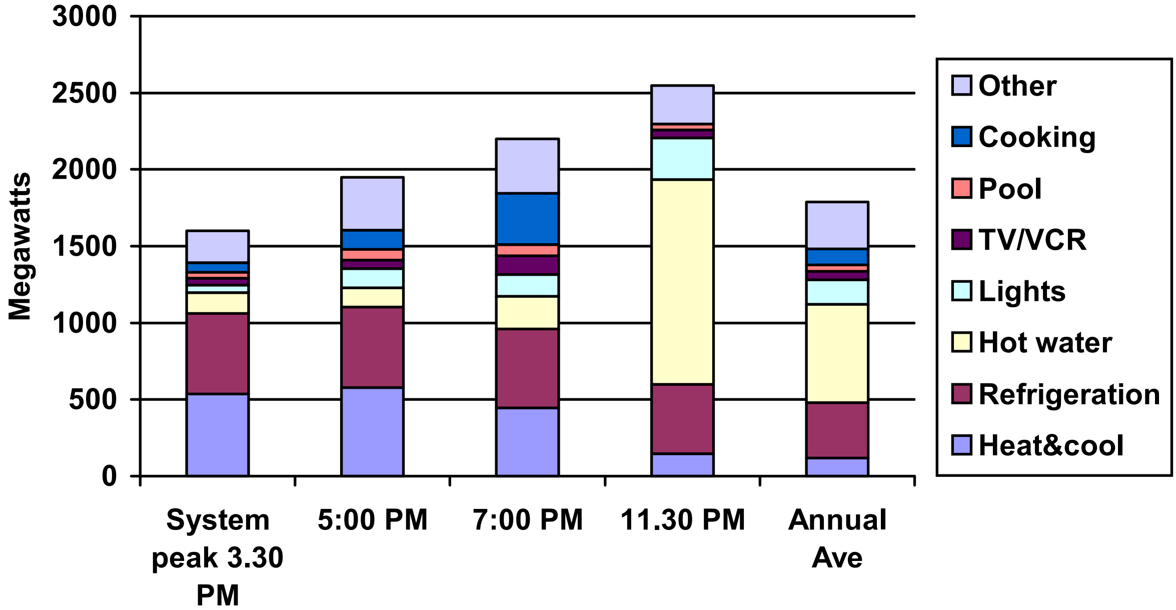
There is no doubt that air-conditioning is a large and rapidly growing component of summer peak residential demand – and this will be discussed later. But it is not the only issue.

Figure 2 shows the contributors to NSW residential peak summer day demand at four times of day in 1994, and compares these levels of demand with the annual average. This begs some questions:

- At what time do we want to reduce demand?
- Are we looking at just local distribution systems, transmission loads or total generation – or all of them?

Figure 2 shows that if we are interested in limiting peak summer residential demand over all of NSW, which drives generation and transmission investment, we might focus on electric hot water and its contribution late at night. If we are looking at managing distribution costs in recently developed residential areas where gas hot water and air-conditioning are common, then we may be interested in limiting demand at around 5 to 7 pm. If we are interested in state-wide system peak demand, which affects generation and transmission, then we will be interested in demand at the system peak in the early afternoon. So there is not a single peak that needs to be 'fixed'.

Figure 2. 1994 NSW residential electricity demand on peak summer day at four times compared with average annual demand.



From Figure 2 it can be seen that refrigeration is a major summer peak demand issue, while pool filter pumps make a significant contribution and are amenable to load management without impacting on amenity. By early evening, even cooking and lighting are beginning to contribute significantly to demand. So a combination of appliance and equipment energy efficiency improvement, fuel switching away from electricity for cooking and hot water, and load management of pool pumps, hot water services and other equipment (including computers, standby power, etc) can help address electricity infrastructure costs. What's more, they can also cut greenhouse gas emissions and household energy bills. So why are they being ignored by many key players? Could it be that the structure of the electricity market provides no incentive to address them?

Residential cooling issues

When we look at residential cooling, we see that three groups of issues drive this demand:

- building envelope
- cooling technology selected
- user behaviour

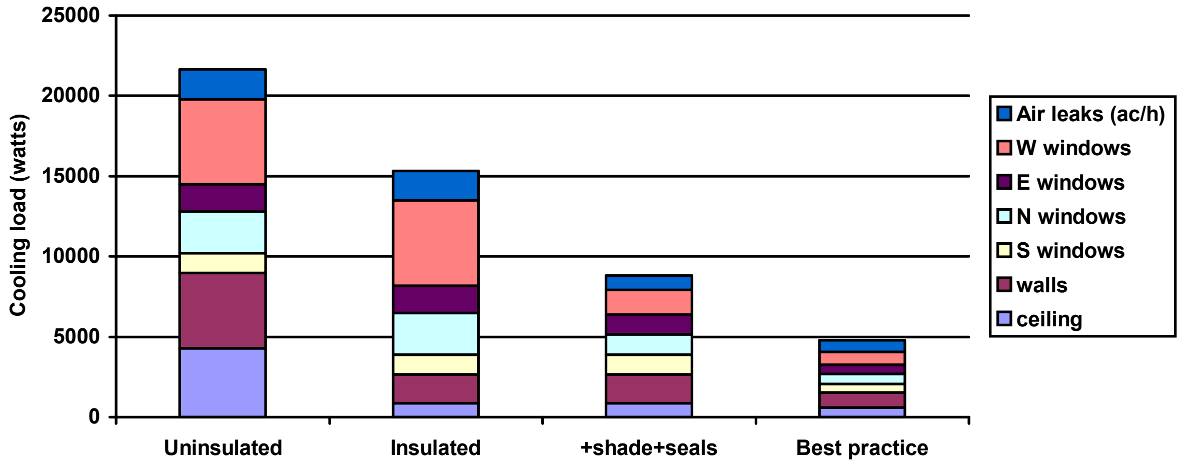
Insulation, shading, advanced glazing, draughtproofing and appropriate orientation can dramatically reduce peak heating and cooling demand. Figure 3 shows the notional cooling requirements based on steady-state heat flows of a 150 square metre house with 36 square metres of glazing equally distributed across north, south east and west facades and one airchange per hour air leakage. This analysis applies to mid-afternoon on a 40 degree day and ignores the significant effect of thermal inertia due to the mass of the building. It is also assumed that the floor is thermally neutral. The 'Best Practice' option includes advanced low-emissivity double glazing.

So a typical builder-specified 10 kW output ducted air conditioner cannot maintain a high level of comfort in such a house unless it has some insulation and shading – although it will make some improvement. The west windows alone, without shading, are responsible for around 5 kW of cooling load.

It can be seen that aggressive energy efficiency measures cut the cooling load of the insulated but unshaded house by two-thirds. But the combination of shading, insulation and draughtproofing only cuts requirements to just under 9 kW – not much less than the capacity of a typical central air conditioner: so moderate efficiency improvements may not necessarily deliver as much reduction in peak demand as expected, where cooling equipment is undersized (as is common due to its high capital cost) – although the occupants will be cooler. On the other hand, the effects of thermal mass, particularly concrete slab-on-ground floors, can stabilise temperatures and both delay and reduce peak cooling demand. This factor was not considered here.

The overall message here is that building envelope improvements can dramatically reduce peak cooling loads – but actual reductions in peak electricity demand will depend to some extent on equipment sizing and the extent to which the efficiency measures are driven. So moderate efficiency measures may not make much difference to peak electricity demand. If the circumstances are not properly understood, this lack of impact may be used as 'proof' that energy efficiency doesn't work.

Figure 3. Indicative maximum afternoon cooling requirements of a 150 square metre dwelling on a 40C day, ignoring thermal inertia effects.



An often ignored but very important building issue is air leakage. An unsealed ceiling exhaust fan, alone, can increase cooling load by several kilowatts on a hot windy day by allowing large amounts of outdoor air to enter the house. Subtle factors such as this add to the risk that energy efficiency programs will fall short of expectations.

The selection of cooling technology is critical to summer peak demand. Obviously, use of evaporative cooling instead of refrigerative cooling can make a big difference to electricity demand in climates where wet bulb temperatures are not too high. But if refrigerative cooling is used, a number of factors can impact on efficiency:

- Equipment efficiency (often called Coefficient of Performance), but also cycling and other losses
- Heat gain to ducts or other distribution systems
- Area cooled
- Controls

There is scope to improve the efficiency of new air conditioners, and programs such as energy labelling and Minimum Energy Performance Standards can do this. Indeed, the Japanese *TopRunner* program (www.eccj.or.jp) is driving COPs upwards from today's 2-2.5. Evaluation of the fundamentals of thermodynamics suggests that there is scope to deliver 4-5 units of cooling from each unit of electricity. To put this into context, it seems feasible to air-condition a thermally-efficient house using 1 kilowatt of electricity, or a bedroom at night using the same amount of electricity as is now used by a ceiling fan.

Existing and new equipment can also have its efficiency improved by add-on measures, for example an evaporative pre-cooler can improve COP. Ductwork in ceilings is notorious for energy waste. Pumping cold air through poorly insulated, leaky ducts in a hot ceiling is a recipe for energy waste of 2 kW or more. Upgrading ductwork by improving its airtightness and insulation can be a significant energy saver. In California, buildings with ductwork inside the conditioned space instead of in the roof receive a bonus in energy ratings.

Zoning of cooling can cut peak load, particularly in a two storey house with living areas downstairs. If cooling of bedrooms is delayed till late in the day, outdoor temperatures have usually fallen and solar loads are reduced – unless the building has west windows and/or uninsulated walls. Smart controls offer substantial potential for management of peak demand, especially if they include the capacity to take instructions from the electricity supplier and from remote locations. Anecdotally, it seems that some householders actually leave air-conditioning running on the hottest days, so that their house will not be too hot when they arrive home (CRA, 2003). Smart controls could eliminate this problem.

User behaviour is also a critical piece of the jigsaw. The significance of leaving equipment on has already been mentioned, but to this can be added issues such as the thermostat setting chosen, the area cooled and management of window coverings. Another less obvious issue is the opening of windows while cooling. Leaving two windows open 100 mm on opposite sides of a house on a hot windy day can increase heat gain by 7 kilowatts or more!

Residential distributed generation

Interest in distributed generation at the residential level is increasing rapidly, particularly with regard to photovoltaic cells. It can be seen from the above analysis that, ignoring mass effects, a very energy-efficient house requires less than 5 kW of cooling under very extreme conditions. If a high efficiency air conditioner were used (COP of 5), only 1 kW of electricity would be required to cool the whole house. In reality, only a proportion of homes are occupied during afternoons, and actual cooling loads would be lower. On this basis, there is potential to consider application of distributed PV systems as a summer peak demand management tool, and to place significant value on their role of avoiding capital investment in centralised supply and networks. Watt et al (2003) suggest that roof-top PV has an output profile more closely matched to commercial sector demand, so there is a case to focus such developments on parts of the network where mixed-use buildings and activities exist. Small fuel cells and micro-cogeneration systems are also moving towards viability, especially in high and medium density housing.

Residential load management and fuel switching

Load management and fuel switching can certainly play important roles in both reducing residential demand at times that can deliver network and generation capacity benefits. They have not been discussed in this paper because their benefits are already widely recognised.

Energy storage, as electricity or as 'coolth' also shows substantial potential to help shift cooling loads to times of the day when ambient conditions are more favourable, or when natural energy flows can play useful roles. Phase change materials, heavy materials, earth-linked buildings and features, smart ventilation systems, and other strategies all show promise. Indeed, as more homes install rainwater tanks, they offer potential to play a role in managing energy use for maintaining comfort.

<u>Residential overview</u>

Depending on the time(s) of day and year when it is considered important to reduce residential electricity demand, different equipment and activities contribute to the demand. So different strategies can be used to deliver demand reductions. Combining energy efficiency, load management and fuel switching offers excellent opportunities to reduce peak demand, annual greenhouse gas emissions and annual energy bills. Ignoring energy efficiency may solve the peak demand problem for a few years, but it will fail to capture the other benefits that have substantial value. But how do we capture these opportunities?

Commercial Sector

There is no doubt that the commercial sector is a major contributor to peak summer electricity demand. Daytime commercial sector demand is typically double night-time load, while on hot days, demand during the afternoon can be 30-50% higher than on mild days.

Much of the emphasis of energy efficiency programs in the commercial sector has been on large office buildings, because they are visible, large and can be easily targeted. However small, often low-rise, commercial buildings comprise around half of total commercial sector floor area – and most of the stock outside CBD areas. Further, the retail sector is a large and rapidly growing contributor to both electricity use and peak demand.

While air-conditioning is typically the dominant end-use for commercial sector electricity on hot days, this is often the end result of other activity. For example:

- Inefficient lighting in air-conditioned buildings, particularly the retail sector, adds to cooling loads as well as using electricity directly
- Massive flows of hot, often humid outdoor air into open shops and other commercial buildings contribute both sensible and latent heat loads to buildings. And where this moisture enters refrigeration equipment, the multiple phase changes from vapour to liquid to ice to liquid can consume up to 1 kilowatt-hour per litre
- Inefficient cooking equipment not only dumps enormous amounts of heat into fast food stores and supermarkets, but the exhaust fans used to remove heat, odours and fumes further increase the rate of outdoor air entering the buildings

Rob Helstroom, formerly of CSIRO and now at DIPNR, found that a large proportion of the cooling load in Sydney was actually latent heat – that is, the need to condense water vapour from air, as shown in Figure 4. This research underpinned the development of an innovative micro-cogeneration system at Hornsby Library, which uses waste heat to recharge desiccant for dehumidification in summer. This combination of distributed generation and cooling technology offers great promise in humid climates such as Sydney's.

To an even greater extent than in the residential sector, energy efficiency opportunities abound in the commercial sector. Analysis of commercial equipment such as chip fryers, commercial coldrooms and coffee makers reveals large savings potential. Indeed, a pertinent question to ask is whether it is possible to make this equipment much more energy-wasteful than it is. For example, a chip fryer is basically a metal box with hot oil exposed to moving air blown across it by an exhaust fan. This exposure to air increases the rate of oxidation of the oil, leading to more frequent replacement. Often the air has been air-conditioned before it is removed from the building by the exhaust fan. Likewise, computer centres are over-air-conditioned with inefficient equipment, extremely inefficient lighting is the norm, and so on. Building envelopes are also thermally poor, as reflected in Figure 5. Even when a building envelope is thermally efficient, energy waste from equipment running inefficiently on part-load, fan and pump energy, standby energy and many other factors work against us capturing the full savings potential.

Figure 4. Relative contributions of latent and sensible heat to cooling requirements around Australia (Helstroom, 2002)

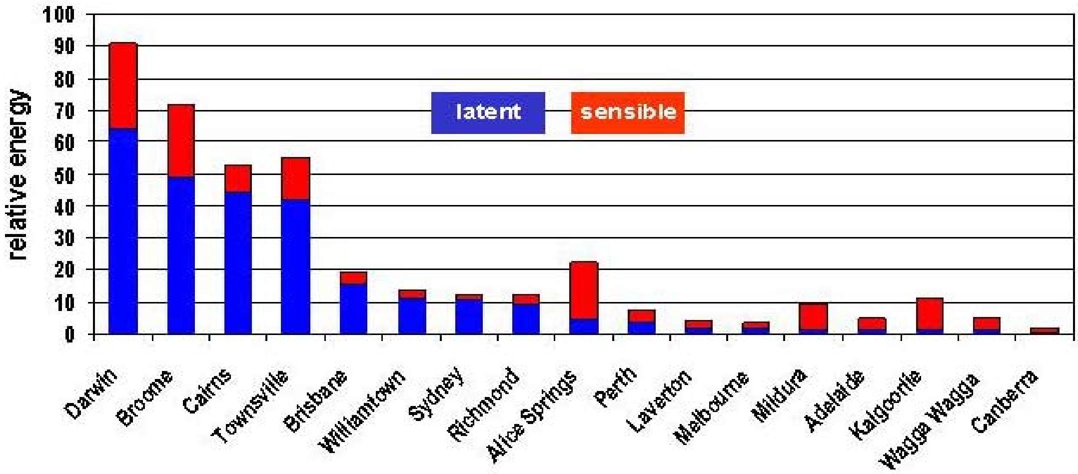
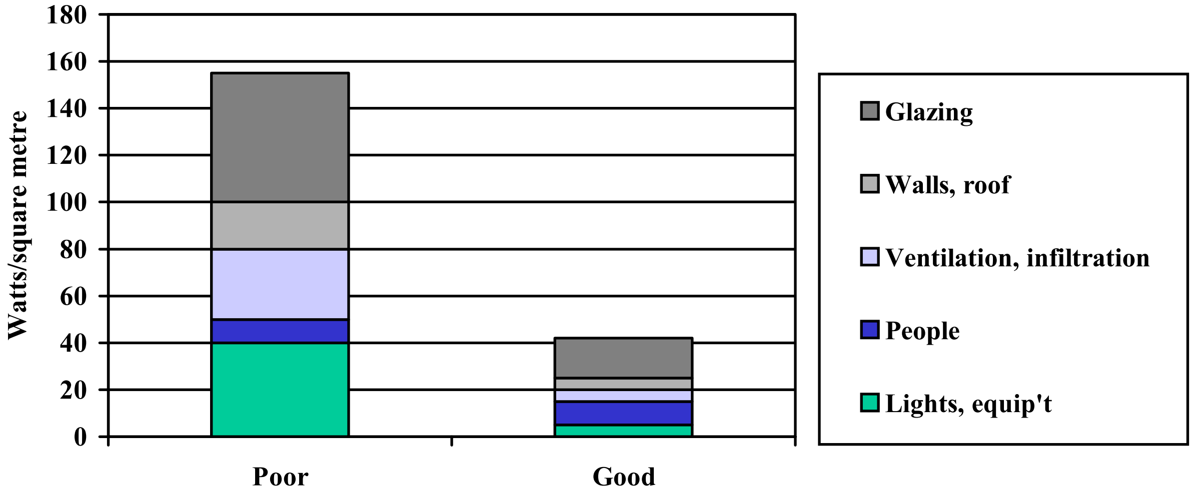


Figure 5. Scope for reduction in peak cooling requirements of a multi-storey office building with each floor 1,000 square metres and glazing to 40% of wall area (Pears, 2000). Note that a reduction in cooling requirements does not necessarily translate to an equivalent reduction in cooling energy.



As noted earlier, a large proportion of commercial sector energy use occurs in low-rise office buildings and retail facilities. These buildings suffer from serious inefficiencies. For example, ducted air-conditioning systems in low-rise buildings often waste large amounts of energy. One problem building in Melbourne involved leaky, poorly insulated ducts located in a roof space that reached over 60C in hot weather. The heat gain of the ducts was so great that air delivered by the outlets furthest from the air-conditioning unit was measured at 28C – so the air-conditioning system was actually heating the building! Upgrading duct insulation improved efficiency significantly, but air leakage from ductwork and fittings still meant that significant inefficiencies remained.

As for the residential sector, it is clear that there are very substantial energy efficiency opportunities in the commercial sector. And distributed generation with renewable energy, microturbines and, soon, fuel cells, offers the opportunity to avoid investment in conventional power generation, transmission and distribution. The challenge is how do we capture these savings?

Strategies to Capture Energy Efficiency and Distributed Generation Opportunities

Many papers and books have been written about the barriers to energy efficiency (see, for example, Greene and Pears, 2003). Some hard-core economists and policy people still reject the notion that cost-effective opportunities exist. But the savings are really there. And the more we look for, the more we will find (see Laitner and Sanstad, 2004). However, it is not easy.

Deeply-ingrained mechanisms are working against us. For example, as discussed earlier, a salesperson has a strong vested interest in selling a larger air conditioner, boiling water unit, hot water service, or whatever, because (s)he makes more money from the same (or sometimes less) work. Even if an electricity supplier is compensated for lost revenue from demand-side action, there is a deep-seated belief that such activity reduces the long-term viability of the supplier by reducing the sales volume over which it can spread its costs. After all, a sign of a healthy business is growth in sales volume.

While some existing programs such as the Australian Building Greenhouse Rating Scheme, appliance energy labelling and Minimum Energy Performance Standards have delivered impressive savings, and emerging programs such as BASIX show much promise, we have a long way to go.

In this paper, I propose to flag some more radical approaches that are consistent with the increasing urgency of cutting greenhouse gas emissions while also managing investment in expansion of conventional energy supply infrastructure. These measures are potentially very cost-effective, and could therefore contribute to economic growth by shifting investment to areas of higher rates of return and higher employment than alternative investment in energy supply.

A key principle being questioned here is the assumption that we have the right to use as much fossil fuel-sourced electricity as we like whenever we like, for whatever we like – and often subsidised by other consumers. If we consider global equity, this is unreasonable: we have an obligation to limit our resource consumption and environmental impacts, and to pay our fair share. This does *not* mean we must freeze in the dark or limit our electricity consumption – but it does mean that we need to satisfy an increasing proportion of our requirements through energy efficiency and low or zero emission energy sources.

Residential

Households receive little feedback on their energy use. Electricity bills should include not just daily electricity use information, but also benchmarks against which individual households can compare their usage. Those with above-benchmark usage could qualify for information and assistance programs. A basis for benchmarks exists as a result of studies such as Fiebig and Woodland's early 1990s study for the NSW Department of Minerals and Energy, and the NABERS environmental rating scheme has also developed benchmarks.

High consumers

Based on limited data, it seems that around 5% of Australian households consume 15% of household electricity (Pears, 1998). High summer electricity bills correlate reasonably well with high peak demand. So electricity retailers have sufficient information to target high peak demand households with programs aimed at reducing their demand. But it would contravene privacy information if they were to offer this information to others. So we need a mechanism to either encourage or require electricity retailers to help these households to cut their demand, or to encourage or require them to assist other agents to work with these households. For example:

- Retailers could send notices to high demand customers in selected areas inviting them to contact the energy efficiency agents in order to benefit from programs. Such programs would need to incorporate incentives to make action attractive
- Retailers could make these households high priority for installation of interval metering and time of use tariffs, although this would need to be phased in with assistance programs to help them reduce the cost impacts of the tariffs.

While it would be desirable if electricity retailers could be encouraged to voluntarily follow this approach, clear sanctions need to be put in place and made visible for those that fail to enthusiastically participate. As US President Roosevelt once said, "speak softly and carry a big stick".

Existing homes and rental properties

The time of sale or rental is a time when large amounts of money change hands, and refurbishment often occurs. This is a tactically important time to place obligations on sellers or landlords to upgrade performance and introduce improved metering and feedback systems. The ACT's legislation for energy rating of existing homes at time of sale is a useful model that shows the world did not end when information was required, and that such information increases the financial value of energy efficient homes. But a more comprehensive scheme that includes assessment of fixed appliances and equipment for their greenhouse performance is needed. The pilot *Energy Smart Home Rating Scheme* being developed by SEDA may well provide an appropriate tool. Such a scheme would support development of a home auditing and retrofitting industry, and could provide a driver for existing market intermediaries to increase their focus on energy efficiency as well.

New homes

BASIX is an important step forward, in that it places limits on peak cooling demand of new homes. But it is not particularly tough, at least partly due to its mandatory nature. The NSW Government should consider offering incentives for new homes that exceed the minimum BASIX rating.

Looking towards the longer term, we could consider placing limits on the maximum level of demand a dwelling may have, unless it pays a significant proportion of the capital required to pay for the energy supply infrastructure it requires, or it agrees to pay a premium for usage above that level. This is not new. In Italy, most households are limited to a maximum demand of 3 kilowatts (Pagliano, 2001). They manage their energy use within this limit and live to tell the tale. While most Australians would consider it impossible to limit their demand to such a low level, it is certainly feasible for an energy-efficient household with smart load management capability that can shed or cycle non-essential loads if necessary, and possibly some energy storage.

Appliances and equipment

A large proportion of residential sector energy use and greenhouse gas emissions results from use of appliances and equipment, as well as standby power. While Australia's appliance energy efficiency program is world-class, many products and systems 'fall through the cracks'. There is a need to change the basis of Australia's appliance and equipment efficiency program. Instead of specifying standards and energy labels for individual products, the onus should be placed on designers, manufacturers, importers and installers to demonstrate that they are achieving the highest possible efficiency. The NSW Government should be promoting this approach in national fora, but it can also apply pressure by publishing data on the performance of products that do not have energy labels, and by introducing incentives for products that achieve high efficiency. For example, promotion of energy-efficient security systems, automatic garage door openers, intercoms, gas central heating thermostats, etc that achieve low standby energy use could make a difference for NSW households, while supporting development of more comprehensive national standards.

There is some evidence to suggest that energy use by old, little-used equipment is a significant contributor to total household electricity use - those old VCRs and fridges in the spare bedroom or laundry use disproportionately large amounts of power. Programs that encourage people to retire this equipment could deliver useful savings. For example, the recent Phoenix Fridge project run by Moreland Energy Foundation in Melbourne found that a significant proportion of old refrigerators had serious faults. If householders were informed that their old fridges and appliances were costing them hundreds of dollars each year, they may be interested in donating them to charity or taking advantage of 'buy-back' programs.

Commercial sector

The commercial sector is particularly difficult to address because of many issues including the lack of focus of businesses on their energy use, which is a small component of their costs (often less than 0.5% of input costs), and due partly to their lack of in-house expertise and their dependence on subcontractors who also pay little attention to energy efficiency. No programs have yet targeted shopfitters and office fit-out contractors, who drive tenant energy use in shops and offices. The building development and construction process is fragmented and loaded with incentives that entrench energy waste.

Existing commercial sector energy consumers

As in the residential sector, electricity retailers hold very useful information that would allow high peak demand contributors to be identified and targeted. While it would be useful to combine energy use data with building floor areas and types of businesses, this may not always be possible. But at a basic level, electricity retailers can identify customers with high summer bills relative to spring/autumn bills: they are key targets for demand reduction programs. Many commercial customers now have interval meters, so that it is possible for electricity retailers to identify contributors to peak demand very easily. We need to ask why many of these customers have not already been targeted for energy efficiency and demand management programs, and government policy needs to ensure that they are targeted.

Market intermediaries such as shopfitters, salespeople, electricians, interior designers and engineers play major roles in driving energy waste in the commercial sector. Training, incentives, information and benchmarking schemes are needed to improve performance. At the same time, we need to recognise that the incentives for energy waste are significant, and either incentives or regulations are needed to change behaviour. Energy market reform is very unlikely to drive change in these areas.

Also, in many cases all the products available are inefficient. Product development and commercialisation programs are needed. Many commercial sector products are manufactured in relatively small volumes by small manufacturers who have little RD&D capacity: they need help to produce super-efficient pizza ovens, bains marie, refrigerated display cases, and so on. It may well be that 'buy back' programs are also needed to capture inefficient products that would otherwise be sold second-hand to school canteens or milk bars.

Significant amounts of inefficient equipment such as drink vending machines and glass door merchandising units are provided by drink and other product manufacturers for use in retail environments. These companies have little interest in their running costs, because they don't pay the energy bills. Most of this equipment is extremely inefficient. Ideally, national standards should be introduced, but there is scope for information programs and to retrofit equipment to improve its performance, and for sub-standard equipment to be subject to 'buy-back' schemes or simply banned.

Annual public reporting of energy use is critical to accountability. It also provides information for the emerging energy services industry to use to identify potential clients. Further, the electricity supply industry should be required to publish an annual 'Statement of Opportunities' for DSM businesses that highlights regions of the electricity grid where constraints and problems are expected to emerge over the ensuing five years, and regions where electricity distributors, transmission agencies and retailers should be *required* to offer financial incentives for avoided peak demand. If this is too difficult, the NSW government should step in and provide the information and incentives – with the incentives being funded by a levy on electricity sales. State governments have traditionally provided subsidised information on resource potential for the minerals and other industries: the above information is the equivalent information for the energy efficiency industry, so governments have a role to provide it.

New facilities and buildings

New commercial buildings are still not subject to even the most basic building energy regulations, although national codes are expected to appear over the next few years. The Australian Building Greenhouse Rating Scheme provides a useful framework for benchmarking and improving performance of new office buildings and tenancies. However it needs to be extended to cover other types of buildings, including aged care facilities, health care facilities, retail, hotels and motels, and so on. Benchmark data is available from some other countries and from some government programs, so that star rating scales could be set fairly quickly, particularly if mandatory annual reporting of energy use was introduced. Where specific types of equipment use large amounts of energy in such facilities, requirements for separate metering and reporting would facilitate meaningful benchmarking as well as providing valuable feedback to the businesses.

A requirement for regular reporting of performance of building performance is critical to accountability and ongoing improvement. Visible reporting is also an important driver to build demand for the services of energy services businesses.

One way of overcoming the widespread 'split incentive' problem for new buildings would be to require developers of new buildings to pay for the estimated lifecycle greenhouse gas emissions of their building up-front so that the base building would achieve net zero lifecycle emissions. This would provide a financial signal for them to invest in energy efficiency and other greenhouse emission reduction measures. They would then have to buy RECs, NGACs or other offsets to cover the remaining emissions estimated over, say, a 25 year building life.

An incentive for designers would be a requirement that no new building be eligible for any award until it could demonstrate its greenhouse performance over at least a 12 month period. As a start towards this, the NSW government could fund the modelling, monitoring and provision of information on energy performance of finalists for awards, so that the judges could at least consider energy performance in their deliberations.

In recent discussions with a manufacturer of components for the aircraft industry, I was told that aircraft manufacturers pay a bounty to component manufacturers for weight reduction. The electricity supply industry (or, alternatively, the government) could pay bounties for high efficiency products and systems installed.

Broad measures

One of the problems we humans face is that we act on the assumption that infrastructure will be provided to support anything we do that uses energy. This creates a never-ending spiral of energy growth. As a first step, we need to define some regions where a clear limit is placed on total electricity usage and peak demand. Within these areas, mechanisms must be trialled to limit local demand within existing limits. Of course, distributed energy production would be allowed to contribute to the outcome. In these areas, combinations of regulations and incentives would be used to drive demand-side action and distributed generation at rates that avoided both the need for additional externally-sourced supply, and the risk of black-outs.

There is also a need for stronger promotion of Green Power. One possible option would be to encourage businesses other than electricity retailers to develop and offer to customers separate packages to offset emissions. For example, a business could buy up Renewable Energy Certificates and NGACs, then offer energy consumers offset packages to balance their emissions from both electricity and gas consumption. This would open up the market and apply pressure to electricity retailers to price Green Power competitively. It would also allow energy users to offset all their energy use, not just electricity. Products such as GreenFleet's *Tree Totaller* website (www.greenfleet.com.au) show what could be done.

Conclusion

Energy efficiency and distributed generation are the forgotten tools that can not only avoid the need for expansion of conventional energy supply infrastructure, but can also cut greenhouse gas emissions and energy bills. They also improve the resilience of our energy systems.

But capturing the opportunities is difficult, and requires strong and sustained effort, resources and political will. It's worth it.

References

Charles River Associates and Gallaugher & Associates (2001) *Electricity Demand Side Management Study: Review of Issues and Options for Government* Report for VENCorp, Government of Victoria, Melbourne

Charles River and Associates (2003) *Impact of Air-conditioning on Integral Energy's Network* Report for Integral Energy submitted to NSW Government Inquiry

Greene D and Pears A (2003) *Policy Options for Energy Efficiency in Australia* Australian CRC for Renewable Energy Policy Group, Murdoch University WA

Pagliano L, Alari P and Ruggieri G (2001) *The Italian energy saving obligation to gas and electricity distribution companies. Scenario and case studies calculations show high environmental and economic benefits to actors (DISCOs, ESCOs, customers) and society* lorenzo.pagliano@polimi.it End-use Efficiency Research Group – eERG, Politecnico di Milano, Piazza Leonardo da Vinci 32, 20133 Milano

Pears A (1998) *Strategic Study of Household Energy and Greenhouse Issues* Report for Environment Australia (now Australian Greenhouse Office), Canberra www.energyrating.gov.au

Pears, A (2000) *Saving Energy in Commercial Buildings: How Much Scope is There?* Proc Annual Conference, Sustainable Energy Industry Association, Melbourne Oct

Watt, M. Oliphant, H. Outhred and R. Collins, "Using PV to meet Peak Summer Electricity Loads" *in Proc. ANZSES'2003*, Melbourne, November, 2003