ENVIRONMENT DESIGN GUIDE

URBAN AIR QUALITY

John J Todd

This note GEN 34, originally published in November 2000, was reviewed by John Todd in August 2005. This summary page includes recent updates to the topic since publication.

SUMMARY OF

ACTIONS TOWARDS SUSTAINABLE OUTCOMES

Environmental Issues/Principal Impacts

- Evidence continues to mount that motor vehicles and residential space heating and cooling are the two most important sources of harmful air pollutants in urban Australia.
- Publication of the National Environment Protection (Air Toxics) Measure in 2004 creates a regulatory environment where emissions from motor vehicles and woodheaters are likely to come under greater scrutiny.
- However, environmental issues have slipped slightly down the community's list of priorities in recent years. This places greater responsibility on planners, designers and architects to encourage clients to aim for improved air quality in all projects.

Basic Strategies

In many design situations, boundaries and constraints limit the application of cutting EDGe actions. In these circumstances, designers should at least consider the following:

- Basic strategies remain unchanged – air pollution issues need to be understood by designers and appropriate mitigation measures incorporated in project design.
- Emphasis on energy efficient homes and commercial buildings is essential to reduce heating and cooling requirements. Appropriate landscaping can reduce fuel use for heating and lawn-mowing and careful selection of plants reduces irritating types of pollen.
- Sensible suburban design can reduce motor vehicle use.
- Difficulties with enforcement of low-emission woodheater requirements have become apparent (Bagchi *et al*, 2003) suggesting alternative heating options are preferred until the problems are resolved.

Cutting EDGe Strategies

- Building and urban design professionals should routinely factor in an air pollution inventory for any job they undertake. Design and structure modifications should be considered and the implications for air quality (indoor and out) considered. By considering materials and design, in the same way embodied energy and lifetime energy use are considered, a gradual move away from high air pollution design to low air pollution design could be achieved.

Synergies and References

- Since publication of GEN 34 Environment Australia has changed its name to Department of the Environment and Heritage (DEH) and its website is now http://www.deh.gov.au. The National Environment Protection Council (NEPC) has become part of the Environment Protection and Heritage Council (EPHC) and is accessed through the EPHC website http://www.ephc.gov.au.
- The *National Environment Protection (Air Toxics) Measure*, together with discussion of sources and health impacts of air toxics is available at http://www.ephc.gov.au then follow the links to NEPC then NEPM.

- Bagchi, K, Wiersma, L, Moran, C, Kiss, P, Power, M and Caire, J, 2003, *National woodheater audit program: particle emissions from retail models*, Proceedings of Linking Air Pollution Science, Policy and Management – National Clean Air Conference, Newcastle, 2003, Clean Air Society of Australia & New Zealand, Eastwood, NSW, Australia.

The author has resigned from the University of Tasmania and now is Director of the air pollution and renewable energy consulting business, Eco-Energy Options Pty Ltd.

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Air pollution in the sprawling Australian suburbs and many rural cities occasionally reaches levels that may adversely affect our health. Fine particles, polluting gases and a complex cocktail of organic chemicals are in the air we breathe. The two most significant urban sources of air pollution are motor vehicles and home heating using firewood. Other sources include gas heating, evaporation from paints and cleaning fluids, aerosol sprays, backyard burning and lawn mowers. Building and urban design professionals can significantly reduce air pollution through careful design and specification.

1.0 INTRODUCTION

This note discusses the important issue of urban air quality, providing an overview of the nature and sources of urban air pollutants and suggestions for practical means of reducing emissions of pollutants through good design. This note does not address the problem of indoor air quality (in private homes, offices, shops and motor vehicles). In many cases indoor pollutants are at higher concentrations than those outdoors, but since air is constantly moving into and out of our buildings, the outdoor air quality has some influence on indoors. For more information about indoor air quality see Brown (1997) or EPA (1993).

Most Australians spend two thirds of their time in the suburbs. The young and the elderly, the two groups most susceptible to health impacts of air pollutants, spend almost all their time there. This suggests that particular attention should be paid to these sprawling areas surrounding the commercial and industrial hubs of Australian cities. This demographic trend has not gone unnoticed by pollution control authorities. Air quality management is undergoing an important shift in emphasis. Over the past thirty years most effort has gone into controlling the emissions of air pollutants from major industries (point sources) and motor vehicles (mobile sources). The goal has been to force industry and motor vehicle manufacturers to reduce emissions of pollutants to levels approaching world best practice. This on-going push for lower and lower emissions has paid off. Air quality monitoring in major Australian cities shows some improvement over the past twenty years, despite the growth in population, motor vehicle numbers and industry. However, as the large sources of air pollution are reduced, the significance of other sources becomes much more noticeable. Firewood use for domestic heating, for example, is now recognised as one of the major sources of fine particles and carbon monoxide in most Australian cities in winter months.

Two important developments have offset the satisfaction we might feel as a result of the modest improvements in air quality. One is the result of large epidemiological studies conducted over the past decade that suggest the health impacts of air pollutants might be worse than we used to suspect. Thus, we have a 'moving set of goalposts' and we now realise that still cleaner air is needed to protect the health of citizens. A recent study of the effects of air pollution on mortality in Melbourne (EPA 2000) found clear correlations between daily mortality and both ozone concentration and nitrogen dioxide concentration. Possible, but statistically less significant, correlations were found between daily mortality and fine particles and carbon monoxide. This is a very significant finding, because it shows that the current levels of air pollution in our cities are impacting on the health of the general population. Mortality figures are usually the 'tip-of-the-iceberg', so it is highly likely that the present air quality is causing some morbidity leading to work absenteeism and general feelings of ill health. While this study relates to Melbourne, it is probably a reasonable reflection of urban Australia in general.

The second important development is our ability to routinely measure minute concentrations of many chemicals in the air thought to be dangerous to human health. These chemicals, collectively referred to as air toxics, will require careful study and new approaches to air quality management (see discussion of air toxics below).

2.0 AIR POLLUTANTS

In 1995, the Australian states and the Commonwealth government reached a landmark agreement on air quality. The states agreed to transfer some of their powers in relation to environmental protection (including air quality) to a National Council that has one representative from each state or territory and one representative from the Commonwealth (the Minister responsible for environmental protection is the representative in each case). This Council, the National Environment Protection Council (NEPC), has set several national environmental protection measures (see NEPC 2000 for more details). The National Environment Protection Measure for Ambient Air Quality (Air NEPM) was adopted in June 1998. It focuses on six priority air pollutants (CO, SO_2, lead, NO_X, ozone and particles). It sets target ambient concentrations for these pollutants to be met by 2008. Significantly, the NEPM is aimed at monitoring air quality throughout major urban areas, not just adjacent to industry or major highways. It sets average population exposure levels intended to maintain an acceptable level of health across the whole community. Table 1 lists the new national ambient air quality goals.

Pollutant	Measurement period for calculating average	Maximum concentration	Goal by 2008, maximum number of exceedences
Carbon monoxide	8 hours	9 ppm	1 day per year
Nitrogen dioxide	1 hour 1 year	0.12 ppm 0.03 ppm	1 day per year none
Photochemical oxidants (as O_3)	1 hour 4 hours	0.10 ppm 0.08 ppm	1 day per year 1 day per year
Sulphur dioxide	1 hour 1 day 1 year	0.20 ppm 0.08 ppm 0.02 ppm	1 day per year 1 day per year none
Lead	1 year	0.50 µg/m^3	none
Respirable particles	1 day	50 µg/m^3	5 days per year

Legend
µg = micrograms ppm = parts per million

Table 1 NEPM ambient air quality goals

These air quality goals do not represent perfectly healthy air. Instead, they are a balance between the economic costs of achieving these goals throughout the country, and the anticipated health impacts if the goals are exceeded. The economic arguments leading to the setting of these goals are detailed in the Air NEPM (NEPC 1998).

These priority air pollutants are not intended as a complete measure of air quality. Rather, they are indicators of the general health of the atmosphere. The priority pollutants are widely measured, so they provide useful comparisons between regions. In many cases they have also been measured for many years, so they provide very useful time-series of pollution levels that can be used to test the effectiveness of mitigation programs.

3.0 HEALTH IMPACTS

Each day 9,000 to 12,000 litres of air pass into and out of our lungs, more if we are exercising or doing heavy work. This large volume of air carries the oxygen necessary for survival, but it also carries a complex mix of natural and human induced contaminants. The upper respiratory tract (nose, mouth and throat) acts as a filter for larger dust particles, absorbs some gases, and warms and humidifies the air.

The lower respiratory tract (lungs) contains branching passageways getting smaller and smaller, but giving the lungs a large surface area of 120 to 150m^2. The membranes in the smaller passages allow oxygen to pass into the blood stream and carbon dioxide to pass out. However, some pollutants can also pass through this membrane, carbon monoxide being a good example. Other pollutants may remain in the lungs, asbestos fibres for example.

Another important feature of urban air quality is the high community concern about air pollution. The recent survey of environmental concerns (ABS 1999) showed that air pollution headed the list of 18 different environmental problems that Australians were worried about. Thirty four per cent of urban residents listed air pollution as a concern. This level of concern will encourage politicians to take action, so we can expect to see on-going tightening of regulations and changes in behaviour aimed at improving urban air quality.

A very brief discussion of the heath impacts of several common pollutants is presented below. There are many more detailed discussions of health impacts of these pollutants (e.g. Streeton 1990, NEPC 2000, Boyle et al 1996).

Fine particles and respirable particles

In recent years, there has been a lot of attention paid to fine particles in the atmosphere, that is, particles less than 2.5 microns (millionths of a metre or µm) in diameter. These very small particles penetrate deep into the lungs, while larger particles are trapped in the nose or throat. Even in 'clean' air, we breathe millions of fine particles into and out of our lungs each day. In polluted air, it seems that the normal cleansing functions of the lungs become overloaded and health problems become apparent.

In the United States, several studies in recent years have indicated that for each 10µg/m^3 (millionths of a gram per cubic metre) increase in respirable particles (averaged over 24 hours) there is a 1% increase in mortality (e.g. Schwartz 1993, Dockery et al 1992). In Europe, a similar, but slightly smaller 0.5% increase has been measured (Vedal 1997). The fine particles appear to cause respiratory and heart problems. At this stage, the epidemiological studies suggest that the chemical composition of the particles is not a critical factor, it is simply the mass of these fine particles in the air. These findings have far reaching implications for air pollution control. The situation is complex, with considerable variation in findings from one study to the next, and some experts feel that there may be more to the problem than simply the concentration of fine particles (Vedal 1997).

Carbon monoxide (CO)

At low concentrations (10 to 50 parts per million (ppm)) CO causes headaches and decreases reaction times. It can cause angina and impair vision. At high concentrations (300 to 500 ppm) it causes coma and death. Being odourless and colourless, people may not be aware that they are exposed to CO, which makes it more difficult to control. Motor vehicles and woodheaters are significant suburban sources of CO.

Nitrogen dioxide (NO_2)

Nitrogen dioxide is an important contributor to the development of ozone in photochemical smog. It is also an air pollutant in its own right. Some asthmatics can have increased airway responsiveness to nitrogen dioxide at levels of 0.2 ppm. Hourly or longer-term exposure could increase the frequency of other common respiratory illnesses. Motor vehicles are the major source of oxides of nitrogen, but gas heating, water heating and cooking also contribute.

Lead (Pb)

Atmospheric lead levels in suburban Australia are decreasing as more vehicles use lead free petrol. There have been significant reductions in average levels of lead in children's blood over the past 3 years (Australian Institute of Health and Welfare 1995), possibly associated with the phasing out of leaded petrol, which commenced in 1986. However, there are large quantities of lead in old paint on buildings that could be released into the atmosphere if painted wood is burnt or if old paint is burnt off prior to repainting. This could result in short term, but high, exposure in some people, and is cause for concern. Lead exposure (through air, water or food) can result in a range of health effects. Young children and pregnant women are at greatest risk of lead poisoning. Children may exhibit a range of central nervous system disorders, including reduced learning ability.

Ozone (O_3)

Ozone has a characteristic odour, it makes eyes water and can cause a sore throat. At concentrations as low as 0.06 ppm it can irritate the lower respiratory tract. Even in healthy individuals, it can adversely affect respiration, especially when exercising. Ozone can also harm vegetation and cause deterioration of rubber and some paints and dyes.

Sulphur dioxide (SO_2)

Sulphur dioxide has a strong, pungent odour. It attacks the respiratory tract directly causing a cough or gasping for breath. It aggravates existing respiratory problems. The infamous London fogs, laden with SO_2, caused 4,000 deaths in one week in 1952. Similar pollution episodes occurred in other industrial regions in Europe and North America. Sulphur dioxide contributes to acid rain, damaging vegetation and buildings.

Air toxics

There are many hundreds of organic and inorganic chemicals in the atmosphere, sometimes present as gases and sometimes attached to fine particles. Many are known to, or suspected to, harm human health if their concentrations get too high. A few of the more common air toxics include benzene, formaldehyde, toluene, vinyl chloride, polycyclic aromatic hydrocarbons (PAHs), ammonia, cadmium compounds, mercury compounds, arsenic compounds, and asbestos fibres. Most of the organic compounds degrade quickly in the environment, but some, such as dioxin, persist for long periods and accumulate in the food chain. The Environment Australia website offers a good overview of air toxics (Environment Australia 2000).

Safe concentrations

While some air pollutants might reach fatal concentrations in exceptional circumstances, such as carbon monoxide levels from petrol engines in closed spaces, we are generally dealing with levels of air pollution that cause much more subtle health impacts. Current levels of air pollution in major urban areas in Australia are at concentrations that may cause health impacts that are restricted to vulnerable groups, such as the elderly and very young. In some instances, there may be 'mild' health effects on many people, such as headaches or eye irritation and, in other cases, there may be severe health impacts, even death, on a very small number of susceptible people.

The difficulty in working near the limits of detectable health impacts is that there is considerable uncertainty. Some studies show health impacts, while others under apparently identical conditions do not. In general, environmental agencies try to err on the side of caution, setting acceptable limits that are on the lower limits of the uncertainty about health impacts. In some cases, this is difficult because there are no clear health thresholds, such as the case with fine particles in the atmosphere. The 'precautionary' approach has to be tempered by economic, technical and social considerations. While it might sound crass, the fact is that some risk must be accepted. If the estimated cost of saving one life through control of an air pollutant is $10 million, but one life could be saved by spending $1 million on new equipment for a hospital, then, with limited money available, the air pollution control measures may be deferred.

4.0 AIR QUALITY IN THE SUBURBS

Urban planning over the past few decades has resulted in a welcome separation of most polluting industries from residential areas, although there are still remnants of large industry scattered through Australia's suburbs where the spread of housing has engulfed once remote industrial sites. However, even when the industry itself has gone, there may be problems of dust and fumes from contaminated soils. With most industry isolated from the suburbs, air pollution in the suburbs is largely generated locally, from cars and trucks, home heating, backyard incinerators, burning off, and even lawn mowers or vapour from paint. Some longer distance transport of pollutants from industrial areas and power stations does occur, but there is little the designer can do about this problem. It needs to be dealt with at the source.

The following lists of air pollution measurements illustrate the nature and severity of urban air pollutants in Australia.

Pollution levels in Melbourne over the period 1991 to 1996 (source EPA 2000)

	Mean (ppm)	maximum (ppm)	NEPM goal (ppm)
Ozone (4 hour average)	0.025	0.11	0.08
Ozone (1 hour average)	0.027	0.13	0.10
NO_2 (1 hour average)	0.024	0.08	0.12
CO (8 hour average)	0.95	5.70	9.00

Pollution levels in Perth over the period 1990 to 1998 (source DEP 2000)

	NEPM goal exceeded (days)
Ozone (1 hour average)	16
Ozone (4 hour average)	27
NO_2 (1 hour average)	4
NO_2 (annual average)	none
CO (8 hour average)	2
Respirable particles (24 hour average)	22

Pollution levels in Launceston, Tasmania (source DPIWE 2000)

Respirable particles (24 hour average)	1997	1998
NEPM goal exceeded (days)	47	45
Highest 24 hour values ($\mu g/m^3$)	120 (approx)	120 (approx)
Annual average ($\mu g/m^3$)	22.1	24.9

These examples provide a picture of urban Australia as having air quality that is generally good (e.g. the mean values for Melbourne are well below the NEPM goals), but the air quality goals set out in the NEPM are exceeded now and then. In other words, there is a need to improve. The high number of days when the particulate levels in Launceston exceed the NEPM goal, illustrate that even a small city (population 100,000) can have air quality problems.

5.0 URBAN SOURCES OF AIR POLLUTION

Most air pollution results from combustion processes such as burning petrol or diesel in motor vehicles, burning firewood or use of gas for heating or cooking. The pollutants occur because the combustion process is never absolutely complete. Residues of partially burnt fuel, or contaminants in the fuel, escape the combustion process and cause air pollution. The two most serious sources of air pollution in urban areas are motor vehicles and woodheaters/fireplaces.

5.1 Transport

Motor vehicles are one of the largest sources of urban air pollutants. They contribute around 80% of carbon monoxide, 60% of oxides of nitrogen and 40% of Volatile Organic Compounds (VOCs). They also contribute significant quantities of fine particles and sulphur dioxide.

Recent improvements in design, such as the addition of catalytic converters in car exhausts, have meant significant reductions in emissions. For example, cars fitted with catalysts (i.e. post-1985) produce about one quarter as much unburnt hydrocarbons and one third as much carbon monoxide as pre-1976 vehicles per kilometre travelled.

Motor vehicle emissions are reduced when traffic flows smoothly, rather than stop-start motoring, as experienced in suburban roads. Travel in residential zones typically produces 50% more air pollution per kilometre travelled than travel on a freeway.

Improvements in new vehicle emissions, improved fuel efficiency, and new types of motor vehicles offer some scope for on-going reductions in vehicle emissions. LPG fuelled vehicles have slightly lower emissions of carbon monoxide and oxides of nitrogen, but slightly higher emissions of Volatile Organic Compounds. Electric vehicles provide an excellent opportunity for reduced urban emissions, however the air pollution is transferred to the power stations generating the electricity.

5.2 Space heating

It is estimated that 1,050,000 households in Australia use firewood as their main heating fuel (ABS 1999) and a further 300,000 use firewood as an occasional or secondary heating fuel (Wood Heating Association 1997). Thus, almost 20% of all households use firewood for heating. About 4.5 million tonnes of firewood are consumed each year for domestic heating.

Prior to 1992 there were no controls over the emissions of smoke from woodheaters or open fireplaces. The publication of the Australian Standard AS4013-1992 *Domestic solid fuel burning appliances - Method for determination of flue gas emission* 1992, set a maximum emission factor of 5.5 g/kg for particles, encouraging many Australian heater manufacturers to manufacture and sell appliances that complied with the Standard. In 1999, the Standard was tightened, setting a maximum emission factor of 4 g/kg for new heater models. One problem is that around 75% of the woodheaters in use were installed before 1992 and so have much higher emissions than the best models now on the market.

Table 2 illustrates the problem associated with older models of woodheaters and open fireplaces. They produce ten times as much smoke as the best woodheater models available. Table 2 also illustrates the problem of poor heater operation. A heater operated poorly will produce roughly twice as much smoke as the same heater operated correctly.

Table 2 **Estimates of average emission factors for various types of wood-burning appliances. An emission factor is the weight of smoke particles emitted (grams) per kilogram of wood burnt.**

Models	Correct operation	Poor operation
Open fireplace	15.0 g/kg	15.0 g/kg
Woodheater pre-1992	7.0 g/kg	15.0 g/kg
Woodheater 1992-1999	3.5 g/kg	7.0 g/kg
Woodheater post-1999	2.6 g/kg	5.2 g/kg
Best available woodheater	1.5 g/kg	3.0 g/kg

In urban areas where a high proportion of homes use open fires and woodheaters, up to two thirds of the particulate air pollution in winter months might come from this source. The large number of high pollution days in Launceston, Tasmania, for example, is due to the high use of woodheaters and poor dispersion of pollutants in the local airshed.

5.3 Water heating

Heating water for showers, baths and washing is one of the largest demands for energy in the residential sector. Natural gas is a popular fuel for water heating in areas with reticulated natural gas. Generally speaking, gas is a clean fuel, producing few significant emissions. However, it does contribute almost two per cent of oxides of nitrogen (NO_X) to the urban airshed (Todd et al 1997). This figure could be reduced to negligible levels if the current 'blue flame' burners in the water heaters (producing about 60 nanogram of NO_X per Joule of energy) were replaced with low NO_X burners (only 3.5 ng/J).

5.4 Evaporative emissions

There are many substances used in urban homes and commercial buildings that emit VOCs through evaporation. These include paints, paint thinners, aerosol products and various solvent products. Most of the VOCs will find their way into the outdoors, although there will be some deposition within buildings. The following discussion draws heavily on information presented in the National Pollutant Inventory (NPi) (Boyle et al 1996).

Paints and thinners

For paints, all VOCs in the original paint are eventually emitted into the atmosphere. For oil based paints this is 26 to 50% by weight of the paint, and for water based paints it is 5 to 7%. Thinners are assumed to totally evaporate. Total VOC emissions in the non-industrial sector is estimated as 8,700 tonnes/year from oil based paints (21 million litres of paint) and 11,200 tonnes/year from water based paints (93 million litres). The much higher volume of water based paints used means that there are more VOCs emitted in total from the low VOC paints. There are also some paints on the market with extremely low VOC content. For example, *Dulux Breathe Easy* has 0.01% by volume VOCs.

Industrial coatings and thinners are estimated to contribute an additional 59,500 tonnes of VOCs per year (Boyle et al 1996).

Aerosol products

Depending on the nature of the aerosol, 20 to 50% of the weight of the product is emitted as evaporated VOCs. In 1992, for example, 4,071 tonnes of air fresheners and disinfectants were used, each tonne emitting 400 kg of VOCs (i.e. total emissions were 1,630 tonnes of VOCs). Insect sprays (6,975 tonnes of product), hairsprays and dressings (6,985 tonnes of product) are examples of other aerosol products. The NPi estimate total annual emissions of VOCs from aerosol products as 782 g/capita/year.

Solvent products

Emissions of VOCs from solvent products are about 2.54 kg/capita/year (i.e. about 3 times larger than from aerosols). The main contributing sources are general household products (0.86 kg/capita/year), toiletries (0.64 kg/capita/year), rubbing compounds (0.29 kg/capita/year) and windshield washing fluids (0.29 kg/capita/year).

5.5 Lawn mowers

Lawn mowers produce emissions which are a notable source of urban air pollutants. The main sources of the emissions are the exhaust, evaporation from the engine and fuel storage, and petrol spillage. Approximately 90% of Australians own a lawn mower (Environment Australia 1997) and they are typically operated 19 to 24 hours per year (Boyle et al 1996).

Lawn mowers contribute less than 1% of the principle urban air pollutants in Australia (Priest 1996), which suggests they are relatively insignificant. However, when viewed in comparison to motor vehicles, for example, they are obviously a source that should be controlled. To illustrate the nature of the problem, an older style lawn mower operating for twenty hours a year produces the same amount of smog-forming, VOCs as a 1996 car driven for almost 42,000 kilometres (Gascape 1996). The US EPA estimates that in the United States over 77 million litres of petrol are spilled each year when refueling lawn and garden equipment - more than the amount of oil spilled by the Exxon Valdez in Alaska in 1989 (Lamarre 1996).

Emissions from small utility engines, 2-stroke and 4-stroke, are unregulated in Australia. The 2-stroke engines produce roughly 10 times as much air pollution as the 4-stroke engines, but two thirds of the lawn mowers and motorised lawn care equipment in Australia is powered by two-stroke engines (Priest 1996). The current technology used in electric vehicles is being applied to the development of cordless electric lawn mowers. These are attractive for a number of reasons; they are relatively quiet, use and storage of petrol is eliminated and engine maintenance is reduced. Electric mowers are also inexpensive to run (approximately $5 per year) and the initial outlay is comparable with the cost of buying a conventional mower (Lamarre 1996).

6.0 ROLE OF THE PLANNER

The above discussion has built up a picture of the suburbanite heating their homes, driving their cars, mowing the lawn, heating their water, spraying weeds in the garden, painting the house, and using cleaning fluids, all of which contribute to air pollution. The formal responsibility for minimising these emissions lies mainly with the State environmental protection authorities and local government. But the nature of these sources is such that everyone has a role to play in improving air quality. The role of building and urban design professionals is crucial in establishing an infrastructure that facilitates minimisation of air pollution. This means designing homes that require minimum use of fuel for heating or cooling, making non-motorised local trips convenient and safe, and providing appliances that are efficient and clean.

One critical issue that all planners and designers can address is that of combustion. As this is the major source of urban air pollution, anything that reduces the amount of fuel burnt in motor vehicles, lawn mowers, domestic space-heating, water heating, backyard burning or, indirectly, coal or gas burnt in power stations will improve air quality.

Transport

The greatest opportunity for reducing transport emissions is at the green-fields planning stage. Design to allow people to walk, cycle or skate to the local places they need to go regularly has the potential to greatly reduce urban motor vehicle use. Green-field opportunities are rare. Most planners will have to contend with an existing infrastructure and will need innovative approaches to reduce the dependence upon private cars.

The key to pollution reducing transport planning is the provision of convenient, safe alternatives to the use of private cars. This might include pedestrian and cycle short-cuts to schools, shopping centres, sports fields and entertainment venues. Convenient access to rail and bus services will also help reduce private car use. Safe cycle paths for children to reach schools can reduce the need for daily drop-off and pick-up of school children.

Design and renovation of private homes and commercial properties

There is enormous scope for reducing the energy use in new and existing buildings through insulation, solar design, selection of efficient appliances and modification of the microclimate. For building and urban design professionals, this offers some of the most practical options for improving urban air quality. Most libraries have many excellent books and reports are available on energy efficient building design. Some local examples include Ballinger et al 1992, and SOLARCH 1993. These books and reports discuss insulation, double glazing and low emissivity glass, and passive solar design. There has been a tendency to take a very conservative view on the economic benefits of low energy building design in Australia. However, the benefits go well beyond simple dollar payback periods. Every low energy building constructed contributes to improved air quality, lower emissions of climate change gases, and greater independence from fluctuating world energy prices.

For example, a home with modest insulation (e.g. ceiling insulation, draught proofing, and well-fitted curtains) will benefit air quality in two ways, compared with an uninsulated home. Firstly, if space-heating is required, less firewood, gas or electricity is needed to achieve comfortable indoor conditions and, secondly, there will be many evenings in spring and autumn when it requires no supplementary heating at all. A well designed, well insulated passive solar home should not require any supplementary heating or cooling in most of Australia's climate zones.

Solar water heating

Solar water heating for domestic hot water supply and swimming pool heating are another effective way of reducing urban air pollution. Gas water heaters contribute significant quantities of oxides of nitrogen (NO_X) to urban airsheds. Solar systems will contribute 50% or more of the annual energy requirements.

Open fireplaces and woodheaters

One significant contribution that designers can make in reducing air pollution emissions from new homes is to discourage the installation of open fireplaces. If a low emission controlled combustion heater is substituted for the fireplace, emissions can be reduced by a factor of 10 or more. For example, a household using an open fireplace one evening per week, burning 20kg of firewood, will produce three times as much air pollution as a household burning a low emission woodheater seven evenings per week burning 10kg of firewood per evening. As a bonus, a freestanding controlled combustion woodheater is much cheaper to install than a masonry fireplace. While an enclosed heater will never create precisely the same atmosphere as an open fire, some new models with large, glass bay windows do come close.

If woodheaters are installed, the model specified should be at the low-emission end of the allowable range of heaters available. There is a good selection of models with emission factors below 2 g/kg.

Any house fitted with a woodheater should also be provided with a covered, well-ventilated, storage area for firewood. Dry firewood produces less air pollution than wet firewood.

Appliances

Low energy household and business appliances should be specified for all new and renovated homes and businesses. Large differences in energy use, for appliances performing identical tasks, are common. Careful attention to energy efficiency in selection of appliances can significantly reduce energy consumption.

Evaporative emissions

Specification of materials and surface coverings should ensure that low emission paints are used, the use of glues should be minimised, carpet and carpet underlay can be a significant source of indoor pollutants.

Gardens and vegetation

Gardens, parks and strategic use of vegetation can play an important role in modifying the microclimate around homes, and even whole neighbourhoods. The microclimate has a significant impact on energy required for heating and cooling. Thus, air quality can be improved by sensible modification of the microclimate.

In a hot climate, vegetation serves two important functions. It provides shading for buildings and ground surfaces and so reduces direct solar heating. Just as important is the role of evaporation from vegetation and soil. When moisture evaporates it absorbs energy from the air and so cools the air. Evaporative air conditioners work on this principle. So a park or a garden acts like a large natural air conditioner, reducing the need for energy consuming air conditioners in buildings.

When the weather is cool, it is important not to shade surfaces that contribute to heating of buildings. In some cases, use of deciduous plants will allow summer shading and winter sun, in other cases careful integration of native vegetation and building design can give excellent results. Vegetation can also be used to provide shelter from prevailing cold winds, thus reducing heat loss in buildings caused by excessive draughts.

Another important consideration when selecting plants for parks and gardens is allergies and hay fever (e.g. see AAAAI 2000). Placing plants that distribute pollen known to aggravate respiratory and allergic responses in urban areas is no better than introducing a new source of air pollution.

A relatively minor consideration when planning residential gardens, is the provision of outdoor power points to encourage electric lawn-mowers. Better still, small areas of lawn, planted with slow growing grass, will make hand mowing practical. For large public spaces, selection of slow growing grass varieties is one practical means of reducing air pollution associated with lawn mowing.

7.0 CONCLUSION

Building and urban design professionals will influence urban air quality through their normal professional work. By making conscious decisions to select energy efficient options for buildings and appliances, specifying low emission surface coverings, incorporating microclimate design, and providing walking/cycling-friendly infrastructure, significant improvements in urban air quality are possible.

As yet, there is no package of information or standard methodology for assessing the air quality impact of buildings and urban design. This gap in planning tools will, no doubt, be filled in due course. Until that happens, building and urban design professionals seeking sustainable outcomes, should routinely factor-in an air pollution inventory for any job they undertake. Design and structure modifications should be considered and the implications for air quality (indoor and out) investigated. By considering materials and design, in the same way embodied energy and lifetime energy use are considered, a gradual move away from high air pollution design to low air pollution design could be achieved.

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