East-West Environment and Policy Institute

Research Report No. 6

Air Pollution and Energy in Australia: Economic and Policy Implications

by Alan Gilpin
Hanns Hartmann

East-West Center
Honolulu, Hawaii

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FOREWORD

The link between energy availability and economic growth has been the focus of much discussion during the last several decades. More recently, the implications of energy conversion for environmental quality also have received increasing attention. The need to plan for a postpetroleum economy has provided additional impetus to such studies, since the commercial energy sources most likely to supply additional energy during the rest of this century are coal and uranium, both of which have more serious environmental problems. With these considerations in mind, the East-West Environment and Policy Institute has initiated a project on The Environmental Dimensions of Energy Policies. The major goal of the project is to provide policymakers with analyses that could be helpful in meeting the twin goals of energy supplies and a sustainable environment.

An area of high priority in the Asia-Pacific region, and within the project, has been the analysis of the links between air quality management and energy policies. A Workshop on that theme was held at the East-West Center in March 1980, with participation from nine countries in the region. Papers dealing with different aspects of the experience in Australia were prepared by Alan Gilpin, and by Hanns Hartmann. Participants at the Workshop felt that the approaches discussed by them would be useful to a wider audience. The Institute requested them to prepare a joint paper, to which they kindly consented. We feel that this product of their collaboration provides valuable insights dealing with issues of economic growth, environmental quality, and energy use in a country with an increasingly important role in the global energy economy.

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Project Coordinator

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ABSTRACT

Australia's development into a technological society has brought environmental problems as well as social and economic benefits. Air pollution, connected as it is to energy use, is examined in the light of energy reserves and their consumption and in the light of the increasing debate between the producers and consumers and the conservationists. Air pollution levels in the major urban centers are being affected by population growth and by the increase in pollution sources. The control policies and legislation of both the nation and the six states are described. Australia is undertaking some air pollution research (eg, the Sydney Oxidant Study and the Australian Baseline Air Monitoring Station). Photochemical smog—ozone, oxides of nitrogen, and lead—and its impact on health in Australia's major cities is being studied. A presumed increase in energy consumption by a factor of three by the year 2000 makes a national strategy for air pollution control imperative. The economic considerations inherent in pollution control policies are examined, as well as the need for cost/benefit analysis. Four resource policy areas, which may ensure the achievement of a range of public objectives, are suggested—economic, social, environment and conservation, and national settlement.

INTRODUCTION

Development of a technological society in Australia, while conferring the usual benefits, has also damaged the environment in a manner similar to that experienced in other countries. Environmental problems in Australia, however, have been less severe than those experienced elsewhere. Because problems of air pollution, in particular, are connected with the usage of energy, the country's position regarding energy reserves and their consumption are being examined.

Arguments are increasing between the energy producing and consuming sectors and the conservationists. Ideally, the resolution of opposing claims should be based on impartial considerations which weigh scientific, technical, economic, and social factors. Impartiality is, of course, very difficult because knowledge in many relevant areas is either lacking entirely or incomplete. In addition, emotions and politics play a large part.

Scientific and technical data were used extensively by Australia in the formulation of policies and regulations but were not necessarily decisive factors. Some of the economic and policy implications of air quality objectives that have resulted from this debate are worth considering.

AUSTRALIA

Australia's compact landmass of more than 12.5 million km^2 dominates the southwest Pacific. It is about the same size as the continental United States and about 80 percent the size of Europe. It lies wholly in the southern hemisphere, stretching from the tropics into the "roaring forties." Surrounded by vast stretches of ocean on three sides, Australia has near neighbors only in the north.

The population now stands at 14 million. Because of the aridity of the continent's center, most Australians live within a short distance of the coast, the majority of them in large coastal cities.

Politically, Australia is a federation of six sovereign states, which have delegated certain powers to the central government. The powers to control energy and the environment, however, are not so delegated, and the federal government's capacity to intervene in these matters is therefore somewhat limited.

Australia is a democratic society where free speech is taken for granted. This results in a very lively and wide-ranging debate on all matters affecting the environment, as well as on energy questions.

ENERGY IN AUSTRALIA

Nonrenewable Energy Sources

As far as overall energy resources are concerned, Australia is indeed a lucky country. Table 1 shows its nonrenewable, identified economic energy resources.[1] The demonstrated and inferred recoverable resources were estimated in 1977 at 2,716,100 peta joules (PJ:10^{15} joules) with the demonstrated reserves alone being 1,195,000 PJ. Against this total, Australian consumption of primary energy in 1977 was 2,865 PJ. Thus, if the larger figure is taken, resources would last 1300 years at present consumption rates.

Matters are, of course, not quite so simple because of the uneven geographical distribution of the resources and the fact that presently

Table 1. Australia's Nonrenewable, Identified Economic Energy Resources

Resource	Quantity		Specific Energy (PG)	
	Demonstrated	Demonstrated and Inferred	Demonstrated	Demonstrated and Inferred
Crude oil and condensate (bbl)				
In situ	$4{,}900 \times 10^6$	$5{,}000 \times 10^6$	29,700	30,000
Recoverable[a]	$2{,}070 \times 10^6$	$2{,}087 \times 10^6$	12,400	12,500
Sales gas & LPG (m^3)				
In situ	545×10^9	590×10^9	21,000	22,700
Recoverable[b]	327×10^9	354×10^9	12,600	13,600
Black coal (MT)				
In situ	$36{,}300 \times 10^6$	$196{,}000 \times 10^6$	1,040,000	5,600,000
Recoverable[c]	$20{,}260 \times 10^6$	$110{,}000 \times 10^6$	580,000	3,125,000
Brown coal (MT)				
In situ	$40{,}930 \times 10^6$	$40{,}930 \times 10^6$	400,000	400,000
Recoverable	$29{,}000 \times 10^6$	$39{,}000 \times 10^6$	380,000	380,000
Uranium (MT)				
In situ[d]	346×10^3	439×10^3	195,000	245,000
Recoverable[e]	289×10^3	333×10^3	160,000	185,000
Total				
In situ			1,685,700	6,297,700
Recoverable			1,145,000	3,716,100

[a] Recovery factor for crude oil used for condensate.
[b] Recovery factor of 60 percent has been assumed.
[c] Recovery factor calculated for demonstrated resources is assumed to apply to inferred resources.
[d] B.M.R. estimates 16 May 1977.
[e] Australian Atomic Energy Commission estimates 30 June 1977.

discovered oil reserves will supply only two-thirds of the country's requirements to about 1990, even on revised estimates. Figure 1 shows the uneven geographical distribution. Black coal deposits occur almost exclusively in New South Wales and Queensland, along the east coast. They constitute 84 percent of all demonstrated and inferred reserves. Both steam coal and high-quality coking coal are present, with some of the seams up to 10 m thick. The greater proportion of these coals has a sulphur content of less than 1 percent after washing.

Victoria has one of the world's largest deposits of brown coal that can be won by open-cut mining. This coal has a very high moisture content (up to 66 percent) but negligible sulphur and ash. It is used to generate more than 80 percent of Victoria's electricity. While it represents only about 10 percent of the country's reserves, less than 2 percent of the deposit has been used to produce the greater part of the state's electricity for a period of 60 years.

Figure 1. Energy Resources in Australia.

The other three states (South Australia, Western Australia, and Tasmania) possess only minor deposits of coal, and none of it is of high quality.

The recoverable, demonstrated, and inferred uranium reserves amount to 185,000 PJ, or 5 percent of resources.

This leaves gas and oil together at just 0.7 percent of reserves. Gas reserves on the same basis are 13,600 and oil reserves 12,500 PJ.

The largest gas reserves are offshore at diametrically opposite points of the continent. The series of gas and oil fields in Bass Strait (between Tasmania and the mainland) are in a strategically favorable position for the relatively large Melbourne market, which they should be able to supply well past the turn of the century. The Cooper field in the north of South Australia supplies both that state and New South Wales. The reserves are considerably less than in Bass Strait but will supply both areas beyond the year 2000 as well.

Very large gas reserves exist on the northwest shelf nearly 3000 km north of Perth. A pipeline to that city is being planned, but to justify the huge investment (an estimated US$4600 million [$A4000 million]), just over half the gas will have to be exported in the form of liquefied natural gas (LNG).

About a million metric tons (MT) of liquefied petroleum gas (LPG) obtained from presently operating gas fields is being exported, mainly to Japan. The home market is satisfied with LPG from oil refinery production.

Of the 157,000,000 barrels (bbl) of oil produced in Australia in 1977, 92 percent came from Bass Strait and the remainder from Western Australia, apart from a small amount (0.25 percent of the total) which was recovered in Queensland.

Total 1977 Australian energy consumption, 2865 PJ, was composed as follows (percent):

Black coal	28.2
Brown coal	10.9
Petroleum products	47.2
Natural gas	8.0
Hydroelectricity	2.1
Wood	1.1
Bagasse	2.5
	100.0

This amounts to a per capita consumption of about 200×10^9J which is only about 60 percent of the United States' per capita consumption. Unless there is a fundamental modification in the pattern of life, present consumption is likely to increase substantially by the end of the century.

Thus, oil, at nearly 50 percent, dominates Australia's energy consumption. About two-thirds of this oil is produced in Australia and the rest is imported. Australian crude is very light and yields 92 percent of the country's gasoline requirement. Lubricating oils and other heavy products must be obtained from imported stock.

This dependence on foreign oil, which is expected to grow rapidly after 1990 when local production will taper off, is the primary cause for concern.

While heating fuel is not a great problem, because of a warm climate and the as yet adequate reserves of gas, the availability of sufficient transport fuels is of great importance.

One solution is to convert motor vehicles to operate on LPG, which, if taken to the limit of available supply, would replace one quarter of the country's gasoline consumption of 10 million MT per year. More could be replaced by deeper cracking of the imported oil. This would require large investments in refineries, which are not economically justified at present.

Conservation would be another method for reducing dependence on imports, but this has not yet been practiced successfully.

Talk of a national energy policy exists; the prestigious National Energy Advisory Committee (NEAC) has made proposals. Unfortunately, a national energy policy is no more popular in Australia than elsewhere. The only measure taken so far has been to raise the price of local crude to world parity. This has had a somewhat inflationary effect but has increased both oil company and federal government revenue, thus relieving pressure on taxation and allegedly providing the oil companies with more money for exploration.

Renewable Energy Sources

A certain amount of work is proceeding on substitute sources of energy. Solar energy is renewable and virtually nonpolluting; because of this, it appeals to many as the ultimate source of energy, superseding both fossil and nuclear fuels. Already some 25,000 houses throughout Australia have solar hot water systems, although this is the equivalent of less than 1 percent of total energy consumption. In 1973, a report by the Australian Academy of Science (AAS) affirmed that the solar energy resources of Australia are very large and that "we have one of the best national opportunities to harness it." Using known methods, the report states, more than half of the nation's low-temperature thermal energy needs could be supplied by solar energy.[2]

Solar radiation provides a continuous energy supply, which averages about 5×10^{22} J per year, corresponding to power over the year of 200 Watts (W)/m^2. The AAS report asserts that this energy could be harnessed using only a small fraction of the area of the country. A great deal of research and development will be necessary, however, if it is to be used for high quality purposes, such as electricity generation. In view of this, solar energy was not considered a large-scale commercial electricity source before 1990 by the AAS. Clearly, it could be deployed earlier in other areas.

The report urged expansion of research in the use of solar energy for industrial purposes and electricity generation, particularly because it could well result in an alternative to nuclear power within a realistic time scale. In any event, research could make available a vast untapped energy source and obviate much pollution of the atmosphere.

The Senate Standing Committee on National Resources (SSCNR), in a report on solar energy published in 1977, thought that solar energy would not make a significant contribution to Australia's energy needs before the end of the century. The report stated, however, that the development of solar energy needed to be considered within the context of an overall energy strategy.[3] It would certainly not make any significant contribution to overcoming Australia's prospective shortages of liquid fuels. The SSCNR report envisaged a twofold role for solar energy:

1. Low-grade heat for industrial application.
2. Heating and cooling of buildings and small-scale power generation in isolated areas.

The report drew attention to certain environmental disadvantages of solar energy, both direct and indirect. The visual impact of solar collectors on houses and factory roofs would need to be considered. In large-scale installations, the local climatological effects of solar farms, which occupy considerable areas of land, would need to be studied. Such farms might comprise fields of reflecting mirrors or other forms of collectors. Using indirect solar collection methods, a farm might comprise banks of large windmills generating electricity.

Another source of potential environmental consequences would be the use of large land areas for the growing of energy crops—for example, eucalypt forests, cassava, and sugarcane—for the production of fuels by bioconversion methods. The land-use conflicts, the environmental effects of large-scale felling and woodchip operations, soil nutrient and erosion problems, and the special effects related to monoculture would need to be investigated thoroughly.

Energy Resources Policies

The SSCNR report comments on the lack of any recognizable energy policy in Australia, noted also by the first report of the Ranger Uranium Environmental Inquiry[4] and the reports of the Royal Commission on Petroleum. The establishment of an energy policy for Australia is considered an important priority. The SSCNR report recommends that the Commonwealth government establish a statutory body, the Australian Energy Commission (AEC), to have overall responsibility for developing and coordinating a long-term energy policy. Within this context, an appropriate research effort for solar energy could be decided in relation to the whole range of research needs in the energy field.

It is the authors' view that a sustained research program is needed in the area of electricity generation. Experimentation with potentially low-cost solar cells presents the exciting prospect of augmenting our electricity supplies cheaply from an inexhaustible source, while reducing the environmental and psychological stresses imposed by other sources of energy.

As expressed by Sir George Porter at his lecture in Canberra in 1976: "We should use the income of solar energy instead of the capital of fossil fuel and ensure that, in the next century, the lights will not go out."[5]

Solar water heaters boosted by either gas or electricity are being installed in all areas. They are at present not economical but are being bought as a practical way to conserve energy. It is believed by Australian solar researchers that solar energy will first become economical to provide air conditioning in the northwestern mining cities by making full use of solar energy during the periods when it is most available.[6]

Australia has large deposits of oil shale, mainly in Queensland. A project to produce oil from this source has been started. When fully operational, it should produce about one-third of Australia's *present* liquid fuel requirements.

The production of oil from coal is being studied and is gaining in popularity. Plants would have to be erected in cooperation with foreign investors because of the huge capital requirements.

Victoria's brown coal has the advantage of cheapness in this context, as its high water content makes it unsuitable for export.

Alcohol in admixture with gasoline is very likely to be used eventually, but it is at present still uneconomical.

Thus, the only energy problem facing Australia in the near future is a certain shortfall of gasoline. This is also the country's most sensitive problem, as road transport in all its forms is essential to the normal functioning of the economy and, indeed, for its survival. Therefore, most of the arguments between energy technologists and conservationists concentrate on this point.

Of course, there is also an argument about atomic energy. As no nuclear electricity plants are planned for Australia in the immediate future, this argument is concerned primarily with the mining and export of uranium ore.

The Ranger Uranium Environmental Inquiry reported to the Australian government on 28 October 1976 and 17 May 1977. It detailed more than 100 findings and recommendations. The government accepted almost all of these recommendations. Where the government decided on a course other than that recommended by the inquiry, it did so with the intent of achieving the same purposes and satisfying the same principles. In some cases, the government adopted more stringent controls than those recommended. On that basis, the government decided that further mining and export of Australian uranium should go ahead.

The government accepted all the recommendations and findings of the inquiry related to the hazards of mining and milling uranium and to the use of uranium in power generation for peaceful purposes.

The Australian government supports the Ranger Inquiry's recommendation for the fullest and most effective safeguards on uranium exports.

International safeguards exist to verify that nuclear material is not diverted from a country's peaceful nuclear industry to nuclear weapons. The main systems of safeguards are administered by the International Atomic Energy Agency (IAEA), a body with wide international membership and ties with the United Nations.

IAEA safeguards are applied under an agreement between the IAEA and the country being inspected. They operate by requiring the country to make periodic reports of quantities, disposition, and usage of the nuclear material it possesses. IAEA nuclear inspectors correlate what they find through inspection and sampling with what the country has declared. To the extent necessary to obtain sufficient confidence in its findings the IAEA also applies the complementary techniques of containment (eg, seals on locks, safes) and independent surveillance. In addition to this basic safeguard system, the Australian government negotiates separate safeguard agreements with purchasers.

AIR POLLUTION IN AUSTRALIA

Pollution problems in Australia are similar to those experienced elsewhere, with variations due to the country's geography and demographic development. Air pollution in Australia has been associated with the combustion of fuel, as in other countries. Up to the 1960s, homes were heated with firewood burnt in open grates, therefore air pollution from domestic sources was not great. Most of the air pollution problems arose from industrial fuels used in poorly designed equipment. Up to about 1960, air pollution consisted mainly of smoke and dust.

Air pollution exists mainly in the big cities. These are remote from each other, and polluted air frequently is blown out to sea and not across state boundaries. As far as is known, it does not cross international borders at any time.

From 1960 onward, regulatory authorities gradually achieved control over smoke and dust. Some photochemical smog then made its appearance, at least in Sydney and Melbourne, Visibility is affected severely, frequently in Sydney and occasionally in Melbourne, and some photochemical damage to plants has been reported. No incidence of eye irritation is known.

The overall situation was summed up in the 1977 Annual Report of the State Pollution Control Commission (SPCC) of N.S.W.[7]

1. The character of air pollution has changed, with traditional pollutants (smoke, soot, acid gases, etc.) being reduced to reasonable

levels, while new ubiquitous pollutants, such as photochemical smog, are emerging.
2. Urban growth in itself makes an important contribution to air pollution levels, since increasingly stringent controls at source tend to be offset by increases in the number of sources.
3. The community at large is now more widely involved as need for control extends from large factories to the individual citizen's automobile and means of waste disposal.

In Melbourne, the State Environment Protection Authority[8] issues a bulletin twice a day for publication in the daily press which grades air pollution for the hours 8:00 to 9:00 AM and 2:00 to 3:00 PM according to an arbitrary index. For the year 1976, there were 208 bulletins reporting light pollution, 12 reporting significant pollution, and 3 reporting heavy pollution. These reports were based on monitoring results from one station that recorded the worst results.

The following is a summary of monitoring results (for 1976) in three major centers. Figures are not strictly comparable as each city has only a few monitoring stations and data are reported on different bases.

Carbon Monoxide

In Sydney,[9] carbon monoxide levels have been decreasing steadily in the central business district over a period of six years. At one site the World Health Organization (WHO) long-term aim—8 parts per million (ppm)—was exceeded on 51 days (117 the previous year). However, at another station it was still exceeded on 240 days per year.

In Melbourne,[10] the 24-hr average reading for the two worst stations was 2.6 ppm and 3.5 ppm, respectively. The maximum 24-hr readings for the same stations were 7.0 and 10.2 ppm. The 1-hr averages for the same stations were 5.0 and 6.8 ppm and the maximums 18.5 and 20.0 ppm.

In Brisbane,[11] a maximum 8-hr mean of 16.5 ppm was reported and a maximum 1-hr mean of 32 ppm.

Oxides of Nitrogen

In Sydney,[12] oxides of nitrogen reach their highest levels between 8:00 and 11:00 PM with about 1.0 parts per hundred million (pphm) nitrogen dioxide (NO_2) and 1.0 to 3.0 pphm nitric oxide (NO). Lowest figures are observed in the afternoon. The rise after sundown is due to poor ventilation.

In Melbourne,[13] 24-hr averages in the central business district are between 3.0 and 4.0 pphm for NO and about 2.0 for NO_2. For NO, 1-hr averages are around 12 and for NO_2 they are around 4. Maximum 1-hr figures have been as high as 85 for NO and 14.0 for NO_2.

In Brisbane,[14] maximum 1-hr mean concentrations of 42 pphm were observed for NO and about 5 pphm for NO_2.

Ozone

Photochemical smog now occurs in all large cities in Australia. Extensive studies have been carried out in Sydney where the problem is more severe than elsewhere in the country, both because it is the biggest city and because of the peculiarities of its topography. Some studies for ozone have been carried out in Melbourne, as well as regular monitoring at a number of sites.

In Sydney,[15] for the whole monitoring network averaged over three years, the WHO 1-hr goal (a 1-hr maximum of 5–6 pphm) was exceeded on 161 days and 15 pphm for 1 hr was exceeded on 27 days. Over the day, the maximum at any one monitoring station occurred early in the afternoon. Levels declined thereafter and throughout the night with a minimum early in the morning. This reduction is accomplished by fresh emissions of oxides of nitrogen overnight. At monitoring stations where the oxides of nitrogen emissions at night are absent, the reduction of ozone is far less marked.

In Melbourne,[16] studies in the late 1960s showed that ozone levels at certain peak hours gradually increased above background levels.[17] In recent years, the WHO 1-hr goal was exceeded on 32 days in a 2-year period. Higher figures of up to 25 pphm are observed occasionally.

In Brisbane,[18] at one inner-city site the WHO 1-hr goal was exceeded 56 times during one year.

Sulphur Dioxide

In Sydney,[19] the WHO long-term goal (2.1 pphm annual mean, with 98 percent of all observations below 7 pphm) has not been exceeded in the recent past.

In Melbourne,[20] figures for SO_2 have decreased in recent years as follows (pphm):

	1974	1975	1976	1977	1978
Average 24-hr average	1.3	1.4	0.9	0.33	0.19
Average 1-hr maximum	2.4	2.6	2.0	0.7	0.53

This is certainly due to the replacement of fuel oil by natural gas.

In Brisbane,[21] figures have been consistently below WHO long-term goals.

Lead

Only in Melbourne[22] was there regular monitoring of lead. Figures varied as follows:

mg/m^3	1976	1977	1978
Average 24-hr average	0.68	0.74	0.56

The greatest problems are no doubt in Sydney. The Sydney Metropolitan Area, which occupies almost the entire Sydney Basin, faces many urban problems. Communications by road are hampered by urban sprawl and by the city's dissection with waterways; goods, services, and people must cover long distances across the city and surrounding suburbs. Sydney's dependence on the motor car has led to inherent air pollution problems. The development of efficient public transport networks has not kept pace with Sydney's growth over the last 25 years. As a result, the largest and most urbanized city in Australia has the highest potential for pollution.

Serious control of air pollution in New South Wales began in 1964 when regulations were first proclaimed under the Clean Air Act of 1961. Initially, control was directed toward primary pollutants which, although not yet controlled fully, have been reduced by means of tighter controls imposed on polluters. In 1978-1979, some 1622 premises in Sydney had licenses under the Clean Air Act. These premises included such industries as oil refineries, chemical works, scrap metal recovery works, ceramic works, and concrete batching works, most of which carry out operations that involve the burning of fuel. Although they adopted generally the best practicable means for controlling emissions, large quantities of pollutants still are emitted from these sources.

Photochemical pollution has emerged as a major and growing threat to Sydney's environment. Unlike conditions in other Australian capital cities, peak concentrations may reach intensities similar to those experienced in Los Angeles and Tokyo, the worst affected cities in the world, especially with regard to ozone levels. Under adverse meteorological conditions, oxidant levels in Sydney may reach values as high as 0.15 to 0.30 ppm. In the United States, such levels are associated with overt health effects such as eye and respiratory tract irritation and increased asthma attacks.

While levels in Los Angeles and Tokyo are on a downward trend, however, levels in Sydney appear to be increasing. More strict antipollution measures will be necessary if the quality of air is not to continue to deteriorate with increasing danger to the community's health and detrimental effects on vegetation and materials, as well as decreased visibility. The Sydney Basin lies often beneath a pall of smog.

Motor vehicles and support industries are the major emitters of hydrocarbons in Sydney. Despite regulations that control evaporative emissions from fuel tanks and carburetors and exhaust emissions from new cars, emission reductions achieved to date have not kept pace with the growth of emission sources. As a result, ozone levels have increased over the past seven years. At present, approximately 660 MT of hydrocarbons are emitted into Sydney's atmosphere each working day. To reduce ozone levels from the current mean maximum of approximately 0.03 ppm to 0.10 ppm would require limiting hydrocarbon emissions in the Sydney region to about 150 MT per day.[23] At this level, effects from smog can be considered negligible. With current technology, this reduction can be achieved only at a cost many would consider excessive. Also, with the present growth rate of numbers of vehicles in New South Wales in excess of 5 percent per year, it follows that an average reduction in vehicle emissions of at least 5 percent per year is needed simply to maintain the status quo, which is acknowledged to be unsatisfactory.

In 1979, the National Health and Medical Research Council (NHMRC) considered that, as a long-term goal, the number of days in a year with maximum hourly average ozone concentrations above 0.12 ppm should not exceed 1. The council recommended that action designed to attain this goal should be implemented as soon as possible.[24] The ozone level in the atmosphere of Sydney exceeds the 0.12 ppm level on about 40 days a year and reached 0.38 ppm in 1977.

AUSTRALIAN ENVIRONMENT POLICIES

Under the Australian system of government, responsibility for environmental issues is shared between the six state governments and federal or Commonwealth government. All six state governments have ministers responsible for environmental matters, such as conservation, environment protection, and land-use planning, supported by an array of departments and agencies. Each state is different in its administrative arrangements, a consequence of political and historical factors.

State bodies include the Department of Environment and Planning, and the State Pollution Control Commission, New South Wales; the Ministry for Conservation, Victoria; the Air Pollution and Water Quality Councils of Queensland; the Department for the Environment, South Australia; the Environmental Protection Authority, Western Australia; and the Department of Environment, Tasmania. The states control pollution and conduct environmental impact assessments.

At the national level, environmental matters became recognized in 1971 with the creation of the portfolio of Environment, Aborigines, and the Arts. With the change of government in 1972, a separate environment portfolio was created. Following a further change of government in 1975, a new Department of Environment, Housing, and Community Development was created. This was abolished in 1979, the environment element being incorporated into the Department of Home Affairs and the Environment. Enviromental impact assessment is conducted under the Environment Protection (Impact of Proposals) Act 1974/75. Special inquiries have been conducted by the federal government into such issues as Fraser Island sand-mining, the flooding of Lake Pedder, and the mining and export of uranium.

Early air pollution control legislation in Australia was confined to that which helped avoid public nuisances and any threat to public health. The nuisance and offensive trade provisions of local government and public health legislation allowed action on dense smoke, fumes, and offensive smells in some specific instances.

The London smog disaster of 1952, in which four thousand people died, had a profound effect on the Australian states; they began to investigate for the first time the extent of air pollution, both existing and prospective, within the principal urban areas. The outcome was the development of clean air legislation, mainly in the form of separate clean air acts. Some of this legislation (eg, in New South Wales) resembles British legislation (the Alkali, Etc. Works Regulation Act of 1906 and the Clean Air Act of 1956) in bringing the heavier or scheduled industries under state supervision, while leaving much general industry under the supervision of local authorities. In other cases, (eg, Victoria) the legislation was based initially on the British Clean Air Act of 1956 in being concerned primarily with smoke problems from industry in general; although later the scope of the act was extended and strengthened by the Environment Protection Act.

There can be no doubt that the independent activities of the six states produced a patchwork effect in terms of legislation and administration. Annual meetings of air pollution control officers from all the states attempted to ameliorate the problems, but there were clearly fundamental weaknesses both in the form legislation had taken and in the type of organizations set up to implement the legislation in most of the states.

Much state legislation was fragmentary, tending to leave large areas of responsibility to local authorities. In Britain, a substantial proportion of the environmental health officers who implement clean air legislation hold a diploma in air pollution control issued after examination by the Royal Society of Health. No similar qualification exists in Australia. Only the legislation of Western Australia and Queensland is comprehensive in the sense that all air pollution control work is undertaken by a single authority.

The type of organization set up to implement clean air legislation is also a vital element in effectiveness. Except in the case of Queensland, when the responsible body was often the State Department of Health, while the personnel usually belonged to a division not primarily concerned with air pollution. In Queensland alone the organization is headed by a director of air pollution control responsible directly to an Air Pollution Council and a minister. In more recent years, in both Victoria and New South Wales, air pollution control staff have been transferred to new environment agencies.

Under the clean air legislation of all states, power exists to reject proposals for new plants if their location is not considered suitable. There is thus an ultimate sanction on the planning decisions of local authorities and other state departments. Planning by negation, however, though valuable is not enough. Town planning must seek to take air pollution into account if it is to make a positive contribution to a satisfactory solution. The position will not be resolved satisfactorily until all proposed town plans and major planning schemes are considered within a full environmental context.

LEGISLATION

National Legislation

The federal government has no statutory power in this area but does play an important coordinating role. Because of the lack of direct influence, however, the Environment portfolio has been treated as an appendage to other concerns, and either the ministers change at every cabinet reshuffle or else the portfolio is attached to yet another ministry.

The minister, however, presides over the Environment Council, which consists of all the state ministers. It is concerned with coordinating state activities as far as possible.

The most important achievement of the federal government in this area is the promulgation of the Australian Design Rules (ADR) for the control of motorcar exhaust emissions. These were developed through the Australian Transport Advisory Council on which state control agencies, transport ministers, motorcar manufacturers, and the oil industry are represented.

The latest rule in force since 1 July 1976 is ADR 27A. This is essentially the same as the U.S. 1973/74 standards and prescribes the following limits:

Table 2. National Emission Standards (Recommendations)

Pollutant	Applicable to	Standard	Notes
Smoke	All stationary fuel-burning sources	Ringelmann 1	R. 3 acceptable for lighting up or soot blowing
	Shipping	R. 1	
	Locomotives (diesels)	R. 1	R. 3 acceptable for lighting up or soot blowing
	Aircraft	R. 1	
	Motor vehicles (diesel or petrol)	R. 1 or equivalent	
Solid particles	Boilers burning solid fuels	0.25 g/m^3	12% CO_2
	Incinerators:		
	(a) less than 300 kg/hr	0.5 g/m^3	12% CO_2
	(b) more than 300 kg/hr	0.25 g/m^3	12% CO_2
	Furnaces for the heating of metals, except cold blast foundry cupolas	0.1 g/m^3	
	Any other trade, industry, process, industrial plant, or fuel-burning equipment	0.25 g/m^3	
Soot	Any boiler or furnace burning liquid or gaseous fuels	Bacharach shade 3	Other than for lighting up or soot blowing
Sulphuric acid mist and sulphur trioxide	Any trade, industry, or process	0.1 g/m^3 as SO_2	
Acid gases	Any trade, industry, or process manufacturing sulphuric acid	0.3 g/m^3 as SO_3	
Nitric acid or oxides of nitrogen	Any trade, industry, or process except nitric or sulphuric acid plants or gas fired power stations	0.5 g/m^3 as NO_2	
Nitric acid or oxides of nitrogen	Manufacture HNO_3 H_2SO_4	2.0 g/m^3 1 g/m^3 both as NO_2	Tailgas must be colorless

Table 2 Continued

Pollutant	Applicable to	Standard	Notes
Oxides of nitrogen	Gas-fired power stations	0.35 g/m^3 as NO_2	
Carbon monoxide	Any trade, industry, or process	1.0 g/m^3	
Hydrogen sulphide	Any trade, industry, or process	5 mg/m^3 as H_2S	
Total of antimony, arsenic, cadmium, lead, mercury	Any trade, industry, or process	10 mg/m^3	Addition of each metal or compound expressed as the metal in each case

Hydrocarbons	2.1 g/km
Carbon monoxide	24.2 g/km
Oxides of nitrogen	1.9 g/km
Evaporation test for hydrocarbons with a limit of 2 g/test	

The design rules are adopted in all states by parallel legislation.

The prestigious NHMRC issued National Emission Standards in 1972. These were revised in 1979. The standards do not have legal standing but are issued as recommendations on what control should be achieved in new plants.

These standards are given in Table 2. They were prepared by a subcommittee of the council, on which there is a number of doctors, and also by the air pollution control officers of the states.

State Legislation

New South Wales

Under the Clean Air Act of 1961, the minister for Planning and Environment has the power to issue regulations. In practice, this power was originally administered by the Health Department and is now exercised by the State Pollution Control Commission (SPCC), a body established to deal with the four major areas of concern: air, water, noise, and solid waste.

Regulations under the act were proclaimed in 1964 and prescribed, among other things, a wide range of emission standards. In 1972, the act was amended to allow the control of open-burning and the formulation of regulations for motor vehicle emissions.

All premises are subject to the act, but those at which certain operations are executed, or where more than 300 kg of combustible material can be burnt per hour, are subject to the regulations through licensing, controls, and monitoring. As these are listed in a schedule attached to the regulations, the term *scheduled premises* is used to described such stationary sources.

Standards of concentration and rates of emission for major industries and/or pollutants are given in Table 3.

Since January 1973, all new scheduled premises using fuel oil in the most industrialized part of the state have been obliged to use only oil with a maximum sulphur content of 1 percent.

In 1974, regulations were introduced to control emissions of smoke, hydrocarbons, and carbon monoxide from motor vehicles. In the same year, the penalties under the act were increased greatly and a new section dealing with the control of odors was added. Since October 1974, further restrictions apply to the sulphur content of fuel oil as follows:

Hourly Consumption Rate (capacity)	Maximum Sulphur Content Permitted (%)	Geographical Application
200 kg	0.5	Metropolitan
200-500 kg*	1.0	Metropolitan
500 kg	2.5	Entire state

*and all new plants on scheduled premises.

The limit of 0.1 g/m^3 of SO_3 which has applied since January 1972, has restricted brick kilns and other processes that use large quantities of excess air to a practical limit of 0.9 percent sulphur in their fuel oil. Premises which have control equipment for reducing sulphur compound emissions may use fuel with more than the maximum permitted sulphur content provided the actual emissions do not exceed those associated with the use of fuel containing the maximum permitted sulphur content.

Sulphur dioxide emissions are controlled by requiring all occupiers of scheduled premises to obtain approval for stack heights before construction starts. The Bosanquet–Sutton or other suitable calculation procedures are used to determine heights needed to ensure that ground level concentrations do not exceed 16–20 pphm SO_2. In practice, this means that all premises with stacks of less than 21 m height must use fuel with no more than 0.3 percent sulphur content.

There are no regulations for hydrocarbons, but evaluations are underway that probably will lead to hydrocarbon standards.

Table 3. New South Wales: Standards of Concentration and Emission Rates for Scheduled Premises

Pollutant	Regulation Applicable to	Permitted Maximum	Notes
Smoke	All station fuel-burning equipment except:	Ringelmann 2	R. 3 for lighting up to limit of 20 min/24 hr
	Kilns for firing bricks, tiles, refactories, etc.	R. 2 or R. 3 in some cases	R. 3 for maximum 10 min/hr
Particulate	All stationary sources except:	0.4 g/m^3	
	Boilers or incinerators	0.4 g/m^3	Adjusted to 12% CO_2
Soot	All stationary sources	R. 3	
H_2SO_4 Mist	Any trade, industry, or process emitting H_2SO_4 mist or SO_3 except:	0.2 g/m^3	0.1 g/m^3 for all plants built after 1 January 1972
	(a) manufacture of H_2SO_4 using other than elemental S at an S source;	0.9 g/m^3 as SO_3	
	(b) manufacture of H_2SO_4 from elemental S	7.0 g/m^3 as SO_3	
NO_X, HNO_3	Any trade, industry, or process except:	2.5 g/m^3 as NO_2	Measured after process completion and before admixture with other gases.
	Manufacture of HNO_3 or H_2SO_4	4.5 g/m^3 as NO_2	Measured as for preceding item.
F, HF, Inorganic F compounds	Any trade, industry, or process except:	0.1 g/m^3 as HF	Measured after process completion and before admixture with other gases.
	Manufacture of Al from Al_2O_3	0.04 g/m^3 as HF	
Cl	Any trade, industry, or process	0.2 g/m^3 as Cl_2	
H_2S	Any trade, industry, or process	5 ppmv/v	
Pb, As, Sb, Cd, Hg, or compounds thereof		0.2 g/m^3 total expressed as the element	

Regulations specifying a maximum lead content for both grades of gasoline became operative from 1 January 1975 for the Newcastle–Sydney–Wollongong region (the area containing the bulk of both the state's population and its industry).

Maximum Lead Content in Gasoline

1 Jan. 1975 to 31 Dec. 1977	0.64
1 Jan. 1978 to 31 Dec. 1979	0.45
1 Jan. 1979 on	0.40

It should be noted that the philosophy in New South Wales is one of "best practicable means," and consequently no air quality standards have been set nor is there any intention of doing so.

The Clean Air Act provides for the control of air pollution from any premises and prescribes that certain works may not be carried out without approval. The occupier of premises may be required to carry out appropriate works. Emission standards may be prescribed and enforced; where such standards have not been prescribed, the best practicable means must be used to prevent or minimize air pollution.

Licensing provisions apply to premises scheduled under the act. Conditions designed to prevent or reduce air pollution may be attached to the license. The act prohibits the sale or use of motor vehicles tha emit excessive air impurities and provides for the fitting of antipollution devices. The minister may prohibit the use of fuel or any class of fuel, fuel-burning plant, or industrial plant in nominated areas. He may order the cessation of any activity which is, or is likely to be injurious to public health or which may cause discomfort or inconvenience to persons. Penalties under the act range up to $A10,000 (US$11,500) for a single offense and to $A5000 (US$5750) for each day the offense continues.

The control of air pollution came initially under the Health Commission. In 1970, the SPCC was created; in 1974, this commission absorbed the staffs of the air pollution control and water pollution control branches of the Health Commission. The powers to license and control scheduled premises are now vested in the commission, which is responsible to the minister for Planning and Environment.

To implement the Clean Air Act, the commission employs engineers, chemists, and technicians who engage in day-to-day control activities, monitor air pollution levels in the atmosphere, and conduct research into the scientific aspects of the problem. Source testing plays an important part in the implementation of emissions standards; the practical aspect of this work has been well developed over the years.

The commission uses two basic approaches to air pollution control in a complementary manner:

1. Air quality management—the aim is to prevent pollution levels in the atmosphere from exceeding nominated levels. The setting of ambient air quality standards necessitates extensive air quality monitoring programs coupled with intensive research.
2. Best practicable means—the aim is to control pollution at source to a level that is technologically practical and economically feasible. This approach may not necessarily achieve satisfactory air quality, but in practice it often does so.

During the 10-year period 1965–1975, manufacturing industry in New South Wales spent about US$127.5 million ($A85 million) on air pollution control equipment.

The definition of the words "best practicable means" in the act is of considerable importance. It refers not only to the provision for and the efficient maintenance of appliances adequate for preventing the escape of noxious or offensive gases (including smoke, grit, and dust) but also to the manner in which such appliances are used, and to the proper supervision by the owner of any operation in which such gases are evolved. The obligation to adopt the best practicable means is continuous, and this may entail alterations in plant and method as new techniques for controlling emissions become available.

The adoption of the best practicable means in any instance may include the installation of such equipment as bag filters, wet washers, multicell cyclones, and electrostatic precipitators for arresting mists, fumes, and dusts.
Environmental Impact Assessment. An environmental impact statement is a considered report, following careful studies, which discloses the likely or certain environmental consequences of a proposed project, thus alerting the decision maker, the public, and government to the environmental risks involved. The statement's findings should enable better informed decisions to be made, perhaps by the rejection or deferment of the proposal or by its approval subject to compliance with specified conditions. The impact statement procedure often affords the public an opportunity to participate in decision making that may affect the environment. The preparation or discussion of statements may involve public hearings or inquiries. The State Pollution Control Commission conducted 12 major public hearings up to 1980. Hearings are now conducted by a special body of Commissioners of Inquiry.

In New South Wales, effect was given originally to the environmental impact policy by application of the SPCC's Environmental Standard as outlined in publication E1-4, *Principles and Procedures for Environmental Impact Assessment in New South Wales.* This was adopted by the New South Wales government in October 1974. These principles and procedures bind the Crown and have been applied and followed by all public authorities in New South Wales when determining the acceptability or otherwise of their own proposals and of those submitted to them by others.

Although the principal responsibility for environmental control in New South Wales rested initially with the SPCC, the principles and procedures provide that every public authority in New South Wales has the responsibility for protecting the environment by its own actions and by its influence on the actions of others.

The Environmental Planning and Assessment Act of 1979, recently passed by the New South Wales Parliament, gives statutory form to these long-established procedures and transfers the environmental impact assessment function to a new Department of Environment and Planning.

Air Pollution Constraints on Urban Planning. The implications of air pollution for urban planning are receiving increased attention, particularly in light of areal and regional problems which have arisen in various parts of the world. The SPCC of New South Wales prepared a detailed report on the air pollution levels likely to arise in the Sydney Basin if the population of that area reaches 4.3 million by the year 2000.[25] The report considers current levels and the changing character of air pollution in Sydney, the unique topography and weather conditions of the city, projections of emissions based on a study of existing sources, the development and validity of mathematical dispersion models, and the various options for control strategies and techniques. The conclusions reached in the report are, broadly:

1. Air quality in Sydney will inevitably deteriorate unless a lower growth rate and projected population in the basin is accepted.
2. If present pollution levels are not to be exceeded substantially, the ultimate population in the Sydney Basin will need to be restricted to about 3.6 million. This is a tentative estimate and may require revision in light of more exact planning data on those areas actually decided upon for urban and industrial development.
3. Control techniques alone cannot be relied on to achieve acceptable air quality. Land-use planning must become part of the control process.
4. Areas projected currently for development are unfavorable from an air pollution viewpoint. The southwest sector is susceptible to oxidant pollution, the northwest sector is poorly ventilated, and the western area will contribute to pollution in the rest of the basin.

5. More favorable locations for industrial development from an air quality viewpoint have been identified. These are on the fringes of the basin. These areas may have other environmental constraints, however, which outweigh their air quality advantages.
6. Sydney has a year-round air pollution problem, with oxidants predominating in summer and oxides of sulphur and suspended particulates in winter.
7. Should circumstances necessitate conversion to more polluting fuels than those used at present, the vulnerability of the basin to air pollution will become more evident.
8. At the local level, careful planning should ensure that buffer zones exist between troublesome sources and sensitive receptors.

Victoria

Air pollution control was originally vested in the Health Department by the Clean Air Act of 1958. Regulations under that act were administered by that department's Clean Air Branch. Table 4 gives the major emission standards applicable to all industrial premises. These regulations are still in force at present.

Regulations limiting the lead content of gasoline are operative and are similar to those of New South Wales.

The act was based on the "best practicable means" philosophy. In 1972, it was amended to increase the maximum penalty to $A5000 (US$7500) with a daily penalty of $A2000 (US$3000) for breaches of the act, and $A400 (US$600) with a $A100 (US$150) daily penalty for breaches of the regulations.

The Environment Protection Authority (EPA) came into being in July 1971 under the Environment Protection Act of 1970. The authority was to become the central pollution control agency for Victoria, introducing a system under which all waste discharges to the environment would need to be licensed. Thus, the authority became responsible for all air pollution matters in Victoria. The Clean Air Act was not repealed, however, and is in effect concurrently with the new act. Plants temporarily exempted from the licensing provisions of the new act remained in practice subject to the Clean Air Act. Gradually, the role of the Clean Air Act has diminished.

The Environment Protection Act also provides for the declaration of state environment protection policies. These set out the environmental standards to be met in any area in order to protect specified beneficial uses. The procedure for developing a state environment protection policy provides for public review of draft documents. The final version may be submitted to the Governor-in-Council by the authority for declaration. To date, a water quality

Table 4. Victoria: Provisions Applicable to Air Emissions (Clean Air Act of 1958)

Pollutant	Regulation Applicable to	Permitted Maximum	Notes
Smoke	All industrial premises except:	Ringlemann 2	R. 3 for 2 min/hr for single boiler up to 6 min some plant
	Ceramic kilns	R. 2	R. 3 when using a reducing atmosphere for up to 30 min/cycle
Particulate matter	All industrial plants	0.2 gns/NCF (.5 g/m^3)	
H_2SO_4, SO_3	All industrial plants except:	0.1 gns/NCF (.2 g/m^3) as SO_3	
	Manufacture of H_2SO_4 by chamber process	2.0 gns/NCF (4.6 g/m^3) as SO_3	Any NO_X to be included in total
HNO_3, NO_X	All industrial plants except:	1.0 gns/NCF (2.3 g/m^3) as NO_2	
	Those making HNO_3 and/or H_2SO_4	2.0 gns/NCF (4.6 g/m^3) as NO_2	
F, HF + compounds thereof	Plants making superphosphate fertilizers or Al	0.05 gns/NCF (.1 g/m^3) as HF	Other plants appear to be unrestricted
Cl	All industrial plants	0.1 gns/NCF (.2 g/m^3) as Cl_2	
H_2S	All industrial plants	5 ppmv/v	
Pb, As, Sb, Cd, Hg, or compounds thereof	All industrial plants	0.01 gns/NCF (0.02 g/m^3) total as elements	
S Compounds	All industrial plants	0.27 lb mass per million BTU fuel (gross) as S (0.5% S by weight for fuel oil)	

policy has been declared for Port Phillip Bay. An environmental protection policy for air quality is needed urgently in Melbourne. As a result of the waste discharge licensing system program begun in 1973, however, air pollution

Table 5. Victoria: Ambient Air Quality Objectives (Proposed Policy)

Indicator	Unit	Averaging Period	Acceptable Level[a]	Detrimental Level[a]
Carbon monoxide	ppm[b]	1 hr	30	60
		8 hr	10	20
Lead*	$\mu g/m^3$	30 day	1.5	—
Nitrogen dioxide	ppm	1 hr	0.15	0.25
		24 hr	0.06	0.15
Oxidant[c]	ppm	1 hr	0.10	0.15
		8 hr	0.05[d]	0.08[d]
Sulphur dioxide	ppm	1 hr	0.17	0.34
		24 hr	0.06	0.11
Visibility-reducing particulates[e]	km	1 hr	20	

[a] Based on health effects unless indicated otherwise.
[b] Parts per million (volume/volume).
[c] Measured as ozone, the major constituent of photochemical oxidant.
[d] Based on vegetation damage.
[e] Based on aesthetic considerations; determined as local visual distance at relative humidities of up to 90 percent using light scattering measurements.
* In 1979, the NHMRC recommended that the 3-month ambient average air level for lead should not exceed 1.5 $\mu g/m^3$ of air.

caused by industrial discharges has been reduced. Air pollution by motor vehicles has tended to increase, however, notwithstanding the introduction of controls for new vehicles.

A draft Environment Protection Policy for the Air Environment of Victoria[26] was published during 1979 and has been put through the prescribed procedures for public comment. It is expected that the policy will finally be published during 1981.

As required by the act, the draft policy proposes for the first time in Australia actual air quality standards. These are similar to U.S. standards but are defined differently. They are given in Table 5.

Emission standards also have been included both for existing and for newly erected plants. The latter closely follow the recommendations of the NHMRC. The emission standards are given in Tables 6 and 7.

The policy also provides for air quality regions based on industrial production areas.

Table 6. Victoria: Maximum Emission Limits for Existing Stationary Sources (Proposed)

Wastes	Applicable to	Maximum Level* †		Notes
Visible emissions	All stationary sources except: 1. Smoke from fires set for the reduction of a fire hazard or for instruction in the methods of fighting fire 2. Normal agricultural operation	Ringelmann 2 (BS2742C, 1957): or of such capacity as to obscure observer's view to the same degree as emissions corresponding with Ringelmann 2 above		1. Ringelmann 3 acceptable for periods aggregating not more than 3 min in any 60-min period 2. Does not apply to emission of water vapor
Combustion particulates	Solid fuel fired units All other units	0.5 g/m^3 0.25 g/m^3		Gas volume calculated to 12% CO_2; any CO_2 produced by combustion of any liquid or gaseous fuel shall be excluded from the calculation to 12% CO_2
Particulates other than combustion particulates	All stationary sources	Process Weight Rate (kg/mm)	Max. Emission Rate (g/min)	
		0 - 3	17.5	Process weight is the total weight of all materials introduced into any specific process which may discharge contaminants into the atmosphere; solid fuels charged shall be considered as part of the process weight, but liquid and gaseous fuels and air shall not
		3.0 - 10	17.5 + 2.25 per kg/min process weight in excess of 3	
		10 - 100	35 + 1.0 per kg/min process weight in excess of 10	
		Over 100	125 + 0.2 per kg/min process weight in excess of 100	

Total particulate matter	All stationary sources	0.5 g/m^3	
Sulphur dioxide	(a) Sulphuric acid plants (b) All other stationary sources	7.0 g/m^3 2.0 g/m^3	Sulphur recovery units having an effluent process gas discharge containing less than 120 g/min of SO_2 may dilute to meet the provision of subsection 5b
Sulphuric acid mist and sulphur trioxide	All stationary sources	0.2 g/m^3 as SO_2	
Hydrogen sulphide	All stationary sources	7.5 mg/m^3	
Nitric acid and oxides of nitrogen	Nitric acid plants	4.0 g/m^3 of nitric acid plus nitrogen oxides, calculated as NO_2	
Oxides of nitrogen	Fuel burning units (other than internal combustion engines) having a maximum heat input rate greater than 150,000 MJ/hr gross	1.0 g/m^3	Nitrogen oxides calculated as NO_2 at 3% oxygen
Lead and its compounds	All stationary sources	10 mg/m^3 expressed as lead	
Fluorine compounds	All plant manufacturing aluminum from alumina All other sources	0.02 g/m^3 expressed as HF 0.05 g/m^3 expressed as HF	
Chlorine and chlorine compounds	All stationary sources	0.02 g/m^3 expressed as chlorine	

Table 6 Continued

Wastes	Applicable to	Maximum Level*,†	Notes
Total of antimony, arsenic cadmium, lead, and mercury		10 mg/m^3 (addition of each metal or compound expressed as the metal in each case)	
Antimony and its compounds		10 mg/m^3 expressed as antimony	
Arsenic and its compounds		10 mg/m^3 expressed as arsenic	
Beryllium and its compounds		0.1 mg/m^3 expressed as beryllium	
Cadmium		3 mg/m^3 expressed as cadmium	
Mercury and its compounds		3 mg/m^3 expressed as mercury	
Nickel and its compounds except nickel carbonyl		20 mg/m^3 expressed as nickel	
Nickel carbonyl		0.5 mg/m^3 expressed as nickel	

* Gas volumes are expressed dry at O°C at an absolute pressure of 1 atmosphere (101.325 kPa).

† Dilution of wastes to meet maximum limit shall not be permitted except where noted.

Table 7. Victoria: Maximum Emission Limits for New Stationary Sources in Air Quality Control Regions (Proposed)

Wastes	Applicable to	Maximum Level*,†		Notes
Visible emissions	All stationary sources except smoke from fires set for the reduction of a fire hazard or for instruction in the methods of fighting fire	Ringelmann 1 (BS2742C, 1957) of such opacity as to obscure an observer's view to the same degree as emissions corresponding with Ringelmann 1, above		1. Ringelmann 2 acceptable for periods aggregating not more than 3 min in any 60-min period
Combustion particulates	All stationary sources except: Incinerators with design burning rates of 300 kg/hr or less	0.25 g/m^3		Gas volume calculated to 12% CO_2; and CO_2 produced by combustion of any liquid or gaseous fuel shall be excluded from the calculation to 12% CO_2
Particulates other than combustion particulates	All stationary sources	Process Weight Rate (kg/min)	Max. Emission Rate (g/min)	
		0 - 3	14	Process weight is the total weight of all materials introduced into any specific process which may discharge contaminants into the atmosphere: solid fuel charged shall be considered as part of the process weight, but liquid and gaseous fuels and air shall not
		3.0 - 10	14 + 2.0 per kg/min process weight in excess of 3	
		10 - 100	28 + 0.8 per kg/min process weight in excess of 10	
		Over 100	100 + 0.18 per kg/min process weight in excess of 100	

Table 7 Continued

Wastes	Applicable to	Maximum Level*,†	Notes
Total particulate matter	All stationary sources	0.25 g/m^3	
Sulphur dioxide	All stationary sources	1.4 g/m^3	Sulphur recovery units having an effluent process gas discharge containing less than 120 g/min of SO_2 may dilute to meet the provision of Section 5. Emission rates of SO_2 from sulphuric acid plants and sulphur recovery units shall not exceed 1.5 kg/min
Sulphuric acid mist sulphur trioxide	Sulphuric acid plants	0.1 g/m^3 as SO_3	
Hydrogen sulphide	All stationary sources	5.0 mg/m^3	Any source discharging H_2S at a rate of less than 2 g/hr may dilute to meet the provision of Section 7
Nitric acid and oxides of nitrogen	Nitric acid plants	2.0 g/m^3 of nitric acid plus nitrogen oxides, calculated as NO_2	
Oxides of nitrogen	Fuel burning units (other than internal combustion engines) having a maximum head input rate greater than 150,000 MJ/hr gross except	(a) 0.35 g/m^3 for gaseous fuels (b) 0.5 g/m^3 for liquid solid fuel	Nitrogen oxides calculated as NO_2 at 3% oxygen

	Gas turbines for electricity generation	(a) 0.07 g/m^3 for gaseous fuels (b) 0.15 g/m^3 for other fuels	Nitrogen oxides calculated as NO_2 at 15% oxygen
Carbon monoxide	All stationary sources except internal combustion engines and cold blast cupolas	2.5 g/m^3	
Lead and its compounds	All stationary sources	10 mg/m^3 expressed as lead	
Fluorine compounds	Any plant manufacturing aluminum from alumina	0.02 g/m^3 expressed as HF	
	Any other source.	0.05 g/m^3 expressed as HF	
Chlorine and its compounds	All stationary sources	0.2 g/m^3 expressed as chlorine	
Total of antimony, arsenic, cadmium, lead, and mercury		10 mg/m^3 (addition of each metal or compound expressed as the metal in each case)	
Antimony and its compounds		10 mg/m^3 expressed as antimony	
Arsenic and its compounds		10 mg/m^3 expressed as arsenic	
Beryllium and its compounds		0.1 mg/m^3 expressed as beryllium	
Cadmium		3 mg/m^3 expressed as cadmium	
Mercury and its compounds	All stationary sources	3 mg/m^3 expressed as mercury	

Table 7 Continued

Wastes	Applicable to	Maximum Level*·†	Notes
Nickel and its compounds except nickel carbonyl		20 mg/m^3 expressed as nickel	
Nickel carbonyl		0.5 mg/m^3 expressed as nickel	

* Gas volumes are expressed dry at O°C at an absolute pressure of 1 atmosphere (101.325 kPa).

† Dilution of wastes to meet maximum limit shall not be permitted except where noted.

The authority carries out what monitoring it can afford and also may require licensees to monitor their own emissions. Emission standards may be tightened under the policy should this prove necessary in the light of monitoring results.

A major airshed study is in progress in the Latrobe Valley, the site of the state's large brown coal deposits as well as most of its electricity generating plants.

A feature of Victoria's system is the existence of an Environmental Appeals Board where would-be licensees can appeal licensing conditions they believe are too harsh. Further appeals to the State Supreme Court and the Commonwealth High Court are possible.

In 1973, the Ministry for Conservation was created and given important statutory responsibilities in relation to the control of pollution in Victoria. The EPA, while retaining its title, became an agency of the new ministry and subject to coordinating policies. The ministry is represented on the policy and priority review group of the State Co-Ordination Council and on the standing committee of the Australian Environment Council. Other branches of the ministry deal with fisheries and wildlife, land conservation, national parks, soil conservation, and the foreshore of Port Phillip Bay. A special body within the ministry deals with environmental assessment, conservation planning, and broad-scale studies of those areas of Victoria where major development is likely to occur. Many of these diverse activities support the ministry's role as a pollution watchdog.

South Australia

The enabling act is the Health Act of 1935/77, and the Clean Air Regulations of 1969 and 1972 have been issued by the minister for Health under its authority. South Australia operates on the basis of "scheduled premises." These comprise all major and in some cases minor industries and processes with an air pollution potential. Fuel-burning equipment is controlled by scheduling various combustion processes in accordance with the heat release or with the weight and type of materials burned. All industries are subject to the Clean Air Regulations.

Sulphur dioxide is controlled by regulating chimney heights.

While all air pollution control is exercised by the minister for Health, open-burning is controlled by local councils. Burning on sanitary landfill tips, however, is prohibited in Adelaide and some country centers. South Australian emission standards are given in Table 8.

Table 8. South Australia: Standards of Concentration for Air Impurities

Pollutant	Applicable to	Permitted Maximum	Notes
Smoke	All premises other than domestic incinerators and fires except ceramic kilns	R. 2	
		R. 2	R. 4 for up to 5 min/hr
	Multiple sources but single chimney	R. 2	R. 4 for up to 41 min in 8 hr for 4 units
Particulate	All stationary sources except:	0.45 g/m^3	
	Plants for metal heating other than cold blast foundry cupolas	0.11 g/m^3	
Soot	Included in particulate matter		
H_2SO_4, SO_3	Any trade emitting H_2SO_4 mist or SO_3 except	0.23 g/m^3 as SO_3	
	Manufacture of H_2SO_4 by chamber process;	4.5 g/m^3 as SO_3	
	Manufacture of H_2SO_4 by contact process	7.0 g/m^3 as SO_3	Effluent gas not to contain persistent mist
NO_X, HNO_3	Manufacture HNO_3 Manufacture H_2SO_4	4.5 g/m^3 NO_2 2.0 g/m^3 NO_2	
F, HF, inorganic F compounds	Any trade, plant, or industry	0.1 g/m^3 as HF	
Cl	Any trade, plant, or industry	0.23 g/m^3 as Cl_2	
H_2S	Any trade, plant, or industry	0.007 g/m^3	
Pb, As, Sb, Cd, Hg, or Cu, or Compounds thereof	Any trade, plant, or industry	0.02 g/m^3 total expressed as the element	

Table 9. Western Australia: Emission Standards

Pollutant	Applicable to	Permitted Maximum	Notes
Smoke	All industrial premises		
	except during soot blowing,	R. 2	Maximum 4 min
	during any 8-hr period,	R. 2	Maximum 10 min
	multiple sources, and	R. 2	Above maxima are extended
	single chimney, lighting up	R. 2	Maximum 24 min in 24 hr
Particulate Matter	All industrial premises with fuel-burning equipment	—	Construction requires approval of all exhaust gas control equipment

Western Australia

Clean Air Regulations were promulgated in 1967 under the Clean Air Act of 1964. The same concept of scheduled premises is applied as in the eastern states. Industries included are cement works, ceramic works, chemical works, coking plants, ferrous and nonferrous metal plants where melting, casting, or coating operations are executed, grinding and milling works, oil refineries, metal smelters, scrap metal recovery plants, or any premises with boilers. Concrete works and cement product manufacturing works were added in 1971. The NHMRC recommendations are used as guidelines for licensing new scheduled premises.

Sulphur dioxide is controlled by regulating chimney heights. The *United Kingdom Memorandum on Chimney Heights (25/63) Second Edition* is used for calculating the correct heights.[27] This regulation applies to all fuel-burning equipment capable of emitting 3 pounds (lb) of SO_2 in 1 hr (Table 9).

Queensland

Clean Air Regulations came into operation in 1968 under authority of the Clean Air Act of 1963, and, as in the other Australian states (except Victoria), these provide for licensing of scheduled premises and limitation of pollutant discharge. In addition to the premises listed for Western Australia, sugar mills, tanneries, glass works, premix bitumen plants, and alumina refineries are also scheduled.

Table 10. Queensland: Prescribed Standards of Concentration and Rate of Emission of Air Impurities

Pollutant	Applicable to	Permitted Maximum	Notes
Smoke	All industrial plant or fuel-burning equipment except:	—	Plant must be designed so operators can be
	Continuous emission for up to 4 min;	R. 2	aware of smoke discharge without
	Continuous emission for up to 2 min/30 min;	R. 4	leaving their station (TV, mirrors, etc.)
	One boiler furnace or incinerator;	R. 2	10 min/8 hr, 14 min with soot
	Ranging to 4 units and 1 stack	R. 2	blowing 29 + 41 min/8 hr
	Ceramic furnaces	R. 2	Maximum 5 min/hr except when a reducing atmos. needed when R. 3 acceptable
Particulate matter	Any trade, industry, or process except:	0.2 gn/N ft^3 (0.46 g/m^3)	
	Sugar mills;	0.35 gn/N ft^3 (0.8 g/m^3)	Many sugar mills are fitted with bagasse
	Heating of metals other than steelmaking;	0.05 gn/N ft^3 (0.1 g/m^3)	
	Steelmaking	0.2 gn/N ft^3 (0.46 g/m^3)	
H_2SO_4, SO_3	Any trade, industry, or process except:	0.1 gn/N ft^3 (0.23 g/m^3) as SO_3	
	H_2SO_4 manufacture by chamber process	2.0 gn/N ft^3 (4.6 g/m^3)	Limit is total of all acid gases including NO_X & HNO_3
	H_2SO_4 manufacture by contact process	3.0 gn/N ft^3 (6.9 g/m^3)	
NO_X, HNO_2	Any trade, industry, or process except:	1.0 gn/N ft^3 (2.3 g/m^3)	
	NHO_3 manufacture	2.0 gn/N ft^3 (4.6 g/m^3)	

Table 10. Continued

Pollutant	Applicable to	Permitted Maximum	Notes
F, HF, inorganic F compounds	Any trade	0.05 gn/N ft^3 (0.1 g/m^3) as HF	
Cl	Any trade	0.05 gn/N ft^3 (0.23 g/m^3)	
H_2S	Any trade	5 ppmv/v	
Pb, As, Sb, Cd, Hg, Cu or any compound thereof	Any trade	0.01 gn/N ft^3 (0.02 g/m^3) total as element	

All premises with fuel-burning equipment (including incinerators) capable of consuming O.5 MT of coal or its equivalent are scheduled.

Sulphur dioxide is controlled by regulating chimney heights according to the *United Kingdom Memorandum 25/63,* as in Western Australia. The sulphur content of fuel oil is limited to 3 percent by weight throughout the state. Table 10 gives the major standards of concentration for air impurities current in Queensland. Tests are based or adjusted to a flue-gas carbon dioxide content of 12 percent for boilers and incinerators.

Tasmania

Atmospheric pollution prevention regulations made under the Environment Protection Act of 1973 apply to both fixed and mobile sources of air pollution. Scheduled premises are licensed and include all fuel-burning installations, chemical plants, cement works, hot-mix plants, crushing and grinding works, and primary metallurgical works. In-service motor vehicles are required to meet gaseous and smoke emission limits.

If fuel oil containing more than 1 percent sulphur is used, the height of the chimney must be approved by the director of Environmental Control. Chimney heights are calculated generally in accordance with *United Kingdom Memorandum 25/63.*

The lead content of gasoline is regulated.

AIR POLLUTION RESEARCH

In the 1960s, little research focused on air pollution. Control agencies were newly established and were busy getting started. Equipment was still relatively unsophisticated and available staff was restricted. Furthermore, funding in those early days was limited, and, while some very good work was done, it was limited in scope. The scene has now changed. Several of the control agencies are now large and well funded and have sophisticated, modern equipment at their disposal.

The Commonwealth Scientific and Industrial Research Organization (CSIRO) is engaged actively in a variety of programs involving several of its Divisions (Environmental Physics, Atmospheric Physics, and Cloud Physics).

A majority of Australia's universities have environment departments and often run several research programs.

Large industrial organizations also carry out research; and there would not now be any major industrial undertaking that did not have at least one environment officer. All the major industrial organizations have well-equipped and well-staffed environment departments.

Many papers have been and are still being published. The work has been concerned mainly with monitoring and control techniques. There has been practically no work on health effects; interest in this field seems to have started only recently.

Some major cooperative studies, however, are now underway, and a brief account of these will give some idea of the scope of present day work in Australia.

The Australian Baseline Air Monitoring Station[28]

This is Australia's contribution to the World Meteorological Organization's efforts to set up global background air monitoring.

A monitoring station has been set up on Cape Grim on the northwest corner of Tasmania. Situated just inside the "roaring forties," it receives the prevailing westerly winds for a large part of the year. Those parcels of air that travel over water for long distances are suitable for determining background concentrations.

The station is operated by the Commonwealth Department of Science, and most programs are carried out by CSIRO, but universities also take part. Regular measurements include carbon dioxide, halocarbons, oxides of nitrogen, ozone, aerosol particles, radiation, and turbidity, as well as precipitation.

The station has been operating since 1976. One early result shows that the concentration of freon at the end of the first 12 months of operation was only 1 in 10^{12}, which is probably negligible. This figure increased by 20 percent during these 12 months, however, a trend consistent with measurements elsewhere.

The Sydney Oxidant Study

Sydney, with a population of 3 million and a relatively unfavorable geographical position, suffers from an increasing photochemical smog problem, which started in the late 1960s and early 1970s.

In 1975, the SPCC began a major study of the problem. This study, known as the Sydney Oxidant Study, was funded and coordinated by the SPCC and included, as participants, the SPCC itself, Macquarie University (School of Earth Sciences), CSIRO (Division of Process Technology), and Sydney University (School of Mechanical Engineering).

The Latrobe Valley Study

The objectives of this study[29] are:

1. to monitor and describe air quality in the Latrobe Valley;
2. to monitor the meteorology involved in the dispersion of emissions to the air;
3. to make an inventory of emissions to the air from existing and projected sources;
4. to develop mathematical models describing the behavior of emissions to the air;
5. to examine measurements of air quality and make air quality projections in relation to the regional air quality protection policy, and to consider the technical aspects of options for regulating emissions.

In an area approximately 60 mi long by 40 mi wide there will be 18 monitoring stations. Of these, 11 fixed and 3 mobile laboratories will monitor air quality. The remaining 4 stations will be primarily meteorological, each equipped with a 110 m tower for multi-height measurements. These towers will be operated by the Electricity Commission. Another 3 air quality stations will be operated in urban locations in the area by the EPA.

THE SETTING OF STANDARDS

In the beginning—that is in the late 1950s and early 1960s—Australian regulatory authorities tended to follow the British "best practicable means" approach, and any emission standards adopted were generally also copied from those in use in England.

At that period, the principal problems were smoke and dust, and these were relatively easily dealt with. Industry did resist regulation to some extent, but not with any great show of determination in view of the highly visible nature of most of the pollution.

The beginnings of the environmental movement in Australia date from the mid-1960s.

In the absence of monitoring data, assertions made both in the press and at public meetings alleged unspecified high levels of air pollution. Any air pollution was usually intensified in times of persistent inversions when poor visibility gave substance to the complaints. It is generally agreed that the incidence of poor visibility is caused by air pollution, but the precise nature of this haze is not known; neither is the composition of the brown haze which can be seen over all the large cities when approaching by car or by plane. Macquarie University in Sydney has been given a federal government grant to solve this problem.

The regulating authorities during that period responded to the public pressure by tightening their standards gradually. In the absence of local monitoring data, emission standards could not be based on perceived needs. Consciously or unconsciously, the practice evolved of selecting the most stringent standard that could be found in the literature and proposing this for local use. This enabled regulating authorities to appear very strict and allowed them at the same time to exercise discretion with offenders who found it impossible to meet these standards.

Up to about 1970, staffs of clean air branches were very small, and their capacity for action was limited accordingly. Monitoring was restricted to smoke, dust fallout, and sulphur dioxide, which was in accordance with available equipment and the preoccupation of the times. Control action was limited generally to approval of new plants and to attending to complaints received.

The environment movement was, of course, never organized as such. It received its most vocal support, however, from some intellectuals, many of them on the staffs of universities and other tertiary teaching institutions, as well as from the trade union movement. Chiefly, it was the radical wing of the union movement which took extreme environmental views.

In time, the Labour party, associated with the trade union movement, adopted an environmental view and took to castigating the government on environmental affairs in all those states where a Liberal party government was in power. Governments, in all states whether Labour or Liberal, responded by appropriating more funds for their regulating agencies and for expanding their functions. This resulted, in most cases, in the setting up of independent environmental protection agencies responsible either to the Minister of Conservation or at least to a minister other than the Minister of Health.

Nevertheless, justification for stricter standards has always been based on health grounds generally without any evidence.

While the emission standards in the early 1960s were copied almost exclusively from the relevant British standards, they are now being taken in almost all cases from American literature and from U.S. published standards.

AIR POLLUTION AND HEALTH

No real debate occurred on the health effects of air pollution during the 1960s, due probably to a complete absence of data. No medical work was done in Australia during the period, and any medical effects reported were caused by escape of toxic gases during industrial plant breakdowns rather than by general air pollution.

Now, however, debate has been underway for several years. Because of the low sulphur content of Australian indigenous fuels and the control of the use of imported fuel oil, sulphur dioxide is not considered a problem. Interest centers on photochemical smog—ozone, oxides of nitrogen, and lead, respectively.

The situation with regard to photochemical smog has been summarized by Dr. Alan Bell,[30] until recently Director of the Division of Occupational Health and Radiation Control of the Health Commission of New South Wales. He took issue with a statement made frequently in Australia to the effect that "photochemical smog in Sydney is a major problem and the level is as high, or almost as high as in Los Angeles."

In fact, Bell noted that the frequency of higher levels of ozone (0.15 ppm) was variable from year to year, and these levels were sometimes restricted to only one of several monitoring stations. Peak levels of 0.3 ppm could be expected each year, but the number of occasions was uncertain.

The photochemical smog problem in Melbourne did not appear to be as serious as that of Sydney.

None of the state health departments were aware of any adverse effects on health from photochemical smog in their respective areas. No cases of eye irritation had been reported officially. Also, no evidence existed that asthma attacks increased during the oxidant potential months. On the contrary, the number of prescriptions dispensed quarterly for asthma treatment drugs decreased significantly during these periods. Dr. Bell, however, cautioned against relying too much on these findings.

There appears to be only one documented episode of group respiratory irritation thought to be caused by photochemical smog—the so-called Sylvania School episode.

On a day when the SPCC had, by chance, determined the ozone level close to the school, 13 boys playing football and basketball complained, after 30 minutes, of chest pains and shortness of breath, which persisted for 1½ hr despite resting. The boys, whose average age was 13, were taken to a hospital and recovered completely after 2 to 3 hrs. All had been well on the morning of the episode except one who had a sore throat and another who had bronchitis. Only the sports master complained of eye irritation.

The ozone level had been 0.20–0.22 ppm; the humidity was high and the temperature 28°C. No specific cause for the boys' discomfort was found, and the high oxidant level was considered to be the cause.

A 1972/73 medical investigation showed that Sydney children attending schools in polluted areas did not have a higher incidence of pulmonary conditions than other children.[31]

The proposed Victorian State Environment Protection Policy for the Air Environment gives ambient objectives for oxidants (measured as ozone) and averages over 1 hr at three levels (ppm):

Acceptable	0.10
Detrimental	0.15
Alert	0.25

The NHMRC in October 1979 recommended an hourly average ozone level of 0.12 ppm not to be exceeded on more than 1 day per year. A warning is to be issued when the level is expected to go above 0.25 ppm.

Dr. Bell considers these figures too low and believes 0.2 ppm would be an appropriate goal for Australia's capital cities.

The Victoria Health Commission believes that both the acceptable level of 0.10 ppm and the detrimental level of 0.15 ppm are too low. These levels have been exceeded in Melbourne on numerous occasions in recent years without any evidence of resultant ill health. No objection is made, however, because the proposed levels will not be economically disruptive.

The commission on the other hand believes that an alert level of 0.25 ppm is likely to be highly disruptive to the community without health benefit.[32] If an alert level is felt to be necessary, it should be established jointly on medical and engineering grounds, and the emergency abatement plans should be clearly spelt out at the same time.

The drafting of Victoria's policy was done by consultants. Air quality standards were developed for the consultants by a well-known Melbourne physician specializing in respiratory diseases. No references or explanations were given either in the draft policy document or in the explanatory notes issued with it. The consultant answered questions at public meetings, however. The references he quoted were, in the main, American.

The other pollutant which has been controversial is lead. In 1976, gradual reductions in the lead contents of gasoline were enacted in New South Wales, Victoria, and Tasmania, and later in other states. The reductions were opposed by the oil industry on the grounds of increased petrol consumption; a lead filter was proposed as an alternative. Simultaneously, medical opinion was submitted by medical authorities to the effect that there was no evidence that lead in air caused any adverse health effects.

While this was conceded by the Victoria EPA, the proposed regulations were upheld on the grounds that they would be a reasonable precaution against possible as yet undetected effects on children. In the meantime, lead in air became a political issue, used mainly as an argument against freeways in urban areas.

The oil industry has continued to develop and propagate the lead filter.

Victoria's policy now proposes an acceptable lead level of 1.5 $\mu g/m^3$ averaged over a 30-day period. The Health Commission does not believe that this level can be substantiated on scientific grounds. They are aware, however, that this level has been accepted by some health authorities in the United States and that there are many authorities who would regard the scientific evidence as sound.

The commission believes the issue should be held in abeyance until the report of the U.K. working party under Professor Patrick J. Lawther has been submitted.[33]

Two practical studies on lead have been carried out in Australia[34]—one in Sydney and the other in Melbourne. Both endeavored to determine whether lead in the air contributed significantly to lead levels in the blood of school children and whether it caused behavioral problems. The two studies came to exactly opposite conclusions; the Sydney study found that lead in the air had a definite deleterious effect, while the Melbourne study found no discernible effect at all.

It should be noted also that the other levels proposed in Victoria's policy (ie, for sulphur dioxide, oxides of nitrogen, and carbon monoxide) also were considered too low because they could not be substantiated on medical grounds.

ENERGY AND POLLUTION

With a population approaching 15 million, the Australian people account for about 1 percent of world energy consumption. Consumption per capita of about 200×10^9 J, however, is only about four-sevenths of the American level. Unless there is a fundamental modification in the pattern of life, the present total consumption in the order 2.6×10^{18} J of energy per year is also likely to increase substantially by the end of the century. Indeed, in 1973 the Australian Department of Minerals and Energy envisaged a fivefold increase by then. This forecast was based upon an assumption of a substantial increase in per capita consumption and on a population of some 23 million.

In 1975, the National Population (Borrie) Inquiry (First Report)[35] emphasized that there had been a fundamental shift in community attitudes to family size, one which was leading to a sharp reduction in fertility and opening up the prospect of an early though unplanned attainment of zero population growth. Although a large number of alternative assumptions were made, the report chose one set of assumptions as the most realistic, that is, continued net immigration at an average of 50,000 persons per year and a decline in total fertility to a net reproduction rate of 1.00 by 1975/76, with this level of fertility remaining constant over the remainder of the century. The result of these assumptions would be a national population at the year 2000 of about 17.6 million, an increase of 4.48 million over the 1973 population. National energy consumption, under the influence of this one factor, would increase therefore by only one-third, substantially less than previously envisaged. On the other hand, a continuing consumer demand for higher living standards and a vigorous growth of high energy consuming industries could lead readily to a doubling of per capita consumption. Although uncertainties abound, it seems a likely outcome that Australian national energy consumption may increase by a factor of about 3 by the turn of the century.

Of greater concern from an air pollution aspect is the forecast population growth to 17.6 million. Nearly 80 percent or about 14 million would live in the ten largest cities: Sydney, Newcastle, Wollongong, Melbourne, Geelong, Brisbane, Adelaide, Perth, Hobart, and Canberra. Sydney and Melbourne could have populations of up to 4 million each, although an apparently increasing preference for smaller cities could ease the situation. In general, these cities are in natural basins around bays, or near rivers, or in predominantly flat areas with backdrops of mountain ranges. In consequence of topography and meteorology, many of these locations have periods of poor natural ventilation when pollutants tend to accumulate. The problem would be aggravated by increases in population, the processes of urbanization, choice of transport modes, and the concentration of industry.

Table 11. Summary of Estimated Major Emissions from Australian Sources 1964–1985

	Year					
	1964	1968	1972	1976	1980	1985
Totals 10^6 MT	7.9	9.8	11.3	13.7[a]	16.6[a]	21.0[a]
Pollutants (%)	100	100	100	100	100	100
Particulates	16	16	18	18	18	20
SO_2	13	13	11	12	13	13
CO	53	52	51	50	48	46
Hydrocarbons	11	11	12	12	12	10
NO_x	7	8	8	8	7	11
Sources (%)	100	100	100	100	100	100
Stationary	17	15	13	18	18	21
Refuse burning	5	5	6	7	8	8
Transport	42	43	46	36[b]	35[b]	33[b]
Chemical manufacturing	5	5	6	7	7	7
Agriculture	15	15	9	10	9	8
Metallurgy	8	9	12	16	17	17
Minerals	5	5	5	5	5	5
Refineries	3	3	3	1	1	1

[a] The predictions are a 5 percent/year growth, which is in close agreement with growth rates based on fuel consumption estimates by the former Australian Department of Minerals and Energy, and with extrapolations based on per capita consumption and demographic predications.

[b] This decrease is the predicted effect of motorcar emission controls.

SOURCE: W. Strauss and R.G. Cromie, unpublished calculations, 1975. In *Air Pollution*, by A. Gilpin, University of Queensland Press, 1978.

Table 11 is a summary of estimated major emissions from various sources in Australia.

Hence, a need exists for a national strategy for air pollution control to be developed under the auspices of the Australian Environment Council. A national strategy could involve a number of objectives reasonably attainable by the Australian public. These could be to:

1. achieve WHO and NHMRC long-term goals for air pollution levels by the end of the decade;
2. achieve in the long-term a decreasing reliance on fossil fuels through increased deployment of solar energy, simultaneously bypassing the nuclear age;
3. promote a shift of unavoidable discharges from low-level emission points (ie, use higher and fewer chimneys);
4. divert high-sulphur fuel oils to plants designed for high-level dicharges;
5. impose an upper limit of 2.5 percent sulphur on all fuel oil used in Australia and much lower limits in the principal urban areas;
6. promote the use of smaller vehicles and reduce vehicle access to central business districts;
7. introduce progressive vehicle taxes based upon both engine capacity and fuel consumption;
8. increase the role of public transport in the movement of people;
9. improve house insulation;
10. restrain advertising aimed at promoting energy use;
11. promote fuel efficiency and conservation, particularly for petroleum-derived fuels;
12. seek continuous refinements and improvements in the design and reliability of air pollution control techniques;
13. promote cost/benefit studies of air pollution control methods in order to achieve some degree of balance between the marginal costs of control and the marginal benefits to be obtained; and
14. relate national air pollution control strategy to national energy policies as these develop.

Until recently, air pollution and its control were largely the concern of environmental and public health administrators in state and local governments, of scientists and engineers, and to a lesser extent of members of the medical profession. Air pollution control agencies tended to be attached to or within state departments of health. During the last few years, however, air pollution has attracted the attention of ecologists and economists.

Ecologists have demonstrated that many of the activities of people involve damage to our ecological systems. Economists have stressed the importance of achieving the right priorities when devoting substantial resources to the reduction of various forms of pollution and to the protection and enhancement of the environment.

The various forms of pollution can no longer be tackled piecemeal and in isolation; in turn, all form part of the much larger subject of the human environment. This broader perspective embraces air pollution; land pollution; water pollution of rivers, estuaries and oceans; noise pollution; the planning and location of cities and suburbs; land use; the conservation and best use of natural resources; transport modes; and aesthetic considerations.

In turn, the subject of the human environment cannot be divorced from that larger framework of human society itself in all its economic, social, security, and environmental aspects. The need for greater coordination between these many parts has resulted in larger and more comprehensive pollution control and environmental agencies and in the need for links between these agencies and other branches of government. A broader contact with the public and with voluntary bodies has been achieved. The scene has changed significantly in the last five years.

This said, it must never be forgotten that the purpose of coordination is to promote a better overall result without inhibiting the dynamism of progress in particular areas. In the area of air pollution control, continued vigilance is necessary, and much remains to be done if Australians are not to succumb to the insidious effects of the vastly increasing volumes of "aerial sewage" arising from combustion and other sources.

ECONOMICS

In the 1960s, the cost of air pollution control was not a major issue; the situations that had to be corrected were usually glaring, and the cost of the remedies generally not excessive. Exceptions to this existed, of course, but in most cases industry complained on principle against being forced to spend money unproductively. In many cases, however, it could be shown that improved practices also led to significant savings, especially in the control of combustion.

Regulating authorities were generally helpful in the case of industries that were struggling, but there were, of course, instances where hopelessly obsolete plants had to shut down because compliance with regulations or rebuilding of the plant was totally uneconomical.

The situation changed considerably in the 1970s when emission standards became more stringent and in particular when regulating authorities started to include oxides of nitrogen in their chimney height calculations. Some spectacular expenditures were at times demanded, chiefly of large industries. Tightening of particulate emission standards also was responsible for some very high costs. Environmental agitation on the part of concerned groups intensified the argument and was responsible also for some very high expenditures.

The best known example in Australia is that of the Newport Power Station. In 1973, the State Electricity Commission of Victoria applied for a waste discharge license for a 1000-MW natural gas fired power station at Newport in the Melbourne metropolitan area. The commission had designed the plant with the most advanced pollution control equipment available and had planned for 600-ft high stacks.

The EPA issued a license insisting on very strict conditions of monitoring and compliance. At this stage, several trade unions banned construction of the station, labelling it a health hazard.

After a lengthy interval of inactivity, a review panel convened and finally reissued the license but reduced the size of the station to 500 MW.[36] The panel concluded that the complete relocation of the station outside the metropolitan area would cost US$115 million ($A100 million) and could not be justified on economic grounds.

The unions persisted in their ban, and construction was eventually started using nonunion labor. In the meantime, a gas turbine station had to be erected in the Latrobe Valley to prevent power shortages. This again was very costly and caused an environmental debate of its own.

The unions have not withdrawn their opposition to the station; one prominent union official recently stated that the Labour party, if it came to power in Victoria, would not permit the station to be operated.

In Victoria, the questions of whether a licensing authority could or was required to take into account the possible economic consequences for the community and the licensee in setting license conditions on waste discharges was explored in the case of *The Phosphate Co-Operative Company of Australia Ltd.* v. *The Environment Protection Authority of Victoria* in 1977.[37]

The company concerned had obtained from the EPA a license for one of its contact plants used for manufacturing artificial fertilizers. The license carried a number of conditions, one of which prohibited the commencement or continuation of start-up operations if offshore winds were blowing. The appellant objected to this condition, imposed for the control of acid gases, as being too onerous. An appeal was lodged with the Environment Protection Appeal Board, as provided for under the Environment Protection Act of 1970; the board varied the terms of the condition in a manner which did not satisfy the appellant. The appellant appealed to the Supreme Court of Victoria under Section 36(3) of the act (right of appeal on a question of law only). The Supreme Court found in favor of the authority, and the appellant then appealed by special leave to the High Court.

The appeal was limited to two questions that were dealt with in the Supreme Court. One of these questions became material; namely, the question of whether the authority or the board, when imposing or varying conditions in a license, might or ought to take into account the economic consequences to the community or to the appellant of the imposition of the conditions, or to take into account the utility to the public of the appellant as a license holder. It was common ground on the hearing of the appeal to the High Court that the matters which the board might take into account upon an appeal to it from the authority could not extend beyond those which the authority might consider when determining an application for a license to discharge waste.

It was held by the High Court that neither the authority nor, on appeal, the board may, in determining whether a license under the act should be granted or what conditions should be imposed or varied as the case may be, have regard to (1) the economic consequences to the community of the imposition of the conditions, or (2) to the utility to the public of the operations affected by the license, or (3) to the economic cost to the holder of the license of the imposition of the conditions, because, among other reasons:

1. The Environment Protection Act places upon the authority and the appeal board the responsibility of concentrating on the question of environmental gain or detriment, regardless of the related economic consequences or the matter of public interest. The authority's essential role is to determine whether the effect of a discharge will involve the creation of a condition of pollution.
2. The provisions of the act contain nothing in the nature of a positive direction to take into account economic consequences or the matter of public interest, nor anything to suggest that the authority or the board should engage in a process of balancing the one consideration against the other.
3. The provisions of the act contain generally indications contrary to the suggestion that the authority or the board may or must have regard to economic consequences or to the matter of public interest. Under the act, neither body is to contain members chosen for their expertise in the field of economics or as financial or industrial experts; instead, heavy emphasis is placed upon environmental control skills, indicating that it is in this field that the work of both bodies will lie.

Nonetheless, the High Court recognizd that under the act the authority could recommend to the Governor-in-Council a state environmental protection policy which, upon declaration, would need to be observed in respect of the environment generally or any part of it. It was conceivable that such policies might require that, in particular localities, the needs of industry should be catered to. In the case under appeal, no such policy had been declared for the area.

The law was, in the view of the High Court, quite clear, although a member of that court, Justice Stephen, noted that some might think that implementation of the act "remorselessly pursued must lead to curious and perhaps unforeseen consequences of considerable detriment to the community as a whole.[38]

This decision has sparked considerable discussion, and the authority has since convened a seminar to discuss the problem. Engineers and legal experts participated. The main conclusion was that economics could and should be taken into account at the time of policy formulation. As yet, there is argument as to how this should be done.

There is not much information as to cost of air pollution control in Australia. The cost of air pollution control in New South Wales, however, is rising as the problem becomes more complex. Economic analysis will play an important part in future control programs, with knowledge of present and projected control costs as essential input.

Some annual rates of expenditure on pollution control for New South Wales have been estimated by J.D. Court with reasonable confidence as follows (in millions of 1977 dollars):

	US$	$A
Stationary plant—capital	30.8	27
Stationary plant—maintenance	28.5	25
Petrol-driven vehicles—retail price	13.7	12
Administration of Clean Air Act	1.1	1

Expenditure per year is currently about US$19.6 million ($A17 million) and could rise to about US$46 million ($A40 million) by 1985 if satisfactory air quality is to be maintained. The most rapid increase will occur in the control of the "emerging" pollutants, such as photochemical smog, although urban growth will necessitate expenditure on "traditional" pollutants, such as acid gases. Table 12 analyzes capital expenditure on controls in New South Wales in a national context.

These costs indicate the profound influence of the activities of the SPCC upon others, and emphasizes the care that will be needed in weighing costs against benefits in the development of policies. The commission is meeting, in the air pollution control field, the most severe challenge of any environment agency in Australia. The New South Wales government alone in Australia is implementing Stage 3 of ADR 27A for petrol vehicles in recognition that Sydney has more pressing problems than elsewhere.

What appears to concern industry most, however, is the presumption that there can be no compromise where human health is concerned, and that any level of control could be made mandatory as soon as it appears technically feasible, regardless of cost. A cost/benefit approach, therefore, is being

Table 12. Capital Expenditure on Air Pollution Control Equipment (All Types, N. S. W., 1978, $A Thousands)*

Industry	1973	1974	1975	1976	1977	N.S.W. Average/year (73–77)	N.S.W. Proportion of National	Australia Average/year
Cement works	130	40	3,120	230	90	722	.32	2,260
Ceramic works	770	1,410	720	1,500	940	1,068	.40	2,670
Chemical works	1,860	2,040	1,570	2,190	1,950	1,922	.40	4,800
Coal industry works	560	2,440	4,170	3,320	2,000	2,498	.45	5,550
Coke works	510	1,610	2,330	520	490	1,092	.50	2,180
Concrete batching works	240	270	220	360	210	260	.33	790
Fuel-burning equipment	4,630	11,640	17,050	3,410	4,020	8,150	.45	18,110
Grinding and milling works	1,570	710	1,180	800	870	1,026	.36	2,850
Metal works	1,700	1,670	1,230	1,020	1,550	1,434	.36	3,980
Oil refining and storage	3,280	150	170	8,330	3,740	3,134	.36	8,710
Premix bitumen plants	90	340	100	190	220	188	.36	520
Primary metallurgical	1,340	5,910	15,060	4,740	5,920	6,594	.36	18,320
Scrap recovery works	120	140	110	160	70	120	.36	330
Other (nonscheduled)	300	300	300	300	300	300	.36	830
Total	17,100	28,670	47,330	27,070	22,370	28,508	.40	71,900

SOURCE: N. S. W. expenditure data derived from the results of a study by the N. S. W. SPCC. J. Court and R. Couglin, An Analysis of Air Pollution Control Costs in N. S. W., 19 May 1978.

NOTE: Extrapolation of N. S. W. expenditure to Australian average annual expenditure based on N. S. W. and national production and population statistics.

* $A100 thousand = US$115 thousand.

increasingly advocated even though the attendant difficulties are recognized.

The argument is less against presently imposed high costs but against the presumption that regulating authorities could at any time demand improvements which might increase costs many times. It is believed by industry that large escalation of costs should thus be made subject to government decision with full recognition of the consequences involved.

The only point at which the need to conserve fuel and the air pollution control requirements clash in Australia is motor transport. Motor fuel has to be imported. Although only one-third of the country's needs is imported at present, this will increase in the future.

Controls on motor vehicle exhaust emissions were introduced in Australia in 1975 and already have been outlined. The third stage of this regulation (ADR 27A) came into operation in 1979. It did not actually call for lower emission standards but for proof that the required emission standards would be maintained for 80,000 km.

Following an intensive campaign by car makers and others, chiefly the farm lobby, the Australian Transport Advisory Committee decided to postpone introduction of Stage 3 until 1981. This was followed by a further campaign to postpone the introduction to 1985, or alternatively abandon it altogether, or even scrap existing controls. Fuel penalty of 5 percent or even higher was claimed.

While a majority of the states were in favor of further postponement, New South Wales and South Australia threatened "to go it alone." Both states had a Labor government at the time.

The debate is continuing, and further investigations will be made.

The National Energy Advisory Committee (NEAC) has recommended that lead levels in gasoline be increased to conserve fuel, but so far state governments have not acted on this. On the contrary, New South Wales and Victoria proceeded with planned staged reductions.

SOME ECONOMIC PERSPECTIVES

In the early part of the twentieth century, Professor A.C. Pigou (1877–1959) of Cambridge constructed his economics of welfare around the proposition that social benefits and social costs were distinct from private benefits and private costs.[39] Hence, to maximize welfare, all these costs must be considered.

Pigou's theme was that, in general, industrialists are interested not in social but only in the private net product or profit of their operations. Self-interest will tend to bring about equality in the values of the marginal private net product of resources invested in different ways; but it will not tend to bring about equality in the values of the marginal social net product, save in those rare instances when the marginal private and marginal social net product happen to coincide. When there is a divergence, self-interest will not tend to maximize national welfare. He envisaged that when social and private net products differed, they should be brought into equality by government action—for example, by appropriate taxation.

Pigou thus focused attention on what are described today as external effects or "externalities." These are costs and benefits caused by the activities of an industry that are not reflected in the price at which the product is sold or do not influence the quantities purchased: costs not borne by those who occasion them and benefits not paid for by the recipients.

The problem in pollution control is not how to eliminate pollution completely, but how to seek out an "optimum" control allowing for the costs as well as the benefits of abatement. On an assumption of unlimited resources for pollution control, there must come a point where further expenditure cannot be matched by compensating benefits. The best point is reached when the marginal (additional) costs involved equal the marginal (additional) benefits.

This is to state the problem within the environmental sector, however. Resources are never unlimited, and within this larger context the problem may be restated as one involving:

1. an efficient allocation of limited resources within the pollution control and environmental protection arena to ensure that the marginal costs in any direction do not exceed the marginal benefits; and
2. an efficient allocation of limited resources between the pollution control and environmental protection arena, and between this and all other possible uses of such resources.

While it is not difficult to obtain data about the cost of abating pollution by different amounts in various industries, it is much more difficult to obtain credible data about the costs of environmental damage and the benefits of environmental safeguards. In some instances, such as irritation to housewives or the pleasure of looking at clean buildings, cost and benefit quantification presents formidable difficulties.

The decision maker (in this instance, government) is left to combine what hard data are available on environmental issues with a necessarily subjective judgment on the value of the benefits. Lord Ashby, formerly Chairman of the Royal Commission on Environmental Pollution in Britain, suggested that, in respect of environmental matters, we live in an "age of uncertainty."[40] As he has expressed it, there is uncertainty:

- about the facts,
- about what people think about the facts, and
- about the future consequences of present decisions.

Certainly, if you have the data you can draw a curve that shows the marginal cost of abating pollution plotted against the amount abated; also another curve showing marginal damage caused by pollution plotted against pollution left in the air or water (representing the degree of control).

The point where the two curves cross is the optimal position of pollution abatement. Beyond this optimum, damage done by pollution is less than the cost of abating it; below this optimum, it is cheaper to abate pollution than to sustain the damage caused by not abating it. The curves, however, cannot measure adequately the value of intangible costs and benefits and in any event take no account of the interests of future generations. No set of valuations is valid for all members of a group.

More information is certainly needed, for example, on the physical and economic dimensions of impairment and damage. In 1969, the Senate Select Committee on Air Pollution observed: "As far as the Committee is aware there are no total cost estimates for air pollution in Australia."

The committee went on to suggest that "an investigation into the cost of air pollution in Australia should be undertaken without delay because it is only through an awareness of the costs involved that all sections of the community will be prepared to meet the not inconsiderable costs of cleaning the air." Australia still awaits such a comprehensive investigation, although a cost benefit philosophy has been behind most steps in air pollution control.

Many of the benefits of control and the penalties for noncontrol are not easily quantifiable in monetary terms or even in physical terms. It is difficult to predict how much photochemical smog will result from noncontrol of motor vehicles, and by how much this will prove adverse to health and welfare, let alone express it in monetary terms. At least the definition of the costs and benefits has been much improved. Decisions are made, often by government, about these matters. Victoria's government has decided, on the advice of its review panel, that the additional cost of establishing the proposed Newport Power Station elsewhere cannot be justified in order to achieve only marginal gains in the ease of air pollution control in the Melbourne airshed. No reduction in air pollution at significant times would have been achieved.

Despite the difficulties, both of principle and practice, the cost-benefit approach remains indispensable for policymaking. Personal judgments have to be made both about the consequences of alternative policies and about their importance. At the very least, a cost-benefit analysis provides a systematic comparison of choices.

A much more difficult task is to reconcile the wide diversity of opinion which exists in the community about what is at stake. The spectrum may be illustrated by reference to three views:

1. Environmental pollution or degradation is a relatively simple matter

of correcting minor resource misallocations. It is simply a question of priorities.

2. Unless economic growth and population growth are brought to a halt, the world is on a course leading to the destruction of humanity caused by environmental pollution, starvation, and the exhaustion of raw materials. Zero growth conditions must be achieved rapidly.
3. While environmental pollution and degradation are matters of crucial importance, economic growth is essential in order to finance the investments necessary to improve the environment. Growth will also stimulate the best results from science and technology.

ENVIRONMENT POLICY

Environment and conservation policy must relate to other crucial policies dealing with the allocation of resources. Four policy areas are defined below, although the division between them is necessarily arbitrary; the differences are largely a matter of emphasis to ensure that a range of public objectives are embraced adequately.

Economic Policy—to deploy fully the available factors of production (land, labor, and capital) in such combinations and in such places as to produce the goods and services demanded by society at a minimum of cost. The result may be a mixed economy (an economy with substantial public and private sectors) with varying degrees of national planning. It may encompass a resources and energy policy.

Social Policy—to modify where necessary the effects of economic policy to achieve equity, for example, a more equitable distribution of after-tax incomes, supportive services for those unable to participate in the economic process, satisfactory housing for low-income groups, education and fairness of opportunity for self-help and advancement, and a high and stable level of employment for all social groups.

Environment and Conservation Policy—to protect land and other resources (including the free goods of air and water) from degradation due to overuse and misuse. To some extent, environment policy supports economic and social policies insofar as it ensures self-sustaining yields or protects areas of natural beauty. It will interrelate with any resources and energy policy.

National Settlement Policy—to combine and blend the three strands of economic, social, and environment policies to achieve an acceptable national balance in population distribution; in effect, to strike a balance between efficiency, equity, and ecological considerations within a spatial context.

To sum up, the pursuit of environmental quality should aim at:

1. the avoidance of nuisance as measured by the absence of justifiable grounds for complaint;

2. the avoidance of adverse environmental and physiological effects;
3. the preservation and enhancement of visual amenity; and
4. an allocation of resources for environmental measures that regards fully the alternative uses to which those resources might be put to achieve a rough balance of marginal benefits to the community.

"POLLUTER PAYS" PRINCIPLE

The "polluter pays" principle is simply an assertion that those who pollute the air, the water, or the land should meet the full cost of controlling that pollution without the assistance of direct subsidies from public funds or indirect support through special tax relief. Applied as a principle it certainly promotes efficiency in long-term resource allocation, but it may have serious implications for an economy in some short-term or transitional circumstances. Whether such special circumstances can be found anywhere in Australia is a matter of dispute. Certainly, industries' pleas for tax relief have received short shrift at the hands of Commonwealth treasurers.

The costs of controlling pollution and of providing for the protection of the environment generally vary considerably among industries, however, and among different kinds and ages of industrial equipment. Industries vary in profitability, just as firms within each industry vary in profitability, while market situations both at home and overseas also vary considerably at any one time and over time. If large pollution control costs are imposed suddenly on an industry of significance to the economy or to a particular sector or region, and that industry cannot readily muster the resources to correct shortcomings, then difficulties arise. The survival of companies and their employment opportunities may be at stake.

The situation is compounded when some control legislation allows consideration of the question of costs and of local conditions and circumstances. This kind of legislation allows a degree of balance to be struck, both about standards of control and about the time allowed for the implementation of measures.

In 1972, the Australian government endorsed the "polluter pays" principle as enunciated at the United Nations Conference on the Human Environment held in Stockholm. As a member of the Organization for Economic Cooperation and Development (OECD), Australia has also endorsed that body's Declaration of Environmental Policy with its reference to the "polluter pays" principle. At the 1978 Environmental Economics Conference held in Canberra, the minister for Environment, Housing and Community Development reaffirmed that the principle remains one of the key elements of the Commonwealth government's environment policy.[41]

G. E. Littlewood of the Queensland Confederation of Industry at the same conference,[12] said: "The fact that the principle, when applied to industry, is concerned with first costs, and not with final costs, is only dimly appreciated by the general public. Those familiar with the subject know that, in the final analysis, it is not the polluter but the community which must pay through a range of economic consequences."

Dr. N.E. Norman, of Australian Paper Manufacturers Ltd., at the same conference[13] commented on the effects of high control costs, adding:

> The situation is further exacerbated by a purist stance on the polluter pays principle. In contrast to most other OECD countries which espouse this principle, Australia has done nothing to ameliorate the cost of pollution abatement measures instituted voluntarily or by instruction. Apart from directly affecting the trading ability of Australia, the increased costs associated with pollution control are yet another inflationary stimulant. The cost of the product which is increased by the cost of pollution control tends to be a basic material such as steel, glass, nonferrous metals, paper and chemicals, so the cost increase can have an inflationary effect on the whole community. More widespread is the financial strain that a substantial investment in pollution control equipment can place on the resources of a company.

For good measure, Dr. Norman added: "The real problem has come with the establishment of bureaucracies requiring well beyond reasonable pollution control measures."

The Australian Mining Industry Council has accepted that, in the domestic market, the "polluter pays" principle is "irrefutable for all competing businesses are faced with similar pollution control costs."

In the international trade in homogeneous products, such as basic minerals, however, the council sees Australia at a disadvantage. Competition, it is pointed out, is often with developing countries, which are neither members of the OECD nor subscribers to the "polluter pays" principle. As the developing countries do not, in general, subscribe to the same pollution control standards demanded by Australian society, Australian industry cannot pass on the costs of pollution control without risking some loss in competitive position.

The "polluter pays" principle is valueless, the council argues, unless it is adopted by all countries engaged in substantial international trade. For example, the United States of America gives bonuses to small businesses for pollution control assistance and allows five-year accelerated write-off periods to companies involved in capital outlay for pollution control; Sweden has subsidized "old" industries for new pollution control equipment; Japan allows grants and loans to industry for pollution control measures. Both uniformity of approach as well as broadly common standards are necessary if the burden is to be carried fairly.

The council also stresses that by far the highest pollution control costs are incurred at the primary stages of production, the area in which Australia predominates. For example, the pollution costs involved in converting ore to metal far outweigh the costs involved in converting metal to a finished product.

Several industrial organizations have made representations to the Australian treasurer requesting fiscal assistance, such as accelerated depreciation for pollution control equipment, sales tax exemption for monitoring equipment, and low-interest loans for small businesses. The replies indicate that Australia subscribes to the "polluter pays" principle and that no assistance therefore can be given. Unclear as yet is how much Australia has suffered in loss of trade through the adoption of this principle.

CONCLUSION

The energy sector generally stresses the need to conserve energy and above all liquid fuel, provided the environment is not harmed. There appears to be more concern, however, with the social and economic consequences of fuel shortage. Conservationists, on the other hand, tend to believe that there can be no compromise with economics where health is concerned. Air quality standards as such have been proposed only for Victoria, and they were designed with WHO long-term aims in mind. The other states have no official standards but naturally set and justify their emission standards with ambient monitoring figures in mind, that is, on presumptive standards.

Definition is lacking of who is to be protected, with a tacit understanding that it should be the entire population, even those most sensitive to irritants.

Industry has never presented a comprehensive case or demonstrated the economic consequences of pollution control apart from quoting high individual expenditures. The debate is made more difficult because it has become politicized. No immediate solution can be foreseen, but the increasing attempts to carry out comprehensive studies which take into account all factors are encouraging.

NOTES

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4. Fox Inquiry, First Report, 1976.
5. Sir George Porter, *Energy from the Sun.* Canberra: Academy of Science, 1976.
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7. See New South Wales, State Pollution Control Commission, *Annual Report,* 1977.
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9. New South Wales, supra n. 7.
10. Victoria, supra n. 8.
11. Queensland, Air Pollution, *Annual Report, 1975-76.*
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14. Queensland, supra n. 11.
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16. Victoria, supra n. 8.
17. See I.E. Galbally, Ozone and oxidants in the surface air near Melbourne, *Proceedings of the 1972 Clean Air Conference.*
18. Queensland, supra n. 11.
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38. Ibid., p. 55.
39. See A.C. Pigou, *The Economics of Welfare,* 3rd edition (London: MacMillan, 1950).
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