REDUCING CARBON DIOXIDE EMISSIONS FROM AUSTRALIAN ENERGY USE

Dr. Robert Marks
Australian Graduate School of Management,
University of New South Wales,
P.O. Box 1, Kensington, NSW 2033,
Australia

Internet: bobm@agsm.unsw.edu.au

1. Abstract

DEBATE ABOUT the increasing concentration of carbon dioxide (CO_2) in the atmosphere, and fears that it will result in an intensification of the Greenhouse Effect and global warming, have spurred consideration of sustainable development. It has been claimed that technology to improve energy efficiency already exists that is cost-effective without consideration of the gains from abatement of carbon dioxide emissions. Likewise, changes in the behaviour of households or firms that would result in lower energy use per capita have been predicted as answers to the problem. But the question of *implementation* is often ignored or assumed away, while it should correctly be costed into the technology or the behavioral changes. The paper attempts to redress this lacuna in the debate, by anaysing policy options within a framework of exchange, authority, or persuasion. Carbon taxes and lower interest rates are the recommendation.

2. Introduction

Following concern at the increasing concentration of atmospheric carbon dioxide and the possibility that this would lead to global warming through the greenhouse effect, an international conference held in Toronto in 1988 proposed that all countries, including Australia, aim to cut their emissions of carbon dioxide associated with human activity to 80% of their 1988 levels by the year 2005. In this Briefing Paper we focus on the direct emissions from energy use, although other activities, particularly land use changes, will also effect these emissions. We shall not engage in the debate over the effects of

the emissions on atmospheric temperature, but take the Toronto target as an end in itself. After a brief discussion of the sources of energy-related carbon dioxide emissions in Australia, we shall consider options to reduce these emissions, highlighting three different approaches: those based on market exchange, those based on the authority of the state, and those based on persuasion and education. The data quoted in the Table come from Marks and Swan (1990).

TABLE 1. Australia—direct and indirect emissions of carbon dioxide (Mt/y) by end use sector and by fossil fuel—1987/88.

Source: Marks and Swan (1990)

	Black Coal	Brown Coal	Oil Products	Natural Gas	Total Direct	Electr-icity	Grand Total	*Share (%)*
Agriculture & Mining	0.7	0.0	5.8	4.1	10.6	9.1	19.7	*7.5*
Industry	21.8	1.3	11.1	17.2	51.4	47.5	98.9	*37.7*
Transport	0.4	0.0	73.0	0.0	73.4	1.5	74.9	*28.5*
Commercial	0.5	0.2	0.8	1.8	3.3	23.5	26.8	*10.2*
Residential	0.1	0.0	1.3	4.8	6.1	35.9	42.1	*16.0*
Total direct	23.5	1.5	92.0	27.9	144.9	117.4	262.4	*100.0*
Share (%)	*16.2*	*1.0*	*63.5*	*19.3*	*100.0*			
Electricity	69.2	38.3	1.7	8.3	117.4			
Share (%)	*58.9*	*32.6*	*1.5*	*7.1*	*100.0*			
Grand total	92.7	39.8	93.7	36.2	262.4			
Share (%)	*35.3*	*15.0*	*35.7*	*13.8*	*100.0*			

In 1987/88 electricity generation (which is predominantly from coal-fired plants) produced 44.7% of Australia's energy-related carbon dioxide emissions of 262.4 million tonnes from fossil fuels; road transport (petrol, diesel, and LPG) produced 22.3%; and other activities (direct combustion in agriculture, mining, industry, commercial, residential and other transport) produced the remaining 33.0%.

There are five ways in which Australia could reduce these emissions:

1. By capturing or scrubbing the carbon dioxide from the exhaust and flue gases, but this—although technically feasible for some processes—would be prohibitively expensive for most processes, and certainly more costly than alternative measures.

2. By substituting lower-carbon fuels for the high-carbon fuels now in use, such as brown and black coal. The use of hydro-

power or nuclear-generated electricity would produce no carbon dioxide, but there are other potential environmental problems with these fuels, and at the moment we could not readily substitute these sources for the petroleum products used in road and air transport. Nonetheless, a move towards natural gas, which currently supplies 18% of the country's thermal energy and 13.8% of its energy-related carbon dioxide emissions, or towards the renewable energy sources (wood, bagasse, solar, wind, or tidal power) would enable us to continue using energy at the same or growing levels with lower net emissions of carbon dioxide.

3. By moving to machines, buildings, and industrial processes which produce the same services (heating, cooling, lighting, transport, electrolysis, etc.) with lower energy inputs; that is, to engage in greater levels of energy efficiency, such as more fuel-efficient motor vehicles or better insulated buildings.

4. (More drastically): by actually cutting back on the levels of economic activity per person, so that outputs, energy inputs, and carbon dioxide emissions are all cut. An example of this is the 55mph (88 km/hr) speed limit mandated throughout the U.S.A. to reduce the need for imported oil after the 1973 embargo. The cost of cutting carbon dioxide emissions by curtailing end-use activities is much greater than allowing substitution to occur between, for example, an electric hot-water system and a solar system, or between more petrol in a "gas guzzler" and a more fuel-efficient engine.

5. (Ultimately): by reducing our rate of population growth, which might—other things equal—allow us to increase our per-capita energy use and carbon dioxide production, while reducing the aggregate production of the gas.

Given the advances of technological knowledge, there is always a lag in the implementation and availability of energy-saving techniques, and given the durability of the stock of energy-using equipment, there is a further gap between average energy efficiency and the higher levels of energy efficiency of new equipment. For instance, it is possible now to build a four-passenger car to attain 4.6 litres per 100 km, although this would increase the cost of the vehicle by a quarter (Von Hippel and Levi, 1983; Goldemberg et al., 1988); the average fuel efficiency of new cars sold in Australia in 1988 was 11 litres per 100 km; and the average for all cars on Australian roads was 12.1 litres per 100 km (Marks and Swan, 1990). Despite the availability of new, economically viable techniques for energy

substitution and conservation, some observers have claimed that consumers—whether households or companies—are not taking advantage of these techniques by investing in new equipment to save both money and energy, and hence to reduce carbon dioxide emissions.

The economist is wary of claims that there exist profitable opportunities still waiting to be taken advantage of. The wariness is higher in cases of firms in competitive markets apparently ignoring such opportunities, and lower when knowledge of energy-saving possibilities is costly to acquire and when potential savings are a small proportion of total costs. Whether cost-effective or not for individual households or firms, the problem remains for us as a society to induce a change in individuals' and organisations' behaviour: to use "cleaner" fuels, to invest in more energy-efficient equipment, to cut back on end-use activities, or some combination of all three.

3. Issues of Implementation

Once we have decided on the appropriate action or mix of actions, the question arises of implementation—indeed, it may be better to consider action and implementation together. The title of this syndicate poses the dichotomy of individualism or collectivism, public sector or private sector. But this split may well be simplistic. Lindblom (1977) argues that, instead of two, there are three basic methods of social control: exchange, authority, and persuasion. Boulding (1978) also identifies three basic systems: exchange, threat, and integrative. With three rather than two, the possibilities of inducing changes in behaviour become much richer, as we shall see below when examining means to reduce carbon dioxide emissions, after a brief discussion of the three-fold classification.

3.1 Exchange

Exchange is the fundamental relationship on which market systems are built. It is ubiquitous. Exchange is a voluntary relationship between two parties, each of which offers a benefit in order to induce a response. The offer is therefore contingent on achieving the response. Both parties expect to benefit, and, historically, extended exchange in markets has been powerful in organising the specialisation and division of labour and so expanding the wealth of societies and the variety of goods and services available. Exchange implies property, since one cannot sell what one doesn't own. Markets rely on authority to develop beyond bilateral barter, and market exchange must be legitimated to survive (Arrow, 1974).

To what extent can we rely on markets to attain a sustainable society? Not markets solely, since as we shall see all societies contain

elements of all three methods of social control. Properly, functioning, competitive markets, if such existed, would have a lot going for them: such a decentralised system is efficient, that is, it minimises waste so that no reallocation of resources can make any individual or group of individuals better off without making at least one individual worse off, although this efficient outcome is not unique and may result in quite unequal distributions of income across individuals, given unequal endownments (genetic, cultural, and material) inherited at birth.

But the conditions necessary for this efficient outcome are strict. There are many possible causes of "market failure" (individual incompetence and lack of knowledge, uncounted benefits, costly transactions, monopoly power) but two must be of concern to us today: uncounted costs and the existence of public goods. By "uncounted costs" we mean costs external to the calculations of the individual, which are nonetheless real. One example is the costs associated with carbon dioxide emissions apparently borne by all of us, but which are not reflected in the relative prices of "dirty" and "clean" fuels. As a consequence of uncounted costs in a market economy, there is over-provision of the good or service: its private costs of production are less than its social costs.

Uncounted costs are costs external to the firm or organisation. One solution (Pigou, 1932) is to "internalise the externality" by means of a tax calibrated to reflect the social cost of the activity. In the case of carbon-dioxide emissions, the tax would be greater on "dirtier" fuels, and the additional cost would provide a further incentive for polluters to reduce their emissions in the least-cost way, whether by fuel substitution, by energy conservation, or by curtailment of the end-use activity.

By "public goods" we mean those goods (or services) from which benefits spill over to other parties (individuals or organisations) in such a way as to undercut the incentive of any single buyer to buy. One example is agreement by all to reduce carbon-dioxide emissions: there is a temptation for each to "free-ride" on others' actions, since any individual's actions would make virtually no difference to the global problem. Of course, if all try to free-ride, no reductions will occur, and no-one will benefit. Another way of looking at this is that exchanging the action to abate emissions with the reduction in emissions is not contractual, because of the public-good nature of abatement (all will benefit, marginally) and emissions (all will suffer, marginally): private expenditure will marginally benefit everyone else, whose inaction will marginally harm the individual. This can be recognised as an *n*-person Prisoner's Dilemma (Schelling, 1978). If the opportunity to abate the emissions occurs once only, then the incentive to free-ride by doing nothing rather than being the only

person to act and so be disadvantaged with respect to the rest (who free-rode) is strong.

The *n*-person Prisoner's Dilemma is identical with the Tragedy of the Commons (Hardin, 1968), which suggests that the "common property" nature of the atmosphere (Marks, 1989) is a cause of the problem. One solution would be to "enclose" the commons by allocating property rights over the atmosphere. By this means, the owner could manage the "use" of its resource by carbon-dioxide emissions. If this seems unrealistic, then an alternative is the use of "emission permits"; these allow emissions of up to a certain amount per year, and can be traded. Those individuals or organisations for whom abatement is most costly will pay most for the permits; others will reduce their emissions more, at a lower cost. We shall examine case histories of emission taxes and emission permits below.

3.2 Authority

Authority is the basic relationship that characterises membership in formal organisations. To accept membership is to recognise the authority of the organisation's officers. Authority is as fundamental to government as exchange is to the market system. Note that authority may be established by diverse actions, such as Boulding's threat system or indoctrination or (rarely) by deceit, although these actions may also be used to establish a rule of obedience which, so long as it survives, is sufficient itself for control, and may become a relationship of authority. Unlike control through exchange, which always requires that something (the payment) be given up to induce action on another's part, control through authority, once established, is often costless. Indeed, the repeated exercise of authority often helps maintain it.

In the context of carbon-dioxide emissions, as with other pollution, control by authority is the accepted method. Those in authority, the government, enact laws mandating certain restrictions, and transgressors, when caught, are punished. In the case of pollution the restrictions might be standards of emissions, usually in terms of a limit to the flow of emissions over a time period, although the law may also require emission control devices to be fitted (for instance, for exhaust fumes) or the supply and use of "clean" fuels (such as unleaded petrol) or end-use to be curtailed (such as the 55 mph speed limit in the USA mentioned above). In the case of carbon-dioxide emissions, possible laws are (i) limits on the annual emissions of the gas by households or organisations, or by specified machines; (ii) prohibitions on the use of "dirty" fuels, such as brown coal; (iii) regulation of energy-using activities such as a mandated timetable for manufacturers to increase the fuel-efficiency of new vehicles, or a

requirement for energy labelling of appliances by the manufacturer, or for electricity-generation authorities to reduce their emissions. (This may seem unnecessary in the Australian context, since almost all electricity is generated by state-government utilities, but future privatisation and new entrants may form a private generation sector; moreover, the Commonwealth government could conceivably use the "corporations" power of the Constitution to regulate state-government trading corporations.) (iv) regulation of energy-using end-use activities, such as mandating lower room temperatures in winter or higher ones in summer, or prohibiting the establishment of high-energy industries, such as aluminium smelting.

3.3 Persuasion

Although it does not play the distinctive rôle that exchange plays in markets or authority in governments, persuasion is central and fundamental to all social systems. It may occur as ideological instruction and propaganda, as commercial advertising, as free competition of ideas, or as Workshop Briefing Papers. It is a less emotional method than Boulding's Integration, which is related to legitimacy, identity, and community. Note that persuasion is not costless: it takes time and energy to educate even a willing student.

Rather than legislating against emissions or in favour of actions that will reduce emissions, as discussed under the Authority heading above, we can simply amend these to attempts to educate and persuade. Given the uncounted costs and the public-good nature of emissions, as mentioned above under the Exchange heading, there will be difficulties in relying on voluntary actions following persuasion, but if, through whatever means, such persuasion is internalised by individuals and organisations, then so long as they are given the correct information their actions will by and large result in the desired outcomes.

4. Policy Options Available

Following from the discussions above, we have four broad options available:

A. A tax on carbon dioxide emissions.

B. Transferable carbon-dioxide emissions permits.

C. Laws mandating maximum allowable emissions of carbon dioxide by machine or process.

D. Persuasion of the necessity for fuel substitution, or energy conservation, or curtailment of end-use activities.

4.1 Emission Taxes

In order to impose taxes, there must exist an effective government, that is, the government must possess authority. Furthermore, to be effective there must be monitoring of emissions, and to affect behaviour the per-unit tax must be high enough so that previous behaviour would impose a significant additional cost. If the sole purpose is to induce sufficient changes in behaviour to attain an aggregate target, such as that from the Toronto conference, the government must have some idea of the elasticities of emission-related behaviour across a range of industries and individuals. For Australia today this information is dubious. In a recent study of the use of emission taxes, Hahn (1989) found that the main outcome of such taxes was to raise revenue to pay for government abatement. Indeed, charges were rarely set on actual performance (which requires continuous monitoring), rather charges were often related to user classification based on the authorities' expectations of future emissions. "Recycling" the revenues in the industry appears to legitimate the charges, even if there is little apparent effect on emission behaviour. A local example of this is the $80 surcharge on household water rates to subsidise Sydney's sewerage system.

To avoid the problems of monitoring the emissions of carbon dioxide, another solution is to tax the inputs, where the tax is proportional to the carbon content of the fuel and hence to the emissions with a specified degree of combustion. Under this scheme "dirty" fuels, such as brown coal, would be taxed much more highly than "clean" fuels, such as natural gas. As end-users responded to the higher prices of energy derived from relatively "dirty" fuels, there would be growing incentives for fuel substitution and/or energy conservation.

4.2 Emission Permits

Permits are only possible where there is a legitimate authority to issue and enforce them. For international issues, conferences such as the Toronto conference and accompanying treaties provide a contract with no clear sanctions against a country that either doesn't sign or else later repudiates its earlier agreement. For a local jurisdiction, there is a clear advantage of permits over taxes: the ability to trade permits will obviate the need for the government to predict behaviour; all it need do is monitor to ensure that emissions do not exceed the limit permissable. The advantage of tradeable permits was discussed above: they allow a minimum-cost adherence to the emission limits. In his recent study, Hahn (1989) found that permits were effective at reducing emissions if monitoring was cheap and if there was basic agreement on the goal of cutting emissions. (The example he

considered was that of reducing lead levels in gasoline by a system of emission permits tradeable among refineries in the U.S.) It is possible to envisage permits traded among the Australian electricity-generation authorities, but with road transport the problem of monitoring seems insurmountable.

In both cases—emission taxes and emission permits—Hahn noted that recognition by the authorities of the existing practice of emissions seemed to be important in legitimating the instruments. But this very recognition of the status quo may upset advocates of lower or zero emissions. In both cases there is explicit acceptance that some level of emissions be allowed, and although this may not (yet) be contentious for carbon dioxide, it would be for many other polluting effluents.

4.3 Emission Standards

Prohibition of levels of emission above mandated standards, for machines or firms or industries, must either be accepted—internalised—as appropriate and legitimate, or the penalties and likelihood of being caught if cheating must be sufficient to deter most from breaking the law. The greater the cost to the firm of meeting the standard, the higher the penalty. One reason for mandated standards rather than using voluntary self-regulation by the industry is the competitive pressure, especially where monitoring is costly. Even with laws and penalties and monitoring of a kind, deliberate breaches will occur, such as the dumping of toxic chemicals down Sydney sewers from mobile tankers in the dead of night. In this case, monitoring will be more effective if, like Neighbourhood Watch, there are many alert eyes who care.

A common problem of control by authority (including mandated standards) is its clumsiness. In economies which make more use of the authority of central planning, the information flows necessary in both directions are horrendous, and often decisions are irrational in consequence. In particular, the problems of ranking needs, of allocating inputs, and of allocating production are badly handled, and the incentive system militates against efficient allocation of resources. For example, it would be very inefficient to require all activities in Australia to reduce their carbon-dioxide emissions by 20% as an administrative solution to the need to reduce such emissions by 20% in aggregate: for some activities it would be relatively easy, for others it would be very costly. The efficient solution would be for all activities to reduce their emissions up to the point when the cost of a further unit's reduction was equal across all activities. To achieve this by any means is not easy, by central control it is virtually impossible.

A final point: centrally planned economies have been no better at environmentally responsible development than have market economies (Lindblom, 1977; Brown, 1989), although slower economic growth may have resulted in slower degradation.

4.4 Persuasion

As we have tried to emphasize above, no methods of social control can be effective without a degree of agreement on the part of the group whose behaviour must be modified that such modification is desirable. Indeed, for a given level of vigilance, monitoring costs will be lower if the general public is involved and persuaded too. But in a competitive environment where higher costs can result in bankruptcy, there is strong pressure on firms, and increasingly on semi-government corporations, to incur no costs beyond their competitors'. For this reason it would be naïve to expect persuasion (or internalisation) alone to suffice (Cahn, 1981). Furthermore, to rely too heavily on "persuasion" is to risk the emergence of an Orwellian society with the horrors of a Cultural Revolution.

5. Recommendations

After due consideration of the points raised in discussion above, we recommend that Australia's target of a 20% reduction in carbon-dioxide emissions by the year 2005 be achieved by a fossil-fuel tax which reflects the relative carbon-dioxide emissions per unit of thermal energy produced by complete combustion, such revenues raised to be used to alleviate such hardships as may be occasioned by the tax and by other consequences of the greenhouse effect. By this criterion the tax would fall most heavily on brown coal, then black coal, oil, and least heavily on natural gas by virtue of that fuel's relatively high hydrogen content.

6. Further Considerations

In a sustainable world, the future consequences of today's actions must be weighed against the immediate gains. If not, posterity may lose out and sustainability may be threatened. But at a period of high real interest rates, as we see today in Australia, the future may not figure prominently, if at all. For instance, with an 11% p.a. real discount rate, a dollar's gain today will outweigh a certain loss of two dollars seven years hence. (Discount rates will embody uncertainty about the future, including uncertainty about future property or ownership rights, as well as embodying commercial interest rates.) Indeed, with a high enough discount rate, extinction may be a rational action even with secure property rights: the value of harvesting all the

stock today may outweigh the flow of benefits in perpetuity of a properly husbanded, sustainable stock. Are we seeing such behaviour in Amazonia or the forests of Sarawak, or even in parts of Australia today?

When there exists a market for future assets, differences among individuals' time rates of preference are not like differences among other tastes: historically high interest rates are a sign that for many people a dollar in the hand today is far preferable to several dollars in the hand some years hence. And yet these interest rates are accompanied by unprecedented concern about the sustainability of our standards of living. To be really effective, successful policies must also reduce interest rates, so that private and social time horizons coincide more closely.

The author wishes to acknowledge assistance from Hazel Church and an anonymous referee.

References

Arrow, K.J., 1974. *The Limits of Organization*, NY: Norton.

Boulding, K.E., 1978. *Ecodynamics: A New Theory of Societal Evolution*, Beverly Hills: Sage.

Brown, L.R., 1989. Global ecology at the brink, *Challenge*, 32(2):14–22, March/April.

Cahn, R., 1981. An environmental ethic in business, in D.L. Brunner, W. Miller, N. Stockholm (eds.), *Corporations and the Environment: How Should Decisions be Made*, Stanford: Grad. School of Bus.

Goldemberg, J., Johansson, T.B., Reddy, A.K.N., and Williams, R.H., 1988. *Energy for a Sustainable World*, NY: Wiley.

Hahn, R.W.,1989. Economic prescriptions for environmental problems: how the patient followed the doctor's orders, *J. of Econ. Persp.*, 3(2):95–114.

Hardin, G., 1968. The tragedy of the commons, *Science*, 162:1,243–1,248, 13 Dec.

Lindblom, C.E., 1977. *Politics and Markets: The World's Political-Economic Systems*, NY: Basic.

Marks, R.E., 1989. Competition and common property, mimeo., class package notes, AGSM Resource Markets & Management.

Marks, R.E. and Swan, P.L., 1990. Abatement: global action, Australian road transport, and macroeconomic costs, in D.J. Swaine (ed.), *Greenhouse and Energy*, Sydney: Commonwealth Scientific and Industrial Research Organisation, forthcoming.

Pigou, A., 1932. *The Economics of Welfare,* London: Macmillan.

Schelling, T.C., 1978. *Micromotives and Macrobehavior*, NY: Norton.

Von Hippel, F. and Levi, B.G., 1983. Automobile fuel efficiency: the opportunity and the weakness of existing market incentives. *Resources & Conservation,* 10, 103–124.