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Assessing impacts of urban freight measures on air toxic emissions in Inner Sydney

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Abstract

A study to investigate the sensitivity of urban freight patterns to various greenhouse gas abatement policy measures has recently been completed. Although the Sydney urban area was used as the focus of the case study, the estimated impacts of changing freight vehicle operations across the urban area, via vehicle technologies, infrastructure improvements, logistic and land use changes are expected to be generally applicable to Australian cities and potentially applicable to cities elsewhere. This paper presents the results of a case study analysing and evaluating the impacts of a selection of greenhouse gas abatement measures on the emission and dispersion of benzene and 1,3-butadiene in Inner Sydney, the heart of the Sydney metropolitan area. The results discussed cover three demonstration days in February 1997, and are indicative of the type of policy measures that will produce the required reduction in pollution concentration for the air toxics. The results indicate that there were significant differences in the relative impacts of policies for different parts of the urban area. This is a useful finding since it suggests that specific policies could be targeted to give better air quality in places with significant health concerns such as high asthma, or areas with a greater proportion of the population vulnerable to respiratory conditions, such as children or the elderly.

Keywords: Urban freight; Air toxics; Emissions modelling; Pollution exposure

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1. Introduction

Strong growth in urban freight movements and their corresponding environmental impacts, especially in terms of greenhouse gas (GHG) and other air pollution, are of increasing concern to the community. For example, there has been continuous increase in light commercial vehicle (LCV) fleet numbers primarily due to the growth in the service economy. The LCV fleet and related travel has increased by 300% in recent decades (Austroads, 2003). Australia's Bureau of Transport and Regional Economics (BTRE) projects an increase of 107% in VKT by light commercial vehicles (LCVs), 26% by rigid trucks, and 120% by articulated trucks between 2000 and 2020 (Cosgrove, 2003).

Overall, in Australia, the current estimates of the health costs due to all vehicle emissions range from 0.01 to 1% of GDP, some AUD5.3 billion a year (Brindle et al., 1999). Based on the benefit transfer to 2001 Australian dollars from the Infras/IWW (2000) European study, the total human health effects in AUD per 1000 tonne-kilometres estimated for light duty vehicles were in the range \$30–\$130 with an average of \$80 and for heavy duty vehicles \$8–\$24 and an average of \$16. Note that, although pollution per kilometre is higher for heavy duty vehicles, they produce less pollution per tonne-kilometre as they carry large loads. The average values of air pollution health costs are about half the European values from which they are derived. This is consistent with lower emissions per urban hectare in Australia compared to Europe (Marquez et al., 2004b).

While the effects of GHG on climate change is cumulative and global, the adverse impacts of air pollution is local, dispersing over distance and is most intense in urban areas. In view of this, the BTRE, on behalf of the Australian Greenhouse Office (AGO), commissioned a study to investigate the sensitivity of urban freight patterns to a range of policy measures aimed at

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Table 1
Emissions modelled in the BTRE/AGO urban freight study

Direct GHG		Criteria pollutants		Air toxics	
CO_2	Carbon dioxide	CO	Carbon monoxide	C_6H_6	Benzene
$CO_{2\ e}$	Carbon dioxide equivalents	VOC	Volatile organic compounds	C_4H_6	Butadiene
CH_4	Methane	NO_x	Oxides of nitrogen		
N_2O	Nitrous oxide	PM	Particulate matter		
		SO_2	Sulphur dioxide		

reducing GHG emissions. Air pollutant emissions, including two air toxics, were also modelled as part of this BTRE/AGO study. The list of emissions analysed are given in Table 1.

The aim of the BTRE/AGO study is to understand the way that the urban freight market in Australian cities will react to various policy instruments and the extent of resulting changes in emissions. The sheer number of freight management actions available, from parking restrictions to less polluting engines, makes it difficult to evaluate each one individually. However, when these actions are translated into changes in trips or increases in link speeds, numbers of actions produce similar outcomes. For example, improved fuel efficiency and reduced emissions, could be achieved by a range of vehicle, engine and fuel technologies. Similarly, a reduction in traffic congestion, which would benefit the efficiency of urban freight operations and reduce emissions, might be produced by policy instruments ranging from on-road parking restrictions to road pricing.

In other words, although there is a wide range of possible policy measures that could be applied, many of these are just different ways of achieving the same outcome. Thus, the decision was made to model instruments in terms of a set of ‘‘outcome scenarios’’, each representing a number of component traffic and policy actions, which, if implemented individually, could be expected to produce the same outcomes. As a result, the study focussed on identifying the operational outcomes of policy instruments (or combinations of policies) and modelling the effects on emissions.

The first stage of this study, conducted in April to July 2002, used a literature search and expert advice to develop a qualitative understanding of the urban freight task, and investigate a range of potential policy measures. A modelling framework was designed to test the measures. The first stage concluded with a workshop for the project steering committee and other stakeholders. This led to an agreed set of measures to be tested (shown in Table 2) by the instruments proposed.

Table 2
Proposed policy instruments

Category	Instruments (outcome scenarios)
Infrastructure measures	1. Reduced congestion during peak travel 2. Improved traffic management 3. An orbital road project
Vehicle movement measures	4. Higher (and lower) load factors 5. Real-time traffic information
Planning and land use measures	6. Industry relocation as a result of an orbital road
Vehicle measures	7. ‘Best Practice’ truck fleet fuel efficiency

This ‘‘outcome scenario’’ approach meant only policy outcomes rather than individual traffic actions per se could be tested. The approach suited the study purposes since the selected outcome scenarios allow the simultaneous testing of numbers of alternative actions, within generic groupings. The focus of the study was on what types of outcomes might be most desirable or effective in reducing GHG emissions from urban freight. Moreover, if, as expected, the study showed GHG impacts were dependent on location of measures, it would also show individual measures would require case-specific modelling.

In summary, the selected policy instruments actually refer to a set of desired outcome scenarios perhaps achieved from a set of unspecified initiatives. Thus, ‘reduced congestion during peak travel’ may be brought about by a combination of various traffic initiatives, taxation policies, and infrastructure projects. The focus of the study is not on the individual initiatives that can help bring about a ‘reduced congestion during peak travel’, but rather on the impact that this instrument, once it has been achieved, will have on urban freight. This approach saved the study from being bogged down with the complexities of assessing each of a myriad of individual initiatives available.

The results of the BTRE/AGO study, consisting of a Final Report and five technical reports, have been submitted and will soon be made available from the BTRE website (www.btre.gov.au). A number of papers have been published discussing the results of the study. In particular, Marquez and Smith (2004a,b) and Taylor et al. (2004) presented the results for the GHG and criteria pollutant components of the study while Marquez et al. (2004a) provides some preliminary valuation of the potential GHG savings from the outcome scenarios. This paper is the first to focus on the air toxics component of the BTRE/AGO study. Using results from three ‘‘demonstration days’’, this paper presents indicative (rather than definitive) measures for assessing the impacts of five of the policy instruments, specifically as these relate to emissions of and population exposure to benzene and 1,3-butadiene (or simply butadiene) in Inner Sydney, the heart of the Sydney Greater Metropolitan Region (GMR) and location of the all-important central business and commercial district (CBD).

2. Air toxics and health effects

Air toxics cover a wide range of pollutants including heavy metals, polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), and persistent organic pollutants (POPs). While there is no universally accepted definition of air toxics, the more recognised definitions, such as those used by the US EPA and World Health Organisation, share a number of common elements. Australia’s Air Toxics Program (ATP), uses the following definition: ‘‘*Air toxics are gaseous, aerosol or particulate pollutants (other than the six criteria pollutants) which are present in the air in low concentrations with characteristics such as toxicity or persistence so as to be a hazard to human, plant or animal life. The terms ‘air toxics’ and*