The Environmental Impacts of Changing Urban Structure in the South Eastern Growth Area of Melbourne.

William Young,
Associate Professor,
Department of Civil Engineering,
Monash University

Sophia Schyschow,
Transport Engineer
Environment Protection Authority (Victoria)

Abstract:

The rapid spread of urban Australia is often seen as increasing travel and pollution. The development of self contained cities in outer areas may enable people to work, live and recreate locally, hence decreasing travel and reducing some of the concerns about outward growth. This paper examines the Economically Sustainable Development and National Greenhouse Strategies recommendations on urban form relating to sustainable development and the reduction in greenhouse emissions. It compares the environmental impacts of two types of urban development in the context of different urban forms. The south eastern growth area of Melbourne is chosen since it represents an area of considerable population growth.

Contact Author:

Assoc. Prof. William Young
Department of Civil Engineering
Monash University
CLAYTON VIC 3168

Telephone: (03) 905-4949
Fax: (03) 905-4944

1. INTRODUCTION

The National Greenhouse Response Strategy (NGRS) was set down in 1992. As part of the Strategy, Governments are required to examine more efficient and equitable patterns of urban settlement. The Victorian Department of Planning and Development has commenced a review of its planning directions which, amongst others, will incorporate environmental considerations. To assist with this review and complement other studies, the Environment Protection Authority (EPA) quantified the transport emissions from the South Eastern Growth Area under a number of different development scenarios. The scenarios related to increased density and self containment. The aim of the study reported in this paper was to quantify the level of greenhouse gas emissions for transport and the emissions of other local air pollutants which include CO, NOx, and lead emissions from motor vehicles for the South Eastern Growth Area, having regards to different development options.

The LAND model was used to assess the greenhouse emissions and other local air pollutants under different development scenarios. The LAND model is an educational game that can be used to indicate order of magnitude changes in the environmental consequences of transport and urban system. More detailed estimates of the impacts of such changes would require a more detailed model and a consequent increase in data requirements.

2. CONTEXT

The study presented in this report follows a number of other studies in Victoria. R.J. Nairn and Partners (1992) presented a report outlining the long term environmental impacts of three diverse land use patterns. These patterns were the:

- "Trend Scenario" which reflected expected distributions of growth in Melbourne's growth corridors.
- "Compact Scenario" which contained greater population in the existing urban areas
- "Twin City Scenario" which had two major centres, one in Dandenong and the other in the inner areas

The study generally concluded that the alternate land uses were not likely to make a great deal of impact on a regional scale within a forty year time scale. However there would be a large difference at the local scale depending on the transport network connections chosen. Reductions in CO_2, CO, NO_x and HC resulted from progressive improvements in car efficiency. If these efficiencies were not introduced then there would be nett increases in the level of emissions over the study period. Importantly the report concluded that since there was little difference in the impact of three growth scenarios the 20% reduction in emissions required in the Toronto accord is unlikely to be achieved solely by varying the urban form.

In 1993 a greenhouse neighbourhood project provided further insights into the impact of urban form on transport and the environment. The study (Loder and Bayly 1993a,b)

set out to test a number of key relationships and hypotheses for reducing car related transport emissions in "greenfiled" residential sites. These were:

- the impact of increased residential density and other land use densities (hypothesis: higher densities reduce trip length by supporting a greater range of local facilities),
- the impact of distribution of employment opportunities and services within or close to the neighbourhood (hypothesis: increased local jobs and services reduce trip lengths and encourage non-motorised modes of travel),
- the impact of varying levels of public transport provision (hypothesis: better public transport will replace some less fuel efficient car trips), and
- the impact of the design of the local road system (hypothesis: different street layouts potentially affect fuel consumption and local sections of car trips and encourage modal shift changes to non-motorised modes).

Three neighbourhood types were investigated. These were:

- Conventional: A conventional suburban area typical of the 1980's. The net residential density was 10 dwellings per hectare, little local employment and retail opportunities, a hierarchical street pattern and many culs-de-sac.
- VicCode: A residential area based on the design principles of the "Victorian Code of Residential Development", with net residential densities of 15 dwellings per hectare, slightly more local employment and retailing opportunities, a more interconnected than hierarchical street pattern with some culs-de-sac, and some mix of dwelling types, with some detached houses on small and standard lots
- Traditional Neighbourhood Development (TND): A mixed use neighbourhood with net residential densities averaging 25 dwellings per hectare, a high level of local retail and employment opportunities, with one job available for every two resident workers; a highly interconnected street network typical of the inner "grid pattern" areas of Melbourne, with few culs-de-sac; and a mix of attached and detached dwelling types.

The study showed that car travel times, fuel usage and emissions could be reduced as densities rose. Changes in the street layout also produce marginal reductions in emissions. The introduction of more local jobs and an increase in the land use mix was found to be the most important factor in reducing motorised travel and emissions. The study showed a reduction in car travel time of 35 percent from the Conventional to the TND (8.3 to 5.4 minutes) during peak periods. The reduction in CO_2 was from 1.15 kg/hour/dwelling to 0.70 kg/hour/dwelling or 33% during peak periods. The reduction in fuel consumption was 0.45 litres/hour/dwelling to 0.29 kg/hour/dwelling or 36% during peak periods. The estimated car related greenhouse gas emissions per dwelling ranged from 3.3 tonnes for the conventional layout, through 2.2 tonnes for the VicCode to 1.4 for the Traditional Neighbourhood Development.

The analysis indicated that the greater variety and supply of local land use, together with substantially higher residential densities lead to an increase in walking and cycling as an alternate mode to car travel. Investigation of public transport improvements

indicated that a 20% reduction in travel time would result in a 3% increase in patronage. Slight improvements in public transport use could be attributed to the higher densities and car travel time changes.

3. THE SOUTH EASTERN GROWTH AREA

Between the late 1960's and late 1980's the idea of urban expansion in Melbourne was to allow it to occur in seven nominated growth areas. In 1987, the Government introduced the Metropolitan policy "Shaping Melbourne's Future" which gave priority to three of these. The South East being one. The South Eastern Growth Area generally includes the local government areas of Berwick, Cranbourne and Pakenham (MPE 1989). More specifically the growth area is presented in Figure 1. The area was expected (MPE 1989) to attract young growing families with moderate incomes earned by both the husband and wife. The families are likely to own at least one car. If the main breadwinner in the house is male he is likely to work as a tradesman, machine operator or labourer. This family is likely to be paying off a house.

The development of employment within the area was seen as an important need. On average 27.2 per cent worked within the growth area municipalities. This degree of self containment was consistent with the 26 percent of people working within their own municipalities in the entire Melbourne Statistical Division (MPE 1989).

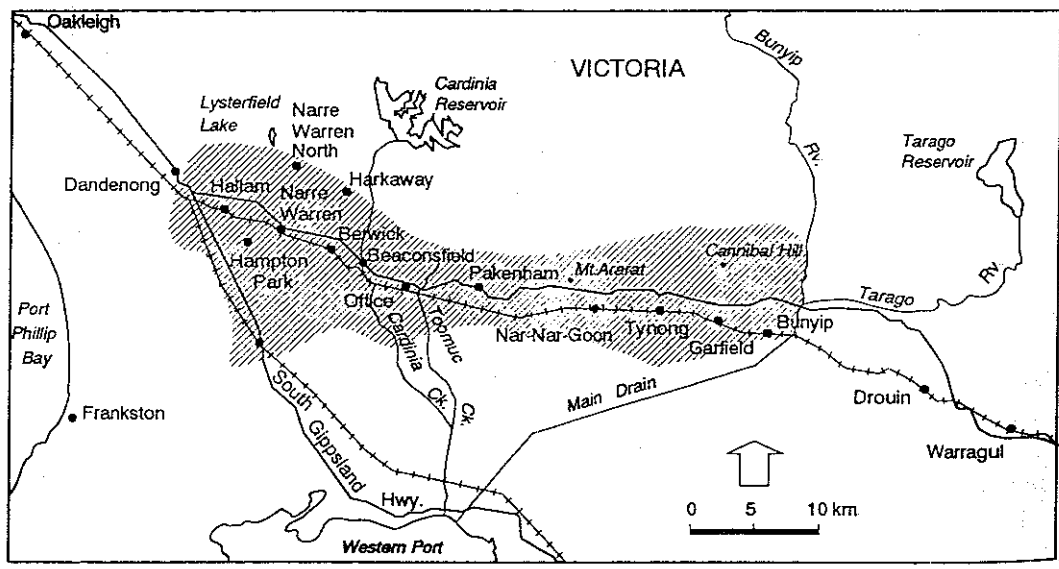

Figure 1 The South-eastern Growth Area

The need for a high level of transport provision, particularly good public transport was seen as a method of encouraging housing and employment into the area. Further, the need for well planned settlements focusing on activity centres to reduce travel times was seen as a method of reducing greenhouse emissions. These activity centres were seen to contain a wide range of facilities: administrative, cultural, recreational, social, sports, legal, welfare as well as retail.

In November 1990 the then Department of Planning and Urban Growth released a South East Growth Area Plan (MPE 1990a, 1990b), which outlined broad principles to accommodate the anticipated growth in the region. It contains most of the urban growth to the western part of the growth area around established areas. This option had the least internal and off-site impact on the environmental, heritage and agricultural qualities of the area.

4. THE LAND MODEL

The investigation of the impact of growth in the South Eastern Growth Area was investigated using the LAND package. LAND is an urban land use - transport - environment interaction game. It revolves around a dynamic updating of land use in a city using a one year cycle. The model requests that the base year and transport network for the study be set up (Gu, Young and Haines 1993). The networks used in setting up the model during the testing are a series of networks taken from road and public transport maps and a coarse representation of local government areas (LGA's).

The overall model structure is outlined in Figure 2. It follows a sequential path. The land use distribution for a particular year is determined. This distribution is used to determine the transport demands. The transport demands are then used to predict the environmental outputs. The land use and transport data is then used to determine the distribution of land use for the following year. This circular process continues until the model has reached the end of the study period.

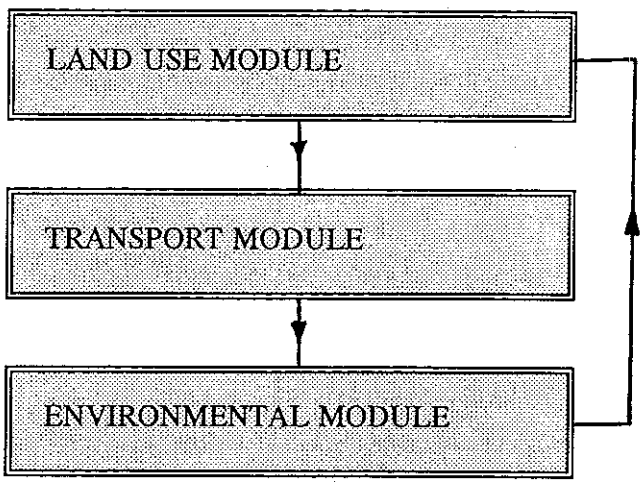

Figure 2 **General structure of the LAND simulation model**

More specifically, the model is based on the major decision making groups in urban areas. These are the household, businesses, developers, government bodies and governments. Not all bodies are considered in detail. The major detail relates to the household and businesses (employment). The developers are seen to cater for household needs, so measures of household demand indicates where developers will build. The developer activity is input exogenously in the form of new housing and employment facilities. The public bodies are considered in a similar fashion. Measures of deficiency can be provided and the user can update housing and job location exogenously. The role of the government is limited to one of controlling land availability.

LAND starts from the land use module which estimates the location of activities in the different study area zones. The location activities consists of population, houses, households, employment, unemployment and jobs. These in turn are inputs to the transport module in the form of trip matrices. The transport module determines the travel pattern, and the generalised travel costs which in turn impacts on further location decisions. After the travel patterns are estimated, the environmental impacts of the transport system are calculated. LAND updates location activities, transport patterns and environmental impacts every year.

5. ANALYSIS

The previous sections have described the background to the study and the character of the LAND model. It should be emphasised that LAND is an educational game and as such provide a indication of the order of magnitude of the impacts of particular policies. Determining the exact response to a particular policy would require a considerable more complex model with considerable larger data require-ments. The study presented in this section uses the LAND model to investigate the impacts of increasing the density of development in the South Eastern Growth Area of Melbourne. The study aims to provide an indication of the impact of:

- increasing the density of housing from 10 dwellings per hectare to 25 dwellings per hectare, and
- increasing the level of take up of local jobs by workers living in the South Eastern Growth Area.

Before these scenarios were tested it was necessary to set up the zoning pattern, network description and determine the demographic changes. The zoning pattern (Figure 3) used was based on that adopted for the South Eastern Metropolitan Transport Study (MPE 1990a,b; Taylor 1994)

The job and housing patterns were based on that used for South Eastern Metropolitan Transport Study and the 1991 Census. The transport network was developed to replicate the major transport links in the metropolitan region. The links in the South Eastern Growth Area were considered in more detail (Figure 4). In 1991 there were 3,009,884 people and 1,285,689 jobs in Melbourne (ABSVIC 1991). This grew to 3,557,625 people and 1,642,524 jobs over the study period (1991-2011).

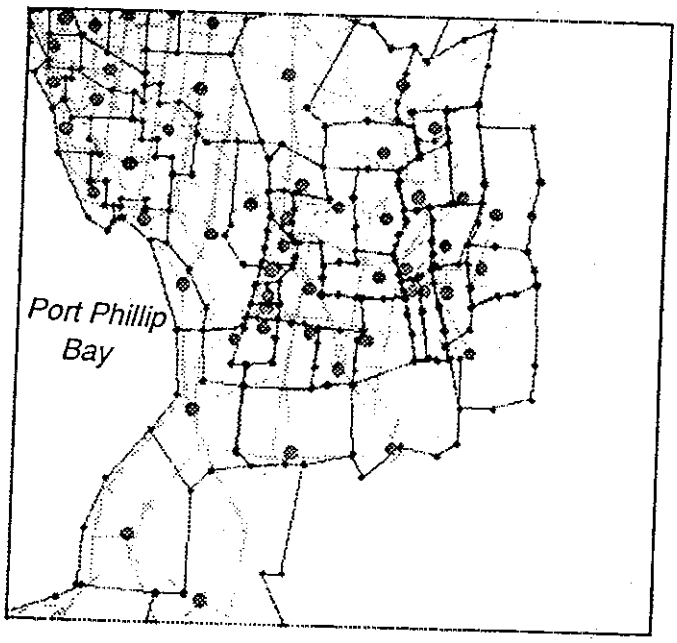

Figure 3 **Zonal pattern for South Eastern Growth Area**

The South Eastern Growth Area study

The South Eastern Growth Area study presented in this section uses the LAND model to investigate the impacts of increasing the density and self containment in the South Eastern Growth Area of Melbourne. To answer these questions a number of distributions of housing and jobs opportunities were set up and LAND was used to predict the travel and environmental outputs. The scenarios were:

1. A "*business as usual*" growth scenario where existing trends of urban growth were used as a basis for determining travel and emissions levels. The base data for the growth trend was extracted from the R.J. Nairn and Partners (1992) study of land use changes in Melbourne. Table 1 presents the demographic information for the South Eastern Growth Area. It can be seen that the South Eastern Growth Area contains 167,584 people and 38,179 jobs in 1991. In the year 2011 this was predicted to grow to 424,835 people and 69,786 jobs

2. A "dense" corridor scenario where housing growth in the South Eastern Growth Area between 1991 and 2011 was consolidated at 25 houses per hectare. The growth area zones chosen for this increase in density were those closest to the western border of the study area. The population and jobs in the South Eastern Growth Area remain the same as those for the "business as usual" scenario (Table 1). The distribution of jobs present in the "business as usual" scenario was retained and the level of job take up by local residents was also retained for this scenario. All the remaining scenarios used this distribution of houses.

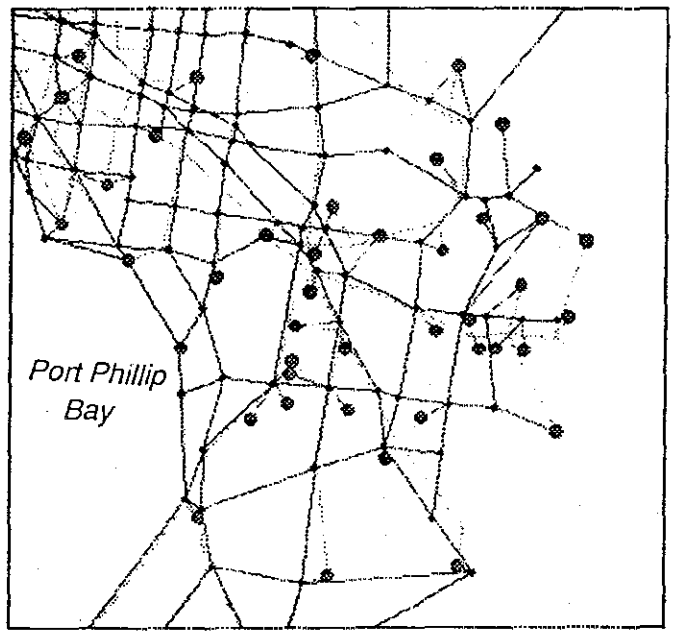

Figure 4 Transport network for South Eastern Growth Area

3. The take up of local jobs by workers living in the South Eastern Growth Area in the "dense" city scenario was that related to the calibration of the model. It was approximately 20 per cent: approximately 14,000 in 2011. A scenario to investigate the impact of an increased take up of local jobs was investigated. The level of take up of local jobs in the model was increased to fifty per cent: approximately 30,500 in 2005 and 35,000 in 2011. The population and jobs in the South Eastern Growth Area remain the same as those for the "business as usual" scenario (Table 1). Achieving this increase would require careful planning and judgement as to the character of the workforce in the area and the jobs that match this workforce. This was termed the "*dense city with increased local resident job take up*" scenario.

4. Another option could be to increase the jobs in the South Eastern Growth Area to match the number of workers. Without appropriate policies there would be more workers in the South Eastern Growth Area than jobs. The impact of increasing the jobs opportunities to match the number of workers could provide an indication of the results of urban policies of job decentralisation. To investigate this scenario the number of jobs in the South Eastern Growth Area were increased to the level of the number of workers. Table 1 shows that the total number of jobs was increased to 181,588 in 2011. The shortfall in job opportunities in the South Eastern Growth Area must be taken from other parts of the urban area. This could be carried out in a number of ways:

- job opportunities could be reduced evenly over the remainder of the urban area, or
- jobs could be reduced in the same proportion as they are utilised by workers in the South Eastern Growth Area in the trend scenario.

The latter option was chosen here since it better represented the linkages between home and work. The remaining scenarios used this new distribution of workplaces. Because of the character of the LAND model this scenario includes a twenty per cent take up of local jobs by people living in the growth area: approximately 36,000 in 2011. It is called the "*dense city with equal local workers and jobs*" scenario.

Table 1 South Eastern Growth Area demographics for scenarios tested

Scenario	Year	Population	Dwellings	Jobs
Initial year	1991	167,584	54,909	38,179
Business as usual (10 dwellings per hectare)	2011	424,835	162,859	69,786
Dense (25 dwellings per hectare)	2011	424,835	162,859	69,786
Dense city with increased resident job take up	2011	424,835	162,859	69,786
Dense city with equal local workers and jobs	2011	424,835	162,859	181,588
Dense city with equal local workers and jobs and fifty per cent job take up	2011	424,835	162,859	181,588

5 The take up of jobs in the previous option relates to the levels of take up presently experienced in Melbourne. The impact of increasing the level of self containment of the growth area could be investigated by increasing the level of take up of jobs by local workers to fifty percent: approximately 90,000 in 2011. The population and jobs in the South Eastern Growth Area remain the same as that for the previous scenario (Table 1). This is called the "*dense city with equal local workers and jobs and fifty per cent job take up*" scenario.

The impact of these scenarios at an urban level can be obtained by direct comparison of the outputs of each run of the model. All of the above scenarios assume that there will be no energy efficiency improvements in automobile technology during the study period. These changes were excluded from the study since the main aim was to look at changes in density and self containment. The results of the study are therefore likely to overestimate the levels of emissions and fuel consumption since technological improvements over the next twenty year will certainly reduce fuel consumption and emission levels. The impact of these scenarios on travel, fuel consumption and emissions will be discussed in the following sections.

Travel

The travel in Melbourne in 2011 for each of the scenarios is shown in Table 2. It can be seen that private travel varies from 120,575,207 to 118,654,259 vehicle kilometres for the scenarios. The total number of private vehicle trips ranged between 8,296,379 and 8,291,204. Public transport travel was considerably lower. It varied from 2,684,756 to 2,716,820 person kilometres. The total number of person trips varied between 772,696 and 783,647.

Table 2 Daily travel in Melbourne in 2011

Scenario	Private vehicle trips	Private vehicle kilometres	Public passenger trips	Public passenger kilometres
Business as usual (10 dwellings per hectare)	8,296,379	120,575,207	772,696	2,684,756
Dense (25 dwellings per hectare)	8,294,550	120,139,469	780,532	2,710,491
Dense city with increased resident job take up	8,293,202	118,852,791	782,590	2,693,320
Dense city with equal local workers and jobs	8,295,364	119,923,556	782,669	2,716,820
Dense city with equal local workers and jobs and fifty percent job take up	8,291,204	118,654,259	783,647	2,706,183

In order to investigate the impact on people in the South Eastern Growth Area it is necessary to obtain an indication of the level of travel and emissions that would be present if there were no change (population and jobs) in the study area. A no development scenario was, therefore, run as a basis for determining the impact of growth in the South Eastern Growth Area. This run assumed no growth in population occurred in the South Eastern Growth Area. The jobs associated with the growth were also not created. The growth that did not take place in the South Eastern Growth Area was removed from that of the remainder of Melbourne. This extreme is unrealistic given existing growth trends in the corridor but the difference in travel, emissions and energy consumption between it and the above scenarios would enable the order of magnitude of the local impacts to be assessed. This is the "*No development in the South Eastern Growth Area*" scenario. Table 3 shows the travel 2011 resulting from this scenario. It can be seen that considerably less travel takes place when there is no development in the south east.

Table 4 shows the travel in South Eastern Growth Area generated by the population and job growth in the area in 2011. These figures were calculated by subtracting the no development scenario figures (Table 3) from those presented for each of the scenario described earlier (Table 2). It can be seen that in 2011 private vehicle travel varies between 6,950,631 and 5,029,683 vehicle kilometres. The total number of trips varies between 533,617 and 559,779. For public transport the number of trips varies between 13,800 and 24,751 person trips.

Table 3 Travel in Melbourne for no development in South Eastern Growth Area scenario

Year	Private vehicle trips	Private vehicle kilometres	Public passenger trips	Public passenger kilometres
2011	7,759,585	113,624,576	758,894	2,600,620

Table 4 Increased travel resulting from changes in the South Eastern Growth Area for 2011

Scenario	Private vehicle trips	Private vehicle kilometres	Public passenger trips	Public passenger kilometres
Business as usual (10 dwellings per hectare)	536,794	6,950,631	13,800	84,136
Dense (25 dwellings per hectare)	534,965	6,514,893	21,636	109,871
Dense city with increased local residential job take up	533,617	5,228,215	23,694	92,700
Dense city with equal local workers and jobs	559,779	6,398,980	24,232	116,209
Dense city with equal local workers and jobs and fifty percent job take up	531,619	5,029,683	24,751	105,563

The change in travel described here does not take into account the movement of people from motorised to non-motorised travel, rather it takes into account the reduced trip length associated with particular levels of self containment. Reductions in vehicle travel may result from increases in pedestrian travel. In turn this may decrease the levels of fuel consumption and emissions reported here.

Fuel consumption

The comparison of the changes in fuel consumption for the five scenarios investigated is shown in Tables 5. It presents the fuel consumption for the year 2011 for each of the scenarios assuming there are no changes in vehicle technology. The "business as usual" scenario provides a base for comparison. It shows 7.53 x 10^6 litres / day. The increasing of density shows only a small 0.35 per cent reduction in fuel consumption over the entire urban area. If the number of jobs in the South Eastern Growth Area is set as equal to the number of workers then the reduction in petrol consumed over the entire urban area is 0.60 per cent. However, if the level of self containment of jobs is increased to 50 per cent then the level of fuel consumption is reduced by 3.25 per cent.

The fuel consumed in litres per peak hour per dwelling in 2011 range between 0.51 and 0.49, this is higher than that found by Loder and Bayly (1993a,b).

Table 5 Petrol consumption for scenarios for Melbourne in 2011

Scenario	Petrol (lt/day)	Per cent change	Petrol consumption (litres/hour/ dwelling)
Business as usual (10 dwellings per hectare)	7,532,919	0	0.51
Dense (25 dwellings per hectare)	7,506,214	0.35	0.51
Dense city with increased resident job take up	7,373,027	2.12	0.50
Dense city with equal local workers and jobs	7,489,178	0.60	0.51
Dense city with equal local workers and jobs and fifty per cent take up	7,288,352	3.25	0.49

A clearer indication of the level of reduction in fuel use can be obtained by concentrating on growth in the South Eastern Growth Area alone. The households in this area may have their trip patterns changed more substantially than those in the rest of the urban area. Further, if these findings were extrapolated to other outer areas then the impact of the changes on people in the growth area is very relevant. This comparison is shown in Table 6.

LAND predicted that the level of petrol consumed in 2011 was reduced by 4.05 percent for the increase in density, 6.64 per cent for the equalisation of jobs and workers in the South Eastern Growth Area and 37.1 per cent if the level of self containment is increased to fifty percent. The fuel consumed during the peak hour for each dwelling

ranges from a high of 0.61 to 0.38. The is slightly higher than the values obtained from Loder and Bayly (1993a,b). The fuel consumption per dwelling is higher than that found in the rest of the urban area. This results from the fact that most employment activity is still closer to the central area and that people would tend to travel further in the outer suburban areas than their equivalent in the central city area.

Table 6 Increased petrol consumed as a result of changes in the South Eastern Growth Area in 2011

Scenario	Petrol (lt/day)	Percent reduction	Petrol consumption (litres/peak hour/ dwelling)
Business as usual (10 dwellings per hectare)	659,127	0	0.61
Dense (25 dwellings per hectare)	632,442	4.05	0.59
Dense city with increased local resident job take up	499,235	24.3	0.46
Dense city with equal local workers and jobs	615,386	6.64	0.57
Dense city with equal local workers and jobs and fifty per cent job take up	414,560	37.1	0.38

Emission levels

Table 7 presents the emissions for 2011 for each of the scenarios assuming there are no changes in vehicle technology. The trend scenario provides a base for comparison. It shows 38.9 x 10^6 kilograms/day of CO_2. This is substantially higher than that determined by Loder and Bayly (1993a,b). However, the Nairn study incorporated changes in vehicle technological improvements into the determination of emissions

The increasing of densities shows only a small 0.36 per cent reduction over the entire urban area. If the number of jobs in the South Eastern Growth Area is set as equal to the number of workers then the reduction in CO_2 emissions over the entire urban area is 0.60 per cent. If the take up of local jobs is increased to 50 per cent then the level of CO_2 emissions is reduced by 3.24 per cent. The CO_2 emissions per peak hour per dwelling range between 2.50 and 2.66 kilograms per peak hour per dwelling, this is higher than those found by Loder and Bayly (1993a,b).

As with fuel consumption, a clearer indication of the level of reduction can be obtained by concentrating on the South Eastern Growth Area only. This comparison is shown in Table 8.

Table 7 **Daily carbon dioxide emission levels for study scenarios for Melbourne in 2011**

Scenario	CO_2 (kg/day)	Percent reduction	CO_2 produced (kg/peak hour/ dwelling)
Business as usual (10 dwellings per hectare)	38,946,907	0.00	2.63
Dense (25 dwellings per hectare)	38,807,734	0.36	2.63
Dense city with increased local resident job take up	38,121,116	2.13	2.58
Dense city with equal local workers and jobs	38,714,829	0.60	2.62
Dense city with equal local workers and jobs and fifty per cent job take up	37,681,396	3.24	2.55

Table 8 **Increased carbon dioxide emissions for study scenarios for change in South Eastern Growth Area in 2011**

Scenario	CO_2 (kg/day)	Percent reduction	CO_2 produced (kg/ peak hour/ dwelling
Business as usual (10 dwellings per hectare)	2,936,478	0	4.06
Dense (25 dwellings per hectare)	2,841,490	2.33	3.93
Dense city with increased local resident job take up	2,318,392	21.0	3.21
Dense city with equal local workers and jobs	2,764,740	5.85	3.82
Dense city with equal local workers and jobs and fifty percent job take up	2,010,111	31.5	2.78

The level of CO_2 emissions are reduced by 4.09 percent for the increase in density, 6.82 per cent for the equalisation of jobs and workers in the South Eastern Growth Area and 37.2 per cent if the level of self containment is increased to fifty percent. The CO_2 produced during the peak hour for each dwelling ranges from a high of 3.15 to 1.98. This is higher than that found by Loder and Bayly (1993a,b)

Table 9 presents the levels of emissions other than CO_2 for the entire urban area and the South Eastern Growth Area. The reduction in carbon monoxide (CO), hydrocarbons (HC) and Nitrous oxides (NOx) are similar to those found for CO_2. The lead (Pb) emissions show a greater reduction due to increased use of unleaded petrol.

Table 9 **Increased carbon dioxide emissions for study scenarios for change in South Eastern Growth Area in 2011**

Scenario	CO_2 (kg/day)	Percent reduction	CO_2 produced (kg/ peak hour/dwelling
Business as usual (10 dwellings per hectare)	3,401,038	0.00	3 15
Dense (25 dwellings per hectare)	3,261,862	4.09	3 02
Dense city with increased local resident job take up	2,575,239	24.3	2.39
Dense city with equal local workers and jobs	3,168,956	6 82	2.94
Dense city with equal local workers and jobs and fifty percent job take up	2,135,524	37.2	1.98

6. GENERAL DISCUSSION

The findings of this study support those of previous studies (e g. Loder and Bayly 1993a). It indicates that increasing urban density provides an opportunity of decreasing travel to work and other activities. The level of reduction is not great and there is a need to combine the move to increased densities with other initiatives to reduce travel, fuel consumption and emissions substantially. In addition to the benefits achieved by increased density encouragement of local workers to take up local jobs and local residents to use local retail and sporting facilities would also decrease travel and emission levels. The extent to which this self containment can be achieved depends on the character of the urban area and the availability of opportunities. In the case of job opportunities creating more jobs in the South Eastern Growth Area will not, in itself, increase the take up of jobs by local workers. The type of workforce in the region must match the character of the jobs provided.

7. ACKNOWLEDGMENTS

The author would like to thank a number of people and organisations for their assistance. The Environment Protection Authority for its support. John Miles and John Davidson from VicRoads for their provision of data on jobs and households in the urban area. John Miles also provided useful input on the approach used in the study

William Taylor from the Public Transport Corporation for providing background for the study and information of the changes that have occurred in the South Eastern Growth Area of Melbourne He also made many useful comments on the study as it developed Krytian Siebert, Ralph Hanson, John Hanna, Alistair Kellock, Victor Sposito and Ivan Motely in the Department of Planning for their assistance in providing data and information on present trends in urban growth.

8. REFERENCES

ABSVIC (1991). Australian Bureau of Statistics Microfiche. Australian Bureau of Census and Statistics, Canberra, Australia.

Gu, K., Young, W. and Haines, A. (1993). *LAND version 2.1 user manual*. Monash University, Department of Civil Engineering.

Loder and Bayly Consulting Group (1993a). "Greenhouse neighbourhood project, The low energy suburb: A Summary Report". Report prepared for the Victorian Government's Department of Planning and Development, Environment Protection Authority and Energy Victoria

Loder and Bayly Consulting Group (1993b) "Greenhouse neighbourhood project, The low energy suburb: A Technical Report". Report prepared for the Victorian Government's Department of Planning and Development, Environment Protection Authority and Energy Victoria.

MPE (1989). "The South-Eastern Growth Area: Technical Report" Ministry of Planning and Environment.

MPE (1990a). "The South-Eastern Growth Area Plan: A Background Report" Ministry of Planning and Environment.

MPE (1990b). "The South-Eastern Growth Area: Minister's Direction". Ministry of Planning and Environment

R.J Nairn and Partners (1992). "Metropolitan Melbourne Transport Model". Report prepared by The Greenhouse Unit, VicRoads and Department of Planning and Housing by R.J Nairn and Partners Pty. Ltd.

Taylor, W. (1994). "South Eastern Metropolitan Growth study: Base data and predictions". Personal communication.