Offsetting Transport Greenhouse Emissions

A.J. RICHARDSON
Director
The Urban Transport Institute and TreeSmart Australia
tony.richardson@tuti.com.au

Presented at the 2007 National Conference of the Australian Institute of Traffic Planning & Management, Canberra, October 2007

ABSTRACT

The transport sector contributes about 15% of Greenhouse Gas emissions in Australia, or around 80 million tonnes of CO_2 per year. While various proposals have been put forward as to how this can be reduced, including travel behaviour change, greater use of public and non-motorised transport, improvements in vehicle technology and fuels and long-term changes in land-use, the fact remains that the total emissions will be reduced only marginally or may even grow with increasing population. While transport emissions are a major issue, people and goods will still need to be transported to maintain a sustainable and economically viable society. Resolving these different perspectives will be a major challenge for transport planners in the future. If Australia is to reduce greenhouse emissions by 50-60% by 2050 (or 20% by 2020), then alternative means of reducing CO_2 in the atmosphere must be considered.

This paper examines a complementary method of reducing CO_2, based on the offsetting of CO_2 emissions by non-transport means. The paper first describes a model for considering Carbon Neutrality (the MAORI model) which includes the steps of Measure, Avoid, Offset, Reduce and Iterate. It then outlines the scale of the land transport task in Australia, followed by an estimation of the greenhouse emissions (especially CO_2) generated by that land transport task. Selecting one of the possible offset methods, biosequestration in forests, it then estimates what would be required physically to offset the total land transport emissions each year, and the likely cost of these offsets. The paper then considers various ways in which these costs could be met by society.

The paper then considers the emissions, and required offsets, for another particular aspect of the transport task; international aviation for flights into and out of Australia. It compares the cost of the required offsets with the economic benefits of tourism, and suggests that “carbon neutral air travel” may be of economic benefit to Australia.

The paper concludes by highlighting that while global warming is a major problem, it would be possible to make major impacts on reducing CO_2 emissions from the transport sector by a relatively small cost spread over the entire population of travellers

1 Introduction

The topics of Global Warming and Carbon Neutrality have received dramatically increased attention over the past 12 months in Australia. Since the first visit of Al Gore to Australia in October 2006 to promote his film and book “An Inconvenient Truth” (Gore, 2006), a number of events have conspired to raise public awareness of the topics of Global Warming and Carbon Neutrality. The Stern Review (Stern, 2006) that was presented to the British Government highlighted the short-term and long-term consequences of global warming. While there are numerous findings in that substantial volume, the one that appears to have received most attention is the one that concludes that “the benefits of strong, early action on climate change outweigh the costs”. A range of public and political events have raised the level of awareness of the extent and consequences of global warning. Many publications (e.g. Flannery, 2005) have expressed in very understandable terms the nature and implications of the problem. The Australian Government awarded Tim Flannery the title of “Australian of the Year”, even though he remains publicly critical of the government’s policies on global warming. The topics have infiltrated the public mind to such an extent that television programs and series are now based on the topic (e.g. The Carbon Cops).

The transport sector contributes about 15% of Greenhouse Gas emissions in Australia, or around 80 million tonnes of CO_2 per year. While various proposals have been put forward as to how this can be reduced, including travel behaviour change, greater use of public and non-motorised transport, improvements in vehicle technology and fuels and long-term changes in land-use, the fact remains that the total emissions will be reduced only marginally or may even grow with increasing population. If Australia is to reduce greenhouse emissions by 50-60% by 2050 (or 20% by 2020), then alternative means of reducing CO_2 in the atmosphere from the transport sector must be considered. A previous paper (Richardson et al., 2005) have, for example, demonstrated that CO_2 reductions via tree planting may be much more cost effective than CO_2 reductions via travel behavior change programs.

The current paper extends this theme by describing a method of reducing CO_2 emissions from transport based on the offsetting of CO_2 emissions by non-transport means. The paper first outlines an overall framework for considering carbon neutrality in the transport sector (and elsewhere). It then considers what would be required physically to offset the total land transport emissions each year in Australia, and the likely cost of those offsets.

The paper then considers the emissions, and required offsets, for another particular aspect of the transport task; international aviation for flights into and out of Australia. International tourism flights are especially important to the Australian economy. International tourism is estimated to add approximately $22 billion to the Australian economy each year. However, Australia’s geographic location means that long distances must be flown by most visitors in order to get to Australia. As noted by Forsyth (2007) “The impact of climate change and the policies designed to mitigate it are being recognised as a big issue for tourism destinations such as Australia, which are far from their markets”. In an increasingly “carbon sensitive” world, there are predictions that long-distance air travel will be under considerable pressure in the future, and this could have serious consequences for international tourism to Australia (and also for international tourism from Australia). The paper therefore compares the cost of the required offsets with the economic benefits of tourism, and suggests that a policy of "carbon neutral air travel" may be of economic benefit to Australia.

2 The MAORI Model of Carbon Neutrality

In seeking to achieve Carbon Neutrality, many individuals and organisations have adopted a range of strategies. For example, the Victorian EPA has recently announced its intention to go Carbon Neutral (www.epa.vic.gov.au/greenhouse/carbon_offsets). In doing so, it has produced a booklet (EPA goes Carbon Neutral) in which they outline a set of Carbon Management Principles, consisting of the following steps:

- Measure
- Set Objectives
- Avoid
- Reduce
- Contain
- Assess
- Offset

In considering the role of offsets, they note that offsets "are an important final component to becoming carbon neutral".

While agreeing with many of the sentiments behind the EPA Carbon Neutral Principles, it is considered that offsets should be used earlier and should be a central component of an overall Carbon Neutral strategy, rather than an afterthought. To this end, TreeSmart Australia works with the MAORI[1] model of Carbon Neutrality, with the following steps:

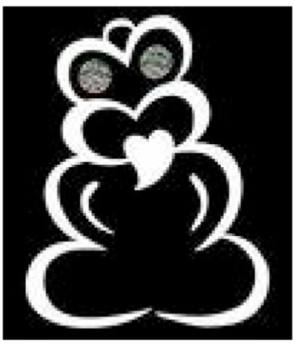
Measure

Avoid

Offset

Reduce

Iterate



[1] The word MAORI is used for its memorability, and not necessarily for its cultural association with the indigenous people of New Zealand. This is despite New Zealand having a long history of farm forestry, and the fact that I learned most of what I know about farm forestry from a New Zealander, Mr. John Woodley.

Measure

The first step in going Carbon Neutral is to ***Measure*** (or at least estimate) the emissions associated with the specific activities. In the context of transport, this is a relatively straight-forward task for land-based transport, since greenhouse emissions (mainly CO_2) are directly related to fuel consumption, and many methods exist for modeling and measuring fuel consumption from land-based transport. For air transport, the position is not quite so clear, since CO_2 is not the only (or the major) greenhouse emission from air transport. At high altitudes, other emissions (even water vapour) are significant contributors to greenhouse emissions, with the result that total greenhouse emissions are about 2-3 times as much as the CO_2 emissions. The UK Commission for Integrated Transport (2003) has recommended a factor of 2.7 be applied to CO_2 emissions to account for the non- CO_2 emissions from air transport, although debate persists as to the best value of this factor to apply.

Avoid

Having identified the greenhouse emissions attributable to an individual, a household or an organization, there may be some activities that result in emissions that are relatively easy to ***Avoid***. These activities are often referred to as "low-hanging fruit", in that they are easy to reach. Examples of such activities in the context of personal travel might include walking to the local shops instead of driving, combining activities on one round-trip rather than making separate trips, inflating tyres to the correct pressure, and using public transport for trips where public transport is a viable alternative.

However, the number of such activities where emissions can easily be Avoided is likely to be relatively few in number, and the total emissions avoidable is likely to be relatively small. If there were large numbers of such activities, then reducing greenhouse emissions would be fairly straight-forward and easily implemented, and we know that is not the case.

Offset

While other models of Carbon Neutrality (such as the Victorian EPA Principles described above) tend to put offsetting at the end of the chain of activities, the MAORI model puts ***Offsets*** in the centre of activities, for two main reasons.

Firstly, as noted by Stern (2006), there is a need for immediate action with respect to reductions in greenhouse emissions in the atmosphere. While the long-term [2]aim might be to eliminate or change the activities which give rise to the emissions, such changes typically take a considerable period of time (e.g. changing over the fleet to low emission vehicles will take at least 10 years), and we simply can't wait that long to do something about reducing atmospheric CO_2. While waiting for the

[2] In the context of global warming initiatives, long-term refers to a hundred years or more, while short-term refers to less than 50 years. The carbon sequestered in trees growing in harvested plantations with a rotation length of 20-30 years would be regarded as short-term measures, while the carbon sequestered in the timber products after harvest are more long-term measures.

long-term changes to occur, we need to make immediate reductions in atmospheric CO_2, both for our current activities and also for past activities which have contributed to CO_2 emissions.

Secondly, having offset the emissions that cannot easily be avoided this year provides a metric and an incentive to proceed to the next steps in the MAORI process (Reducing and Iterating), as will be described below.

Reduce

Having avoided the polluting activities that can easily be avoided, and then offset the emissions that cannot easily be avoided this year, the next step is to start to ***Reduce*** the emissions that are not easily avoided and that may take some time to completely remove. This process may take several years to completely implement. Examples of such changes (in a household context) might include reducing the number of vehicles in the household, changing those vehicles to low-emission vehicles, and changing residential location to be in a position to make better use of public transport services. From a policy perspective, the type of changes that will reduce emissions in the future might be investing in public transport infrastructure and services, encouraging higher-density urban development, changing taxation laws to remove incentives for vehicle use, implementing user-pays road-pricing systems, introducing carbon tax policies, etc. None of these changes will occur overnight, and yet we need to make immediate changes in atmospheric CO_2 if we are to stave off the inevitable global warming consequences. This is why Offsets come before Reductions in the MAORI model. We need to take short-term action while we start implementing the long-term actions.

Iterate

Some Carbon Neutral models imply that the process of going carbon neutral is a once-off process (or at least they don't stress that it is a continuous process). However, for the same reason that Quality Management is a seen as "a process of continuous improvement" (Taormina, 1996), so "going Carbon Neutral" must also be seen as a process of continuous improvement.

So, the final step in the MAORI model is to ***Iterate***. Thus, after Measuring your greenhouse emissions, Avoiding the easily avoided emissions, Offsetting the rest, and then starting to Reduce your emissions in the long-term, the next step is to Iterate the process and go back around and do it all again next year. Next year, your Measurements should show a reduction in emissions (from those that were easily Avoided and those that you have already been able to Reduce). Your early experience may now show a few more emissions that can be easily Avoided. In year 2, you will still need to Offset what you haven't been able to Avoid or Reduce, but the amount of Offsets required in year 2 should be less than what was required in year 1. Indeed, the true test of the success of the MAORI model is that the offsets should reduce year by year until they reach a minimum level. This minimum level will be unlikely to be zero (since some travel and some emissions will almost always be occurring), but the need for offsets should be reduced year by year. This is particularly relevant in the transport sector, where zero-emission transport fleets are unlikely to ever be developed, and where some level of offsetting will always be required.

The MAORI model of Carbon Neutrality is applicable at the level of the Individual, the Household, the Organization and the Government. It provides a holistic process which enables short-term and long-term strategies to be implemented, with a view to achieving greenhouse emission reductions of sufficient magnitude, and with sufficient speed, to contain global warming within manageable bounds.

The rest of this paper attempts to address two elements of the MAORI model; Measurement and Offsetting. It does not specifically address Avoiding and Reducing greenhouse gas emitting activities in the transport sector, but does not deny that such activities also need to be undertaken in parallel.

3 Greenhouse Emissions from Australian Land Transport

The estimation of greenhouse emissions from Australian land-based transport (excluding trains and trams) is based on a threefold process of estimating:

- The size of the fleet of different vehicle types
- The usage of different types of vehicle
- The emissions from different types of vehicle

Data for this analysis is drawn primarily from the ABS Survey of Motor Vehicle Usage 2005 (ABS, 2006a), and the Australian Greenhouse Office Workbook of Factors for Greenhouse Emissions (AGO, 2006).

A previous paper (Richardson, 2007) has detailed the estimation of these emissions and will not be repeated here. Total emissions from the Australian land transport fleet are summarised in Table 1. It can be seen that the total emissions are about 80 million tones of CO_2-e per year, with over half coming from passenger vehicles and about 35% coming from trucks and light commercial vehicles.

Table 1 – Total Greenhouse Emissions (1000t CO_2-e p.a.) by Vehicle Type by State

	State of Vehicle Registration								
Vehicle Type	NSW	VIC	QLD	WA	SA	TAS	ACT	NT	TOTAL
Passenger Vehicles	14423417	11973967	9323855	4820353	3244987	1116539	785756	273577	45962452
Motorcycles	50820	60471	54590	23676	13874	4072	5278	2714	215493
Light Commercial Vehicles	3659760	2436304	3044142	1303016	823888	402043	105726	164070	11938950
Rigid Trucks	2096268	1559280	1806312	607944	369672	163812	53436	63948	6720672
Articulated Trucks	2251452	3231129	2564883	964908	984600	223176	42666	90255	10353069
Non-Freight Carrying Trucks	44835	80115	42630	25725	8085	4410	2205	2940	210945
Buses	462555	347130	355680	191520	112005	35910	25650	55575	1586025
TOTAL	22989106	19688396	17192092	7937142	5557111	1949962	1020718	653080	76987606

4 An Option for Offsetting Transport Emissions

If it is assumed, as a worst case scenario, that no reductions in kilometres travelled and no improvements in fuel efficiency can be made in the first instance, then a total of about 80 million tonnes of CO_2-e would need to be offset per year to make the land-transport sector "carbon neutral". While such an objective is unrealistic in the short-term, it is informative to see what would be required if this were to be attempted.

While there are many options available for offsetting emissions, it will be assumed in this paper that all the offsetting will be undertaken by way of tree-planting in plantations that are destined for eventual harvesting.

It is recognized that one of the assumptions in the Kyoto Protocol about carbon sequestration in plantations is that if the plantation is harvested at some point in the future, then all the carbon that has been sequestered during the life of the plantation is immediately released back into the atmosphere. The credits that have been accrued during the life of the plantation must then be repaid. While re-planting the trees will allow further sequestration in a new plantation, the sequestration during the initial plantation growth is assumed to be forfeited upon harvesting of that plantation. As a result of this assumption, plantations developed for carbon sequestration purposes have therefore generally been assumed to exist in perpetuity, with no plans for harvesting.

The Kyoto Protocol regulations for carbon trading assume that all carbon is released back to the environment at the moment of harvesting (primarily because of the current difficulties with auditing the history of the timber once harvesting has taken place, and with allocating the sequestration to the appropriate party in an international context). It is clear, however, that carbon will continue to be sequestered for as long as the timber product is in existence. For example, Jaakko Pöyry Consulting (1999) show that many timber products have extended service life spans from 3 years (for paper and paper products) up to 90 years (for timber used in house construction). Ximenes et al. (2005) and Ximenes et al. (2006) go even further and show that carbon continues to be sequestered in timber products well beyond their service life spans, depending on how the products are finally disposed of at the end of their service life. They conclude that approximately 70% of the carbon from harvested logs in Australia is in equivalent long-term storage in forest products. For this reason, the TreeSmart program is based on carbon sequestration in trees that are destined for eventual harvesting and re-planting.

Research conducted by TreeSmart Australia (Richardson, 2005) has also shown that there are several major advantages of harvesting a plantation primarily designed for carbon sequestration.

- By harvesting trees which have reached maturity (and effectively stopped absorbing carbon dioxide) and replacing them with a new planting of rapidly growing younger trees, the total sequestration can be increased over the long-term compared to leaving the original plantation in place;
- By growing the trees for eventual harvesting as sawlogs, a significant proportion of the carbon in the trees can continue to be sequestered in long-lived timber products (while the next plantation of trees starts sequestering more carbon in the new living trees);
- The wood not used for sawlogs (e.g. thinnings, prunings and other harvest and processing residue, which comprises about 70% of the volume of a harvested tree) can be used as a fuel substitute, whereby wood burnt efficiently is substituted for other fossil fuels. While the burning of the wood is carbon neutral (since the growing trees only recently sequestered the carbon that is now being released), the carbon that would have

been released from the fossil fuel (that is now not burnt) is now effectively sequestered for a longer period of time. This is especially important in Victoria, where most electricity is generated by the burning of brown coal, which is a particularly significant source of CO_2 emissions. It has been estimated (Ximenes and Davies, 2004), that the release of 1 tonne of CO_2 by the burning of wood for power generation saves about 3.5 tonnes of CO_2 from being released from brown coal for the production of the same amount of electrical power;

- By having another incentive for growing the trees (i.e to harvest them), plantation owners are more likely to take better care of the trees, and undertake regular monitoring, resulting in lower mortality rates and higher growth rates in the trees;
- By having the sequestered carbon in more than one asset (i.e. living trees and timber products) the sequestered carbon is better protected from catastrophic damage by fire and other natural causes, by diversifying the portfolio of sequestration pools;
- The income derived from carbon sequestration is a valuable "off-farm" income source for many farmers;
- The encouragement of harvested eucalypt plantations provides an alternative source of hardwood timbers, compared to native forests; and
- The income obtained from harvesting cross-subsidises the costs involved in planting for sequestration, thereby improving the cost-effectiveness of the carbon sequestration.

The results of the research are succinctly summarised in Figure 1, which compares long-term sequestration in perpetual (unharvested) forests and harvested plantations.

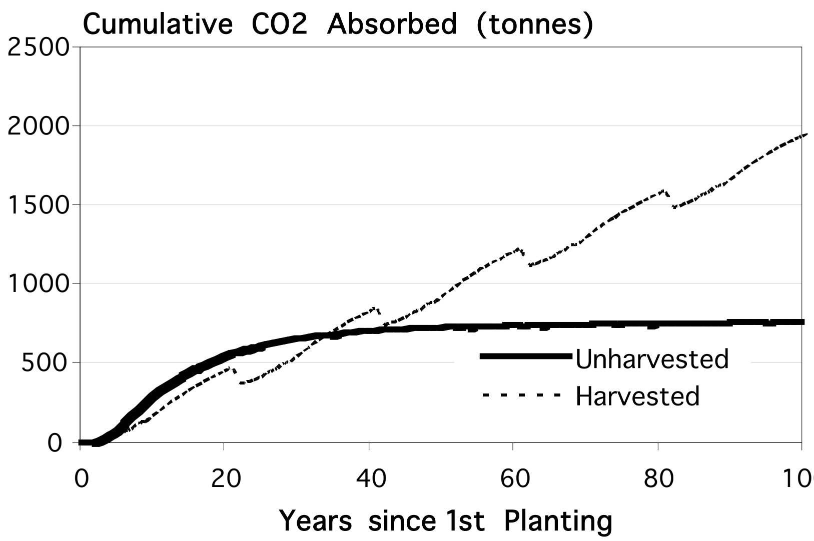


Figure 1 – Comparison of Unharvested and Harvested Plantation Sequestration

While unharvested plantations initially sequester more carbon, because they are not subjected to a pruning and thinning regime, they effectively stop sequestering carbon after about 30-40 years. On the other hand, the sequestration in harvested plantations, and their harvest products, keeps increasing at an approximately constant rate (with periodic fluctuations) so long as the plantation continues to be replanted after each harvest.

Taking account of the costs and revenues of establishing and managing unharvested and harvested plantations, and assuming that all costs, revenues AND sequestered carbon is subject to a common economic discount rate (to recognise the fact that costs, revenues and sequestrations that occur this year are worth more that the same costs, revenues and sequestrations occurring in 100 years time) (Boscolo et al, 1998), it has been shown that (over a 100-year project lifetime) harvested plantations absorb more CO_2 than unharvested plantations and do so with a cost-effectiveness that is at least three to four times greater than for an unharvested plantation.

This situation has gradually been recognized and accepted by many in the carbon sequestration and emissions trading community. Indeed, the recent report of the Prime Ministerial Task Group on Emissions Trading concluded that "Current methodologies in international emissions accounting assume that all carbon within a tree is emitted upon harvest. However, carbon remains locked in the timber until it decays. Australia should make it a priority to explore and demonstrate more rigorous methodologies for plantation offsets, which take into account the carbon contained in harvested wood products" (Chap. 6.3.2, Report of the Task Group on Emissions Trading, 2007).

4.1 The Extent and Cost of Required Offsets

Assume, for the moment, that all the offsetting of land-transport emissions is to be done by way of tree-planting programs in harvested plantations. The question that arises is how much tree planting would need to be done, and how much would it cost? Richardson (2005) has shown that a harvested eucalypt plantation growing at an average rate of 16 m3/ha/year over a 20-year rotation would sequester an average of about 20 tonnes CO_2 per hectare per year (in the early years of the plantation, the rate of sequestration would be lower than this, but in the middle years of the rotation (year 5-15) the rate of sequestration would be higher than this average rate).

At this rate of tree growth and sequestration (which would be typical of areas with an annual rainfall of 600-700mm), the required hectares of plantation would be as shown in Table 2.

Table 2 – Hectares of Plantation Required for Offsetting by Vehicle Type by State

	State of Vehicle Registration								
Vehicle Type	NSW	VIC	QLD	WA	SA	TAS	ACT	NT	TOTAL
Passenger Vehicles	721171	598698	466193	241018	162249	55827	39288	13679	2298123
Motorcycles	2541	3024	2729	1184	694	204	264	136	10775
Light Commercial Vehicles	182988	121815	152207	65151	41194	20102	5286	8204	596948
Rigid Trucks	104813	77964	90316	30397	18484	8191	2672	3197	336034
Articulated Trucks	112573	161556	128244	48245	49230	11159	2133	4513	517653
Non-Freight Carrying Trucks	2242	4006	2132	1286	404	221	110	147	10547
Buses	23128	17357	17784	9576	5600	1796	1283	2779	79301
TOTAL	1149455	984420	859605	396857	277856	97498	51036	32654	3849380

The area of plantation required would be inversely proportional to the average rainfall. Under the assumed conditions, approximately 4 million hectares of plantation would be required to offset

100% of the land-transport emissions. To put this in perspective, Victoria would require nearly one million hectares of plantation, and the bushfires in Victoria over summer 2006-07 consumed about 1.3 million hectares of forest.

Note that, once planted, these hectares of plantation can be re-used on an ongoing basis to offset emissions in future years, because the increase in sequestration each year is being used to offset the transport emissions each year. That is, the 4 million hectares would be the total amount of forest required, and this amount would not need to be re-planted every year. Indeed, no re-planting would be needed until the trees are harvested, and then the same land could be used again for the next plantation. This is different to some early models of tree-planting sequestration (e.g. Greenfleet) where one year's vehicle emissions were offset by a lifetime of sequestration in a small number of trees. Another year of emissions would require more trees to be planted, since the existing trees would still be sequestering the emissions from the original subscription. Such a model will be untenable in future carbon trading schemes, where "future borrowing" of sequestration will not be allowed to offset current emissions.

4.2 Paying for the Offsets

The question then arises as to the likely cost of such a tree planting exercise. If the trees are being planted for other reasons, such as salinity control or the production of timber products or bioenergy from harvested plantations, then not all of the cost of planting and maintenance need be borne by carbon sequestration payments (this is another advantage of using harvested plantations that generate other income streams). Rather, the cost of offsetting will be determined by the market price of sequestered carbon. This cost will depend on whether the carbon is being bought in a mandatory market (such as in Europe) or in a voluntary market (such as currently in Australia). The cost in a mandatory market will be higher than in a voluntary market. Even though Australia does not yet have a formal carbon trading system, there are a number of voluntary offset programs in place, where individuals and organizations can offset their emissions. A review of the websites for these programs shows that the average cost per tonne of CO_2 is approximately $12 (this is also the average price submitted in a recent tender process to offset the emissions of the Victorian Government vehicle fleet). If this price of $12/tonne is accepted for the moment, then the total cost for offsetting 100% of land-transport emissions in Australia would be approximately $1 billion per year.

A final question is how this cost could be paid, and by whom. It is possible that the cost could be met by Government (perhaps shared between Federal and State Governments) if it was seen that such expenditure was in the national interest. While this is clearly the case, it is unlikely that governments would meet the entire cost of this investment because of perceived budgetary constraints. In addition, it may be perceived as desirable if the costs of the offsets were charged as user-pays contributions, so that the cost of the polluting activities was made more obvious to those parties creating the pollution. In such a situation, three user-pays options present themselves, with payments being charged on a per-vehicle, per-kilometre or per-litre basis.

Annual Compulsory Environmental Insurance (CEI)

If offset costs were charged to travellers on an annual per-vehicle basis, this could be included in annual vehicle registration charges. Just as Compulsory Third-Party Insurance (CTPI) is automatically added to vehicle registration charges each year to cover the possible personal damage caused to third parties in motor accidents, so a Compulsory Environmental Insurance (CEI) could be added to cover the possible damage caused to the environment through motoring. If the costs of offsetting were spread across all vehicles (within each state and vehicle class), then the average CEI annual costs would be approximately $67/vehicle/year. Passenger vehicles would be required to pay an annual CEI Premium of $50 p.a. (compared to about $200-$300 for CTPI, depending on type of vehicle and location of registration), while large articulated trucks would be required to pay a CEI of about $1800 p.a., because of the longer distances travelled and their higher fuel consumption (and hence greenhouse emissions).

While CEI would be relatively simple to administer, since there is an existing administration system in place in all states and there is already a comparable product in CTPI from which to draw experience, it would not be the most equitable system of user-pays charging. Firstly, it would be best to have a different CEI Premium for different size vehicles and for vehicles using different fuel types. While this would be possible, it would add to the complexity of the system. Importantly, however, it would not allow for the different usage of vehicles of similar size and fuel type. A vehicle travelling 5,000km/year would be charged the same CEI as a vehicle travelling 50,000km/year. Clearly, such a system would not convey the proper market signals to encourage users to travel less.

Per-kilometre Offsetting Costs

An attempt could be made to introduce distance travelled into a user-pays CEI charge by charging vehicles on the basis of distance travelled, where the total cost within each state and vehicle class is divided by the kilometres travelled within that group. It can be seen that the overall CEI cost per kilometre travelled is 0.4 cents/km, rising to 2.0 cents/km for articulated trucks. While it is doubtful that a workable administrative system could be developed to implement these charges (short of fitting each vehicle with a GPS system, as is done in some European heavy vehicle road pricing schemes), this method is useful in highlighting the relatively low cost of CEI compared to the overall costs of motoring. Motoring organizations around Australia (e.g. NRMA, RACV) release figures annually showing the total costs of vehicle ownership and operation. While varying by age and type of vehicle, a figure of 50 cents/km is often taken as a reasonable average cost. This would suggest that the CEI cost (at 0.4 cents/km) is about 1% of the total cost of owning and operating a vehicle. This figure can be confirmed by considering the results from the 2003-04 Household Expenditure Survey conducted by the ABS (ABS, 2006b), in which it was found that the average household spent $140/week on transport (most of which was spent on motor vehicles). This equates to about $7000 p.a. Given that the average household has 1.5 vehicles, which would cost $75 p.a. for CEI Premiums, this again shows that the cost of the CEI is about 1% of the total current expenditure on vehicle ownership and operation.

Fuel Surcharge Offsetting Payment

The disadvantages of the annual and per-kilometre CEI payments are overcome to a great extent by adopting a per-litre fuel surcharge as a way of meeting the costs of offsetting. This has the advantage of ensuring that the payments made are directly related to the amount of fuel consumed (which will be a function of the type and size of the vehicle and the distance travelled by the vehicle) and can also be varied by the type of fuel consumed (which have different Fuel Factors in terms of kg CO_2/litre fuel). This method also has the advantage that an administrative system is already in place for the collection of various fuel taxes, so that adding the CEI surcharge on top (or replacing an existing tax with the CEI surcharge) would be a relatively simple procedure.

If the total cost of the offsetting was divided by the number of litres of fuel used in each state and vehicle class, a simple fuel surcharge rate emerges for each type of fuel (since emissions and hence offsetting costs are directly proportional to litres of fuel consumed). For petrol, the CEI surcharge would be 3.1 cents/litre, while for diesel, the surcharge would be 3.6 cents/litre (other fuel types would have their own rates, but they are not calculated in this paper). Given that the average cost of petrol is around $1.30/litre (at time of writing), it can be seen that the CEI surcharge would be less than the daily fluctuations of petrol price at the pump.

So long as consumers saw that the CEI surcharge was actually being used to remove CO_2 from the atmosphere, and was not just another fuel tax, public acceptance of such a payment should be reasonable. A random survey of 1000 Australian households in February 2007 (conducted for TreeSmart Australia by I-view Pty Ltd, as part of their ongoing omnibus surveys) showed that among the 890 licenced drivers in the sample, 70% were willing to pay an extra 3 cents/litre if they knew that the money was going to be used to offset their greenhouse emissions. Those aged under 35 were more willing to pay (83% willing to pay) than those aged over 55 (59%). Those with children in the household were more willing to pay (75%) than those without children in the household (65%)..

5 International Aviation Offsetting

While land transport is a very significant source of greenhouse emissions (80 million tonnes CO_2-e in Australian each year), an emerging problem is international aviation to and from Australia. While global air travel emissions are estimated at only 2% of the total, compared to 15% for land transport, the situation is different in Australia, given Australia's geographic isolation. As will be seen later, greenhouse emissions from international air travel to and from Australia is comparable in size to Australia's land transport emissions. This is a potentially serious issue which has not yet been fully recognised (perhaps because aviation was not included in the original Kyoto Protocol).

To illustrate the magnitude of the issue, consider the scale of Australian inbound and outbound tourism using international aviation. Using 2006 data from Tourism Research Australia (Tourism Forecast Committee, 2006), Table 3 shows the number and origin of inbound tourism trips (nearly all of which use air travel), while Table 4 shows the number and destination of outbound tourism trips. Note that in this context, "tourism" includes more than just holiday trips, and covers business and family trips as well. The tables also show the CO_2-e emissions factors for each flight, which accounts for the radiative forcing effect, using a factor of 2.7 (Commission for Integrated Transport, 2003), and the total emissions for each origin/destination flight.

Table 3 – Inbound Tourism Trips, 2006

Origin Country	Number of Tourists	Average One-way Distance	kg CO2-e/pax.km	Total t CO2-e
New Zealand	672000	2212	0.42	1,253,231
Japan	813000	7831	0.37	4,771,554
United Kingdom	368000	17000	0.30	3,732,798
United States	317000	14454	0.32	2,928,358
China	54000	7886	0.37	318,777
Singapore	223000	6306	0.39	1,089,703
Korea	228000	8336	0.37	1,408,483
Malaysia	134000	6617	0.38	682,529
Hong Kong	153000	7380	0.38	854,716
Germany	125000	16116	0.31	1,231,650
India	21000	10435	0.35	154,726
Indonesia	154000	5530	0.39	670,902
Taiwan	159000	7268	0.38	876,923
Thailand	89000	7541	0.38	506,231
Middle East	33000	12789	0.33	281,440
Other Asia	62000	8753	0.37	398,377
France	35000	16966	0.30	354,644
Ireland	21000	17231	0.30	214,509
Italy	41000	16325	0.30	406,892
Netherlands	39000	16654	0.30	391,285
Switzerland	39000	16580	0.30	390,338
Other Europe	130000	15988	0.31	1,275,187
Canada	61000	14320	0.32	560,215
South Africa	43000	11079	0.35	331,267
Rest Of World	203000	9134	0.36	1,349,475
TOTAL	4217000	9134	0.36	26,434,209

Table 4 – Outbound Tourism Trips, 2006

Destination Country	Number of Tourists	Average One-way Distance	kg CO2-e/pax.km	Total t CO2-e
New Zealand	865000	2212	0.42	1,613,162
United States	440000	14454	0.32	4,064,598
United Kingdom	413000	17000	0.30	4,189,254
Indonesia	195000	5530	0.39	849,519
Hong Kong	196000	7380	0.38	1,094,930
Singapore	211000	6306	0.39	1,031,064
Thailand	288000	7541	0.38	1,638,142
Malaysia	168000	6617	0.38	855,708
Fiji	202000	4971	0.40	800,461
China	251000	7886	0.37	1,481,723
Rest Of World	1711000	7871	0.32	8,666,273
TOTAL	4940000	7871	0.32	26,284,833

It can be seen that the number of people visiting Australia is somewhat less than the number of Australians travelling overseas, but that the overseas tourists are travelling slightly further to get to Australia than the Australians are travelling to their overseas destinations. As a result, the total emissions for each group is about 26 million tonnes CO_2-e per year (compared to 80 million for land transport).

To illustrate the economic implications of offsetting these emissions, Table 5 shows the area of harvested plantations that would need to be planted to totally offset these annual emissions, the average cost of these offsets per return flight for each traveller, and the total cost of offsets for each origin country. It can be seen that 1.3 million hectares would need to be planted, at a total offset cost of $317 million, which equates to about $75 per return trip per traveller (similar calculations have been performed for outbound tourism, yielding an average offset cost of $64 per return trip per traveller). For trips from the United Kingdom, the average offset cost is $122. This compares with an estimated average cost of the return flight of about $2500 (which will vary depending on the conditions attached to the ticket). Thus the offset is approximately 5% of the cost of the ticket.

To put these costs into better perspective, Table 5 also includes the estimated economic value to Australia of these inbound tourism trips from each of the origin countries (Tourism Forecast Committee, 2006). The estimated economic value of inbound tourism to Australia is approximately $22 billion per year. Thus, the cost of the offsets ($317 million) is approximately 1.5% of the economic value of the tourism. Using the UK example from above, the offset cost is 5% of the ticket cost, but the offset cost is only 1.2% of the total tourism expenditure by tourists from the UK.

Table 5 – Inbound Tourism Offsetting Costs, 2006

Origin Country	Hectare -years	Average Offset Cost	Total Offset Cost	Economic Value ($)	% of Value
New Zealand	62,662	$22	$15,038,768	$2,000,000,000	0.8%
Japan	238,578	$70	$57,258,649	$1,900,000,000	3.0%
United Kingdom	186,640	$122	$44,793,572	$3,700,000,000	1.2%
United States	146,418	$111	$35,140,296	$2,000,000,000	1.8%
China	15,939	$71	$3,825,324	$1,700,000,000	0.2%
Singapore	54,485	$59	$13,076,436	$800,000,000	1.6%
Korea	70,424	$74	$16,901,796	$1,200,000,000	1.4%
Malaysia	34,126	$61	$8,190,346	$600,000,000	1.4%
Hong Kong	42,736	$67	$10,256,592	$600,000,000	1.7%
Germany	61,582	$118	$14,779,798	$800,000,000	1.8%
India	7,736	$88	$1,856,710	$400,000,000	0.5%
Indonesia	33,545	$52	$8,050,824	$400,000,000	2.0%
Taiwan	43,846	$66	$10,523,080	$300,000,000	3.5%
Thailand	25,312	$68	$6,074,778	$300,000,000	2.0%
Middle East	14,072	$102	$3,377,274	$300,000,000	1.1%
Other Asia	19,919	$77	$4,780,521	$400,000,000	1.2%
France	17,732	$122	$4,255,726	$300,000,000	1.4%
Ireland	10,725	$123	$2,574,114	$500,000,000	0.5%
Italy	20,345	$119	$4,882,708	$300,000,000	1.6%
Netherlands	19,564	$120	$4,695,419	$300,000,000	1.6%
Switzerland	19,517	$120	$4,684,056	$300,000,000	1.6%
Other Europe	63,759	$118	$15,302,244	$1,000,000,000	1.5%
Canada	28,011	$110	$6,722,582	$600,000,000	1.1%
South Africa	16,563	$92	$3,975,202	$300,000,000	1.3%
Rest Of World	67,474	$80	$16,193,695	$700,000,000	2.3%
TOTAL	1,321,710	$75	$317,210,510	$21,700,000,000	1.5%

Given the pressure being placed on various sectors of the economy to become "carbon neutral", it might be worthwhile for the Australian Government to pro-actively offset emissions from all flights into and out of Australia by the imposition of an Environmental Landing Fee (ELF) of an average of about $70 per passenger landing (this would account for each two-way flight). This value would vary depending on the origin or destination of the flight, as shown in Table 5. The imposition of an ELF might subtract 1.5% from the economic value of tourism, but perhaps it might just safeguard the remaining 98.5% from significant downturns in the tourism market. For example, Greenpeace UK has recently been linked to an advertising campaign urging UK tourists not to fly to Australia for holidays (The Age, 2007), while the United Nations world Tourism Organisation has identified air travel emissions as a major threat to global tourism, unless addressed in the near future.

6 Conclusion

This paper has described what would be required to offset the greenhouse emissions from Australia's land-transport operations and international air travel. In the context of a model of Carbon Neutrality (the MAORI Model), the central role of offsetting has been highlighted as a way of providing immediate short-term relief from CO_2 emissions, and as a way of encouraging behavioural and technological changes that will be required for ongoing long-term relief.

Using data from the ABS and the AGO, the paper has then estimated the greenhouse emissions from Australian land-based transport (excluding trains and trams), based on:

- The size of the fleet of different vehicle types
- The usage of different types of vehicle
- The emissions from different types of vehicle

It is confirmed that the annual greenhouse emissions from Australian land-transport is about 80 million tonnes CO_2-e.

Using data from the Tourism Forecast Committee (2006), it also estimates the emissions from inbound and outbound international air travel, and shows that these annual emissions are about 50 million tonnes CO_2-e.

The paper then outlines a method for offsetting these emissions, based on the planting, maintenance, harvesting and re-planting of plantations across Australia. If all the land-transport emissions offsetting was done in this way, then it is shown that approximately 3.8 million hectares of plantation would need to be established. The international air travel would require a further 2.6 million hectares.

The cost of offsetting by tree-planting is then explored, and it is shown to cost around $1 billion/year at current carbon costs for offsetting 100% of land-transport emissions, and about $600 million for international air travel. Options for paying for the land-transport offsetting are then explored in the context of various user-pays schemes. It is shown that an annual Compulsory Environmental Insurance (CEI) included in vehicle registration charges would cost around $50 p.a. for passenger vehicles. A per-kilometre CEI charge would be around 0.4 cents/km for passenger vehicles, and this is shown to be only 1% of current household expenditures on vehicle ownership and operation. A per-litre fuel surcharge to cover CEI would be 3.1 cents/litre for petrol and 3.6 cents/litre for diesel. The air travel offsets could be paid for by an Environmental Landing Fee (ELF) of approximately $70 per passenger, which would be about 1.5% of total economic value of international tourism to Australia.

While the total costs of the offsetting appear to be quite large ($1.6 billion p.a. for land and air travel), the costs at the level of the individual are very modest when considered on a per-vehicle, per-kilometre or per-litre basis for land transport, or in comparison with total tourism expenditure for air travel. The question is not about whether we can or should offset our transport greenhouse emissions, the question is about what is the most convenient way to do so.

7 References

Australian Bureau of Statistics (2006a). *Survey of Motor Vehicle Use 2005*. ABS Publication 9208.0.

Australian Bureau of Statistics (2006b). *Household Expenditure Survey 2003-04*. ABS Publication 6530.0.

Australian Greenhouse Office (2006). *AGO Factors and Methods Workbook. December 2006.* Department of the Environment and Heritage (www.greenhouse.gov.au/workbook).

Boscolo, M., Vincent, J.R. and Panayotou, T (1998). *Discounting Costs and Benefits in Carbon Sequestration Projects*. Development Discussion Paper 638, Harvard Institute for International Development, Harvard University, Boston

Commission for Integrated Transport (2003), United Kingdom, (www.cfit.gov.uk/docs/2003/aec)

Flannery, T (2005). *The Weather Makers: The History and Future Impact of Climate Change.* The Text Publishing Company: Melbourne

Forsyth, P. (2007). *Carbon policies to hurt tourism.* The Age, 4 October 2007. http://www.theage.com.au/articles/2007/10/03/1191091193301.html

Gore, A. (2006). *An Inconvenient Truth: The Planetary Emergency of Global Warming and what we can do about it*. Bloomsbury Publishing: London.

Jaakko Pöyry Consulting (1999). *Usage and Life Cycle of Wood Products*. Technical Report No. 8, Australian Greenhouse Office, Canberra

Macintosh, A. and Downie, C. (2007). *A Flight Risk? Aviation and climate change in Australia*. Discussion Paper 94, The Australia Institute.

Richardson, A.J. (2005). "The Cost-Effectiveness of Carbon Sequestration in Harvested and Unharvested Eucalypt Plantations". *Greenhouse 2005 Conference*, Melbourne, Australia

Richardson, A.J. (2007). "Offsetting Australia's Land Transport Emissions". *30th Australasian Transport Research Forum*, Melbourne, Australia

Richardson, A.J., Seethaler, R.K. and Woodley, J.R. (2005). “TravelSmart and TreeSmart: Alternative Ways of Reducing Greenhouse Gas Levels”, *Papers of the 28th Australasian Transport Research Forum,* Sydney

Stern, N. (2006). *Stern Review: The Economics of Climate Change*. A Report to the Prime Minister and Chancellor of the Exchequer, United Kingdom.

Taormina, T. (1996). *Virtual Leadership and the ISO9000 Imperative*. Prentice-Hall, New Jersey.

Task Group on Emissions Trading (2007). *Report of the Task Group on Emissions Trading*. Department of the Prime Minister and Cabinet, Canberra, ACT.

The Age (2007). *Greenpeace denies role in anti-flying ad*. The Age, August 2, 2007.

Tourism Forecast Committee (2007), *Forecast 2007 Issue 1,* Tourism Research Australia, Canberra. ISBN 0 642 28583 7

Ximenes F., Robinson, M. and Wright, B. (2006). *Forests, Wood and Australia’s Carbon Balance*, Forest and Wood Products Research and Development Corporation and the Cooperative Research Centre for Greenhouse Accounting, Canberra.

Ximenes, F. and Davies. I. (2004). *TimberCAM – a Carbon Accounting Model for Wood and Wood Products, User’s Guide v1.15*. CRC for Greenhouse Accounting.

Ximenes, F., Gardner, D. and Cowie. A. (2005). “Tracking the Fate of Carbon in Forest Products in Australia”. *Greenhouse 2005 Conference*, Melbourne, Australia.