The Effect of Adelaide's Proposed Transit Oriented Developments in Reducing Private Car Fuel Usage and Carbon Emissions

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Abstract

In 2010, the Government of South Australia released its new strategic Plan for metropolitan Adelaide *'The 30 Year Plan for Greater Adelaide'* (30YPGA) intended to guide metropolitan Adelaide's development for the next three decades. A major initiative in this spatial Plan was the concept of reorienting the city from car based transport infrastructure towards public transit oriented infrastructure through the development of transit oriented developments (TODs) connected by light rail, rail or high speed bus corridors along transit corridors. The reasoning behind this new form of development is partly to accommodate planned population growth for the Adelaide metropolitan region of 560,000, which would boost the population of Adelaide's metropolitan region from 1.14 million in 2010 to just over 1.7 million people by 2040 and reduce the city's environmental impact from travel related carbon emissions and energy consumption. The Plan takes advantage of an existing heavy rail network, an extended light rail route and a high speed guided busway (OBahn) to support the development of 14 TODs managed by the State Government. The 30YPGA has designated a further 20 sites that incorporate transit oriented development principles and design characteristics that local governments would be expected to promote, manage and develop. Implicit in the thinking behind the 30YPGA is that a network of TODs on transit corridors would encour-

age a large modal shift from private cars to public transit for commuting trips. This paper models and predicts the magnitude of the environmental benefit of the proposed transit improvements to metropolitan Adelaide's public transport networks by analyzing journey to work census data (by modal choice) for commuting trips to and from Adelaide's suburbs to the Central Business District (CBD). The paper then concludes with planning recommendations in light of the modeled results.

1. Introduction

In the 2011 Population and Housing Census (ABS, Community Profiles, 2013), the preferred modal choice for the bulk of journey-to-work commuting of people who travelled to work in metropolitan Adelaide (as defined by the Adelaide Statistical Division) on the day of the 2011 Census was done in private motor vehicles, predominantly as a driver, accounting for 77.0% of commuting trips, and a further 6.6% of commuting trips were as a car passenger. Public transport commuting by train only carried 3.0% of commuters, despite the existence of a light rail and heavy rail commuter network spanning the metropolitan area. Buses by comparison accounted for 7.2% of commuting trips. Car users to Adelaide's CBD are provided with ample parking with approximately 55,000 off-street parking spaces and up to 19,000 on-street parking spaces (City of Adelaide, 2012). The actual number of commuting trips on the day of the 2011 Census across metropolitan Adelaide was 484,728 within an area that covers 3,258km^2 in a triangular zone that extends approximately 80km north to south and up to 40km at its widest point over east to west axis with topographical relief ranging from sea level up to nearly 700m above sea level. Although much of the metropolitan area is on a gently sloping plain rising from the Gulf St Vincent along the city's western flank to the Mount Lofty Ranges on its eastern flank, at least a third of the city is in hilly terrain that constrains the delivery of accessible and frequent public transport. The structure of Adelaide's dwelling stock with 83.5% in 2011 (*89% in 2006*) in the form of single houses and 6.9% (*4.1% in 2006*) as apartments reflects a change to increased urban densities, but nevertheless it is still a city of very low overall densities (with a gross residential density of 0.4 dwellings/ha) (ABS, Community Profiles, 2007), a further factor that confounds the efficient and economically viable provisioning of public transport.

Adelaide's metropolitan area is mono-centric in nature with a strongly dominant CBD accommodating a weekday population of 228,673 persons (of which 118,200 persons are employees and 86,700 are students) and 19,640 permanent residents within the City of Adelaide. The City of Adelaide has a target to increase this population to 40,000 persons by 2031. The current metropolitan Adelaide population was 1.26 million in 2012. Transport networks (three rail routes, one light rail route, one guided busway and 16 roads), radiate out from the CBD and into the metropolitan region. The centres that do exist within the metropolitan area outside the CBD tend to be regional shopping malls at major transport nodes or district shopping centres, however, the non-CBD employment of 391,069 (77% of Adelaide's workforce), tends to be dispersed in locations across the metropolitan area, although there are pockets of concentrated employment at Bedford Park (which has a university, office park and hospital) in Adelaide's southern suburbs and at Mawson Lakes (a university, office park and modest commercial development) in Adelaide's northern suburbs. The regional centre of Elizabeth, 28km northeast of Adelaide's CBD, which was originally conceived as a new satellite town in 1955 independent of Adelaide and utilized the British New Town model for inspiration, does have industrial employment including the massive General Motors Holden car manufacturing plant and a large number of automotive suppliers (Hutchings, 2007). The implication of this pattern of development on commuters' travel patterns has resulted in very large tidal commuter flows, predominantly as car drivers, into and out of the Adelaide CBD during peak business hours on weekdays (i.e. 7am-9am, and 4pm-7pm)

Recognizing that a mono-centric metropolitan pattern of very low density car oriented urban development was environmentally unsustainable and inefficient, the South Australian Government launched their 30 Year Plan for Greater Adelaide (30YPGA) in 2010 with major investments in public transit of approximately $2 billion planned (new lines, track upgrades, stations, park and ride facilities and rail electrification) (Government of South Australia, 2010). Where this Plan was a major improvement on previous iterations of strategic planning for metropolitan Adelaide was in proposing a network of 14 Transit Oriented Developments (TODs) accommodating 60,000 new dwellings (4,286 dwellings/TOD) (see table 1) with a further 20 centres designated to incorporate TOD 'principles and design characteristics' (Government of South Australia, 2010, p78). Priority developments were highlighted as Bowden Village, Cheltenham/Woodville, Keswick/Wayville, Marion/Oaklands, Noarlunga, Port Adelaide and Tonsley/Bedford Park. Figure 1 illustrates the 30YPGA's strategic plan for a network of TODs and transit corridors envisaged for metropolitan Adelaide by 2040. The concept of a TOD as defined in the 30YPGA was that it was to be a mixed use, higher density development serviced by a major public transport station or interchange. These TODs would accommodate residential development of higher densities, retail services, employment activities and high quality public open spaces. Importantly, from the Strategy's design principles, they are intended to be self-contained, accessible and walkable communities allowing residents to partake in a complete lifestyle without having to commute elsewhere.

Table 1: Transit Oriented Developments and Transit Station Improvements designated in Adelaide's 30 Year Plan for Greater Adelaide

TODs	30YPGA designation
Bedford Park	Rail TOD
Bowden	Tram and Rail TOD (with nearby park & ride)
Elizabeth	Rail TOD with transit interchange
Gawler	Rail with Planned Park & Ride Station
Glenelg	Tram TOD
Hallett Cove	Rail with Planned Park & Ride Station
Mawson Lakes	Rail TOD with transit interchange with park & ride
Modbury	Bus (Obahn) TOD with Planned Park & Ride
Munno Para	Rail with Transport Interchange upgrade
Noarlunga Downs	Rail TOD with transit interchange
Oaklands Park	Rail TOD with transit interchange
Port Adelaide	Rail TOD and transport interchange upgrade
Salisbury	Rail TOD with transit interchange
Smithfield	Rail Transport Interchange with Park & Ride
Wayville	Rail TOD
West Lakes	Bus now, (tram in future) TOD
Woodville	Rail TOD

However, judging by the experience thus far with metropolitan Perth, an Australian city with similar urban morphology to Adelaide, albeit somewhat larger (1.8 million people), and which is much further advanced with investments in a complete modern commuter rail transit system, Perth has not transitioned beyond park and ride commuter railway stations despite clear strategic planning intentions for an eventual TOD commuter railway network (Curtis et. al. (2012) and Olaru et. al. (2011)). In the short to medium term, this means that the initial benefit from a network of TODs across metropolitan Adelaide should result in suburban commuters travelling to Adelaide's CBD opting to switch their travel mode from car based commuting to public transit via a TOD or transport node. For non-CBD commuting to suburban jobs in Adelaide, because of the lack of cross metropolitan public transit routes

Figure 1: Proposed TODs in the 30YPGA (South Australia, 2010)

and the highly dispersed nature of suburban jobs (i.e. with poor locational matching of suburban jobs to housing), it is likely that the majority of commuters will continue to drive their private car to work. Table 2 examines the share of car driver commuting trips as a proportion of total journey to work commuting trips for each of Adelaide's proposed TODs and upgraded stations. These range from 54.7% for West Lakes (a wealthy area but with diesel buses currently the only public transit offering) to as little as 24.7% for Bowden, the closest proposed TOD to Adelaide's CBD in an area that is close enough to walk and cycle to Adelaide's CBD which has transit rich offerings (rail, tram and bus routes) with high service frequencies and a multiplicity of route destinations.

Table 2: Share of TOD Car Driver Commuter Trips to Adelaide CBD

TODs	Daily work commuter trips (car as driver) to Adelaide CBD 2006 ABS Census	Total daily work commuter trips (to Adelaide CBD) 2006 ABS Census	Share of Car as Driver Trips of total trips
Bedford Park	40	91	44.0%
Bowden	22	89	24.7%
Elizabeth	7	24	29.2%
Gawler	7	26	26.9%
Glenelg	129	317	40.7%
Hallett Cove	381	1,121	34.0%
Mawson Lakes	193	463	41.7%
Modbury	112	331	33.8%
Munno Para	14	42	33.3%
Noarlunga Downs	43	117	36.8%
Oaklands Park	63	221	28.5%
Port Adelaide	35	82	42.7%
Salisbury	86	271	31.7%
Smithfield	12	44	27.3%
Wayville	128	348	36.8%
West Lakes	282	516	54.7%
Woodville	67	170	39.4%
TOTAL	1621	4273	37.9%

What is somewhat confounding from the statistics of car usage in Adelaide is that the per capita per annum motor vehicle travel is amongst the lowest for all of the Australian capital cities (9,400km/annum/vehicle compared to Melbourne at 13,200km/annum /vehicle), despite Adelaide being the most car dependent of Australian cities by modal share (ABS, 2011). Table 3 details driving distances for commuters (both individually and in aggregate) for the population and housing census data (ABS, 2007).

Hence, with this context in mind, the main objective of this research project was to investigate what the fuel savings (and by proxy, the energy and carbon emissions) would be for suburban commuters of Adelaide suburbs to Adelaide CBD if they switched their commuter travel mode from driving a private motor vehicle to public transport using the most relevant part of the planned network of TODs in metropolitan Adelaide as set out in the 30YPGA.

Table 3: Car Commuting Travel Distances, TODs to Adelaide CBD

TODs	Car Drivers (2006) ABS Census TODs to Adelaide CBD	Daily work commuter trips Distance to Adelaide CBD by road (km)	Aggregate Daily work commuter trips distances TODs to Adelaide CBD by road (km)
Bedford Park	40	12.1	484
Bowden	22	4.9	108
Elizabeth	7	27.9	195
Gawler	7	39.2	274
Glenelg	129	11.1	1,432
Hallett Cove	381	23.3	8,877
Mawson Lakes	193	15.7	3,030
Modbury	112	15.0	1,680
Munno Para	14	32.3	452
Noarlunga Downs	43	33.5	1,441
Oaklands Park	63	13.2	832
Port Adelaide	35	15.7	550
Salisbury	86	20.2	1,737
Smithfield	12	31.0	372
Wayville	128	3.1	397
West Lakes	282	14.3	4,033
Woodville	67	9.5	637
SubTOTAL (TODs & 30YPGA upgrades):	1,621		26,530
TOTAL (Metro. Adel.	39,385		487,877
Average commute (km): All Adelaide suburbs to CBD		12.4	
Average commute (km): TODs to CBD		16.4	

2. Past Research

The conceptual understanding of TODs in terms of its key design principles (i.e. a transit network with higher urban densities around each transit node) is not particularly new in the history of urban planning. When London's underground rail network came into being in the mid-19th century spurring the growth of far flung villages and suburbs in London's metropolitan area, urban development in the form of the contemporary definition of TODs was recognizable. Newman & Kenworthy (1989) have conceptualized well the phenomenon of the transit oriented city and its relation to metropolitan urban form. The contemporary concept of a TOD has been thoroughly developed in the United States over the past 4 decades, commencing with various rail based mass urban public transport schemes such as San Francisco/ Oakland's Bay Area Rapid Transit (BART), Metropolitan Atlanta Rapid Transit Authority (MARTA), Washington D.C.'s Metropolitan Area Transit Agency (WMATA) in the 1970s and most recently culminating in TriMet's network of TODs in Portland, Oregon since the 1980s (Dittmar & Poticha (2004); Cevero (1998); Adler & Dill (2004)). The American experiences with TODs and their effect in attracting commuters to public transit has the greatest relevance to Adelaide, and indeed, the South Australian Government were so impressed by what Portland (Oregon) in the US achieved in establishing light rail and TODs in Portland that the former head of TriMet, Fred Hanson was appointed Chief Executive Office of Adelaide's Urban Renewal Authority an organization with the expressed intent of implementing the urban development objectives of the 30YPGA (Renewal SA, 2012). The principal shortcoming of work in the area of TODs is that it has there is an absence of research on what the specific reductions in fuel consumption and carbon emissions are when TODs and investment in major public transit systems are developed in metropolitan areas, particularly for suburb to CBD commuting.

Gilbert and Perl's (2009) entitled '*Transport Revolutions: Moving People and Freight Without Oil'* provided case studies for the United States and China that envisaged what the transport scene would look like in 2025 based on a number of assumptions based on current trends of oil availability, production capacity and global demand. Their techniques for providing estimates for 2025 were somewhat opaque, however, they predicted that personal local travel in the US would have to be reduced by 45% with substantial modal shifts to electric cars and more modest shifts to electrically powered public transit (11.9% of total trips). For China, the prediction was for local area personal travel to almost double with electrically powered public transit accounting for 23.5% of trips. The focus in Gilbert and Perl's work is on transport solutions with little mention of the changes to urban form that would be needed to make increased public transit usage a likely outcome.

The most relevant body of research in the context of Australian cities on the issue of oil consumption (i.e. petroleum motor fuels) is Dodson and Sipe's (2008) Griffith University research paper entitled "Unsettling Suburbia: The New Landscape of Oil and Mortgage Vulnerability in Australian Cities". Dodson and Sipe's 2008 study was a landmark research effort that attracted national attention because of its innovative use of GIS to map Australian capital city households (in Melbourne, Brisbane, Sydney, Adelaide and Perth) according to their vulnerability assessment for mortgages, petroleum, and inflation risks and expenditure (VAMPIRE). The paper's focus was primarily on the socio-economic impacts of rising oil prices, and the inflationary effects in the Australian economy of variable interest rate based housing mortgage costs and world parity oil pricing. VAMPIRE used these two variables (i.e. housing mortgage costs and oil prices), to calculate a numerical index drawing on 2001 and 2006 Australian population and housing census data which was subsequently mapped for Melbourne, Brisbane, Sydney, Adelaide and Perth. Whilst VAMPIRE was a derived index, it did not show the exact impact of fuel consumed and carbon emissions emitted for households.

3. Methodology

Journey to work cross-tabulation data for travel mode by suburb was obtained for the 2006 Census of Population and Housing for the Adelaide Statistical Division. This data is not publicly available as particular suburb to suburb journey to work cross-tabulations because it is derived data but had to be created by contracting this analysis through the Australian Bureau of Statistics. The methodology employed in that survey is beyond the scope of this paper to discuss, suffice to say that the census accurately represents the characteristics and behavior of the Australian community because it achieves a sampling of virtually the whole population due it being an enforced legal obligation to co-operate in the survey. Travel desire lines were mapped to illustrate the diversity of commuter car trips from across the Adelaide metropolitan area to Adelaide's CBD (see figure 2). Although there has been a more recent Australian national census conducted on the 9th of August 2011, at the time of this research, this census data had not yet been released for detailed analysis.

The computational process was straightforward, with macros established in a Microsoft Excel spreadsheet to multiply the average fuel likely to be consumed by a car driving commuter by the road distance on the arterial and suburban distributor road network from the centroid of the suburb to the centre of the Adelaide CBD (Victoria Square). The existing arterial and suburban distributor road network of metropolitan Adelaide, as set out in the mapping software based on Apple's iOS 6 operating system, were the basis for the mapping of suburb to city centre car commuting routes and distances. The use of a centroid in a mapped zone (in this case a suburb), is a useful technique for providing a mean of the commuting distances between a pair of zones for households within the originating commuting zone (i.e. the suburb). This was done for all of Adelaide's 402 suburbs. Apple's mapping program, using Apple's operating system iOS 6 on an Ipad3, was used to compute the most direct and practical road distance in kilometres and travel times for each suburb/city centre pairing. Apple's mapping software provided an estimate of the suburb's centroid, which on visual inspection of each suburb, appeared to be reasonably accurate. In the interests of methodological consistency, the Apple mapping derived suburb centroid was used in estimating all trip pairing distances. The actual mapping algorithms used by Apple in their mapping software is not discussed in this paper, however, all distance pairings and routes were verified with actual car commuting trips on the road network by the author and a manually cross-checked comparison was made with a conventional hard copy street directory for any obvious distance based anomalies that sometimes occurred with Apple Maps confusing a suburb entry with a street name. Often Apple's mapping software (see figure 3) provides three routing options with any suburb to suburb route estimation. In most cases, Apple's recommended route was the most logical (and readily adopted) choice for a route pairing. There had been initial glitches in Apple's mapping software when first released in Australia in 2012, but these problems did not appear to have affected the maps produced for metropolitan Adelaide. The actual amount of fuel consumed by commuters from each suburb to Adelaide's city centre was automatically calculated using a macro in the Excel spreadsheet:

$$\sum Fuel_{(1 \text{ to } n)} = \left(\sum Commuters_{(1 \text{ to } n)} \right) * E_{avg.} \times RD_{(sub.\ centroid\ to\ CBD)} \quad (1)$$

Where:

Fuel=total fuel in litres; Commuters=commuters who drive a car; n=number of commuters

E avg = Average fuel economy for the Australian passenger vehicle fleet in 2010 (11.3 litres/100km);

RD = Direct road distance from centroid of an Adelaide suburb to Adelaide CBD(i.e. Victoria Square)

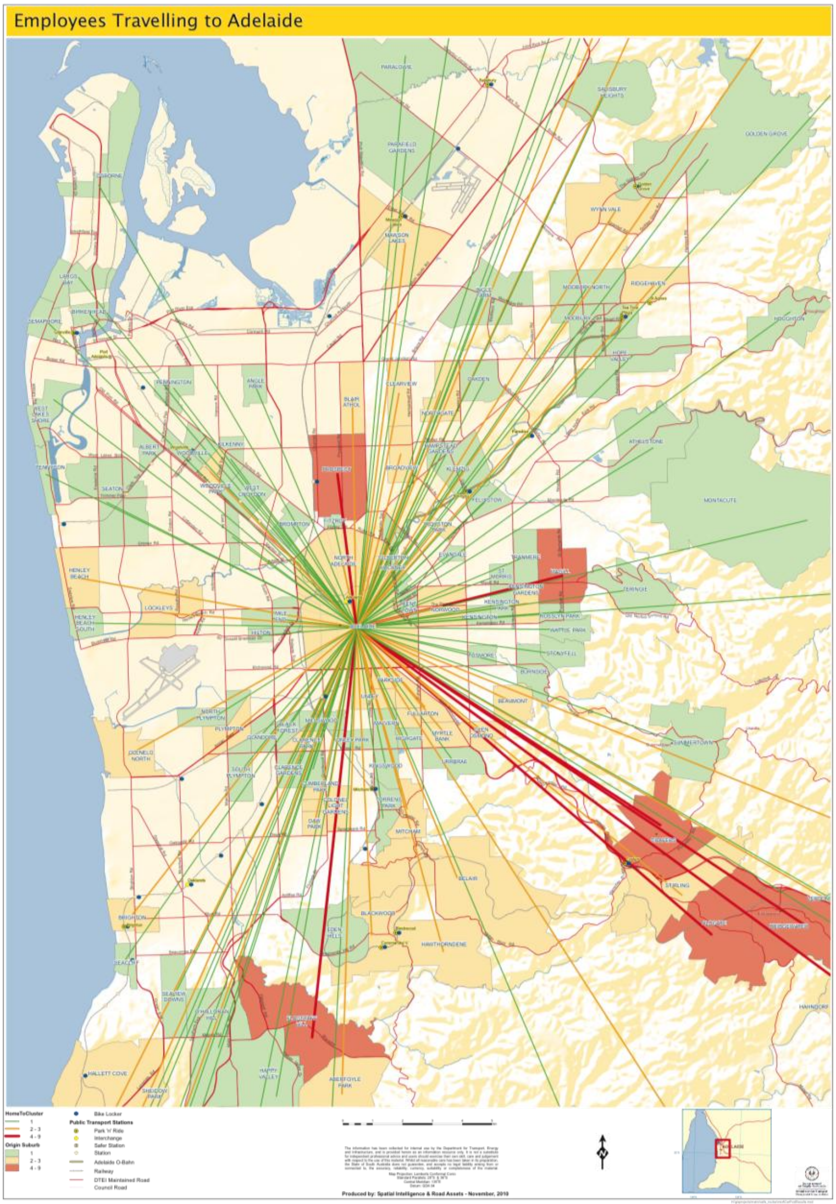

Figure 2: Employees Travelling to Adelaide illustrating travel desire lines (Government of South Australia using ABS 2006 Population & Housing Census data)

An estimate for the average carbon dioxide emissions produced for the passenger vehicular fleet was determined to be 272.5g/km (see formula (2) and energy consumption 4.08MJ/km (see formula (3), using averages for the Australian vehicle fleet was estimated by applying formula (2).

$$CO_{2\,\text{passenger fleet average g/km}} = (84\%_{\text{petrol}} * 11.1_{\text{l/100km(petrol)}} * 2.354_{\text{kg CO2/litre.petrol}}) + (8.4\%_{\text{diesel}} * 11.4_{\text{l/100km(diesel)}} * 2.681_{\text{kg CO2/litre.diesel}}) + (7.5\%_{\text{other}} * 13.6_{\text{l/100km(other)}} * 2.354_{\text{kg CO2/litre.petrol eq.}}) = 272.5 \text{ grams/km/passenger vehicle} \tag{2}$$

$$MJ_{\text{passenger fleet average MJ/km}} = (84\%_{\text{petrol}} * 11.1_{\text{l/100km(petrol)}} * 36_{\text{MJ/litre.petrol}}) + (8.4\%_{\text{diesel}} * 11.4_{\text{l/100km(diesel)}} * 37.3_{\text{MJ/litre.diesel}}) + (7.5\%_{\text{other}} * 13.6_{\text{l/100km(other)}} * 36_{\text{kg CO2/litre.petrol eq.}}) = 4.08 \text{ MJ/km/passenger vehicle} \tag{3}$$

Note: ‘other’ refers to LPG and CNG automotive fuels and petrol powered hybrid cars.

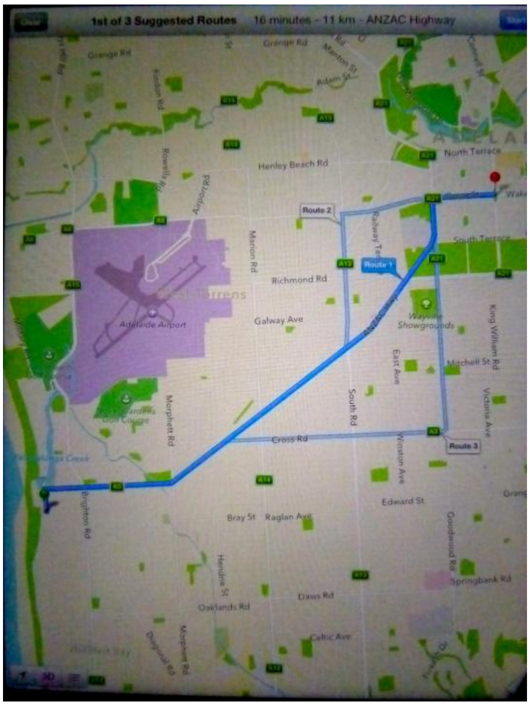

Figure 3: Screen photo showing graphical output of calculation of commuter road distances and route using the Apple IPad3 mapping software.

Average fuel consumption figures for the South Australian passenger vehicle fleet were obtained from the national survey of motor vehicle use for Australia (ABS, 2011), which was determined to be 11.3 litres/100km. South Australia can be taken as a proxy for metropolitan Adelaide because the majority of South Australia's population (77%) is in Adelaide or within urban areas of the state. The composition of the Australian motor vehicle fleet (which can be taken as a proxy for the metropolitan Adelaide motor vehicle fleet) consists of 84% petrol powered vehicles, 8.4% diesel and 7.5% for alternative fuelled vehicles (liquefied petroleum gas or compressed natural gas or dual fuel or hybrid). In 2011, electric cars have had negligible take-up in the Australian passenger vehicle market place (0.005% of sales), and even hybrid cars made up only 0.87% of sales in Australia (Campbell, 2012). This information was used to detail the volume of petroleum fuels consumed by commuters' cars for the weekday journey to work commute from TOD/interchange suburbs to Adelaide's CBD.

The research assumed that all commuters driving a motor vehicle to employment in the Adelaide CBD could switch modes from driving to public transit via the TOD or upgraded transport interchange along one of metropolitan Adelaide's transit corridors as designated in the 30YPGA. Out of the 402 suburbs/localities identified from 2006 journey to work data, a total of 13 TODs (excluding the Adelaide CBD TOD) could theoretically allow motorists to substitute their journey to work commuting trips by car with public transit trips (rail, light rail or by bus-way). There were also an additional 4 train stations that are being upgraded as transport interchanges with park and ride facilities but with a long term strategic objective to develop these stations into future TODs within the 30YPGA.

The rationale behind having complete substitution of car commuting with public transit commuting was to determine the maximum potential for reduction in car fuel usage and carbon emissions. In practice, a 100% substitution of car trips to public transit would be difficult to achieve without draconian regulatory measures that prohibit private car usage in TODs. This is because there are many variables that influence transport modal choice that are determined by behavioural, practicality and societal factors. This research has not included these factors in determining the likely uptake of public transport in TODs because it would be hypothetical and speculative, given that most of Adelaide's TODs and Transit Corridors as envisaged in the 30YPGA are yet to be built. However, a major Australian Research Council funded project is currently being conducted on the Northern Commuter Rail Corridor in Adelaide based on stated preference and revealed preference surveys examining the commuting, housing and residential location preferences of over 500 survey respondents residing in the corridor (in terms of their likelihood to embrace a TOD oriented life-style), but this research is not yet complete (Meng, Holyoak & Taylor, 2011)

The derivation of the net environmental impact of a modal switch from car commuting (as drivers) to public transit (typically rail, tram or OBahn/high speed busway), was derived by means of applying two formulas to the data set, for carbon dioxide emissions (see formula 4) and for the energy consumed (see formula 5) (see table 4). There are assumptions involved with regard to public transit because exact data on the profile of carbon emissions and energy consumption is theoretical to a large extent given that the train and tram fleet will be modernized from diesel electric to all electric units drawing their power from the electricity grid. The key assumption was that the energy and carbon emissions profiles would be equivalent to a typical public transit passenger loading for an electric commuter train, as defined by Hughes (1993, p26) and that the carbon dioxide emissions for trams and buses would be identical. In practice, however, South Australia's electricity grid network is being transformed into a 'green energy' source with 15% of electrical power already coming from wind and solar power, hence diesel and CNG buses will be relatively much more harmful to the environment than will electric rail transit. The derivation of the carbon emissions benefit was obtained by applying formula (4):

$$\sum CO_{2(\text{TODs current})} = (\sum CO_{2\,(\text{TOD to CBD car drivers})} - (\sum CO_{2\,(\text{TOD to CBD public transit users})} \quad (4)$$

Where: $CO_{2\,(\text{TOD to CBD public transit users})}$ *is 160 grams of* CO_2*/passenger.km* and $\sum CO_{2\,(\text{TOD to CBD car drivers})}$ is derived from formulas (2) and (3).

The derivation of the energy benefit was obtained by applying formula (5):

$$\sum MJ_{(\text{TODs current})} = (\sum MJ_{(\text{TOD to CBD car drivers})} - (\sum MJ_{(\text{TOD to CBD public transit users})} \quad (5)$$

4. Results and Findings

Table 4 summarizes the key findings to emerge from the analysis in this research. The current carbon dioxide emissions from motorists commuting to work on a weekday based on the 2006 Census (ABS, 2007) were 133 tonnes/day and 108.2 GJ of petroleum sourced energy were consumed.

Table 4: The environmental benefits of TODs proposed in the 30YPGA

TODs	litres of fuel/day consumed by car commuters (one way commute)	CO_2 Emissions (kg/day)	Energy Consumed (GJ/day)
Bedford Park	55	132	2.0
Bowden	12	29	0.4
Elizabeth	22	53	0.8
Gawler	31	75	1.1
Glenelg	162	390	5.8
Hallett Cove	1,003	2,419	36.2
Mawson Lakes	342	826	12.4
Modbury	190	458	6.9
Munno Para	51	123	1.8
Noarlunga Downs	163	393	5.9
Oaklands Park	94	227	3.4
Port Adelaide	62	150	2.2
Salisbury	196	473	7.1
Smithfield	42	101	1.5
Wayville	45	108	1.6
West Lakes	456	1,099	16.5
Woodville	72	173	2.6
SubTOTAL	2,998	7,229	108.2
TOTAL (current for Metropolitan Adelaide):	55,130	133,082	1,990.5
1. Environmental impact of Public transport (current car drivers switching to public trans-it)		4,245	46.4
2. Net Environmental Benefit of planned TODs and station upgrades in 30YPGA with park & ride and no density increases in TODs		2,985	61.8
3. Net Environmental Benefit of planned TODs and station upgrades in 30YPGA densi-ty increases in TODs (additional 3,000 households/TOD with substituting public transit for 648 CBD bound car trips		49, 199	736.6
4. Percentage reduction for substituting car commuting with public transit for the TODs (re-lates to row (1) above		41.3%	57.1%
5. Percentage reduction for substituting car commuting relative to the whole metropoli-tan area of Adelaide (relates to row (2) above		2.2%	3.1%
6. Percentage reduction for substituting car commuting relative to the whole metropoli-tan area of Adelaide (relates to row (3) above		26%	37%

Whilst the TODs of Mawson Lakes, Glenelg and Bowden (currently under construction), have the urban densities ultimately intended in the 30YPGA (see point (3) in table 4 for an explanation), most of the planned TODs are little more than park and ride transit stops or transit interchanges for car based commuters. Hence, under these circumstances, although the carbon emission and energy reductions in a modal switch to public transit using the TODs/transit interchanges to commute to Adelaide's CBD (as set out in the 30YPGA) by all car commuters would be 2.99 tonnes/day of carbon emissions (a 41.3% fall) and 61.8 GJ/day (a 57.1% fall), when averaged over all suburb to Adelaide CBD commuter trips, the respective reductions are very small indeed (with reductions of 2.2% for carbon emissions and 3.1% for energy consumption). If the development intentions in the 30YPGA are fully realized with approximately 3,000 additional public transit oriented households/TOD, then using current emissions data for electric public transit in South Australia, reductions of carbon emissions of 26% and 37% for energy consumption for all suburb to Adelaide CBD journey to work commuting is achievable. And if the South Australian electricity grid were to be 100% sourced from renewable power sources (such as wind, solar and geothermal which are in abundance in South Australia), then in theory, public transit commuting between Adelaide's suburban TODs and the Adelaide CBD could be made carbon neutral.

5. Conclusions

This paper has examined the maximum theoretical carbon and energy reduction benefits of a complete modal switch from private car commuting from TODs/transit interchanges around metropolitan Adelaide (as outlined in Adelaide's 2010 30YPGA metropolitan planning strategy). Without accompanying increases in urban densities in the proposed TODs, the TODs would be little more than park and ride transit stops and make very small reductions in metropolitan Adelaide's overall carbon and energy emissions profile for suburb to Adelaide CBD commuting (i.e. in the order of 3% at best). However, what is encouraging is that if the TODs urban densities are built as planned, and if the South Australian electricity grid which would power electric public transit (i.e. trams and commuter rail) were from renewable power sources, then substantial reductions in carbon emissions and energy consumption of between 25% and 50 % are theoretically achievable. Rather than be discouraged by the limited current environmental benefits that the TODs appear to be contributing, Adelaide's public policy makers should take heart that if the TODs and transit improvements envisaged in the 30YPGA are fully realized, then metropolitan Adelaide will reap substantial environmental dividends and be on the pathway to becoming an environmentally sustainable city. Notwithstanding these conclusions, further research is needed to determine exactly what the modal split would be in practice for commuters residing in the catchments of the proposed TODs. Adopting the methodology of Meng et al.(2011) in which stated preference and revealed preference surveys were used to determine commuters decision boundaries in transport modal choice (specifically rail public transit), would allow much greater refinement in estimating the future success of Adelaide's future TODs in reducing private car usage.

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