APRIL 2019

Infrastructure Provision in Different Development Settings

Metropolitan Melbourne
Volume 2 Technical Appendix

INFRASTRUCTURE VICTORIA

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Introduction

This report is the second volume of the report *Infrastructure Provision in Different Development Settings: Metropolitan Melbourne*, providing detailed technical information and cost data in support of the Volume 1 Technical Paper.

The Volume 1 Technical Paper is also supported by a consultant report commissioned by Infrastructure Victoria and prepared by SMEC Australia titled *Infrastructure Provision in Different Development Settings: Metropolitan Melbourne – Costing & Analysis Report*.

Appendix 1: Summary cost data

Cost Summary

Infrastructure Element	Greenfield Range ($2018)		Established Range ($2018)		Melbourne average ($2018)	
	Capital Cost per dwelling		Capital Cost per dwelling		Cost per dwelling	
	Low	High	Low	High	Capital	Recurrent
Dwelling Cost	$ 445,465	$ 445,465	$ 542,521	$ 887,944	NA	NA
Transport	$ 45,703	$ 45,703	$ 45,703	$ 45,703	$ 45,703	$ 2,345
Civil Works including drainage	$ 24,643	$ 106,651	$ 1,903	$ 41,053	$ 34,865	$ 1,118
Sewerage	$ 6,332	$ 23,232	$ 2,549	$ 9,210	$ 9,812	$ 279
Water supply	$ 4,097	$ 15,464	$ 1,026	$ 7,907	$ 6,814	$ 200
Electricity	$ 7,470	$ 21,220	$ 2,319	$ 16,987	$ 14,212	$ 318
Gas	$ 2,780	$ 3,430	$ 1,680	$ 8,400	$ 3,766	$ 233
Telecommunications	$ 2,979	$ 5,966	$ 2,427	$ 5,508	$ 3,621	$ 109
Community Infrastructure	$ 14,616	$ 18,100	$ -	$ 38,476	$ 14,616	$ 438
Emergency services infrastructure	$ 817	$ 817	$ -	$ 1,546	$ 817	$ 25
Health Infrastructure	$ 1,200	$ 1,200	$ -	$ 2,400	$ 1,200	$ 36
Education Infrastructure	$ 14,900	$ 17,600	$ -	$ 29,337	$ 16,400	$ 492
Total	$ 571,002	$ 704,848	$ 600,128	$ 1,094,471	$ 151,827	$ 5,593

Costs in Development settings

Infrastructure Element	Greenfield Development Cost per dwelling ($2018)				
	Scenario 1 Capital Low	Scenario 2 Capital medium	Scenario 3 Capital High	Scenario 4 Capital High w/o capacity	Recurrent
Dwelling Cost	$ 445,465	$ 445,465	$ 445,465	$ 445,465	$ 10,560
Transport	$ 45,703	$ 45,703	$ 45,703	$ 45,703	$ 3,539
Civil Works including drainage	$ 24,643	$ 50,463	$ 106,651	$ 106,651	$ 1,507
Sewerage	$ 6,332	$ 10,983	$ 22,132	$ 23,232	$ 232
Water supply	$ 4,097	$ 10,289	$ 14,190	$ 15,464	$ 156
Electricity	$ 7,470	$ 9,665	$ 16,804	$ 21,220	$ 318
Gas	$ 2,780	$ 3,105	$ 3,430	$ 3,430	$ 233
Telecommunications	$ 2,979	$ 3,791	$ 5,966	$ 5,966	$ 114
Community Infrastructure	$ 14,616	$ 14,616	$ 18,100	$ 18,100	$ 543
Emergency services infrastructure	$ 817	$ 817	$ 817	$ 817	$ 25
Health Infrastructure	$ 1,200	$ 1,200	$ 1,200	$ 1,200	$ 36
Education Infrastructure	$ 14,900	$ 16,400	$ 17,600	$ 17,600	$ 371
Total	$ 571,002	$ 612,497	$ 698,058	$ 704,848	$ 17,633

Infrastructure Element	Small Scale Dispersed Infill Development in Middle Established Greyfield Area (2-4 dwelling development)				
	Cost per dwelling ($2018)				
	Scenario 1 Capital Low	Scenario 2 Capital medium	Scenario 3 Capital High	Scenario 4 Capital High w/o capacity	Recurrent
Dwelling Cost	$ 632,052	$ 632,052	$ 632,052	$ 632,052	$ 10,200
Transport	$ -	$ -	$ -	$ 45,703	$ 3,539
Civil Works	$ 17,737	$ 21,982	$ 33,680	$ 33,680	$ 774
Sewerage	$ 3,959	$ 5,139	$ 6,594	$ 7,694	$ 277
Water supply	$ 3,778	$ 4,990	$ 7,381	$ 7,907	$ 197
Electricity	$ 6,159	$ 8,515	$ 11,883	$ 16,299	$ 318
Gas	$ 2,400	$ 5,400	$ 8,400	$ 8,400	$ 233
Telecommunications	$ 2,427	$ 3,765	$ 5,508	$ 5,508	$ 113
Community Infrastructure	$ -	$ -	$ -	$ 18,654	$ 560
Emergency services infrastructure	$ -	$ -	$ -	$ 903	$ 27
Health Infrastructure	$ -	$ -	$ -	$ 1,300	$ 38
Education Infrastructure	$ -	$ 3,267	$ 4,900	$ 13,705	$ 411
Total	$ 668,512	$ 685,109	$ 710,398	$ 791,805	$ 16,687

Infrastructure Element	Precinct Scale Brownfield Development in middle/outer established Area (medium density)				
	Cost per dwelling ($2018)				
	Scenario 1 Capital Low	Scenario 2 Capital medium	Scenario 3 Capital High	Scenario 4 Capital High w/o capacity	Recurrent
Dwelling Cost	$ 664,744	$ 664,744	$ 664,744	$ 664,744	$ 9,180
Transport	$ -	$ -	$ -	$ 45,703	$ 3,539
Civil Works including drainage	$ 17,634	$ 30,951	$ 41,053	$ 41,053	$ 1,044
Sewerage	$ 2,726	$ 5,187	$ 8,110	$ 9,210	$ 277
Water supply	$ 1,463	$ 3,417	$ 5,151	$ 5,677	$ 197
Electricity	$ 5,308	$ 8,343	$ 12,500	$ 16,987	$ 318
Gas	$ 1,680	$ 1,680	$ 1,680	$ 1,680	$ 233
Telecommunications	$ 2,665	$ 3,293	$ 3,993	$ 3,993	$ 99
Community Infrastructure	$ -	$ -	$ -	$ 19,359	$ 581
Emergency services infrastructure	$ -	$ -	$ -	$ 923	$ 27
Health Infrastructure	$ -	$ -	$ -	$ 1,600	$ 49
Education Infrastructure	$ -	$ 3,267	$ 4,900	$ 13,705	$ 411
Total	$ 696,220	$ 720,882	$ 742,131	$ 824,634	$ 15,954

Infrastructure Element	High Density Development in Inner Established Area (high density)				
	Cost per dwelling ($2018)				
	Scenario 1 Capital Low	Scenario 2 Capital medium	Scenario 3 Capital High	Scenario 4 Capital High w/o capacity	Recurrent
Dwelling Cost	$ 765,721	$ 765,721	$ 765,721	$ 765,721	$ 15,876
Transport	$ -	$ -	$ -	$ 45,703	$ 3,539
Civil Works including drainage	$ 1,903	$ 6,343	$ 15,856	$ 15,856	$ 305
Sewerage	$ 1,692	$ 2,549	$ 4,387	$ 5,487	$ 277
Water supply	$ 1,026	$ 1,847	$ 3,605	$ 4,131	$ 197
Electricity	$ 2,319	$ 3,840	$ 7,098	$ 11,431	$ 318
Gas	$ 1,680	$ 1,680	$ 1,680	$ 1,680	$ 233
Telecommunications	$ 2,573	$ 2,993	$ 3,893	$ 3,893	$ 90
Community Infrastructure	$ -	$ -	$ -	$ 38,476	$ 1,154
Emergency services infrastructure	$ -	$ -	$ -	$ 1,546	$ 27
Health Infrastructure	$ -	$ -	$ -	$ 2,400	$ 70
Education Infrastructure	$ -	$ 3,267	$ 4,900	$ 29,337	$ 623
Total	$ 776,914	$ 788,240	$ 807,140	$ 925,661	$ 22,709

Appendix 2: Infrastructure element descriptions and cost data

2.1 Transport

2.1.1 Introduction

Transport infrastructure discussed in this appendix relates to transport infrastructure outside of the development estate. This includes local roads outside of the development estate, arterial roads, toll ways, freeways and public transport infrastructure and rolling stock

Transport infrastructure within the development estate, such as road and pathways are considered as part of the development cost and are included under civil works as defined in the Volume 1 Technical paper section 2.4.

Many varied factors affect the cost of infrastructure besides the development setting, but we have been able to identify typical cost ranges for most types of infrastructure in different settings. Apportioning transport infrastructure costs is more complex than most other infrastructure elements, as service levels have a broader variance than other infrastructure and households have choice on how they use the infrastructure supplied.

Service levels vary significantly across Melbourne in relation to mode choices available, frequency of service and accessibility to multiple locations, whilst an individual household can choose between mode of transport and destination, where options exist. For this reason the report only considers the relative cost of transport in the context of average levels of expenditure for Melbourne and does not identify cost ranges for different development settings. The capital and operational costs for additional transport, both historic and forecast investment have been considered at a metropolitan wide level.

In assessing the capacity of the transport network, Infrastructure Victoria adopted a different approach to the other infrastructure elements, as we had access to separate research undertaken by Infrastructure Victoria that utilised advanced strategic transport models. The modelling considered the year 2016 (taken as reflecting current conditions as this relates to census data), 2031 and 2051, giving an idea of the infrastructure requirements in a 15 and 35 year timeframe.

2.1.2 Existing Industry Structure and Infrastructure

2.1.2.1 Road Network

Victoria's freeway, arterial and municipal road network covers about 151,000 kilometres. Funding responsibility is shared between state, local, and federal government, as well as private operators. The management, maintenance and development of Victoria's roads is shared between VicRoads, municipal councils, Transurban, Connect East , Southern Way, the Department of Environment, Land, Water and Planning and other Government Departments. Table 1 explains the organisations that are responsible for each type of road in Victoria.

The majority of Victoria's traffic is carried on freeways and arterial roads. These roads provide the principal routes for the movement of people and goods between major regions and population centres of the State, and between major metropolitan activity centres, together with links to major freight terminals and tourist areas in both rural and metropolitan areas. VicRoads, as the statutory authority under the Department of Transport (DoT), is the coordinating body for Victoria's freeways and arterial road network. VicRoads arranges for freeways (excluding privately operated freeways) and arterial roads to be maintained, upgraded and constructed as necessary.

Table 1: Victorian road authorities (Source: VicRoads web site)

Road type	Coordinating Road Authority	Responsible Road Authority
Freeway (except privately operated)	VicRoads	VicRoads
Freeway (privately operated)	Varies	Melbourne CityLink – Transurban Eastlink - ConnectEast Peninsula Link - Southern Way
Arterial (urban)	VicRoads	VicRoads (through traffic) Council (service roads, pathways, roadside)
Arterial (non-urban)	VicRoads	VicRoads Council (service roads, pathways)
Municipal	Council	Council
Non-arterial State	DELWP, Parks Victoria,	DELWP, Parks Victoria

Road type	Coordinating Road Authority	Responsible Road Authority
	VicRoads (some)	(VicRoads for small number of these roads)

Where projects are of a large scale or have major private sector interfaces, such projects on or constructing toll roads, a delivery authority, directly under the control of the Department of Transport (DoT) is created. At present the two major road delivery authorities in Victoria are the North East Link Authority and the West Gate Tunnel Authority which are managing the planning and delivery of these two major toll road projects on behalf of DoT. For the purposes of this work, the current and forecast road projects managed by DoT and the authorities under it have been used in this project.

2.1.2.2 Public Transport Network

Victoria's public transport network comprises of metropolitan train, tram, bus networks alongside regional train, town bus and coach services. These services are operated through franchise agreements which are managed by Public Transport Victoria (PTV) on behalf of government. The roles of the two parties are as follows:

Franchise Operators:

- Day-to-day operation of trains and trams to Public Transport Victoria performance standards
- Responsibility for customer service, including tickets sales, passenger security and station staff
- Employment and management of staff
- Maintenance and cleaning of vehicles, tracks and stations.

State Government

- Safety regulation
- Sustainable funding
- Long-term network and strategic planning
- Operational performance management
- Coordination of timetables between trains, trams and buses
- Development and maintenance of the ticketing system.

Of the State Government responsibilities, the latter three roles are undertaken by Public Transport Victoria.

Safety regulation and compliance is undertaken jointly between PTV and Transport Safety Victoria.

As part of delivering 'business as usual' new public transport projects, upgrades and major renewals, PTV works with the operators and the state's public transport asset owner VicTrack to manage and deliver projects.

Where projects are of a large scale or have major interfaces, such as the Level Crossing Removal Project, Melbourne Metro Tunnel and Regional Rail Revival program, delivery authorities under the control of the Department of Transport (DoT) have been created. At present the two major public transport delivery authorities in Victoria are the Level Crossing Removal Authority and Rail Projects Victoria, which are managing the planning and delivery of these major public transport programs on behalf of DoT. For the purposes of this work, the current and forecast road projects managed by DoT and the authorities under it have been used.

2.1.3 Planning for Transport Infrastructure and Forecasting Demand

The Department of Transport (DoT) is the government department responsible for the long-term planning and development of Victoria's transport network. The department is primarily empowered to manage the network through the Transport Integration Act 2010 (TIA) which recognises that land-use and transport planning are interdependent. Changes in transport infrastructure alter the demand for different types of land-use.

The reverse is also true as land-use decisions can change transport patterns. For example, planning scheme amendments can change the demand for different types of transport services and infrastructure. In recognition of this interdependence, the TIA places the same obligations on both transport planners and strategic land-use planners. Transport planners, in transport bodies such as the Department of Transport, VicRoads and Public Transport Victoria must have regard to the land-use impacts of decisions.

In order to understand the needs of this dynamic system of transport and land use development, the DoT has used the Victorian Integrated Transport Model (VITM) to establish a projection for the potential future development of the transport network. This "Reference Case Network" has been created in order to provide a realistic potential forecast of transport network development for planning purposes given a set of assumptions, such as the Victoria in Future population projections.

The 'Reference Case Network' has been created by DoT with the intention of providing a consistent set of inputs to be used when undertaking transport demand modelling, including for the assessment of major transport infrastructure projects and land use developments.

The Reference Case covers:

- forecast potential road and public transport networks
- demographic and land use projections
- model parameters, including costs such as parking costs and vehicle operating costs

Inclusion of a transport project in the Reference Case Network does not represent a commitment by government to invest in that project, nor is the Reference Case Network the Victorian Government's plan for the transport network. The Reference Case land use projections, including employment growth projections, should be regarded as a realistic potential development pathway, given a reasonable set of assumptions, which include transport infrastructure investment. To achieve the projected land use development therefore requires the associated outlook to be realised in transport plans and projects.

When undertaking planning for the transport network, the DoT uses the Reference Case Network to better understand the needs of a growing Victoria under a 'Business as Usual' approach. As part of this approach, DoT updates the network regularly to reflect evolving land use and government commitments to projects and programs.

2.1.4 Existing Conditions and Future Capacity

Infrastructure Victoria has previously commissioned major transport modelling studies to inform the existing and future capacity and demand of Melbourne's transport network. The two studies used for this report, which are available on the Infrastructure Victoria website, are:

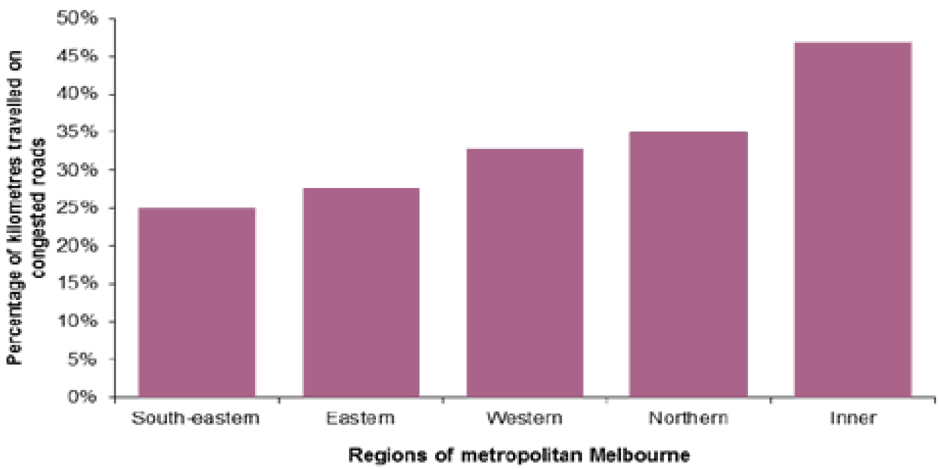
- KPMG/Arup/Jacobs, *Preliminary demand modelling and economic analysis, Infrastructure Victoria final report*, 2016
- KPMG Arup, *Problem assessment report, Infrastructure Victoria* 2017

For the purposes of this report, the KPMG/Arup/Jacobs 2016 report has been used to provide an idea of how the current transport network is performing (modelled as of 2011), with the forecast of future network, travel need, and performance based on the DoT Reference Case as modelled in the KPMG Arup 2017 Report .

Transport modelling commissioned by Infrastructure Victoria indicates that a large percentage of our transport system (modelled as of 2011) is approaching or operating at capacity during the morning peak period. At a network wide level, Melbourne is a highly car dependant city, with mode share of public transport network less than 10%.

This is representative of the travel times being significantly better by car than public transport, particularly to Melbourne's National Employment and Innovation Centres (NEICs) and activity centres. However this low mode share of public transport is not uniform, with inner Melbourne (particularly trips to the Melbourne CBD, Parkville and surrounds) being relatively high at over 50% public transport mode share. Modelling shows that one in three trips undertaken in Western and Northern Melbourne are undertaken in congested conditions. This increases to one in every two in inner Melbourne, as displayed in Figure 1 below.

Figure 1: Current car congestion levels* by metropolitan region during the AM Peak

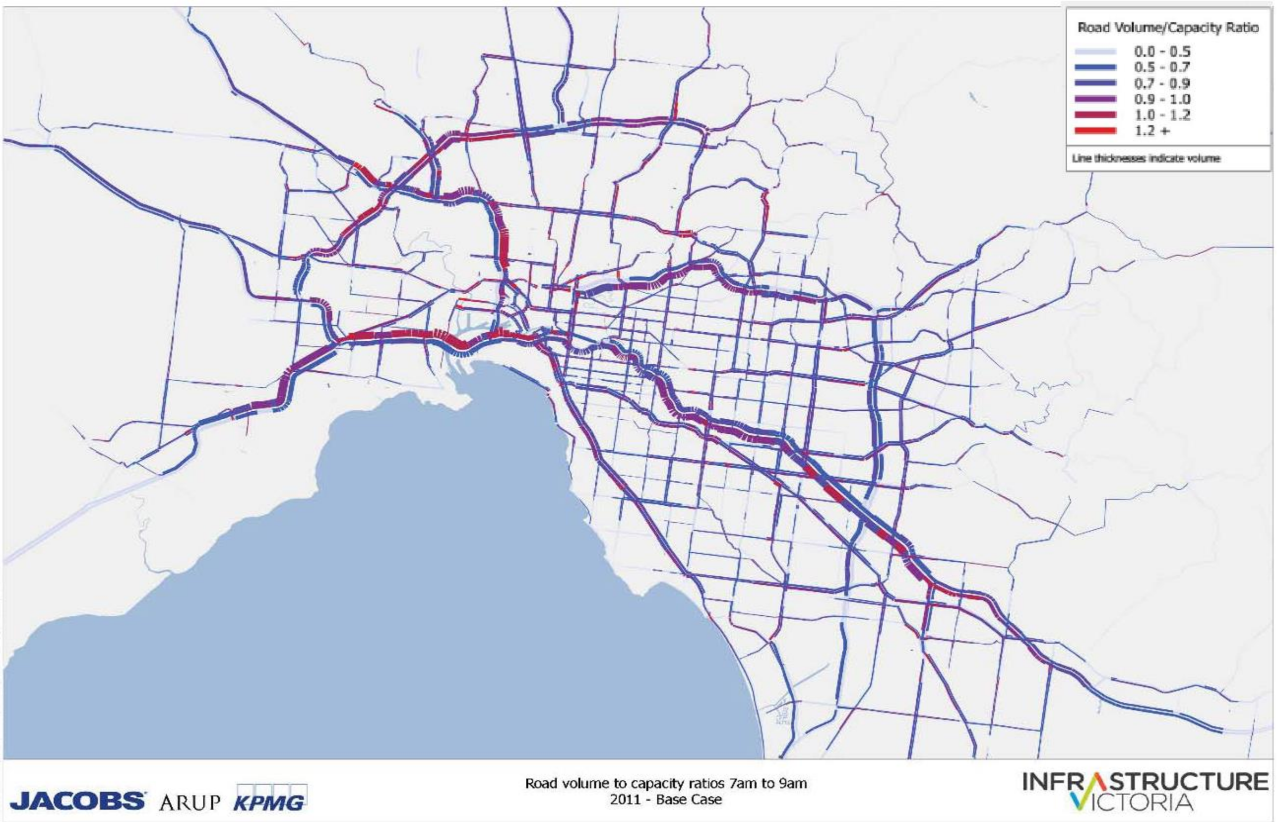


*Congested conditions are defined as roads with a volume to capacity ratio above 90%

Source: KPMG/Arup/Jacobs, Preliminary demand modelling and economic analysis, Infrastructure Victoria, Final Report 2016

This level of road congestion is reflected in the performance of the road network across Melbourne. Melbourne's major freeways and key arterial roads take the bulk of the load of travel demand, with the M1 and M2 (Westgate/Monash and Tullamarine) routes currently operating close to or above theoretical capacity during the morning peak period, as shown in Figure 2.

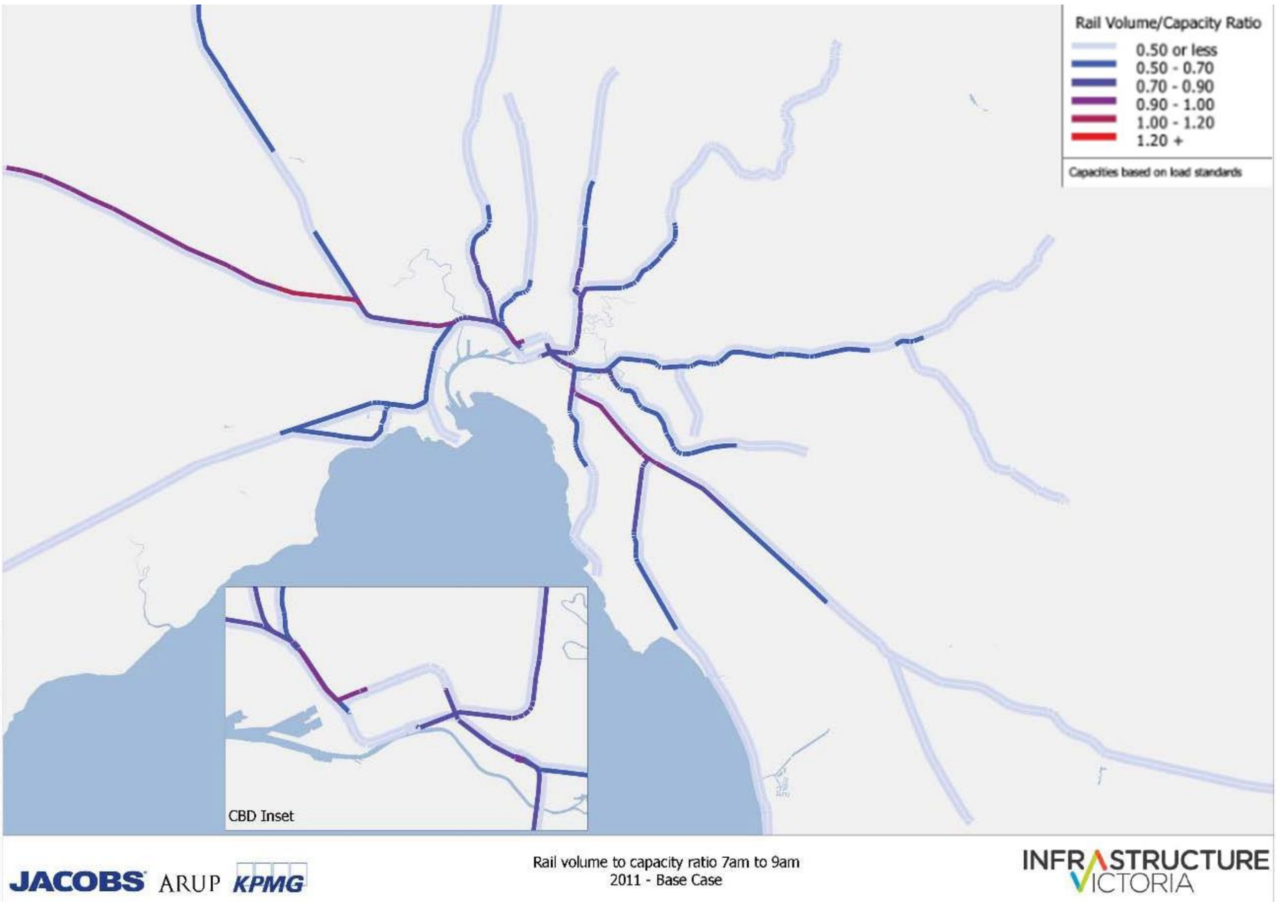
Figure 2: Road volume to capacity ratio 7am to 9am 2011 Base Case



Source: KPMG/Arup/Jacobs, Preliminary demand modelling and economic analysis, Infrastructure Victoria, Final Report 2016

For the predominant mode of public transport, rail, KPMG/Arup/Jacobs 2016 report shows that rail lines are approaching capacity near the city loop and are heavily loaded along long sections of some lines, as displayed in Figure 3 below.

Figure 3: Rail volume to capacity ratio 7am to 9am 2011 Base Case



Source: KPMG/Arup/Jacobs, *Preliminary demand modelling and economic analysis, Infrastructure Victoria final report*, 2016

2.1.5 Transport demand and infrastructure performance in 2031

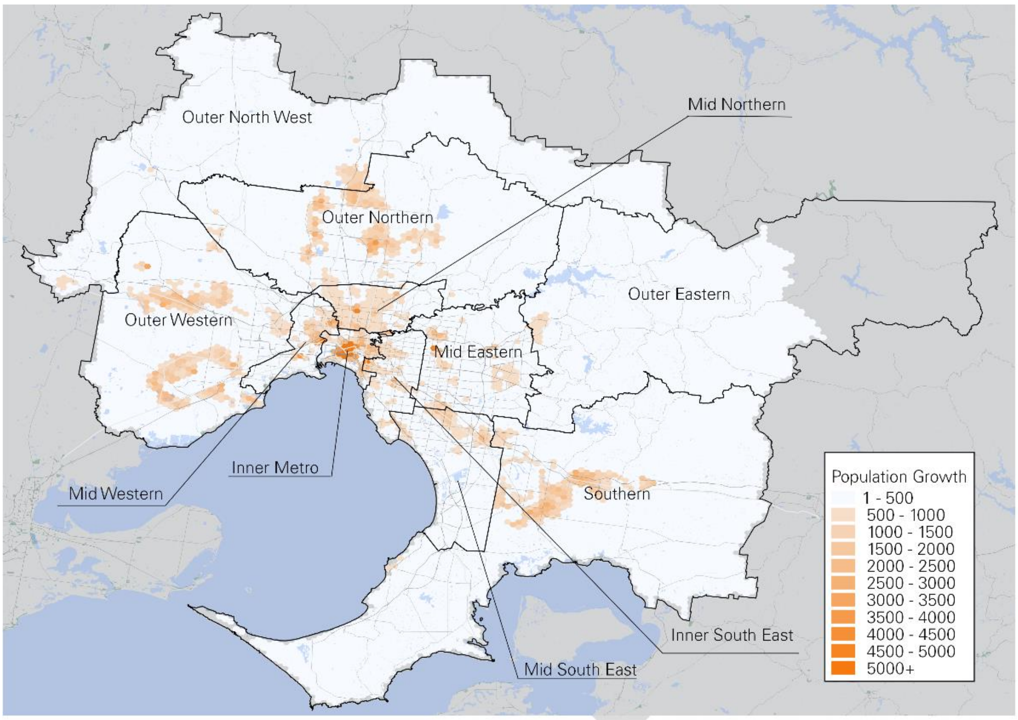
In December 2017, IV released research providing new insights into how Melburnians are predicted to use roads and public transport in 2031 (KPMG Arup 2017). As demand on the transport network grows, the performance of the network changes. These changes manifest in a number of ways: journey times increase, delays grow, speeds decline and reliability problems emerge.

2.1.5.1 Drivers of transport demand

By 2031, the population of metropolitan Melbourne is estimated to grow from 4.5 million people in 2015 to almost six million people. Employment is also expected to grow significantly over the same period, with the creation of an additional 400,000 jobs expected by 2031, increasing the number of daily trips to work in metropolitan Melbourne by just over two million.

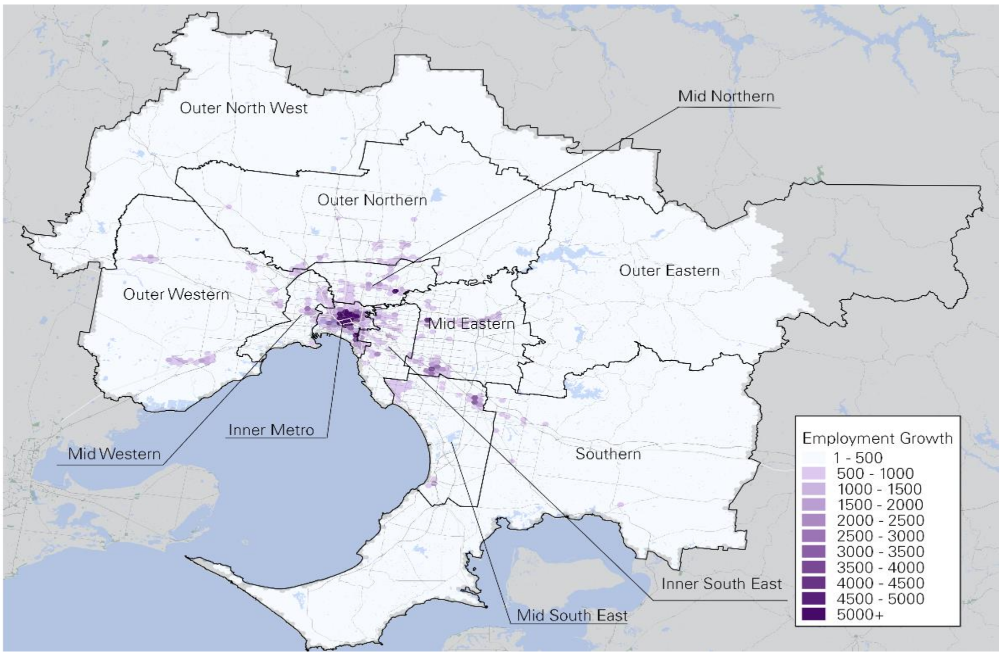
The distribution of this population and employment is not predicted to be even. Approximately two-thirds of the population increase is expected to occur in the existing growth corridors in Melbourne's outer south east, north and west, as well as the inner metro region (Figure 4). Whereas, over three-quarters of the projected increase in employment is forecast to occur in the inner and middle suburbs of Melbourne (Figure 5).

Figure 4: Change in population 2015–2031



Source: KPMG/Arup (2017), Travel demand and movement patterns report. Based on Victoria in Future.

Figure 5: Change in employment 2015–2031

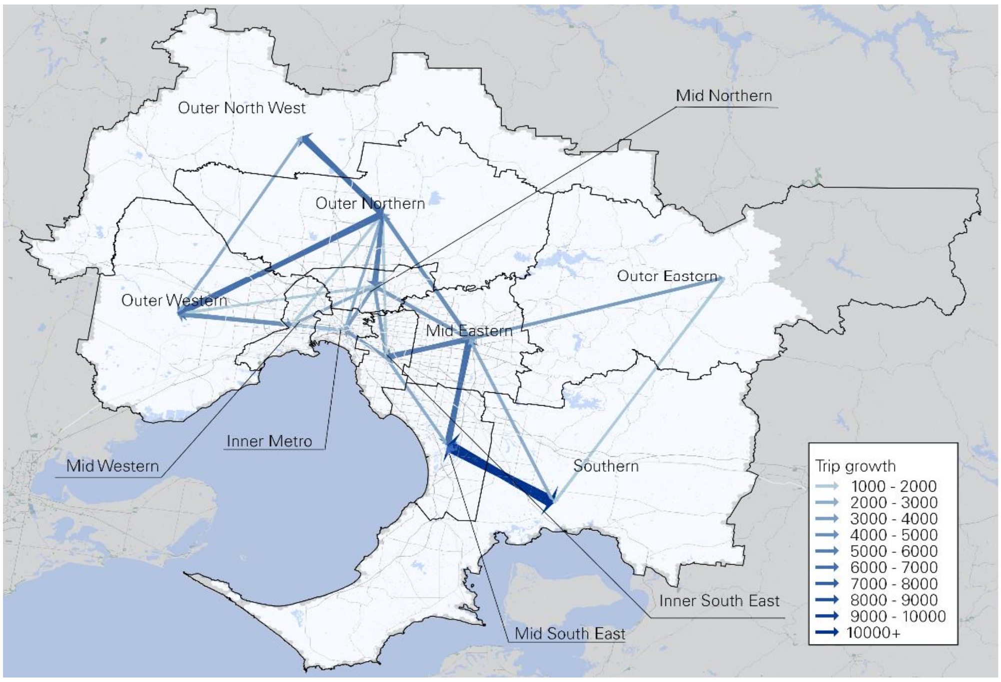


Source: KPMG/Arup (2017), Travel demand and movement patterns report. Based on the Victorian Government's Small Area Land Use Projections.

The distribution of population and employment growth presents a significant transport challenge for Melbourne. More people are projected to live in the outer suburbs, with many needing to travel long distances, often at the same times, to access jobs.

Aside from changes to population, demographics and employment (and its spatial distribution), transport demand is influenced by the supply and management of the road network and the provision of alternative modes of transport. Overall the number of trips on the transport network is forecast to increase by 3.5 million in 2031, rising from over 11.5 million trips in 2016 to nearly 15 million daily trips in 2031. This growth in trips will put significant extra pressure on Melbourne's transport network, in particular because it will not be evenly spread across the city (as we can see in Figure 6). This growth in trips combined with the mismatch between where people work and live means people will be travelling longer distances. There is an estimated increase in daily vehicle kilometres travelled of around 25% by 2031.

Figure 6: Daily car trip (driver or passenger) growth 2015–2031



Source: KPMG/Arup (2017), Travel demand and movement patterns report.

Whilst there is a short to medium term pipeline of transport infrastructure projects committed for development by the Government, and whilst these projects will go some way to providing additional capacity, the forecast growth in travel demand will offset the travel time and reliability benefits of this increase in capacity. This is demonstrated when the performance of the transport network is measured in the transport model by area. To do this KPMG Arup 2017 measured the average daily journey times and distances for each region in 2016 and 2031 to understand the capacity and reliability of the transport network.

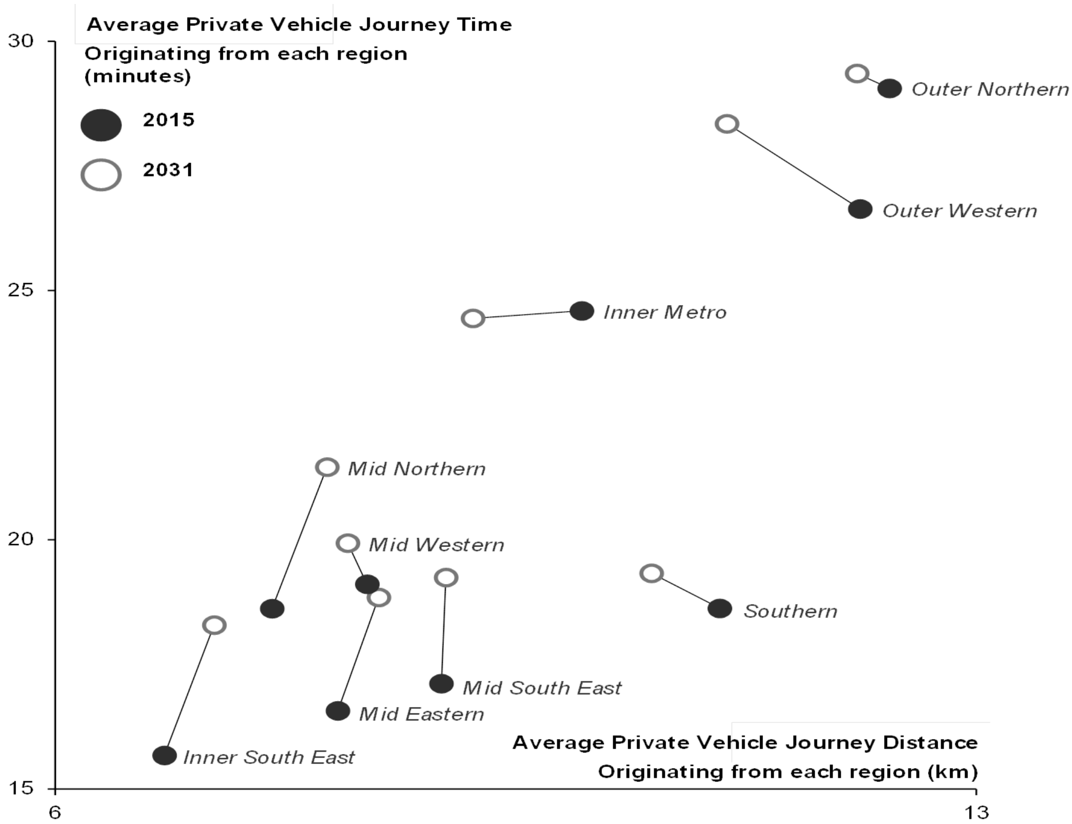
2.1.5.2 Measuring Capacity

Infrastructure Victoria have identified that the two most important indicators of transport congestion are travel time and reliability. Travel time is a measure of the total time that it takes to complete a journey, while reliability is a measure of how dependable travel time is. The performance of the transport network is best determined by assessing the networks ability to manage an increase in demand through analysing changes in travel time and reliability.

2.1.5.3 Travel time deterioration

The growth in transport demand is expected to have an impact on private vehicle journeys in terms of the time spent on the road as well as the distances travelled. How different regions respond to the changes in transport demand between 2015 and 2030 varies across the city (see Figure 7 below). This is due to a number of factors including infrastructure provision and changes in travel patterns.

Figure 7: Average daily private vehicle journey results compared by origin, 2015 to 2031

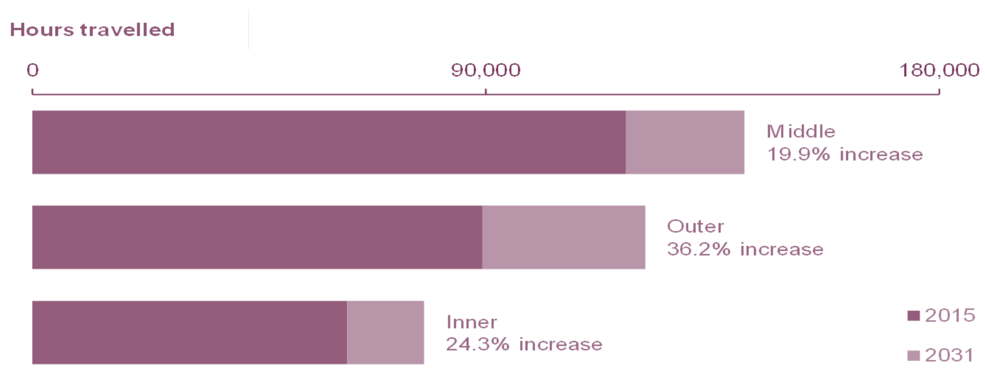


Source: KPMG/Arup (2017), Travel demand and movement patterns report.

2.1.5.4 Reliability

Journey times on Melbourne's roads will become less reliable in coming years. Travel time reliability indicates how dependable and consistent journey times are along a particular stretch of road at a particular time of the day. As a road approaches capacity, reliability deteriorates. This is because roads have a finite capacity depending on a number of factors including number of lanes, speed limit, intersection frequency and geometry. As the traffic volumes on a road near its capacity, traffic flow slows and driver behaviours start to change – resulting in increasing travel times and reduced travel time reliability. In our analysis we use a 70% capacity threshold as a benchmark[1] for when traffic flow and speeds start to be significantly impacted by increasing travel times and reduced travel time reliability (Figure 8).

Figure 8: Hours travelled on roads at or above 70% capacity during the morning peak period



1 We have used a volume-to-capacity benchmark to measure reliability based on the New Zealand Transport Authority (NZTA) Economic Evaluation Manual method using modelled volume-to-capacity ratios for Melbourne.

Source: KPMG/Arup (2017), Travel demand and movement patterns report.

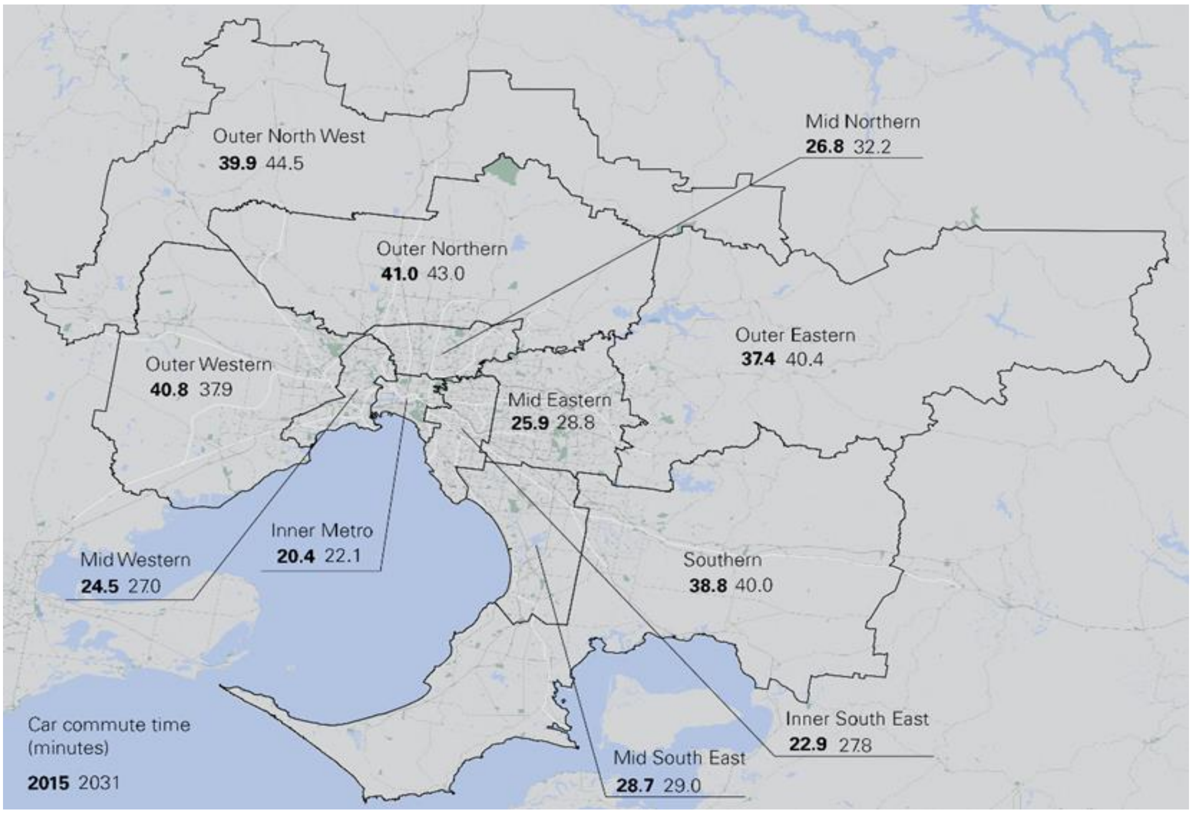
Across the network, the hours spent travelling on roads exceeding this benchmark increase between 2015 and 2031. It is most pronounced during the morning and evening peak periods. Deterioration in reliability is felt most significantly in outer areas where there is a 36% increase in hours spent travelling on roads exceeding the benchmark.

2.1.5.5 Accessibility

Accessibility is effected by two factors, firstly by how close you are to the facilities that you wish to access and secondly by the performance of the transport network. Whilst the inner area is most effected by congestion, due to the lower provision of jobs and services in outer areas of Melbourne, the northern and western areas experience the most transport disadvantage. This relative disadvantage is also forecast to increase over time.

A simple indicator of accessibility is travel time for commuting trips by car. The figure below shows the projected increase by region, indicating residents further from the inner city have longer average commute times. Average commute times are projected to increase between 2015 and 2031 for all regions except the Outer Western region, which has major road infrastructure investment planned (Figure 9).

Figure 9: Average car commuting travel time (minutes), 2015 and 2031



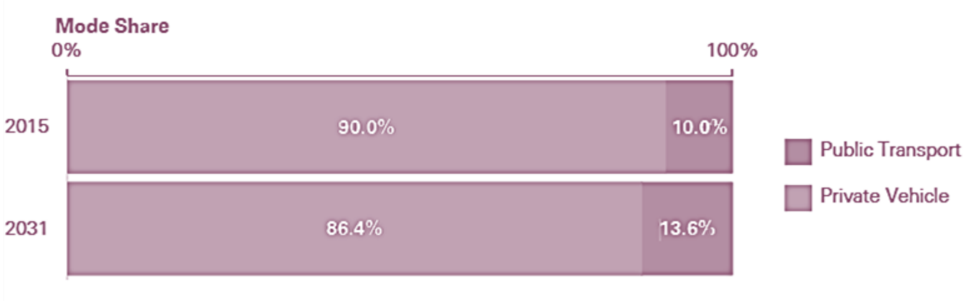
Source: KPMG Arup, Problem assessment report, Infrastructure Victoria 13/10/2017

Each area of Melbourne displays a different response to growing private vehicle travel demand due to a number of factors, including changing infrastructure provision and evolving travel patterns over time. An overall trend shown is that trip distances for outer regions decrease. As the population grows it is expected that there is an increase in employment and amenity, decreasing the distance require to travel and as areas become more established the road network will develop, providing more direct routes. Despite this average reduction in journey distance, average journey times are projected to increase in outer areas, reflecting that more trips are being taken, resulting in the roads operating at close to their capacity.

2.1.5.6 Public transport impacts

Melbourne's public transport network is expected to experience increased demand between 2015 and 2031, yet it will be more accessible, more interconnected and have higher service frequencies across many areas of Greater Melbourne compared with today. Modelling predicts a 76% increase in public transport trips across Melbourne, or 878,000 additional public transport trips each day. Public transport's share of motorised transport mode is forecast to increase from 10% to 14% as shown by Figure 10.

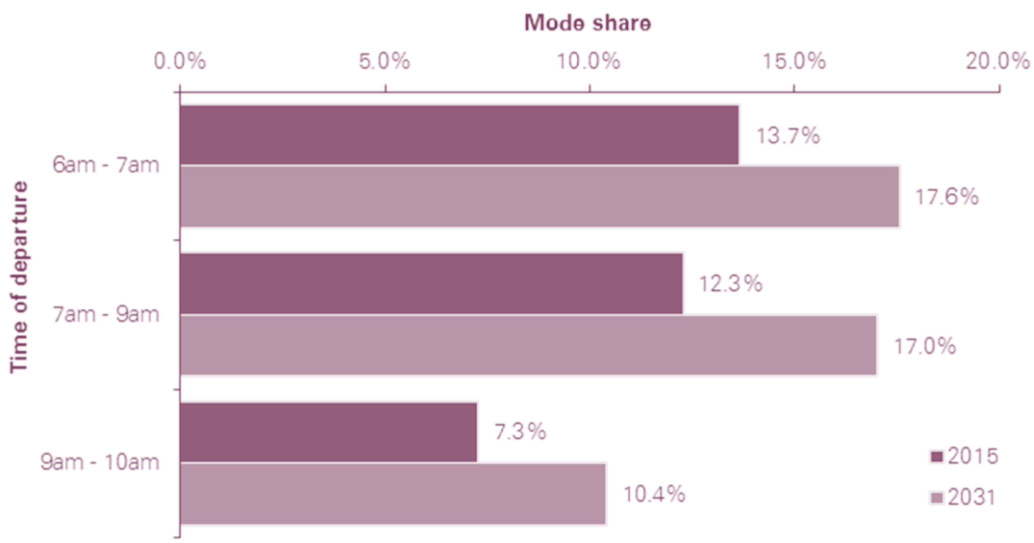
Figure 10: Public transport and private vehicle mode share, 2015–2031



Source: KPMG/Arup (2017), Travel demand and movement patterns report.

The most significant growth in public transport mode share occurs in the peak periods. For trips departing in the morning peak hours (7.00am – 9.00am), the share of public transport as a proportion of motorised travel is projected to increase from 12% to 17% (Figure 11 below).

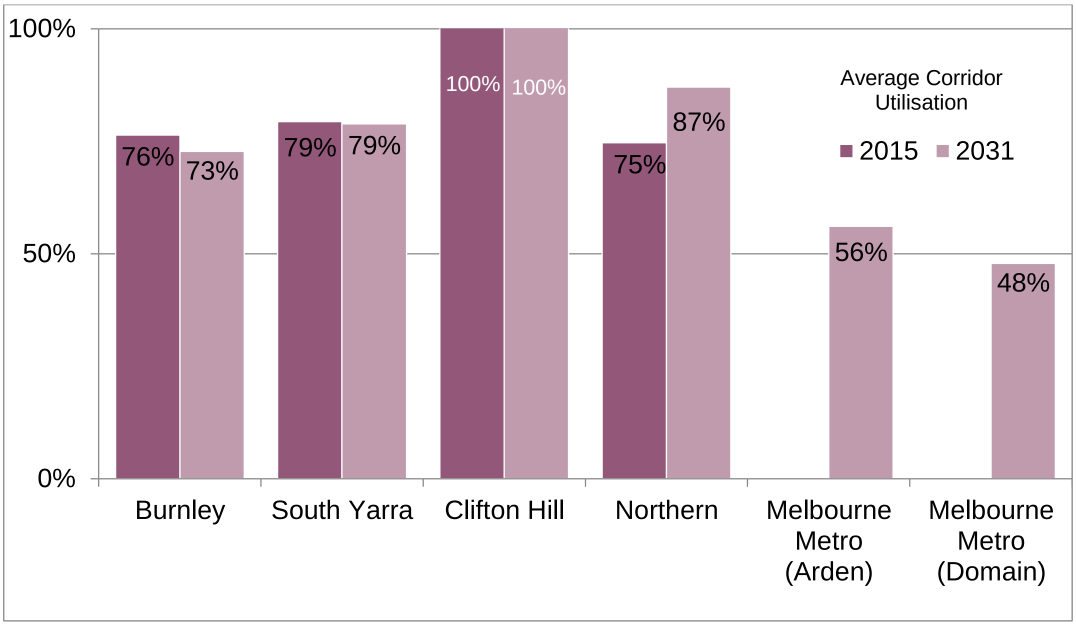
Figure 11: Change in public transport mode share (motorised travel)



Source: KPMG/Arup (2017), Travel demand and movement patterns report.

Due to planned improvements to public transport frequency and improved connectivity provided by projects such as Regional Rail link and Melbourne Metro, modelling by KPMG/Arup2017 indicates that public transport travel experienced in 2031 will be significantly better than today overall, with crowding and travel times to the CBD improving. Only the lines accessing the CBD from the north will show some deterioration, as displayed in Figure 12.

Figure 12: Rail line group utilisation during the morning peak 2015 to 2031



Source: KPMG Arup, Problem assessment report, Infrastructure Victoria 2017

This large increase in demand puts significant pressure on the public transport network. By 2031, some of the key rail groups – Clifton Hill, Caulfield and Northern groups – will be at or over capacity for a longer time during the morning peak period. This aligns with the high population growth expected to the northern and western growth areas of Melbourne.

With large forecast increases public transport patronage between 2015 and 2031, it is important to consider how the public transport system will perform in terms of passenger capacity and throughput. Utilisation in this context refers to how close to capacity a service is operating during a particular time in terms of passenger loads. For rail lines in particular, high passenger loads can often leave travellers waiting on platforms due to at-capacity trains during busy periods. Peak loads are most often experienced on entry or exit from the CBD.

The forecasts indicate that the rail system does have some additional scope to carry additional passengers at 2031. In large part this is an outcome of the additional services that have been enabled by the Melbourne Metro project. However this additional capacity is unlikely to be filled by road users switching to public transport to avoid congestion due to the areas of Melbourne where public transport provides an attractive travel option and where it doesn't.

Train travel predominantly services city-bound trips, while a majority of road trips are suburban or orbital in nature. However as indicated in modelling undertaken for IV's 30-year Infrastructure Strategy, by 2051 this spare capacity is absorbed by additional growth and overall passenger loading levels revert to be worse than the existing situation.

2.1.6 Metropolitan Transport Infrastructure Costs

2.1.6.1 Background

As a 'common good' or asset, the transport network differs from utilities as the use of the asset is not exclusive. In the case of the transport network, the connection cost does not therefore strictly account for purely connecting a dwelling to the transport network (as with power connection) but needs to include the cost of facilitating use of the entire transport network by the dwelling.

Unlike other infrastructure classes, the transport cost of the network is difficult to attribute to a single development setting, geographic area or urban typology. Whilst infrastructure such as road built in growth areas could be attributed to the particular development setting, due to the way the transport network is used by Melbournians. A trip which may begin in a growth area may not be contained to the particular growth area. As the transport network is used by a particular person doing a trip between a growth area and inner Melbourne (for say work), infrastructure capacity in the growth area, outer existing suburb, middle suburb, inner suburb and the central city is being used. This complexity of operation and use of the transport network makes it particularly difficult to apportion transport infrastructure use to a particular dwelling and development setting.

2.1.6.2 What types of costs are associated with transport?

Capital costs represent the cost of expanding and enhancing the network through projects. This can be done through the building of or widening of roads, the upgrade of rail corridors (including extending lines, duplicating track, upgrading signalling) or the addition of rolling stock (to enable more services).

For operational costs, 'OMR' (operational, maintenance and replacement) costs have been estimated represent the annual costs to manage the infrastructure, replacing or augmenting elements as they reach the end of their service life or have compliance issues. OMR costs include the costs of maintaining transport infrastructure and operating the rolling stock, including staffing and energy costs. These are generally represented through state budget papers or agency (VicRoads or PTV) annual reports as maintenance costs and or payments to operators.

For public transport, the State through the franchise agreements has allowance for renewal or assets (through the requirement for franchisees to keep the asset at a safe and operational level) accounted for by the PTV payments to operators in the annual reports.

Whilst some capital projects can include elements of OMR, where these are clear such as capital funding flagged as for renewal these have been included in the OMR costs (particularly for roads). For future forecast costs, a proportion has been added to allow for OMR capital projects. This is based on the historical analysis for costs and is approximately 15% of pure operational costs. As OMR is required to service the existing number of dwellings in Melbourne, the incremental cost of OMR has been used, in line with new projects representing the incremental capital costs of servicing dwelling costs.

To understand the baseline trend, a historical analysis of transport funding between 2008 and 2016 based on existing funded transport projects, incremental operational costs paid and average dwelling completions was completed. This analysis has been underpinned by a review of State Government budgets throughout this period.

2.1.6.3 How we have calculated the Melbourne average baseline costs

When considering historic baseline costs, public transport and road network commitments and operational costs have been analysed over a period of 8 years between 2008 and 2016. Through using figures from publicly available sources such as the State Budget and agency annual reports between the 2008/09 and 2016/17 Financial Years a cost base for the transport network has been established. For the estimates of dwellings, as the timeframe does not align with census data, multiple censuses between 2006 and 2016 have been used, with the number of new dwellings per annum in metropolitan Melbourne averaged.

The per dwelling capital costs associated with providing transport services per dwelling have been determined through the following formula;

$$\text{Per dwelling capital cost} = \frac{\text{Capital Expenditure}}{\text{Final no. dwellings} - \text{Initial no. dwellings}}$$

The annual OMR costs associated with providing transport services per dwelling have been determined through the following formula;

$$\text{Per dwelling annual OMR cost} = \frac{\text{OMR Exp.}}{\text{Av. no. dwellings} \times \text{No. years}}$$

To understand the OMR costs over the 8 year period, we have multiplied the per annum cost by the number of years to provide a total OMR cost.

This been undertaken for both the road and public transport network, with the results combined to provide the total transport (capital and OMR) cost per dwelling.

2.1.6.4 Melbourne average baseline costs

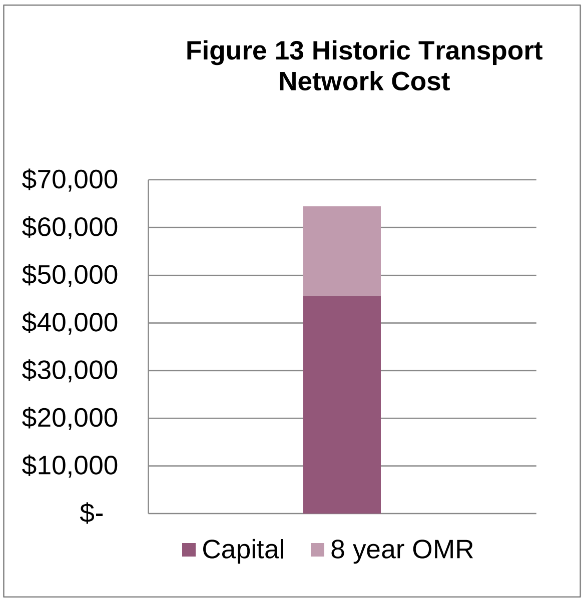
As Melbourne continues to grow, so has the total amount of investment in transport infrastructure and services. Over the past 10-15 years, transport investment has been largely incremental, building off a high base of designed and existing capacity. This has been reflected in the projects and services being provided during the baseline timeframe, with many major projects building off existing corridors (such as widening of motorways) or building off he planned capacity in the Melbourne City Loop. This is reflected in the historic costs, with a typical 70/30 split between capital and operational costs observed.

Total transport network costs

Based on our baseline analysis, the per dwelling cost of transport infrastructure at a network wide level has been calculated to be $45,703 per dwelling, with an annual OMR of $2,345 per dwelling. Over the baseline period, OMR costs amount to a total of $18,760 per dwelling, approximately 29% of the $64,463 in total transport per dwelling costs over the period (figure 13 and table 2 below).

Table 2 Historic Transport Network Cost

Historic Transport Network	Cost per additional dwelling	
Capital	$45,703	71%
8 year OMR	$18,760	29%
Total	$64,463	
Annual OMR cost	$2,345	



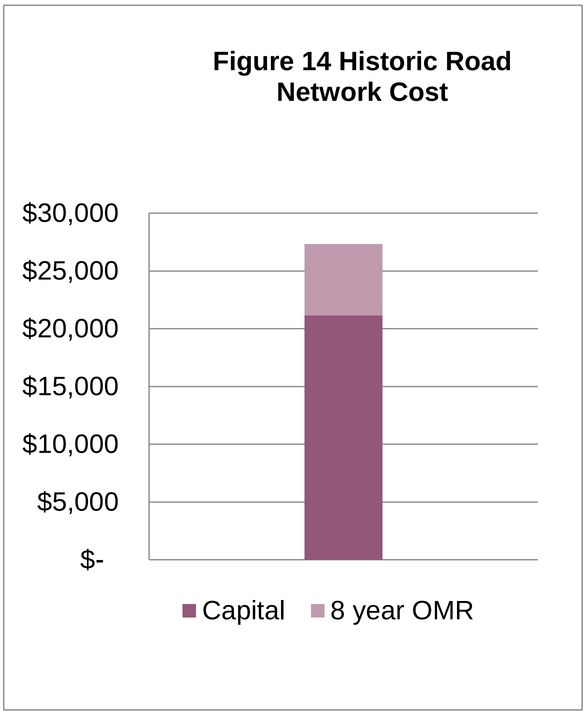
A breakdown by transport mode can be found below.

Road network costs

For the road network, the baseline per dwelling capital cost of infrastructure calculated to be $21,151 per dwelling, with an annual OMR of $770 per dwelling. Over the baseline period, OMR costs amount to a total of $6,160 per dwelling, approximately 23% of the $27,311 in total road per dwelling costs over the period (figure 14 and table 3 below)

Table 3: Historic Road Network Cost

Historic Road Network	Cost per additional dwelling	
Capital	$21,151	77%
8 year OMR	$6,160	23%
Total	$27,311	
Annual OMR cost	$770	



Road infrastructure overall accounts for 42% of the transport infrastructure cost per dwelling. This represents 46% of the total capital transport costs and 33% of total transport OMR costs per dwelling over the baseline period.

Public transport network costs

For the public transport network, the baseline per dwelling cost of infrastructure has been calculated to be $24,552 per dwelling, with an annual OMR of $1,575 per dwelling. Over the baseline period, OMR costs amount to a total of $12,600 per dwelling, approximately 34% of the $37,152 in total public transport per dwelling costs over the period (figure 15 and table 4 below)

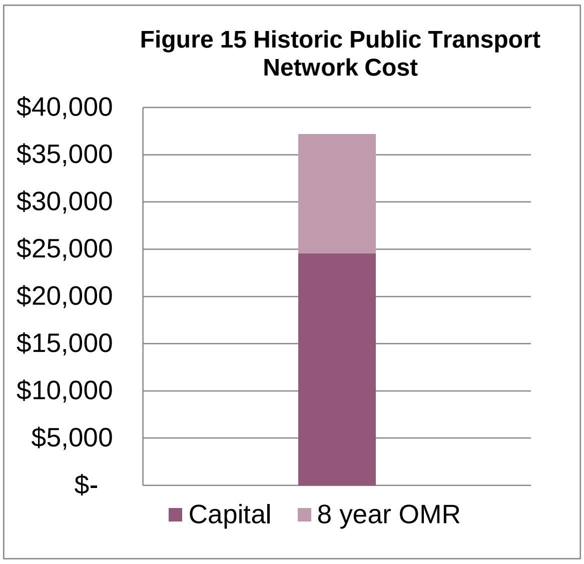


Table 4: Historic Public Transport Network Cost

Historic Public Transport Network	Cost per additional dwelling	
Capital	$24,552	66%
8 year OMR	$12,600	34%
Total	$37,152	
Annual OMR cost	$1,575	

Public transport infrastructure overall accounts for 58% of the transport infrastructure cost per dwelling. This represents 54% of the total capital transport costs and 67% of total transport OMR costs per dwelling over the baseline period. Note the OMR costs are higher than the average due to the more operational cost heaviness of public transport when compared to road with a two thirds one third split of total cost during the costing period.

2.1.7 Sources

2.1.7.1 General

AustRoads (2016), Congestion and reliability review.
New Zealand Transport Agency (2017), Economic evaluation manual.
KPMG Arup, Problem assessment report, Infrastructure Victoria 13/10/2017
Ref: KPMG/Arup/Jacobs, Preliminary demand modelling and economic analysis, Infrastructure Victoria final report, 2016
Victorian Department of Environment, Land, Water and Planning (2016), Victoria in Future 2016.
The Department of Treasury and Finance State Budget Paper 3 – Service Delivery
The Victorian Department of Transport, Reference Case, 2016, 2031 and 2051.

2.1.7.2 Melbourne average public transport costs (Volume 1 Figure 3 and Table 4)

The above Melbourne average cost estimates for public transport have been calculated using figures from these documents publically available on the websites of Vicroads, DTF and the ABS:

PTV:

- PTV Annual Report 2016-17
- PTV Annual Report 2015-16
- PTV Annual Report 2014-15
- PTV Annual Report 2013-14
- PTV Annual Report 2012-13

Department of Treasury and Finance:

- State Budget Capital Program 2017-18
- State Budget Capital Program 2016-17
- State Budget Capital Program 2015-16
- State Budget Capital Program 2014-15
- State Budget Capital Program 2013-14
- State Budget Capital Program 2012-13
- State Budget Capital Program 2011-12
- Public Sector Asset Investment Program 2010-11
- Public Sector Asset Investment Program 2009-10

- Public Sector Asset Investment Program 2008-09

ABS:

- 2016 Census (Melbourne GCCSA) http://www.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/2GMEL
- 2011 Census (Melbourne GCCSA)
- 2006 Census (Melbourne GCCSA)

Dates of figures used:

- Actual dwelling figures for 2006-2016, extrapolated
- Forecast capital expenditure 2008/2009-2017/18
- Actual operational expenditure 2012/13-2016/17

Key assumptions:

- The metropolitan area includes all of greater Melbourne
- V/Line is entirely rural, only services operated by Yarra trams, under the Victorian budget as Metropolitan buses and Metropolitan trains count as metropolitan public transport
- All payments to the rail services (including myki fares) go towards operational costs
- The proportion of all operational costs that goes to metro services is the same as the proportion of payments to metro service providers

2.1.7.3 Melbourne average road costs (Volume 1 Figure 3 and Table 4)

The Melbourne average cost estimates for roads have been calculated using figures from these documents publically available on the websites of Vicroads, DTF and the ABS:

Vicroads: All Vicroads Annual Cashflow Statements: Department of Treasury and Finance:

- State Budget Capital Program 2017-18
- State Budget Capital Program 2016-17
- State Budget Capital Program 2015-16
- State Budget Capital Program 2014-15
- State Budget Capital Program 2013-14
- State Budget Capital Program 2012-13
- State Budget Capital Program 2011-12
- Public Sector Asset Investment Program 2010-11
- Public Sector Asset Investment Program 2009-10

Australian Bureau of Statistics:

- 2016 Census (Melbourne GCCSA) http://www.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/2GMEL
- 2011 Census (Melbourne GCCSA)
- 2006 Census (Melbourne GCCSA)

Dates of figures used:

- Actual dwelling figures for 2011-2016, extrapolated
- Forecast capital expenditure 2009/2010-2016/17
- Actual operational expenditure 2009/10-2016/17

Types of figures used:

- Operating Expenditure
- Capital Expenditure
- Dwelling Numbers

Key assumptions:

We have not included costs of road infrastructure provided by local government and the property developers as part of establishing the development estate as discussed in Volume 1 Technical Report – Section 2.4.

2.2 Water

2.2.1 Introduction

2.2.1.1 Information included in this appendix

The paper is based on inputs provided by water sector stakeholders, ranging from data that has been published in technical reports (listed in section 0) through to where we have been informed by professional judgement from experts within the service provider organisations. Where information is noted as 'advised by stakeholders', this information is informed by professional judgement within the sector. All other information provided is sourced from the reference documents listed.

2.2.1.2 Key stakeholders

The key stakeholders for the water sector are shown in the following table 5. Figure 16 shows the indicative water corporation boundaries across Victoria.

Table 5: Water sector stakeholders

Role	Stakeholder
Price regulator of the water sector.	Essential Services Commission (ESC)
Policy and management of Victoria's water resources including oversight of water corporations.	Department of Environment, Land, Water and planning (DELWP)
Regulation of drinking water quality.	Department of Health and Human Services (DHHS)
Monitors and oversees the environmental performance of the State's water sector.	Environmental Protection Authority (EPA) Victoria
Management of Melbourne's bulk water supply and sewerage systems and the Port Phillip and Westernport catchment waterways, major drainage, stormwater and recycled water systems. Melbourne water also provides water supply to some areas outside of Melbourne.	Melbourne Water (State owned statutory authority)
Melbourne's Metropolitan Retail Water Corporations (3) Role: Operate urban water and sewerage distribution systems for the Melbourne Metropolitan area.	Yarra Valley Water (YVW) City West Water (CWW) South East Water (SEWL) (State owned corporation with State appointed board)
Regional Victorian Water Corporations (13) Urban Water Services Role: Provide water and sewerage services (supply, treatment and distribution) to regional urban customers. * Note: Western water also services parts of the Melbourne Metropolitan area. ** GWM Water and Lower Murray Water act as both a regional and rural corporation. **Rural Victorian Water Corporations (4)** Rural Water Services (provided by 4 corporations) Role: Provide rural water services for irrigation and domestic stock purpose. The services include water supply, drainage and salinity mitigation. Regional Bulk Water Services (provided by 3 corporations). Role: Supply of bulk water to other water corporations in regional areas.	Western Water (WW)*, Barwon Water, Central Highlands Water, Coliban Water, East Gippsland Water, Goulburn Valley Water, Gippsland Water, GWM Water**, Lower Murray Water**, North East Water, South Gippsland Water, Wannon Water, Westernport Water Goulburn-Murray Water, GWM Water**, Lower Murray Water**, Southern Rural Water Goulburn-Murray Water, GWM Water**, Southern Rural Water
Local stormwater management.	Local government

Throughout this report Melbourne Water, the metropolitan water companies and the regional and rural water corporations will be collectively referred to as ‘water businesses’.

2.2.1.3 Overview

Water services for urban areas are provided by three sub sectors being:

- water supply – from catchments, desalination and recycling
- sewerage
- stormwater management.

The Victorian water industry has evolved to adopt a more integrated approach to delivering water services, in order to create more sustainable and liveable communities. This is known as integrated water management (IWM), which brings together all facets of the water cycle to maximise social, environmental and economic outcomes. As a result of this, planning is becoming more integrated across the three subsectors, particularly in greenfield developments and precinct scale redevelopments in established areas. Integrated water management is currently more difficult to implement in established areas experiencing incremental growth, however the industry is working to develop cost effective solutions.

Under the Water Industry Act 1994, the water businesses are obligated to undertake planning and participate in periodic water price reviews. The Essential Services Commission (ESC) conducts periodic water price reviews with each water business to establish customer charges, undertaken typically on a five-year planning cycle. The ESC’s role involves regulating prices, service standards, market conduct and consumer protection. As an input to the price review, water businesses develop water plans which include forecasts for infrastructure, operation and financing costs. Water plans serve two main purposes. They provide:

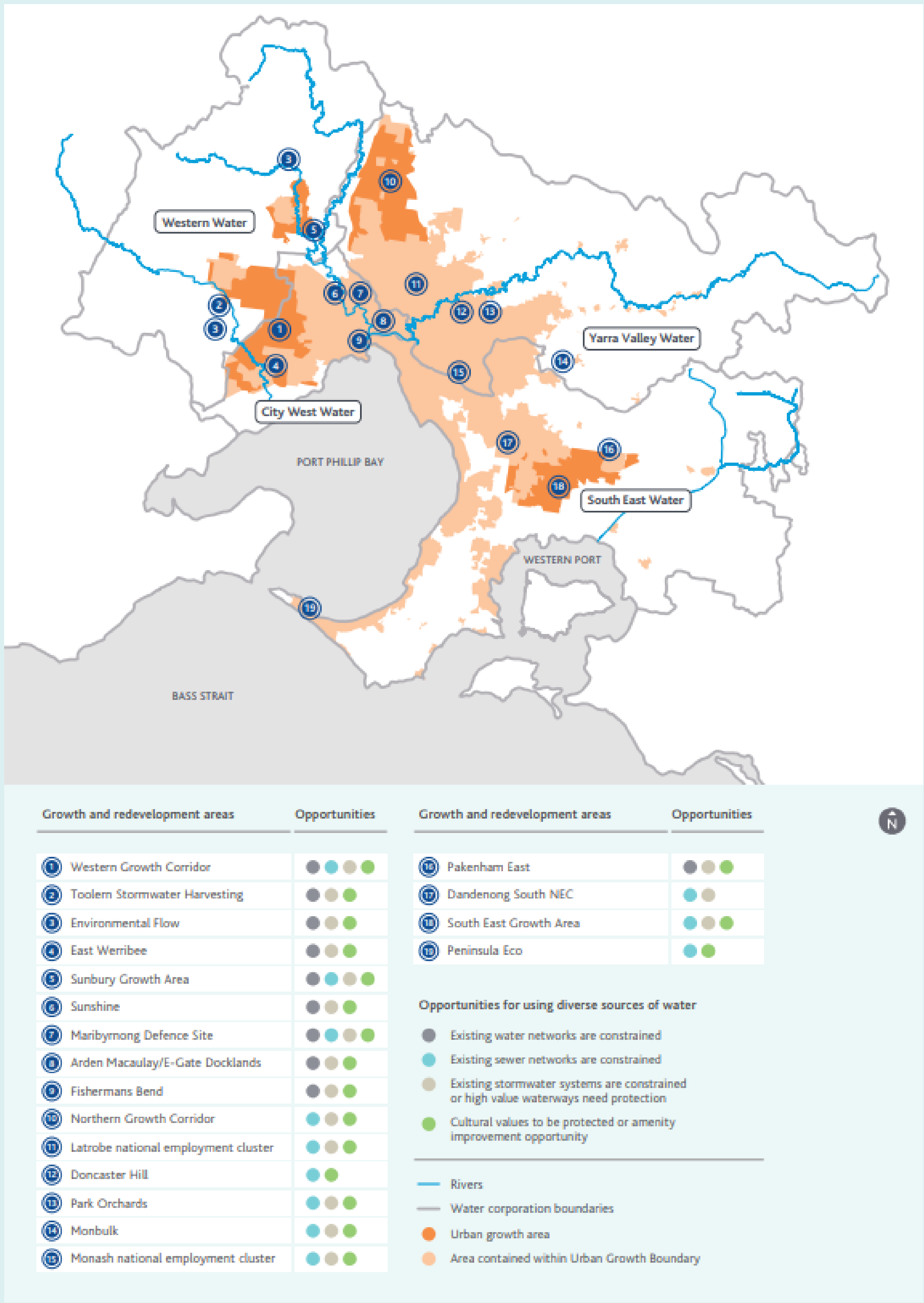
- a mechanism for businesses to commit to a set of outcomes and prices for the next regulatory period
- information the Commission requires to assess businesses’ proposals about services, expenditure, revenue, and tariffs.

The sequence of past and future reviews is as follows:

Table 6: Water industry reviews

Organisation	Next review	Last review
Melbourne Water	2021	2016 for period 2016-2021
Water businesses	2023	2018 for period 2018-2023

Figure 13: Metropolitan water retail company boundaries within the Urban Growth Boundary locations with IWM constraints or opportunities for IWM highlighted



Source: Melbourne Water, *System Strategy* 2017

Water businesses generally have a 20-year long term capital works plans and undertake planning on a 50-year outlook.

Victoria in the Future (VIF) data is used as a basis for customer growth projections and in addition to this water businesses also utilises:

- the Urban Development Program (UDP)
- precinct Structure Plans (PSP) developer information such as masterplans, yield estimates and plans of subdivision
- servicing requests from developers and landowners
- local government advice
- past service data
- consultants forecasting data.

Significant investment was made in Melbourne's water supply and sewer infrastructure in the period of 1970's to 2000, providing a robust system. Since that time water usage has become more efficient and improved modelling techniques and technological advances have enabled the existing assets to be used more effectively.

2.2.2 Water supply system

2.2.2.1 Existing industry structure and infrastructure

Water for Melbourne comes from the following sources:

- Existing storages (1800 GL)
- The Victorian Desalination Plant (150GL per year plus expansion capacity of an extra 50GL)
- Sugarloaf pipeline bringing water from the Murray Goulburn water grid
- Recycled water for non-potable use only

Approximately 80% of Melbourne's potable water is sourced from 157,000 hectares of protected catchments in the Yarra Ranges east of Melbourne. Melbourne Water's supply system contains 10 major reservoirs with a total capacity of 1,800GL. From the major reservoirs the water is transferred through a system comprising over 1000km of pipe, 214km of aqueduct, 65 smaller service reservoirs and 42 treatment plants. Desalinated water from the Victorian Desalination Plant can be transferred by an 84km transfer main and blended in the major reservoirs with catchment water and supplied throughout Melbourne. The Sugarloaf pipeline supplies a further potential source of water from the Murray Goulburn catchment, providing the infrastructure to enable water to be transferred during critical drought periods. The Sugarloaf pipeline is currently not operating and government policy is that it will only be used to supply drinking water when storages are extremely low, or when needed for local fire fighting.

In addition to servicing metropolitan Melbourne, the Melbourne Water supply system also services parts of Barwon Water, Southern Rural Water, Western Water, Gippsland Water, Westernport Water and South Gippsland Water.

Since the majority of Melbourne's water supply comes from protected catchments, this reduces the treatment level required to achieve a safe potable water supply. Water treatment involves chlorination for disinfection, fluoridation to reduce tooth decay and pH correction to reduce the risk of corrosion of water systems and appliances. Around 20% of Melbourne's water receives full treatment. Water that is contained in Sugarloaf and Tarago reservoirs is collected from open catchments and undergoes full treatment.

To service metropolitan Melbourne, the water is transferred from the major reservoirs to service reservoirs, mostly by gravity with some pumping, to provide one to two days' storage which ensures constant supply during peak demand periods. Seasonal water transfers are made to Greenvale Reservoir (13.7GL) during low demand periods to supply the western side of the city during peak periods. From the service reservoirs water is transferred to the four water businesses that service Melbourne. Each water business has different entitlements to the quantity of water that they are allocated from the supply sources. The retail water distribution system contains thousands of kilometres of pipes which carry the water in an interconnected, web-like network. The water pressure in the system is managed to be sufficient but not so high as to damage household plumbing.

Recycled water is currently provided from recycling sewage (at Melbourne Water's Eastern and Western Treatment plants and at smaller plants operated by other water businesses) and from recycling stormwater in localised systems. Recycled water is treated to a fit for purpose level, but usually not to potable levels, due to the additional cost required to achieve this quality and the current government policy position that recycled water is not to be adopted for potable use. The water is therefore used as a substitute for fresh water supply for irrigation, industrial purposes and domestic use such as washing clothes and flushing toilets. In growth areas the Metropolitan Retail Water Corporations have the authority to mandate for residential developments to provide a second water reticulation system for non-potable water, commonly called a 'purple pipe' system. The extent of this across Melbourne is shown in section 0.

2.2.2.2 Forecasting demand

Water has historically been supplied to service residential, commercial, industrial and agricultural uses. The need to provide water to service minimum environmental standards for waterways and the more recently evolving need to provide a supply of water to protect places of significant cultural heritage and recreational use (such as open space and playing fields) has added to the purposes that the water supply must service (Melbourne Water 2017c).

The current demand for water for metropolitan Melbourne on a per capita basis is significantly less than what was anticipated in projections approximately 20 years ago. Domestic water usage on a per capita basis has also almost halved since the 1990's. This is partially due to decreased residential water use arising from water restrictions that were imposed during the millennium drought, and it is also due to homes and gardens becoming smaller and more water efficient. Industrial usage has also reduced due to the decline in industrial activity and high usage industrial firms being targeted to implement water efficiency measures in the period from 1990 to 2000. Two-thirds of water is used for residential purposes however, and so whilst per capita use is decreasing, population growth will increase overall water demand (Melbourne Water 2017c).

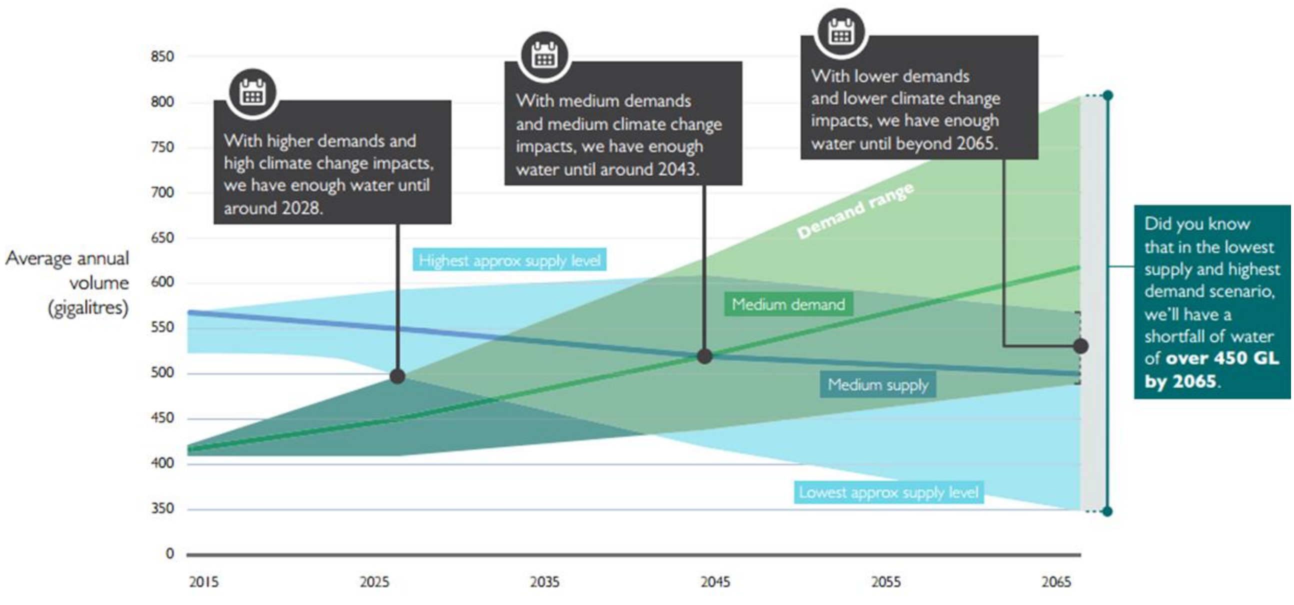
When considering a 50-year horizon, per capita demand, climate change effects and actual population growth demand could vary significantly. Water businesses have therefore adopted a risk based scenario approach to future planning, developing high, medium and low profiles for both demand and supply, which can be monitored over time to guide infrastructure planning.

2.2.2.3 Existing conditions and future capacity

The following section is drawn from the three references Melbourne Water 2014b, 2017b and 2017c.

DELWP and the water businesses have undertaken scenario based planning to determine supply and demand profiles for 50 years into the future, with the outcomes for Melbourne summarised in Figure 7.

Figure 17: Water supply and demand scenarios in Melbourne



Source: Water for a future thriving Melbourne (2017)

This analysis indicates that depending on the scenarios that eventuate, we may require a new supply of water by 2028 or alternatively our current water supplies may be sufficient beyond 2065. Potential sources of additional supply identified by Infrastructure Victoria in the 2016 30-year infrastructure strategy include:

- a 50GL Victorian Desalination Plant expansion
- a new desalination plant
- increased use of recycled water for potable substitution
- broader scale rainwater, stormwater and wastewater harvesting for non-potable (potable substitution) and/or potable use
- water grid optimisation
- recycling of water for potable use.

As Melbourne's water supply system is interconnected, a water supply shortfall will impact most locations within the metropolitan area equally. The exception is areas serviced by Western Water. Western Water's water supply comes from within its existing catchment with an allocation from Melbourne Water, provided since 2004. The Melbourne Water allocation does not however allow for any supply from the desalination plant (Melbourne Water 2018a). In drought periods Western Water's supply shortfall risk is therefore higher than the other Melbourne retail networks.

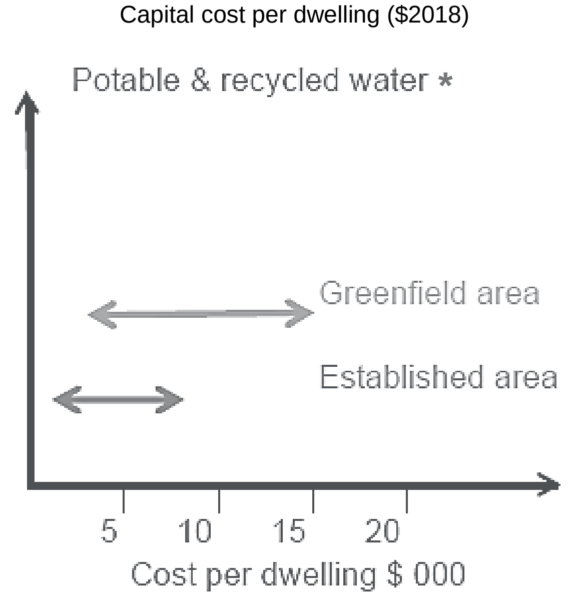
Looking ahead to 2050 and based on Victoria in the Future (VIF) population forecasts, under traditional delivery methods incremental upgrade and augmentation of the Melbourne Water trunk supply system will be required to service population growth. This could be managed by either increased adoption of recycled water in localised treatment facilities in greenfield areas, an upgrade of the Melbourne Water trunk network or a combination of both. The timing of these works will be dependent on the volume of supply water available and the rate and location of population growth and hence there is not a specific trigger point for this augmentation. The major projects required to support growth area expansion with traditional water supplies are augmentation of the Greenvale Reservoir (the major water supply point for the western suburbs and the northern growth areas), provision of a new water reservoir in the Northern Growth Area and augmentation of the water supply to the South East Growth Area.

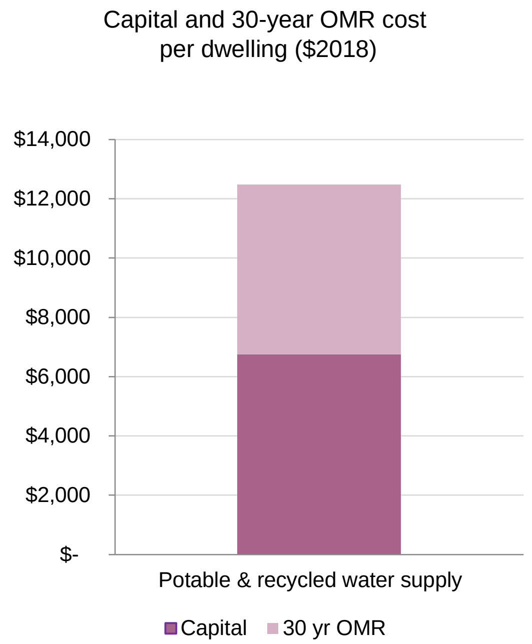
Water distribution networks will also be able to be incrementally expanded to support growth with the need for upgrades of existing infrastructure in established areas increasing over time.

2.2.2.4 Water supply infrastructure costs

Overview

Figure 148: Water supply infrastructure cost variance





* Note recycled water reticulation costs are included for greenfield areas only

Costs have been determined for different development types based on the principles outlined in Table and in the Volume 1 Technical Paper section 2.7 and section 4.1.

The capital costs presented in this report represent the cost of the infrastructure required to provide supply water to a new dwelling, which includes the infrastructure to connect a dwelling into the existing water supply network and the overall infrastructure upgrades required to the water supply network to distribute the additional supply demand. Water supply infrastructure supporting dwellings consist of either a single network for potable water only, or a dual network of separately reticulated potable and recycled water. OMR, or operational, maintenance and replacement costs represent the annual costs to manage the infrastructure, including the cost of operation, maintenance and replacement or augmentation of infrastructure elements as they reach the end of their service life or have compliance issues. The cost of water provision, including water rights or additional water supply augmentation measures such as the operation and construction of centralised desalination plants is not included in the costs. The capital cost and OMR costs of localised water recycling plants operated by the Melbourne metropolitan retail water corporations is however included in the costs.

The majority of costs presented in this analysis are based on traditional methods of water and sewerage management, which do not incorporate a fully integrated water management approach. If modelling of future scenarios is proposed that does not assume current day approaches, use of the figures below may not be appropriate.

Table 7: Principles for assembling costs

Party	Cost element	Development type		Note
		Greenfield	Established areas	
Melbourne Water trunk network	Capital cost for augmentation of the existing network to take greater volumes in response to population growth	Incl	Incl	
	Capital cost for extension of the existing network to service additional growth area population	Incl	NA	
	Annual operation and maintenance cost of the network	Incl	Incl	
	Annual cost of compliance upgrades and renewal of existing aged assets	NA	Incl	Refer Note 1
Distribution network	Capital cost for new a connection	Incl	Incl	
	Capital cost for extension of the existing network to service additional growth area population	Incl	NA	
	Annual operation and maintenance cost of the network	Incl	Incl	
	Annual cost of compliance upgrades and renewal of existing aged assets	NA	Incl	Refer Note 1
Development costs within the estate	The capital cost by the developer to connect and reticulate the water service within the development estate	Incl	Incl	
	Operational cost	NA	NA	Refer Note 2

Note:

1. The annual cost of compliance upgrades and renewals has not been applied to greenfield dwellings as significant cost will not be incurred for the initial 30 years of operation.
2. Unless a body corporate is managing the water assets within the development, operation and maintenance of the water infrastructure within the development will be managed by the distribution network once the development is commissioned.
3. Key: Incl – Cost included NA – Cost not applicable

Water supply cost findings

Indicative costs for typical development settings are summarised in

Table The costs that are provided are indicative of the order of costs that can be experienced in the situation described, rather than definitive costs, as many factors can influence the cost of an actual development as outlined in the in Volume 1 Technical Paper section 2.3. In looking at cost, we were interested in understanding orders of magnitude to guide strategic decision-making, rather than precise costings to inform investment decisions. The case studies were chosen to provide typical costs experienced, rather than extreme costs that could be experienced, however this assessment is acknowledged as subjective.

Findings from the case study costings for water supply infrastructure costs are as follows:

- The capital cost to provide potable water supply infrastructure to a new dwelling in a greenfield location compared to an established area can vary from being equal to being a factor of four times more expensive, when there is capacity in established areas to support growth. Factors affecting cost are the need to extend the existing distribution network, the extent of reticulation within the development site and the requirement to apply check meters to strata title properties.

- A significant variance in the cost to provide water supply is the inclusion of a dual pipe system in greenfield areas that provides potable water supply network and a recycled water supply network, commonly known as a 'purple pipe' system. Inclusion of a dual pipe network effectively doubles the cost of the water reticulation within the development estate from $2,500 per connection to $5,000 per connection in a greenfield development (SMEC, 2018).
- The capital cost of infrastructure to connect a water supply to new greenfield dwellings is typically split approximately equally between the distribution authority infrastructure and the infrastructure within the development estate, with the Melbourne Water trunk network contributing less than 15% of the cost.
- It is not possible to accurately attribute recurrent operation, maintenance and renewal costs (OMR costs) to different development settings as data is not captured to enable reporting on this and it is difficult to allocate costs on a networked system. In greenfield areas the distribution network infrastructure OMR costs are likely to be lower than those in established areas as the infrastructure is newer (requiring less reactive maintenance) and unlikely to require significant renewal for over 30 years following installation. New infrastructure is also made of materials with a significantly longer design life than the existing infrastructure in established areas.
- Where there is capacity to support growth in established areas without augmentation of existing services, water infrastructure capital costs are lower than the greenfield development. However where upgrades are required in established areas, cost can be equal to greenfield areas as the works are undertaken in operational environments requiring system disruptions and traffic management, without the economy of scale achievable in greenfield developments.
- The majority of costs presented in this analysis are based on traditional methods of water and sewerage management, which do not incorporate an integrated water management approach. Adopting an integrated water management approach in a greenfield area can increase the cost of traditional water supply delivery, but offer significant benefits to the environment and potentially lead to costs savings on centralised infrastructure investment. The benefits in each situation must be assesed against the costs to determine the value of the additional expenditure, however if an integrated water management approach is adopted more extensively in future developments, the costs for water supply infrastructure will be higher than reported in this document.

Water supply infrastructure cost data

Drawing from the Essential Services Commission (ESC) 2018 Water Price Review documentation for the three metropolitan water retailers and 2016 Melbourne Water price review, the costs for water connection and operation, maintenance and replacement for the Melbourne metropolitan area are provided in Table 8. These figures are average figures for Melbourne and do not relate to a specific location or development setting. This high level data enables us to compare the relative costs of different infrastructure elements that support residential development.

Table 8: Average water supply infrastructure costs per dwelling in Melbourne

Costs per Dwelling	$ Jul 2018
Developer capital cost within development site	$4,000
Water authority capital costs ($/dwelling)	$2,800
Water authority operation, maintenance and replacement ($/dwelling /year)	$200 pa
Water capital and recurrent OMR over 30 years	$12,800

Note:

- Melbourne Water costs have been distributed evenly across Melbourne on a per connection basis, rather than allocated based on actual infrastructure provision.
- The water authority average connection costs are a weighted average of the three water authorities based on 2017/18 customer numbers.
- The average develop capital cost within the development site is based on Plan Melbourne/VIF projected ratios of future development (35% greenfield and 65% established area development). The cost is made up of 35% greenfield capital medium cost with capacity and 65% average of established area SSID and PSB capital medium cost with capacity.

Table 9 provides indicative costs for different development scenarios based on confidential studies and cost data provided by the water businesses and compiled by Infrastructure Victoria.

Table 9: Typical development setting water costs

Connection description (Confidence in cost data)	Details	Cost per dwelling ($Jul 2018)			Costs source
		Capital cost	Operation, maintenance & replacement $/pa	30-year cost	
Greenfield development Western Growth Area within CWW catchment	Potable water only and significant augmentation of the distribution network not required	$5,100 {$6,300}	$160 {$160}	$9,900 {$11,100}	Water authority advice based on historical development data
	Recycled water for non-potable use and potable supply – purple pipe system	$10,300 {$11,600}	$160 {$160}	$15,100 {$16,400}	SMEC data within development estate
Greenfield development Northern Growth Area	Potable water only	$6,200	$130	$10,000	Water authority advice based on feasibility study
	Recycled water for non-potable use and potable supply – purple pipe system	$10,600	$150	$15,200	ESC submission for additional MW costs
Greenfield development South East Growth Area	Potable water only	$4,700 {$5,900}	$160 {$160}	$9,500 {$10,700}	ESC price proposal data SMEC data within development estate
Medium density brownfield precinct development (Mod)	Capacity available in existing system one to four storey form with a combination of detached, semidetached or attached residential dwelling types – every dwelling separately metered. 100% potable supply	$3,400	$190	$9,100	ESC price proposal data SMEC data within development estate
Middle ring subdivision – 1 dwelling replaced by 2 or 3 (Mod)	Capacity available in existing system Potable water provided only (reticulated recycled water not available)	$5,000	$190	$10,700	ESC price proposal data SMEC data within development estate
High density inner development	Capacity available in existing system	$1,700	$190	$7,455	

Note: Figures in brackets { } allow for additional cost to upgrade the Melbourne Water trunk transfer network when water volumes exceed the current capacity of the Melbourne Water trunk transfer network, which could be as soon as 2025.

2.2.3 Sewerage system

2.2.3.1 Existing industry structure and infrastructure

There are multiple components to a sewerage system, including sewerage collection system (sewer network), treatment, winter storage of effluent and effluent and biosolids release or re-use.

The Melbourne metropolitan retail water corporations, reticulated sewage collection systems take sewage from households, commercial and industrial premises and transfer 90% of it to the Melbourne Water (MW) operated transfer system and treatment plants. The remaining 10% is serviced by treatment plants operated by the Melbourne metropolitan retail water corporations (MW 2017a).

Western Water services western areas of metropolitan Melbourne within the urban growth area, but is currently not connected to the MW sewerage treatment system and all sewerage is treated at treatment plants operated by Western Water. Negotiations are underway between City West Water and Western Water for a portion of the urban growth area east of the outer metropolitan ring road and from the Kororoit Creek catchment in the Melton Growth Corridor to be fed through the City West Water sewerage network into the Melbourne Water sewerage treatment system (Western Water 2017).

The majority of the reticulated collection systems operate under a gravity fed system, however some retail water businesses have adopted pressure sewers at particular locations due to topography, poor soil conditions (sand and high water table) and in areas where there is a requirement for existing vegetation to be retained. The system is more expensive to operate per annum, but can have a lower whole-of-life cost than installing a traditional system at that location. Approximately 50,000 properties within Melbourne are still serviced by septic tank systems, which do not feed into a reticulated system and are being gradually replaced with reticulated systems or enhanced septic systems (VAGO 2018).

In the Melbourne Water transfer network, sewage is transferred mostly via gravity, with pumping provided by nine major pump stations to treatment plants, where it is treated so that it can be reused or made safe for release to the environment. The Melbourne Water transfer and treatment system has two main treatment plants: Eastern Treatment Plant (ETP) located at Bangholme and Western Treatment Plant (WTP) located at Werribee. About 40% of sewage is currently treated at ETP or approximately 330ML a day. ETP has a tertiary filtration plant which will produces treated effluent with low colour and odour of Class A quality which provides up to 100GL per annum of water for reuse in industry, irrigation and domestic third pipe systems. The rest of the effluent from ETP is presently discharged to Bass Strait. About 60% of sewage is currently treated at WTP (approximately 500ML a day) where some recycled water is reused for industry, irrigation and domestic third pipe systems and the remainder is discharged through a series of manmade wetlands into Port Phillip Bay (MW 2017a).

The sewerage system is designed to a standard defined by the EPA Victoria to contain wet weather flows up to a 1 in 5 year average recurrence interval rainfall event. The standard provides a level of service which balances costs and protection for the community. There are emergency relief structures (ERS) throughout the sewerage network which act as a layer of protection for the system by allowing controlled release of highly dilute sewage to rivers and creeks when flows cannot be contained within the transfer system due to extreme wet weather.

2.2.3.2 Forecasting demand

Critical capacity in the sewerage system relates to peak wet weather flows, as stormwater entering the sewerage system during wet weather increases the total volume of material to be transferred. Stormwater enters the sewerage system predominantly through cracks in pipework or illegal routing of stormwater to the sewer system. Greenfield developments should have a lower sewerage load per dwelling than established areas as properly installed new sewerage reticulation system would allow less stormwater inundation. Sewage volumes will increase with population growth however, even though per capita volumes are decreasing.

2.2.3.3 Existing conditions and future capacity

The water authorities have recently released a long term sewerage strategy (Melbourne Water 2018b). Over the long term, water businesses will need to invest in new and upgraded sewerage infrastructure to cater for:

- climate change – rising sea levels impacting existing treatment plants, warmer weather, more severe storm events impacting on the performance of the system and drier conditions increasing the need for environmental watering
- a growing population – increasing at a rapid rate
- a changing urban environment – transitioning from suburbs with large back yards to a mix of high and medium density along with sprawling suburbs on the fringe of the city
- increased demand for recycled water for many purposes
- new approaches to how we deal with waste – moving towards a circular economy
- new technology, increasing affordability of safe, micro-scale alternatives for water supply and sewage treatment, and how we build, monitor and maintain the sewerage system

- the impact of changing industries and emerging contaminants – changing the composition and treatment requirements of sewage
- replacing ageing assets
- changes in regulations and environmental standards

Projected population growth can be supported at most locations in Melbourne through the ongoing incremental expansion of the sewerage transfer and treatment system.

Of the two main Melbourne Water treatment facilities, the Eastern Treatment Plant (ETP) currently has a higher growth potential than the Western Treatment Plant (WTP), as its effluent discharges to ocean outfall rather than the bay. With developments in technology and adoption of more mechanised treatment at WTP, the two treatment plants have the capacity to support the projected population growth in Melbourne for the next 30 years with augmentation. The design of the treatment plants and their large scale are well suited to this augmentation taking place incrementally. The two plants form part of a connected network for treating sewerage and over time it is likely that this network will become more integrated. Over time it is also likely that WTP will become a more mechanised treatment facility to support increased volumes and environmental standards for effluent. The current approximate 50% difference in whole-of-life cost between the two plants will then decrease.

The sewer transfer and distribution network is predominantly designed to operate under a gravity fed legacy system which is operationally cost effective. Where the gravity system can no longer support peak wet weather flows (as described in section 0), the system can be supplemented with local detention storages, pumped systems or the gravity fed system upgraded.

The majority of sewage is likely to continue to be treated by the centralised Melbourne Water built, owned and operated treatment plants, ETP and WTP, however a portion will be treated in standalone treatment facilities in the vicinity of the development. The decision on whether sewage is treated centrally or locally for future developments will be determined on the particular conditions at each location, based on a full assessment of the costs and benefits. A limitation on the ability to treat sewage locally is the ability to discharge treated effluent into the local waterway system or distribute effluent for reuse as a recycled water supply. A limitation on the ability to treat sewage centrally is the cost of extending the existing network to new development areas and undertaking upgrades in established areas to the existing trunk infrastructure.

In northern and western outer growth areas there will be the requirement to provide new treatment facilities or extend connections to the Melbourne Water system, however these can be planned and implemented within a timeframe required to support demand. In western growth areas the most economical solution is likely to be to link into the Melbourne Water system, however in the northern and south eastern growth corridors localised systems may be more economical, attracting higher cost, but offering additional benefits, such as supply of environmental water or reducing demand on the centralised system.

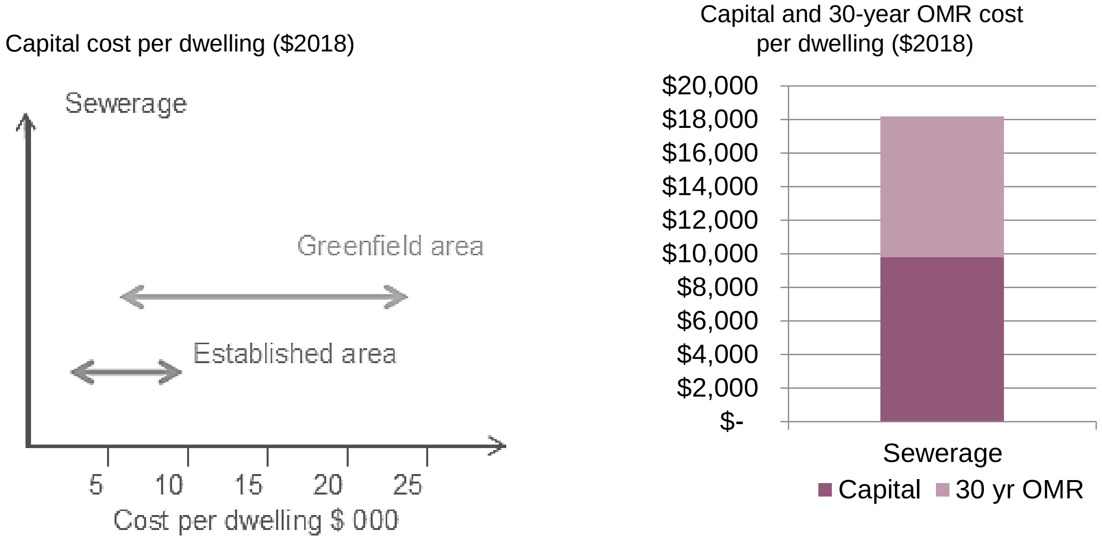
As the system capacity is limited by wet water flows and new developments provide improved pipework that should reduce stormwater infiltration, new developments should be able to be accommodated in established areas in principle. Increased loads on the system due to population growth will however at some stage exceed the capacity of the existing system. In large redevelopment precincts such as Fishermans Bend, precinct-wide solutions will be adopted that can economically deal with the additional sewer loads. Similar to new greenfield developments, the most economical approach will be taken for the region based on principles of integrated water management, considering the options of linking into the Melbourne Water transfer and treatment system or alternatively providing localised solutions. City West Water is currently upgrading the main sewer servicing the CBD. The tunnel is oversized for the demand, with the size being adopted to provide an economical construction method. The remainder of the city areas mains are predominantly from the 1850's and will require replacement over time due to their age, but not due to capacity constraints. The implementation of this will be determined using risk modelling based on failure data. Depending on the sequencing of when mains are required to be replaced, decisions will be made as to if a main should increase or decrease in size, or be decommissioned based on maximising the efficiency of the system.

Some areas in Melbourne's outer established areas still have septic tank systems which are not connected into a reticulated system. Water authorities are reviewing options for optimising performance and mitigating risks of the septic tank systems with local communities. Reticulated systems are more costly to install and operate but in these locations due to the terrain and lack of access to trunk infrastructure.

2.2.3.4 Sewerage infrastructure costs

Overview

Figure 19: Sewerage infrastructure cost variance



Costs have been determined for different development types based on the principles outlined in in Table 10 and the Volume 1 Technical Paper section 2.7 and section 4.1. The capital costs represent the cost of the infrastructure required to connect a new dwelling to a sewerage collection and treatment system which includes the infrastructure to connect a dwelling into the existing sewerage network and the overall infrastructure upgrades required to the sewerage system to transfer and treat the additional supply. OMR, or operational, maintenance and replacement costs represent the annual costs to operate and maintain the infrastructure that transfers and treats the sewerage and replacing or augmenting elements as they reach the end of their service life or have compliance issues.

The majority of costs presented in this analysis are based on current methods of water and sewerage management, which do not incorporate a fully integrated water management approach. If modelling of future scenarios is proposed that does not assume current day approaches, use of the figures below may not be appropriate.

Table 10: Principles for assembling costs

Party	Cost element	Development type		Note
		Greenfield	Established areas	
Melbourne Water trunk network and treatment facilities	Capital cost for augmentation of the existing network to take greater volumes in response to population growth	Incl	Incl	
	Capital cost for extension of the existing network to service additional growth area population	Incl	NA	
	Annual operation and maintenance cost of the network	Incl	Incl	
	Annual cost of compliance upgrades and renewal of existing aged assets	NA	Incl	Refer Note1
Distribution network	Capital cost for a new connection	Incl	Incl	
	Capital cost for extension of the existing network to service additional growth area population	Incl	NA	
	Annual operation and maintenance cost of the network	Incl	Incl	
	Annual cost of compliance upgrades and renewal of existing aged assets	NA	Incl	Refer Note1

Party	Cost element	Development type		Note
		Greenfield	Established areas	
Development costs within the estate	The capital cost by the developer to connect and reticulate the water service within the development estate	Incl	Incl	
	Operational cost	NA	NA	Refer Note 2

Note:

1. The annual cost of compliance upgrades and renewals has not been applied to metropolitan water retail infrastructure for greenfield dwellings as significant cost will not be incurred for the initial 30 years of operation.
2. Unless a body corporate is managing the water assets within the development, operation and maintenance of the water infrastructure within the development will be managed by the distribution network once the development is commissioned.
3. Key: Incl – Cost included NA – Cost not applicable

Cost findings

Indicative costs for typical development settings is summarised in Table 12. The costs that are provided are indicative of the order of costs that can be experienced in the situation described, rather than definitive costs, as many factors can influence the cost of an actual development as outlined in in the Volume 1 Technical Paper, section 2.3. In looking at cost, we were interested in understanding orders of magnitude to guide strategic decision-making, rather than precise costings to inform investment decisions. The case studies were chosen to provide typical costs experienced, rather than extreme costs that could be experienced, however this assessment is acknowledged as subjective.

Findings from the case study costings are as follows:

- The capital cost to provide sewerage infrastructure to a new dwelling in a greenfield location compared to an established area can vary from being equal to four times more expensive, where there is capacity in the existing infrastructure to support growth. Factors affecting cost are the need to extend the existing distribution network and the extent of reticulation within the development site.
- The capital cost to provide sewerage infrastructure to a new dwelling is typically split approximately equally between the distribution authority infrastructure and the infrastructure within the development estate, with the Melbourne Water trunk network infrastructure typically contributing less than 15% of the cost. Distribution authority infrastructure costs in the City West Water region are often lower due to proximity to Melbourne Water infrastructure.
- The recurrent operation, maintenance and renewal costs (OMR costs) are split approximately equally between the distribution network infrastructure and the Melbourne Water trunk network in established areas. In greenfield areas the distribution network infrastructure OMR costs are on average approximately 50% lower than those in established areas as the infrastructure is new and is unlikely to require significant renewal for over 50 years.

Sewerage infrastructure cost data

Drawing from the Essential Services Commission (ESC) 2018 Water Price Review documentation for the three Victorian distributors and 2016 Melbourne Water price review, the costs for water connection and operation, maintenance and replacement for the Melbourne metropolitan area are provided in Table 11. These figures are average figures for Melbourne and do not relate to a specific location or development setting. This high level data enables us to compare the relative costs of different infrastructure elements that support residential development.

Table 11: Average sewerage infrastructure costs per dwelling for Melbourne

Water authority sewerage infrastructure costs per dwelling (Melbourne water and distribution companies)	$Jul 2018
Capital cost within development site	$4,400
Sewerage water authority capital cost ($/dwelling)	$5,400
Sewerage water authority operation, maintenance and replacement ($/dwelling /year)	$280 pa
Water capital and recurrent OMR over 30 years	$18,200

Note:

- Melbourne Water costs have been distributed evenly across Melbourne on a per connection basis, rather than allocated based on actual infrastructure provision.
- Average water authority costs are a weighted average of the three water authorities based on 2017/18 customer numbers.
- The average cost within the development site is based on Plan Melbourne/VIF projected ratios of future development (35% greenfield and 65% established area development). The cost is made up of 35% greenfield capital medium cost with capacity and 65% average of established area SSID and PSB capital medium cost with capacity.

Table 12 provides indicative costs for different development scenarios based on confidential studies and cost data provided by the water businesses and compiled by Infrastructure Victoria.

Table 12: Typical development setting sewerage infrastructure costs

Details		Cost per dwelling ($Jul 2018)			Costs source
		Capital cost	OMR	30-year cost	
Greenfield development Western Growth Area – No extension of MW system	Sewage treated centrally by Melbourne Water	$8,750	$220	$15,400	MW and distributor advice based on historical development data. SMEC data within development estate
Greenfield development Northern Growth Area – Extension of MW system	Traditional centralised MW treatment (117,000 dwellings) Some local treatment of sewerage, based on the volumes of effluent that can be reused (117,000 dwellings)	$11,000 $10,700	$160 $165	$15,700 $15,600	Distributor advice based on feasibility study ESC price proposal data for additional MW costs
Greenfield development South East Growth Area – No extension of MW system	Sewage treated centrally by Melbourne Water	$11,000	$230	$17,900	ESC price proposal data SMEC data within development estate
Middle ring subdivision (one dwelling replaced by two or three) – No extension of MW system	Capacity available in existing system Sewage treated centrally by Melbourne Water	$5,200	$280	$13,600	SMEC data ESC price proposal data MW
Medium density brownfield precinct development – No extension of MW system	One to four storey form with a combination of detached, semidetached or attached residential dwelling types – every dwelling separately metered Sewage treated centrally by Melbourne Water	$5,200	$280	$13,600	SMEC data ESC price proposal data MW
High density development in inner area – No extension of MW system	Sewage treated centrally by Melbourne Water	$2,400	$280	$10,800	SMEC data ESC price proposal data MW

2.2.4 Sources

2.2.4.1 General

City West Water *Integrated Water Cycle Management Strategy* 2016

City West Water *Urban Water Strategy* 2017

Infrastructure Victoria, *30-year infrastructure strategy*, 2016

Melbourne Water, *Better waterways and Drainage for our community*, 2016a

Melbourne Water, *Corporate Plan 2017/18 to 2021/22, 2017a*

Melbourne Water, *Flood Management Strategy Port Phillip and Westernport*, 2016b

Melbourne Water, *2018/19 Desalinated Water Order Advice Summary of Technical Analysis March 2018,* 2018a

Melbourne Water, *Melbourne Sewerage Strategy Discussion Paper*, 2018b

Melbourne Water, *System Strategy*, 2017b

Melbourne Water et al, *Water for a Future-Thriving Melbourne, 2017c*

Melbourne Water*, Melbourne Sewerage Strategy,* 2018

South East Water, *Urban Water Strategy*, 2017

VAGO, Managing the Environmental Impacts of Domestic Wastewater, September 2018

Western Water, *Integrated Water Management Strategy*, 2014

Western Water, *Urban Water Strategy*, 2017

Yarra Valley Water, *Urban Water Strategy*, 2017

Yarra Valley Water, *Water Plan 2013/14 to 2017/18*, 2012

Confidential cost data provided by water authorities

2.2.4.2 Melbourne average water sector costs (Volume 1 Figure 3 and Table 4)

Distribution

The figures in the table 8 and 10 were calculated using figures from these three documents publically available on the website of the Essential Services Commission:

- 2018 Water Price Review, South East Water draft decision, financial model (Excel),
- 2018 Water Price Review, Yarra Valley Water draft decision, financial model (Excel),
- 2018 Water Price Review, City West Water price submission, financial model (Excel),

Dates of figures used

- Actual figures for 2013/14-2017/18
- Forecast figures for 2018/19-2022/23

Types of figures used

- Operating Expenditure (‘Opex Breakdown’ tab)
- Capital Expenditure (‘Capex FO Input’ and ‘Capex FO AC’ tabs)
- Customer Numbers (‘Opex FO’ tab)

Example calculations

$$Connection\ cost\ 2015/16 = \frac{Growth\ Capital\ Expenditure\ 2015/16}{No.\ \ customers\ 2015/16 - No.customers 2014/15}$$

$$Maintenance\ cost\ 2015/16 = \frac{Total\ Capital\ Exp.2015/16 - Growth\ \&\ Corporate\ Capital\ Exp.2015/16 + Operating\ Exp.2015/16}{No.customers\ 2015/16}$$

The cost each year for 10 years is calculated, and then the average of these costs is taken.

Key assumptions

- ‘Operating Expenditure’ only includes ‘Treatment’ and ‘Operations & Maintenance’ costs. This is so only engineering costs on the ground are considered.
- ‘Capital Expenditure’ excludes ‘Corporate’ costs. This is so only engineering costs on the ground related to the actual physical service are considered.
- There is no differentiation between residential and business customers. The cost and customer numbers are included together.
- The number of new connections is simply equal to the increase in the number of customers in a given year compared with the last year.
- All Growth Capital Expenditure is due to the cost of connecting new customers and augmenting the network to cater for the greater demand they cause. No Growth Capital Expenditure occurs because the existing population increases its demand.
- The proportion of total ‘Capital Expenditure’ that is related to ‘Growth’ in each of the years 2013/14-2017/18 is
- the same as the average over the period 2018/19-2022/23.

Transmission & Catchment Management
The figures in the table 8 and 10 were calculated using figures from these three documents publically available on the website of the Essential Services Commission:

- Water Price Review 2016-2021, Melbourne Water final decision,
- Water Price Review 2016-2021, Melbourne Water price submission
- Melbourne Water 2013 Water Plan,

Dates of figures used

- Forecast figures for 2013/14-2015/16, forecast in 2013
- Forecast figures for 2016/17-2020/21, forecast in 2016

Types of figures used

- Operating Expenditure
- Capital Expenditure
- Customer Numbers (from water supply distribution customer numbers as above)

Example calculations

$$Connection\ cost = \frac{Growth\ Capital\ Expenditure}{Final\ no.\ \ customers - Initial\ no.customers}$$

$$Annual\ Maintenance\ cost = \frac{Total\ Capital\ Exp. - Growth\ Capital\ Exp. + Operating\ Exp.}{Av.no.customers \times No.years}$$

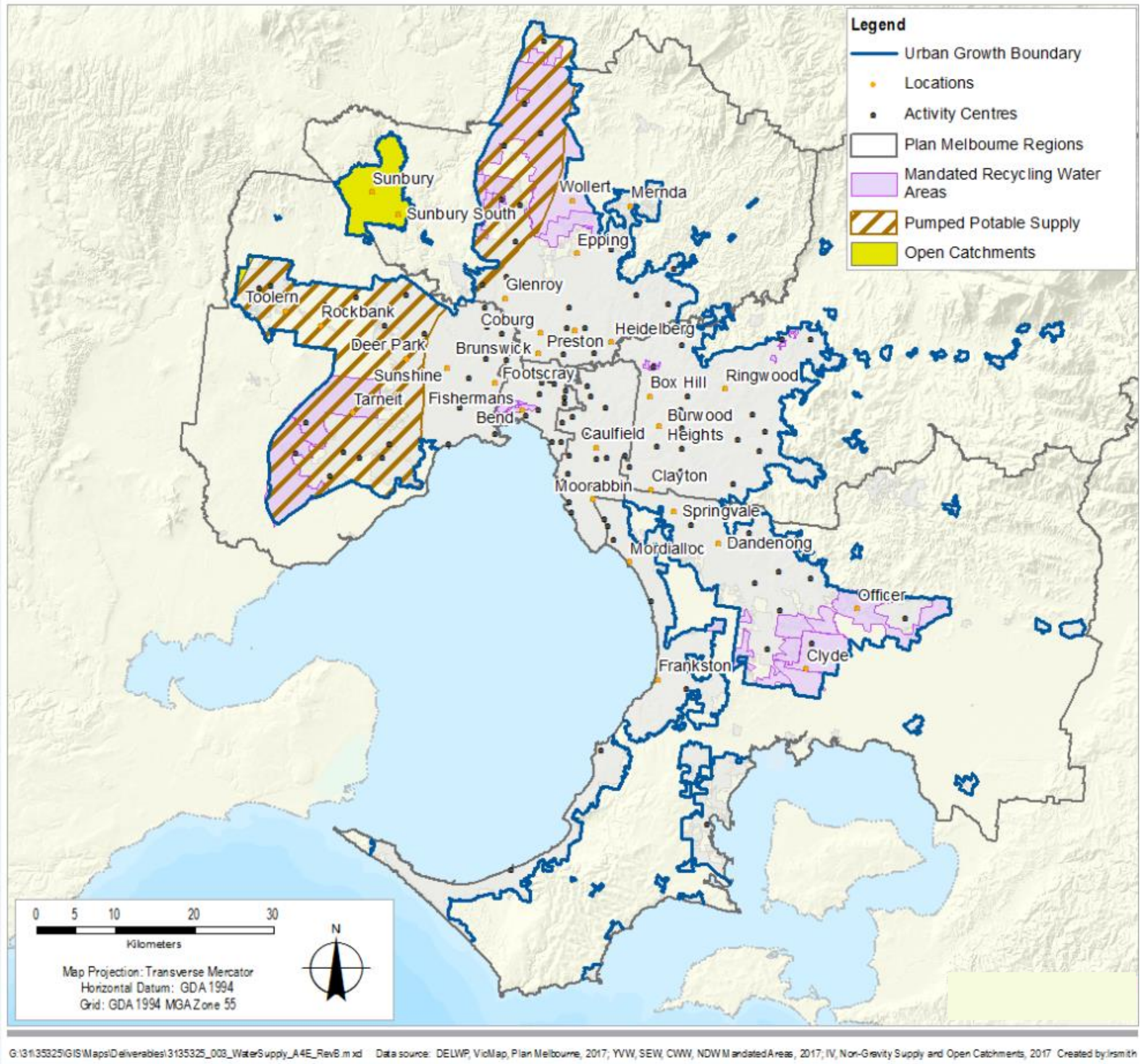
The total cost spent over 8 years is calculated, and then this total is divided to find the average cost over the period.

Key assumptions

- The total number of Melbourne Water customers is taken to be the total sum of customers from City West, South East and Yarra Valley. The number of stormwater customers is assumed to be the total number of water supply customers.
- There is no differentiation between residential and business customers. The cost and customer numbers are included together.
- The number of new connections is simply equal to the increase in the number of customers in a given year compared with the last year.
- Desalination costs are excluded.
- Recycled Water is omitted.
- All Growth Capital Expenditure is due to the cost of connecting new customers and augmenting the network to cater for the greater demand they cause. No Growth Capital Expenditure occurs because the existing population increases its demand.
- Where possible, non-engineering related operating and capital costs have been omitted.

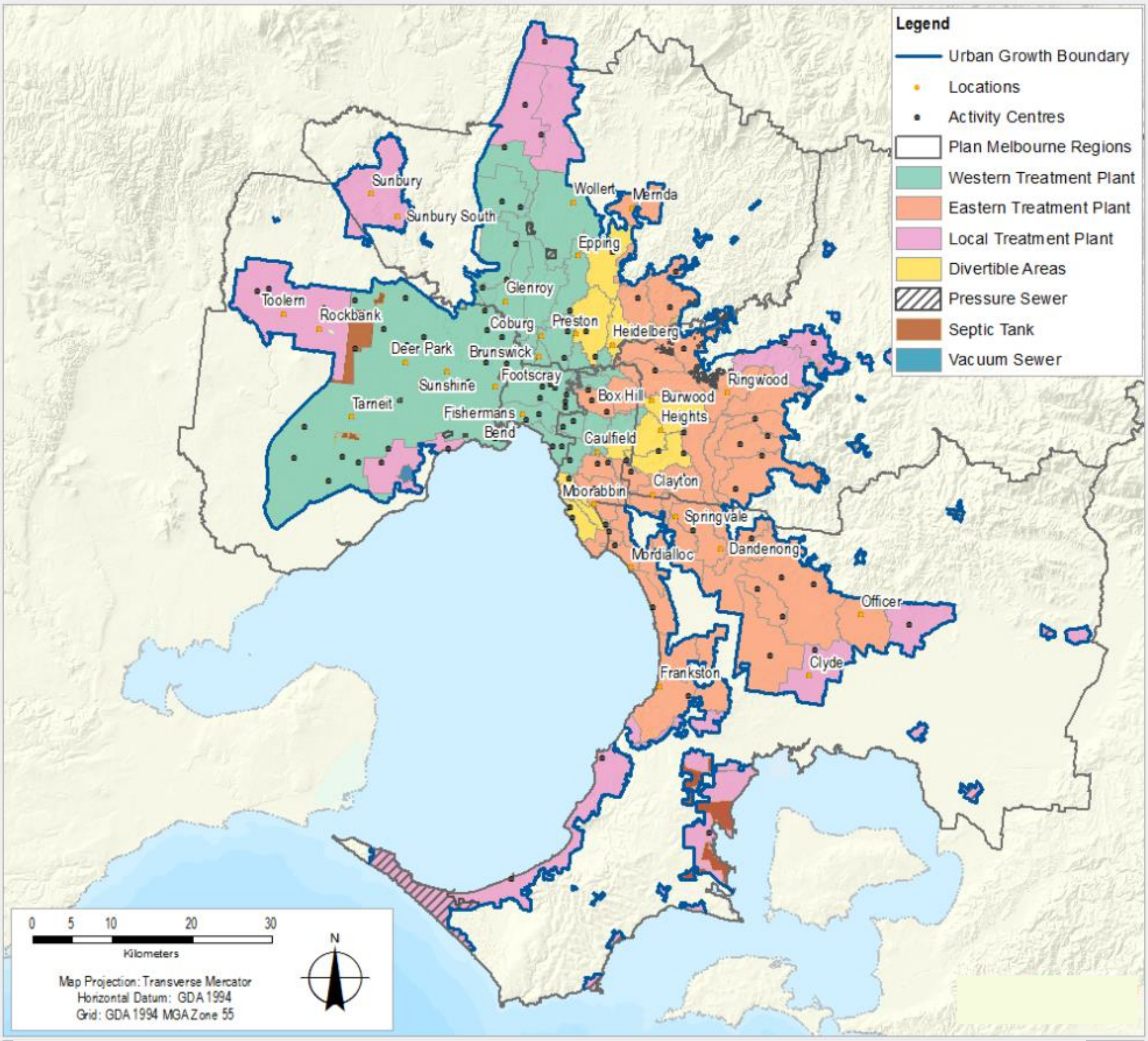
2.2.5 Maps

Figure 20 Water network overview



Data source: DELWP, VicMap, Plan Melbourne, 2017; YVW, SEW, CWW, NDW Mandated Areas, 2017; IV, Non-Gravity Supply and Open Catchments, 2017 (

Figure 21 Sewer network overview



Data source: DELWP, VicMap, Plan Melbourne, 2017; Western Water, City West Water, Yarra Valley Water, South East Water, Sewer Areas, 2017;

2.3 Electricity

2.3.1 Introduction

2.3.1.1 Information included in this appendix

The paper is based on inputs provided by network service providers, ranging from data that has been published in technical reports (listed in Section 0) through to where we have been informed by professional judgement from technical experts within the service provider organisations. Where information is noted as 'advised by stakeholders', this information is informed by professional judgement within the sector. All other information provided is sourced from the reference documents listed.

2.3.1.2 Key stakeholders

The key stakeholders for the electricity utility sector are shown in the following table:

Table 13: Key electricity utility sector stakeholders

Role	Stakeholder
Regulators	Australian Energy Regulator (AER) – Generators, distributors and transmission businesses Essential Services Commission (ESC) – retail businesses and customer interface
Electricity retail and wholesale market operator	Australian Energy Market Operator (AEMO)
Planner of the National Electricity Market (NEM) high-voltage transmission network	Australian Energy Market Operator (AEMO)
Declared Shared Network (DSN) Service provider for the Victorian network (owner and asset provider)	AusNet Transmission Group Pty Ltd (with the exception of interstate connectors)
Distribution Network Service Provider (DNSP) Business	United Energy Distribution
Distribution Network Service Provider (DNSP) Business	Ausnet Services
Distribution Network Service Provider (DNSP) Business	Jemena
Distribution Network Service Provider (DNSP) Business	Powercor Australia
Distribution Network Service Provider (DNSP) Business	CitiPower
Policy maker	Department of Environment, Land, Water and Planning (DELWP)

Table 14: Electricity transmission and distribution network ownership

Role	Stakeholder
Powercor Australia	Cheung Kong Infrastructure / Power Assets Holdings 51%, Spark Infrastructure 49%
Ausnet Services	Listed company (Singapore Power 31.1%, State Grid Corporation 19.9%)
United Energy	Cheung Kong Infrastructure 66%, SGSP Australia (State Grid Corporation 60%, Singapore Power International 40%) 34%
CitiPower	Cheung Kong Infrastructure / Power Assets Holdings 51%, Spark Infrastructure 49%
Jemena	SGSP Australia (State Grid Corporation 60%, Singapore Power International 40%)

Source: Australian Energy Regulator 2017, 'State of the Energy Market 2017'

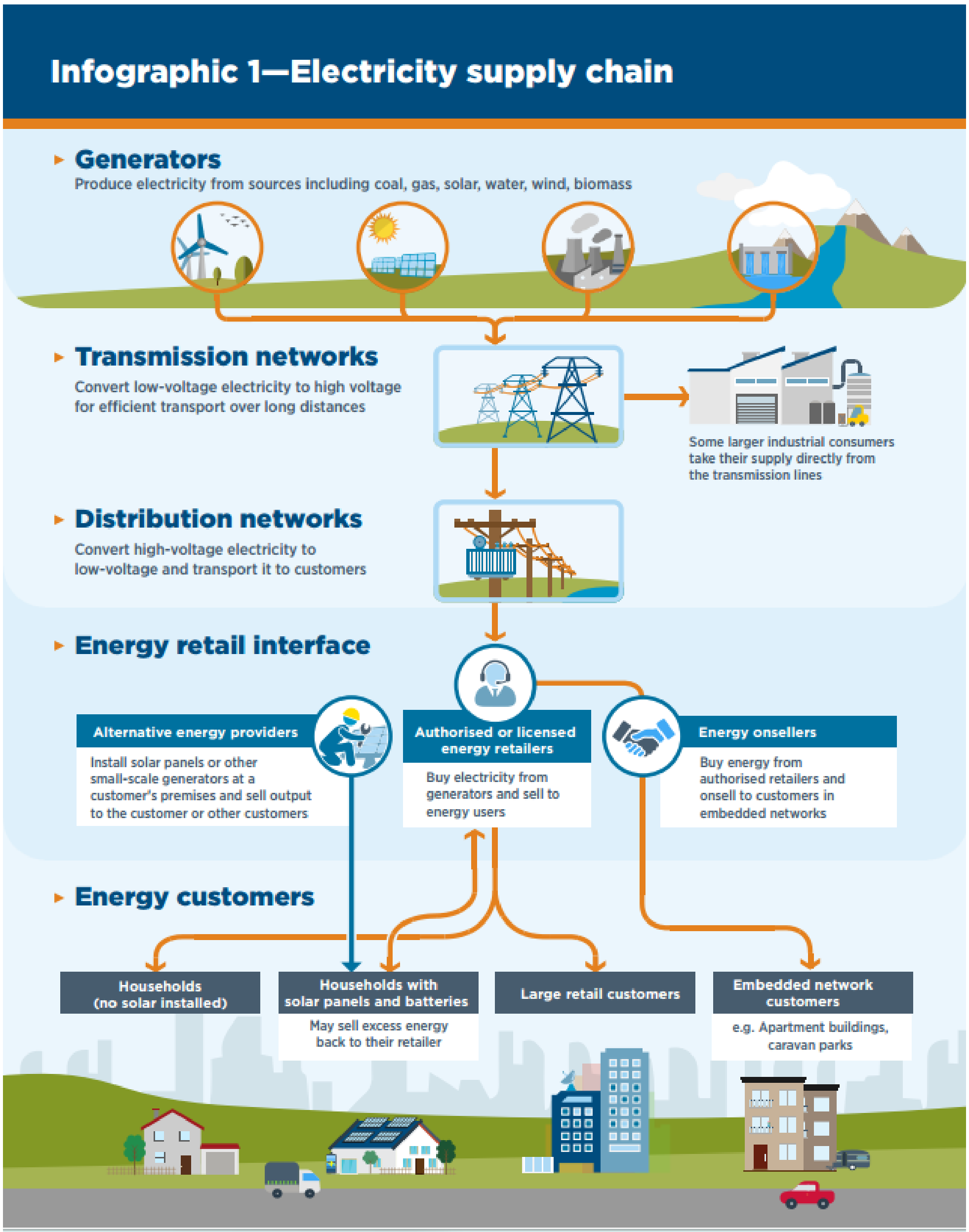
2.3.2 Existing industry structure and infrastructure

2.3.2.1 Overview

The electricity industry in Victoria has four specific sectors within its supply chain. These are shown in the Figure , and classified as follows:

- Generation, which produces electricity from sources such as coal, gas, solar, wind, and biomass).
- Transmission, which converts the electricity into high voltage for efficient transport across large distances to a limited range of distributors.
- Distribution, which converts the electricity into lower, safer voltages for distribution to the end users.
- Retailing – customer interface.

Figure 22: Electricity supply chain



Source: AER, State of the Energy Markets 2017

This report focuses on the transmission and distribution sectors, and the infrastructure associated with their functions. The centralised generation sector is not impacted by urban form and will not vary with different urban forms or locations within Melbourne. This may however vary in the future as we move to greater sources of local and centralised renewable energy generation. However, looking at the current situation it is not necessary to consider power generation. The retail sector does not have an infrastructure component and has consequently also not been included.

The transmission business provides bulk delivery of electricity to a limited number of large customers. Distributors serve a much larger customer base, located within a defined distribution boundary. Distributors are required to provide electricity connections to each new customer within their distribution boundary.

2.3.2.2 Regulatory framework

The Council of Australian Governments (COAG) established the Ministerial Council on Energy (MCE) in June 2001 to provide national oversight of policy development for Australia's energy sector. COAG set up statutory bodies to oversee the three major functions of energy policy rules and regulation development, compliance with regulation and market operation.

In Victoria, these obligations are overseen by:

- The Australian Energy Market Commission (AEMC) – national policy rules and regulation development.
- The Australian Energy Regulator (AER) – the national energy market regulator.
- The Australian Energy Market Operator (AEMO) – market operation. AEMO operates Australia's National Electricity Market (NEM), the interconnected power system in Australia’s eastern and south eastern seaboard, and the Wholesale Electricity Market (WEM) and power system in Western Australia.
- Essential Services Commission (ESC) – the Victorian state based regulator who deals with matters specific to Victoria in relation to consumer interests around price, quality and reliability of essential services including energy.
- Energy Safe Victoria (ESV) – the Victorian state based regulator who deals with matters specific to Victoria in relation to electricity, gas and pipeline safety.

The Victorian Department of Environment, Land, Water and Planning (DELWP) is responsible for the development and oversight of regulation, investment attraction, funding support and preparation for energy emergencies. Its four main priorities are to ensure:

- an efficient and secure energy system
- energy supplies are delivered reliably and safely
- consumers can access energy at affordable prices
- energy supplies and the way they are used are environmentally sustainable and in particular less greenhouse intensive.

Distribution and transmission businesses are subject to full regulation, which requires the service provider to submit an access arrangement to AER, the regulator for approval every five years. Infrastructure upgrades and network reinforcements undertaken by transmission and distribution businesses are financed by regulated revenue that is apportioned to the capital expenditure plan approved by the AER. The costs are recovered from the end user through a standard charging mechanism, with specific connection costs charged by exception. The five-year reports for the distribution businesses were determined in 2016 for the 2016-2020 period.

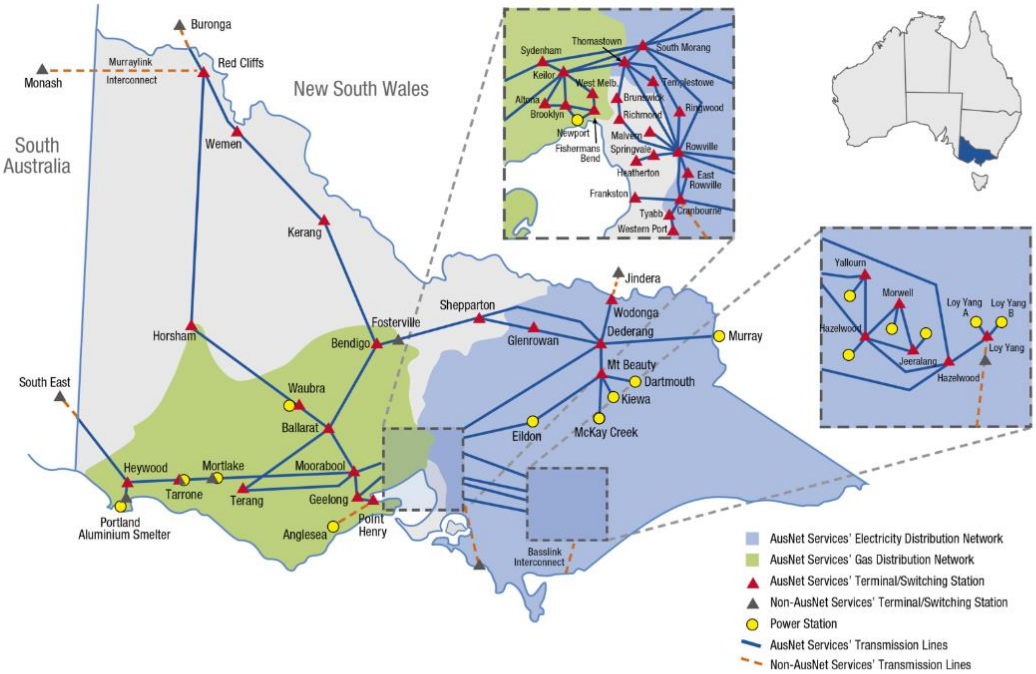
2.3.2.3 Transmission network

Transmission networks transport electricity from generators to large industrial consumers and distribution networks in metropolitan and regional areas, via approximately 6,500km of high voltage powerlines and around 1,300 towers.

The Australian Energy Market Operator (AEMO) operates the National Electricity Market (NEM), the interconnected power system servicing Victoria, New South Wales, Queensland, South Australia and Tasmania, and is responsible for the planning of the network, forecasting and power systems information, security advice, and services to enable the efficient operation of the market.

The AusNet Transmission Group (a subsidiary of AusNet Services) owns and operates the Victorian component of the NEM transmission system infrastructure, which is called the Victorian Declared Shared Network (DSN). As the asset owner, AusNet Transmission Group controls the capital investment in the DSN through the regulatory approvals process managed by the Australian Energy Regulator (AER).

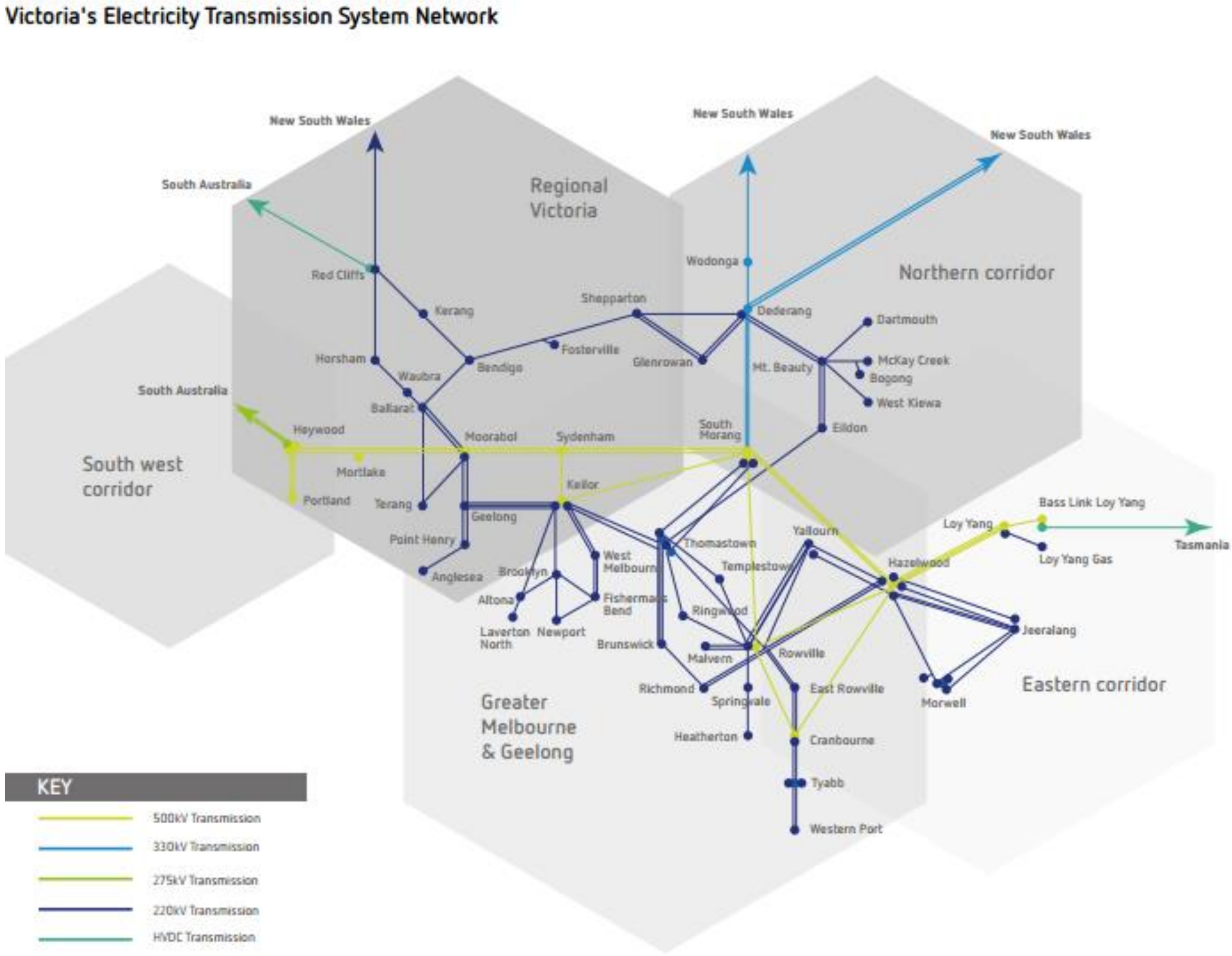
Figure 23: Victorian declared shared network



Source: AusNet Services website

The transmission network connects to the distribution networks at terminal stations. There are 49 terminal stations across Victoria, with a number of these stations providing supply to more than one distribution business. In those instances, joint planning for the terminal station is undertaken between those distribution businesses and AEMO.

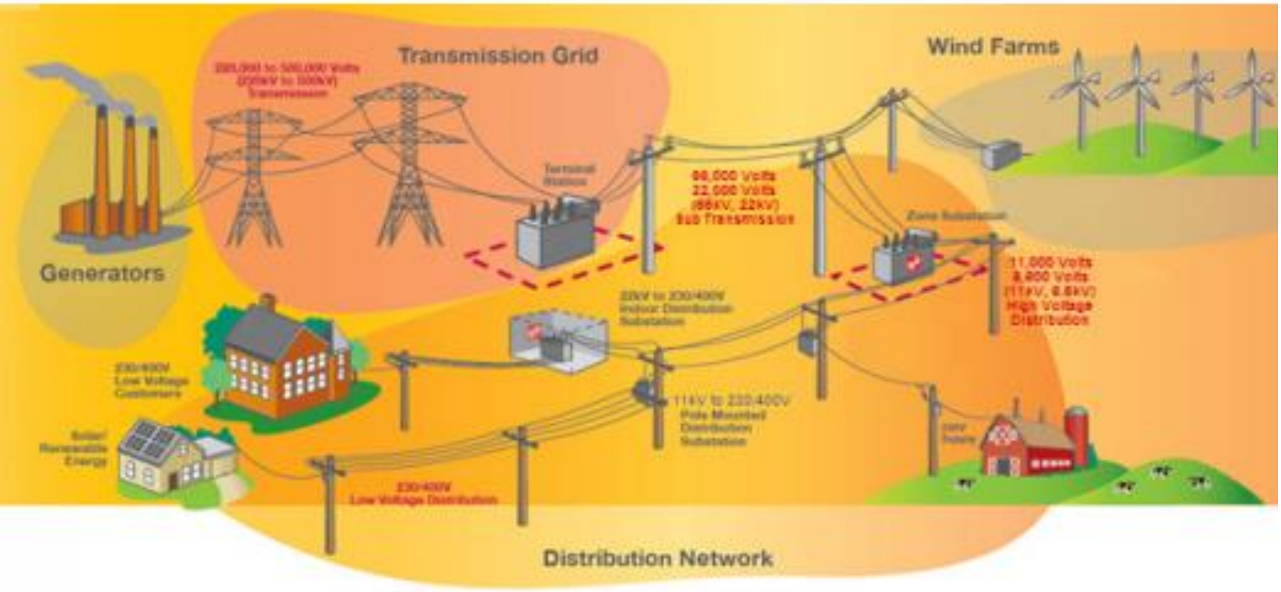
Figure 24: Victoria's electricity transmission system network



Source: AusNet Services website

In Victoria, the distribution businesses are responsible for planning and directing the augmentation of the facilities that connect the distribution systems to the shared transmission system. The five distribution businesses collectively prepared a report annually called the Transmission Connection Planning Report (TCPR) which indicates any emerging capacity constraints. Based on the findings, AusNet Services can incorporate augmentation works in their submission to the AER.

Figure 25: Overview of the operation of the electricity network

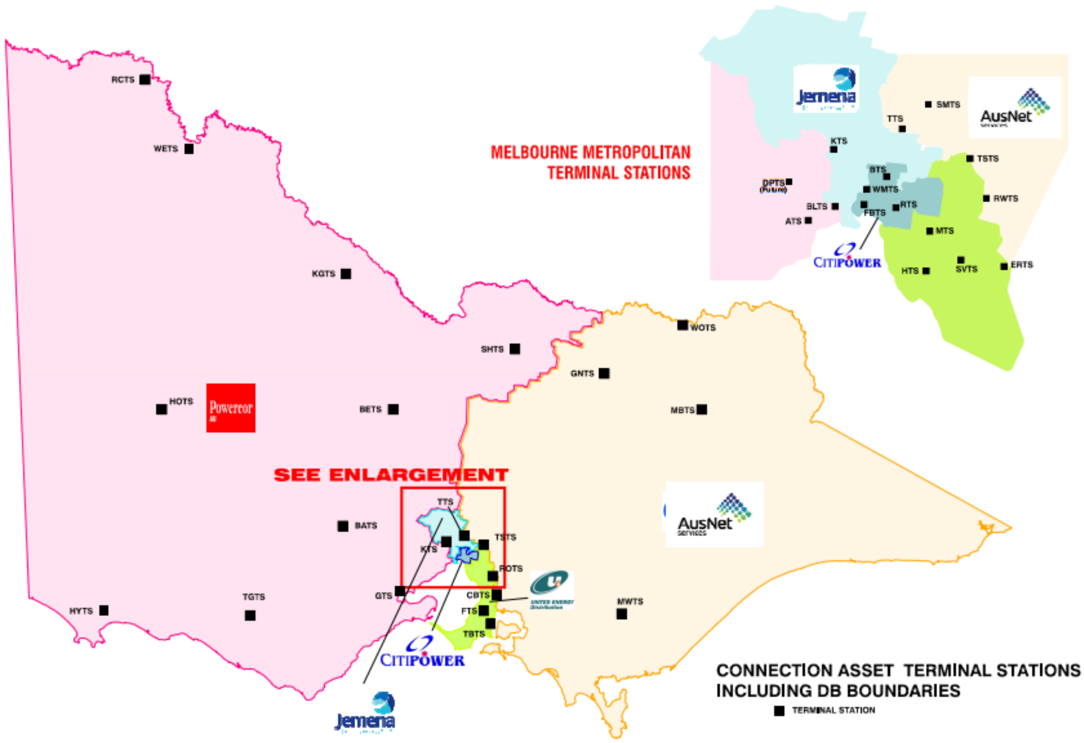


Source: Australian Energy Regulator website

2.3.2.4 Distribution network

Within Victoria, there are five distribution network services providers (DNSP) that own, operate and maintain the distribution network. Each covers part of metropolitan Melbourne, as shown on the maps in figure 26.

Figure 26: The boundaries of the five Distribution Network Service Providers within Victoria



Source: Transmission Connection Planning Report, Victorian Electricity Distribution Businesses, 2016

Distribution networks transport electricity from terminal stations along the distribution lines to customers. Electricity must be stepped down to lower voltages in a distribution network for safe use by customers.

A distribution network consists of the poles wires and underground cables that carry electricity, as well as substations, transformers, switching equipment, and monitoring and signalling equipment. Most of the infrastructure is above ground. The use of underground cables is prevalent in areas of new residential estates, industrial subdivisions and larger urban renewal areas.

2.3.3 Forecasting demand

AEMO prepares a National Forecasting Insights report annually which provides electricity consumption and maximum and minimum demand forecasts over a 20-year outlook period (to 2036-37) for the National Electricity Market (NEM) and each of the five NEM regions: New South Wales (including Australian Capital Territory), Queensland, South Australia, Tasmania, and Victoria. The purpose of the National Forecasting Insights report is to “explore a range of scenarios that represent a probable range of futures for Australia across weak, neutral, and strong economic and energy consumer outlooks”. It also identifies development opportunities to address emerging network limitations within the DSN. In determining demand, it considers population growth, economic growth, consumer confidence, network changes and retail costs, policy assumptions, technology and energy efficient uptake. Each is tested against different sensitivities and incorporates data sources such as ABS projections, national accounts data, and findings from consumer energy meters (AEMO, June 2016). Prior to 2016 the report was called the National Electricity Forecasting Report (NEFR). AEMO also prepares other detailed data to accompany the forecasting reports.

Transmission planning considers both the AEMO forecasting information and Victorian Terminal Station Demand Forecasts prepared by the DNSPs. Sensitivity analysis is undertaken to test that the economic timing of projects is robust under a range of forecast scenarios, including the trend in weather-adjusted historical demand at the connection point.

Distribution networks generally engage external organisations to provide input or undertake assessments of expected demand. These include:

- economic growth and land use mix, particularly within their region
- population growth and characteristics
- environmental considerations, including temperature projections, and physical limitations such as identification of bushfire risks
- price sensitivity
- demand management
- implications of distributed and renewable energy
- energy efficiency measures and acceptance.

Although industrial users collectively consume the largest proportion of Victoria’s energy supply, their share is decreasing. Planning for future demand is becoming more difficult, as there are more variables involved such as energy efficiency measures and use of renewable sources, and the effect of increased peak loads relative to total usage (AEMO, June 2016).

AEMO forecasts that, despite the population growing significantly, demand for electricity in Victoria will flatten until the mid-2020s, when “consumption is predicted to increase, with an overall projected increase of 4.2% over the 20-year outlook period, from 41,243GWh in 2016-2017 to 42,977 GWh in 2036-37 (due to population growth and appliance uptake).”

The maximum DSN demand (which occurs in summer) from retail users will continue to shift to later in the day, due to demand being met by alternative rooftop solar photovoltaic, leading to the early evening becoming the maximum DSN demand period. Minimum demand on the DSN will be expected in the middle of the day by mid-2020.

2.3.4 Existing conditions and future capacity

2.3.4.1 Overall system condition and adequacy

AEMO is responsible for planning and directing the augmentation of the Victorian electricity transmission Declared Shared Network (DSN). The AEMO Victorian Annual Planning Report (VAPR) 2017 considers the adequacy of the Victorian electricity transmission Declared Shared Network (DSN) to meet future reliability and security needs efficiently over the next 10 years. Key trends impacting on the system statewide identified in this report include:

- aging transmission infrastructure: The DSN is aging with most transmission lines more than 40 years old. Frequency of planned maintenance of transmission infrastructure is expected to increase.
- minimum grid demand is projected to halve in Victoria: The projected forecast reduction is predominantly due to increasing rooftop solar photovoltaic
- installation and improvement in energy efficiency. Operating at minimum demand can lead to instability in the network, reducing reliability of supply.
- Withdrawal of coal-fired generation: The withdrawal of coal-fired power stations and energy from other sources in different locations requires careful planning of the grid to manage power system reliability.

AEMO reviewed the loading of network elements to examine how stressed the network was during 2016-17. The Victorian DSN has three distinctive drivers of network stress (VAPR 2017):

- Maximum demand conditions (which typically occur on hot summer days) stress the network, as power transfers may exceed ratings of network elements.
- Under minimum demand conditions, voltages may exceed allowable operating limits.
- High network stress can also occur at times where high levels of Victorian generation are being exported to other regions, typically New South Wales.

However, the major issue for electricity supply is not a need to increase capacity system-wide up to the period 2025. Instead, there needs to be more resilience within the power system, given the transition to renewable sources of electricity supply (such as solar and wind) in place of coal fired generation. In other words: “Victoria’s power system is undergoing unprecedented change, and it is critical that reliability of supply to consumers is maintained during this transition”.

2.3.4.2 Transmission network condition and future capacity

The transmission network is based around a 500kV transmission system, running from the Latrobe Valley, through Melbourne and across south west Victoria to Heywood. This system serves the major load centres and feeds into a 220kV ring around Melbourne, connecting terminal stations positioned roughly in closer concentric rings around Melbourne. It also services country Victoria, supplying the regional centres, as well as interstate interconnections.

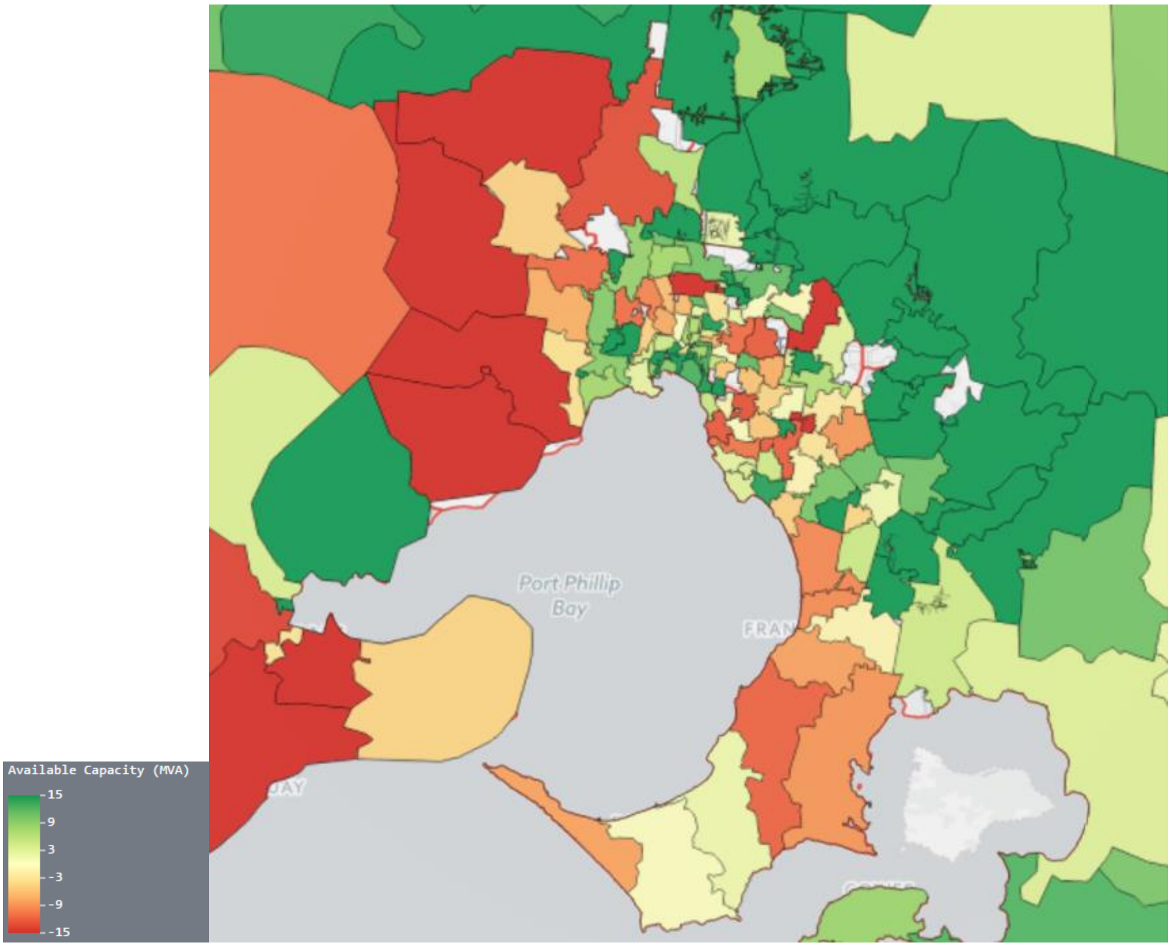
The transmission system in Melbourne is designed in an integrated manner, with the terminal stations interconnected through a mesh-like system. The terminal stations contain a number of transformers, which are designed to allow for some redundancy or failure (described as N-1 – in other words, when one element fails, there is sufficient capacity for the others to pick this up).

All areas of Melbourne are equally serviced and transmission augmentation does not appear a major issue when looking at the costs and issues associated with different development settings in Melbourne (AusNet Transmission Group Pty Ltd 2016).

2.3.4.3 Distribution network

Distribution networks are required to produce a Distribution Annual Planning Report (DAPR) each year, which sets out the analysis of the condition, the need for upgrades of the network and proposals to address this.

Figure 27: Available capacity within the substations and sub-distribution lines (updated frequently)



Source: AREMI, Available Distribution Capacity Map, 2017

Stakeholders have advised that the distribution network in Melbourne is also interconnected through a mesh-like system with interconnection between the substations. There is a similar redundancy designed between the substations, although there are some locations where this redundancy is not as strong, particularly where there is a less extensive network (generally in outer metropolitan Melbourne).

The following findings have been obtained through discussion with experts within the service provider organisations, informed by professional judgement:

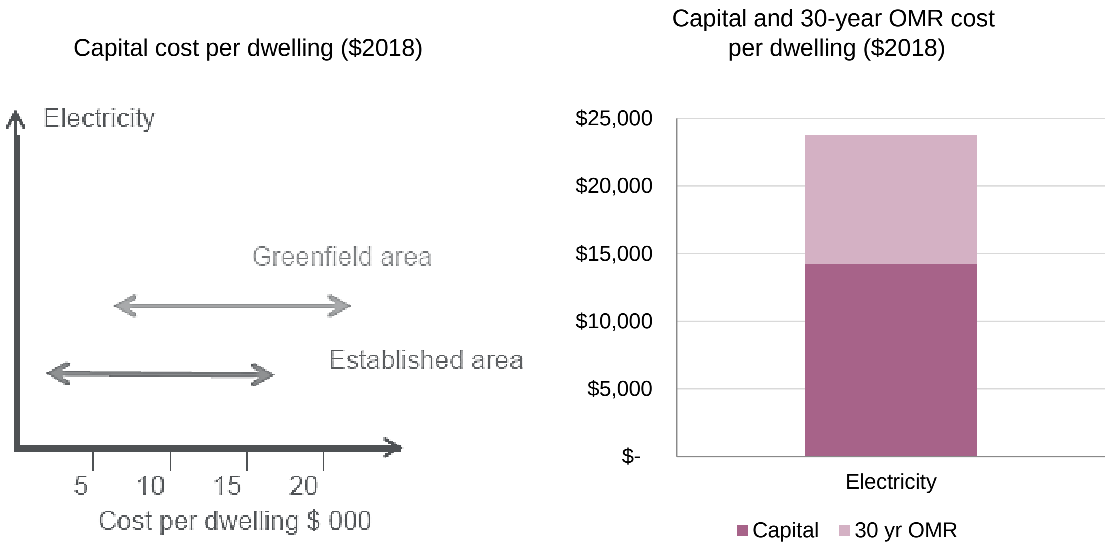
- Each DNSP noted locations where there were higher levels of demand than the existing system was designed to accommodate. For instance, at the edge of the urban growth zone, within locations experiencing higher than average growth levels not offset by corresponding declines in industry, and within some locations where the peak demand aligns with an influx of additional occupants (the Mornington Peninsula, for instance, and Phillip Island).
- Each business is able to identify and spatially display, at a point of time, where there is limited excess capacity within the substations, and sub-distribution lines. However, this information changes frequently as a result of new developments (or closures), and upgrades taking place (including smaller scale augmentation). These changes are captured in the forecasting work undertaken by each distribution business.
- In the majority of cases, the relatively integrated nature of the infrastructure within each distributor's network enables locations with limited supply to be readily augmented. This is more readily achieved in locations with higher density as the distances between substations is less and there are more options to access when load is low. Greenfield locations have fewer alternative solutions to meeting new demands as there are fewer substations to offer solutions.
- There is more redundancy within the Central Business Area of Melbourne to provide greater system security of supply. This is in part a response to the sub-transmission (supply to city) issues that occurred in 2007 and 2009, which are now rectified.

- Within Melbourne, the distribution network generally has sufficient capacity for expected demand, and the versatility of the system allows for transfer of energy if needed. It should be noted that some parts of the network experience higher growth due to large infill developments or expansion of existing or new large electricity consumers, thus requiring additional capacity. In addition to this, other challenges for the distribution systems include:
  - The degree of lead-time in planning for upgrades (larger scale projects, such as precinct scale or large brownfield developments, take time, which allows the upgrades to be factored in). Some land uses, like data centres, are energy intensive but can be accommodated if planned at least two years ahead.
  - Incremental growth, including the cumulative effect of low rise apartment or multi-dwelling townhouse developments, are more challenging to plan for and deliver system upgrades to. This is especially the case if the trigger is not one single development. Larger developments are often easier to implement as they are required to accommodate their own dedicated substations on site, rather than share substation infrastructure with other developments.
  - Land availability for upgrades/additional substations, distribution line easements, etc.
  - System management due to the reduced variability in demand across customers. As a greater proportion of energy usage is for residential customers who require power at the same time, infrastructure must deliver daily energy supply in higher volumes over a shorter time period.
  - High penetration of solar power leading to product quality issues.

2.3.4 Infrastructure costs

2.3.4.1 Overview

Figure 28: Electricity infrastructure cost variance



Costs have been determined for different development types based on the principles outlined in table Table and the Volume 1 Technical Paper section 2.7 and section 4.1.

The capital costs represent the cost of the infrastructure required to provide electricity to a new dwelling, which includes the infrastructure to connect a dwelling into the existing network and the overall infrastructure upgrades required to the network to distribute the additional supply demand. OMR, or operational, maintenance and replacement costs represent the annual costs to operate and maintain the infrastructure and replacing or augmenting elements as they reach the end of their service life or have compliance issues.

The cost of generating the electricity is not included.

Table 15: Principles for assembling costs

Party	Cost element	Development type	
		Greenfield	Established areas
Transmission network (DSN)	Capital cost for augmentation of the existing network to take greater volumes in response to population growth	Incl	Incl
	Annual operation and maintenance cost of the network	Incl	Incl
	Annual cost of compliance upgrades and renewal of existing aged assets	Incl	Incl
Distribution network	Capital cost for new a connection	Incl	Incl
	Capital cost for extension of the existing network to service additional growth area population	Incl	Incl
	Annual operation and maintenance cost of the network	Incl	Incl
	Annual cost of compliance upgrades and renewal of existing aged assets	Incl	Incl
Development costs within the estate	The capital cost by the developer to connect and reticulate the service within the development estate	Incl	Incl
	Operational cost	NA	NA

Key: Incl – Cost included   NA – Cost not applicable

2.3.4.2 Cost findings

Indicative costs for typical development settings are summarised in Table 17. The costs that are provided are indicative of the order of costs that can be experienced in the situation described, rather than definitive costs, as many factors can influence the cost of an actual development as outlined in in the Volume 1 Technical Paper section 2.3. In particular the proximity and capacity of the existing upstream network and other electricity demand changes in the service area will affect the cost of electrical infrastructure for a new dwelling. The most likely scenarios to experience higher costs are established areas experiencing significant independent medium to high density developments and out-of-sequence greenfield developments. The case studies were chosen to provide typical costs experienced, rather than extreme costs that could be experienced, however this assessment is acknowledged as being subjective.

Findings from the case study costings are as follows:

- The capital cost to provide electrical infrastructure to service a new dwelling in a greenfield location compared to an established area can vary from being equal to being a factor of three times more expensive. The capital cost per dwelling is however in the same order of cost across the different development settings for electrical infrastructure compared to the cost of other infrastructure elements such as transport and social infrastructure which have much higher costs.
- The high density option has a much lower cost for electrical infrastructure than all other development settings.
- The capital and OMR transmission infrastructure costs are not significant compared to the electrical infrastructure cost relating to the distribution infrastructure and reticulation within the development estate.
- If upstream augmentation of the distribution network is not required, the capital costs for connection are approximately equally shared between the distribution network and the infrastructure within the development estate. If augmentation of the distribution network is required however, the contribution of capital cost from the distribution network can be over double the cost of infrastructure within the development estate.
- The capacity of electrical infrastructure outside a development estate strongly influences the capital cost. The electricity network is more incrementally managed and expanded in contrast to the gas or water networks. Therefore similar developments in similar development settings can have considerable cost differences simply due to the timing of the development relative to other developments taking place on the local network feeding a development.
- Data was not available on recurrent OMR costs in different locations. Adopting average OMR costs across the network however, over a 30-year period, OMR costs were approximately equal to capital connection costs.
- Benchmarking undertaken by Economic Insights identified the key operating environment characteristics that influence the OMR costs of electricity distribution as customer density (customers per km of line), energy density (throughput per customer) weather factors and terrain (bushfire risk, rural proportion and vegetation encroachment). In the context of

Metropolitan Melbourne, the characteristic that varies operational cost is the customer or dwelling density, with other issues being similar across the different development settings considered within Melbourne.

2.3.4.3 Costs data

Drawing from the Australian Energy Regulator (AER) access determinations for the five Victorian electricity distributors and the Declared Shared Network (DSN) service provider, the costs for electrical connection and operation, maintenance and replacement for the Melbourne metropolitan area are provided in **Error! Reference source not found.** 16 below. These figures are average figures for Melbourne and do not relate to a specific location or development setting. This high level data enables us to compare the relative costs of different infrastructure elements that support residential development.

Table 16: Summary electrical utility costs

Summary electrical utility costs **D18/32431 WS: "Summary"**	**$ 2018**
Developer capital cost within development site	$4,000
Electrical authority capital cost ($/dwelling)	$10,200
Electrical authority operation and operation, maintenance and replacement ($/dwelling /year)	$318
Capital and recurrent cost over 30 years	$23,743

Note:

- The above analysis is conservative, providing a higher connection cost, as it includes all connections capital expenditure (including industrial and commercial) rather than only residential connections. The costs are also based on connection costs, which in higher density developments would reflect more than one dwelling.
- The average figure adopted has been based on Jemena's AER access determination data, as the service area includes greenfield growth areas and established areas, but not high density inner city developments or a large component of rural areas.
- The costs of the DSN service provider have also been included in costs.
- The average cost within the development site is based on Plan Melbourne/VIF projected ratios of future development (35% greenfield and 65% established area development). The average cost is made up of 35% greenfield capital medium cost with capacity and 65% average of established area SSID & PSB capital medium cost with capacity.

Table 17 provides indicative costs for different development scenarios based on confidential cost data provided by the DSNP businesses and compiled by Infrastructure Victoria.

Table 17: Typical development setting electrical infrastructure costs for Metropolitan Melbourne

Connection description	Details	Cost per dwelling ($Jul 2018)			Costs source
		Capital cost	Operation, maintenance and replacement $/pa	30-year cost	
Greenfield development underground supply	With available upstream capacity (cost with low costs within development estate) Without available upstream capacity (cost with high costs within development estate)	$9,700 ($7,500) $14,100 ($21,200)	$318 $318	$19,200 ($17,000) $23,650 ($30,800)	AER price proposals, distributor advice and SMEC advice
Established area 1 dwelling replaced by 2 or 3 overhead supply	With available upstream capacity Without available upstream capacity	$6,700 $8,500	$318 $318	$16,200 $19,400	AER price proposals, distributor advice and SMEC advice
Established area 1 dwelling replaced by 2 or 3 underground supply	With available upstream capacity Without available upstream capacity	$10,300 $14,800	$318 $318	$19,900 $24,300	AER price proposals, distributor advice and SMEC advice
Established area Medium density 20 unit development Pole substation	With available upstream capacity Without available upstream capacity	$8,600 $13,100	$318 $318	$18,200 $22,650	AER price proposals, distributor advice and SMEC advice
Established area Medium density 50 unit development - Kiosk	With available upstream capacity Without available upstream capacity	$8,100 $12,600	$318 $318	$17,700 $22,100	AER price proposals, distributor advice and SMEC advice
Established area High density 150+ unit development Indoor substation	With available upstream capacity (cost with low costs within development estate) Without available upstream capacity	$3,900 ($2,300) $8,300	$318 $318	$13,400 ($11,900) $17,900	AER price proposals, distributor advice and SMEC advice

Note:

1. Equal OMR costs adopted for each development setting as OMR costs relating to different development settings were not available.
2. Medium cost adopted for infrastructure within the development estate unless noted otherwise.

2.3.5 Sources

2.3.5.1 General

AEMO, *Western Victoria Renewable Integration Project Specification report,* April 2017
AusNet Services, *Asset Management Strategy – Victorian Electricity Transmission Network*, July 2015
AusNet Services, *Distribution Annual Planning Report*, 2016
AusNet Transmission Group Pty Ltd – *Transmission Revenue Review 2017-2022. Revised Revenue Proposal*, Sept 2016
Australian Energy Market Operator, *Victorian Annual Planning Report*, June 2017
Australian Energy Market Operator*, 2016 National Transmission Network Development Plan for the National Electricity Market,* December 2016
Australian Energy Regulator, *Annual Benchmarking Report 2017 (current project – information on website)*

Australian Energy Regulator, *Final Decision – Tariff Structure Statement proposals Victorian electricity distribution network service providers – CitiPower, Powercor, AusNet Services, Jemena Electricity Networks and United Energy*, August 2016
Australian Energy Market Operator, *National Electricity Forecasting Report for the National Electricity Market,* June 2016
Australian Energy Regulator, *State of the Energy Market,* May 2017
Citipower, *Distribution Annual Planning Report*, 2016
Jemena, *Distribution Annual Planning Report*, 2016
Kain J & Lawrence D, Economic Insights, *Economic Benchmarking of the Electricity Network Service Providers*, 2013
Powercor, *Distribution Annual Planning Report*, 2016
Powercor, Regulatory Proposal 2016-2020, 2015
United Energy, *Distribution Annual Planning Report*, 2016
Victorian Electricity Distribution Businesses, *Transmission Connection Planning Report,* 2016
Infrastructure Victoria Calculation Spreadsheet: D18/32431

2.3.5.2 Melbourne average electricity sector costs (Volume 1 Figure 3 and Table 4)

The figures in the table 16 were calculated using figures from these documents publically available on the website of the Australian Energy Regulator:

- Citipower
  - 2016 Category Analysis RIN (Excel),
  - 2016 Economic Benchmarking RIN (Excel),
  - 2015 Category Analysis RIN (Excel),
  - 2015 Economic Benchmarking RIN (Excel),
  - 2014 Category Analysis RIN (Excel),
  - 2014 Economic Benchmarking RIN (Excel),
  - 2008-2013 Category Analysis RIN (Excel),
  - 2006-2013 Economic Benchmarking RIN (Excel),
- Jemena
  - 2016 Category Analysis RIN (Excel),
  - 2016 Economic Benchmarking RIN (Excel),
  - 2015 Category Analysis RIN (Excel),
  - 2015 Economic Benchmarking RIN (Excel),
  - 2014 Category Analysis RIN (Excel),
  - 2014 Economic Benchmarking RIN (Excel),
  - 2008-2013 Category Analysis RIN (Excel),
  - 2006-2013 Economic Benchmarking RIN (Excel),
- United Energy
  - 2016 Category Analysis RIN (Excel),
  - 2016 Economic Benchmarking RIN (Excel),
  - 2015 Category Analysis RIN (Excel),
  - 2015 Economic Benchmarking RIN (Excel),
  - 2014 Category Analysis RIN (Excel),
  - 2014 Economic Benchmarking RIN (Excel),
  - 2008-2013 Category Analysis RIN (Excel),
  - 2006-2013 Economic Benchmarking RIN (Excel),

Dates of figures used

- Actual figures for 2009-2016

Types of figures used

- Operating Expenditure ('2.1 Expenditure Summary' tab of 'Category Analysis RIN' document) Operating expenditure considered = Vegetation Management + Maintenance +Emergency response +Network overheads
- Capital Expenditure ('2.1 Expenditure Summary' tab of 'Category Analysis RIN' document) - Total Gross Capex considered = replacement expenditure + connections + augmentation + metering
- Customer Numbers ('3.4 Operation Data' tab of 'Economic Benchmarking RIN' document)
- Connections Numbers ('2.5 Connections' tab of 'Category Analysis RIN' document)

Example calculations

$$Connection\ cost = \frac{Connections\ Capital\ Expenditure}{No.\ Residential\ Connections}$$

$$Maintenance\ cost = \frac{Total\ Capital\ Exp. - Connections\ Capital\ Exp. + Operating\ Exp.}{No.\ Residential\ Customers}$$

The total cost spent over 8 years is calculated, and then this total is divided to find the average cost over the period.

Key assumptions

- All connections capital expenditure for Standard Control Services is spent on new residential connections.
- All operating expenditure and non-connections capital expenditure for Standard Control Services is spent on maintaining residential connections.

2.4 Gas

2.4.1 Introduction – Key stakeholders

Information included in this appendix

The paper is based on inputs provided by relevant service providers, ranging from issues that are well documented in pre-existing technical reports through to issues where we have been informed by professional judgement from technical experts within the service provider organisations. Where information is noted as 'advised by stakeholders', this information is informed by professional judgement. All other information provided is sourced from the reference documents listed.

2.4.1.1 Key stakeholders

The key stakeholders for the gas utility sector are shown in the following table.

Table 18: Gas network stakeholders

Role	Stakeholder
Regulator	Australian Energy Regulator (AER)
Gas retail and wholesale market operator in Victoria	Australian Energy Market Operator (AEMO)
System operator of the Victorian Gas Declared Transmission System (DTS)	Australian Energy Market Operator (AEMO)
DTS Service Provider (owner and asset operator)	APA Group
Distribution business	AusNet Services
Distribution business	Multinet
Distribution business	Australian Gas Networks (AGN) Note: Operations and management of AGN distribution assets is undertaken by APA Group
Policy maker	Department of Environment, Land, Water and Planning (DELWP)

Table 19: Gas distribution network ownership

Distribution network	Owner
AusNet Services	Listed ASX company (49%), Singapore Power International (31.1%) and China State Grid Corporation (19.9%)
Multinet	Cheung Kong Infrastructure (100%)
Australian Gas Networks	Cheung Kong Infrastructure (100%)

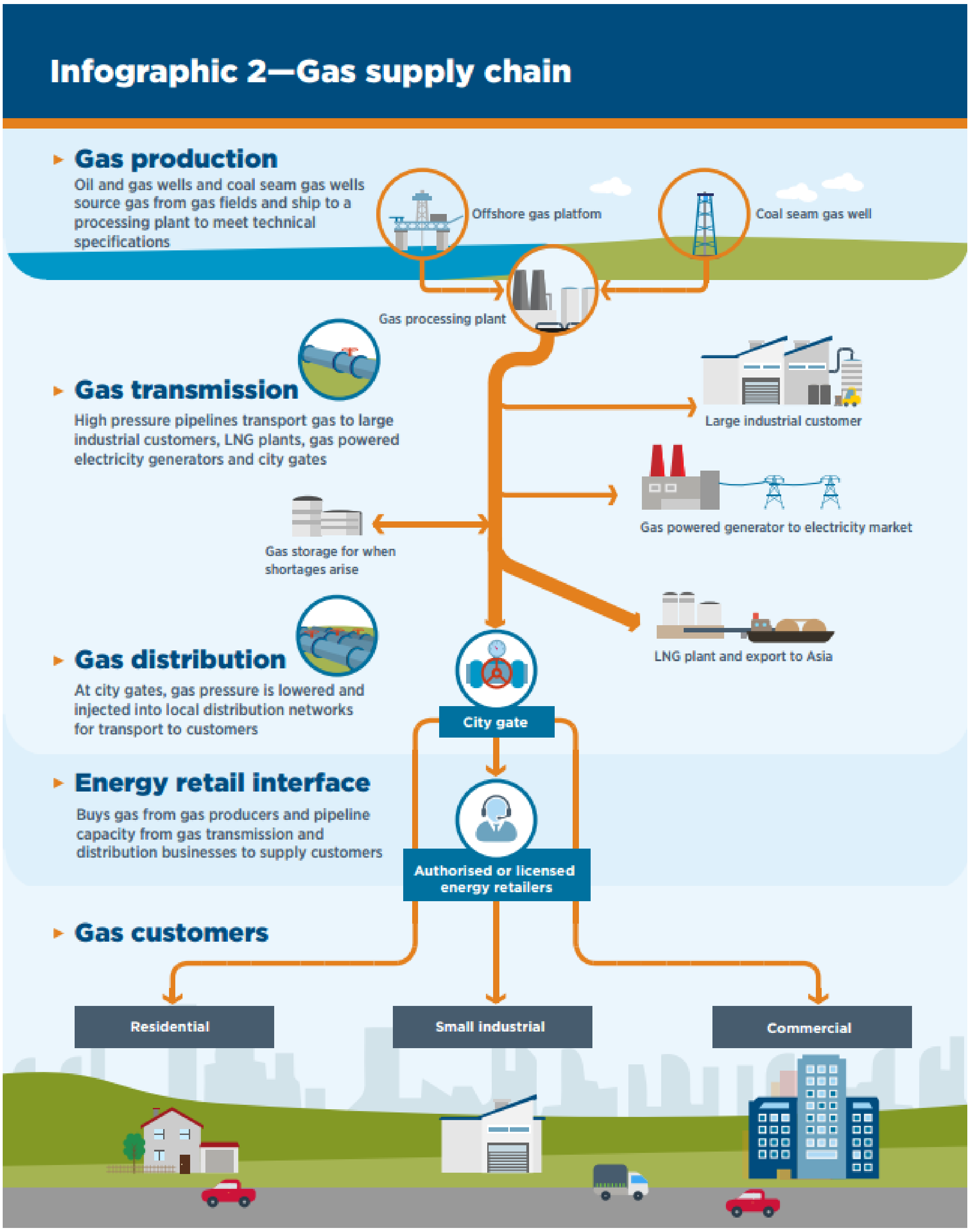
Source: Australian Energy Regulator 'State of the Energy Market' May 2017

2.4.2 Existing industry structure and infrastructure

2.4.2.1 Overview

Gas differs from other utilities in that it is not an essential service and is not required to be connected to every dwelling. The gas industry in Victoria has four specific sectors to take gas from the point of extraction to consumption. These sectors are production, transmission, distribution and retail. The main differences between gas transmission and gas distribution stem from their customer bases: transmission pipelines provide bulk delivery from supply sources to a few large customers including distributors, while distributors deliver gas directly to end-users. Gas distributors serve a much larger number of customers, which are typically clustered in a relatively compact service territory.

Figure 29: Victorian gas supply chain



Source: Australian Energy Regulator 'State of the Energy Market' May 2017

2.4.2.2 Regulatory framework

The National Gas Law (NGL) and National Gas Rules (NGR) provide the overarching regulatory framework for the gas distribution sector. The Australian Energy Regulator (AER) is responsible under the NGL and NGR to regulate the gas transmission and distribution businesses. The main responsibility of the AER in this role is to approve commercial access arrangements proposed by gas pipeline service providers. Gas access arrangement set out the terms and conditions, including prices, under which services will be made available to third parties. The regulator also monitors compliance with 'the code' provisions and, if necessary, arbitrates access disputes. Distribution and transmission businesses are subject to full regulation, which requires the service provider to submit an access arrangement to the regulator for approval on a 5-year cycle, with the 2018 to 2022 period arrangements agreed in 2017.

Infrastructure upgrades and network reinforcements undertaken by transmission and distribution businesses are financed by regulated revenue that is apportioned to the capital expenditure plan and approved by the AER every five years as part of the

Gas Access Arrangement Review (GAAR). Some costs for connection are recoverable from the end user, however this is strictly regulated and excludes the distributor recouping any profit in calculating the cost. Generally residential customers are connected at a flat rate unless there are abnormal cost issues. If a mains extension is required, the customer may be asked to make a contribution to the whole-of-life cost of the gas supply.

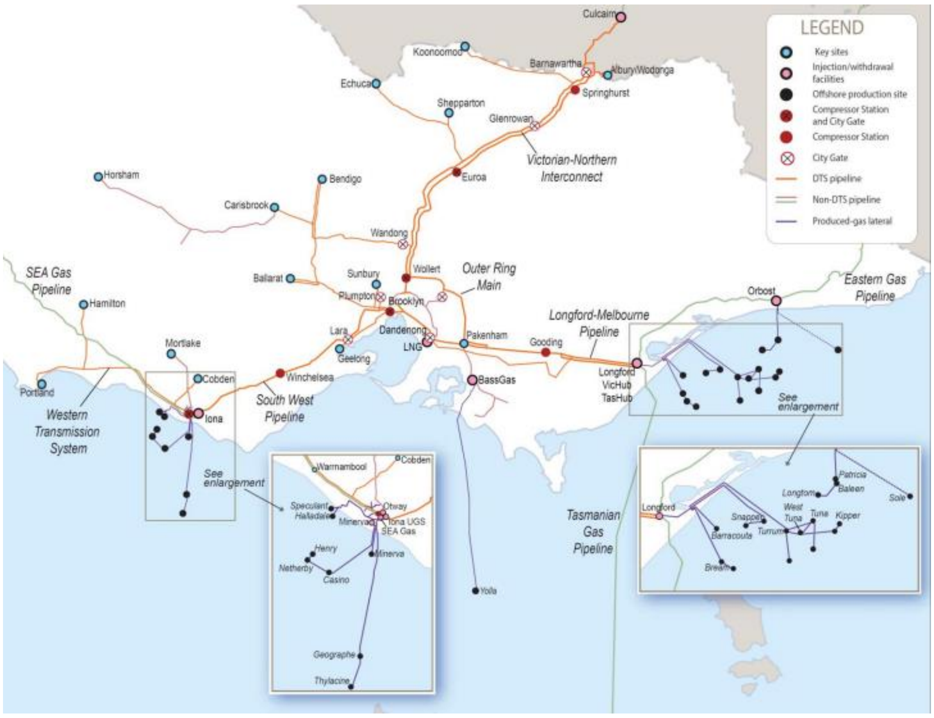
There are two main types of Tariff Customers, Tv (Volume tariff consumers) and Td (Demand tariff consumers). Td consumers have an extremely high peak hourly load (10,000MJ/hour) or annual volume required (10TJ/annum). The rate of volume cost for gas is less expensive for Td customers than for Tv consumers but Td consumers are liable for greater capital expenditure costs related to their system usage.

2.4.2.3 Transmission network

The transmission of natural gas involves transporting gas through pipelines from extraction to reticulation processing facilities at city gates, directly supplying major customers including distribution businesses. Apart from the distribution businesses, major customers are usually industrial users.

AEMO operates the Victorian Gas Declared Transmission System (DTS) and provides information about gas supply and demand, system constraints, capability, and development proposals, to assist in the efficient planning and development of gas markets and facilities. The DTS service provider, APA Group, owns and maintains the DTS assets. As the asset owner, APA undertakes capital investment in the DTS through the access arrangement process with the Australian Energy Regulator (AER).

Figure 30: Map of the Victorian Declared Transmission System (DTS)



Source: AEMO Victorian Gas Planning Report March 2017

Overall residential and small commercial use across Victoria is only approximately 60% of total gas usage, hence the system performance is also strongly influenced by usage demands of the larger commercial and industrial sectors.

Table 20: 2017 gas consumption summary

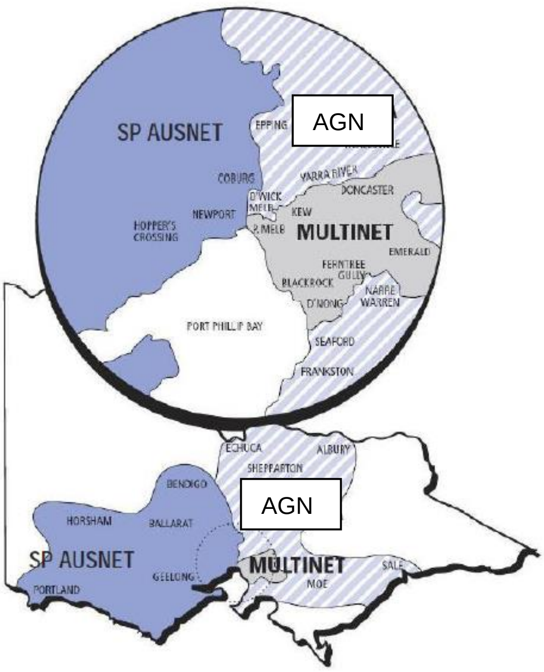
2017 gas consumptions	Residential and small commercial (<10TJ/annum)	Industrial (10TJ/annum)	GPG consumption
Annual consumption	60% 127,000 TJ/annum	31% 68,600 TJ/annum	9% 18,800 TJ/annum
Annual 1-in-2 peak day demand*	80% 944 TJ/day	20% 254 TJ/day	NA
Annual 1-in-20 peak day demand*	80% 1053 TJ/day	20% 257 TJ/day	NA

Source: AEMO Victorian Gas Planning Report March 2017

2.4.2.4 Distribution network

The major gas distribution networks in Australia are privately owned. Victoria privatised its state owned networks in 2000 and distribution is provided by three companies on a regional basis as shown in Figure 31.

Figure 31: Distribution network areas (Note : SP AusNet is now known as AusNet Services)



Source: Essential Services Commission 'Map of Gas Distributors' retrieved from http://www.esc.vic.gov.au/getattachment/92c9ed06-7964-475d-a2ca-329d2408063f/Map-of-Gas-distributors.pdf on 03/05/2012

Gas is depressurised at city gates to appropriate pressures for the distribution of gas to final users which can include commercial and industrial users as well as residential users. Gas is transported in smaller volumes and at lower pressures through the distribution networks than along the transmission pipelines. Gas mains and pipelines are usually installed underground. The majority of the distribution network is now serviced by high pressure mains, following a Victorian mains replacement program commenced in 2012 that is planned to be fully completed by 2033. Where low pressure pipework remains, it is not impacting significantly on system performance and upgrades can be brought forward if localised issues arise.

2.4.3 Forecasting demand

Every two years AEMO prepares and publishes the Victorian Gas Planning Report (VGPR), to assess the DTS supply and system adequacy to meet a forecast 1-in-2 and 1-in-20 peak system demand day over a five-year forward outlook period.

- A 1-in-2 forecast is defined as a peak day gas demand forecast with a 50% probability of exceedance (POE).
- A 1-in-20 forecast is defined as a peak day gas demand forecast for severe weather conditions with a 5% POE.

The report was most recently published in March 2019. As noted in the report, gas usage forecasting takes into account the following key issues:

- weather adjustment
- forecasts of new dwelling construction and percentage rates for take up of gas (for the residential sector)
- improvements in the efficiency of residential appliances and the thermal efficiency of new and existing homes
- reduced water usage and adoption of solar hot water systems, leading to less energy usage for hot water heating
- consumer/developer preference for electrical rather than gas systems in some developments – particularly multi-unit developments
- sensitivity of demand to movements in energy prices (price elasticity of demand)
- reduced industrial usage
- demand for gas powered generation (GPG) of electricity, in particular due to the reduction of coal fired electricity generation in Victoria.

As advised by the stakeholders:

- In planning future demand for the transmission system, demand forecasts are typically based on ABS data for population growth, the VGPR and advice provided by the distribution companies.
- In planning future demand for the distribution system, demand forecasts are based on the use of several data sources including the ABS population data, discussions with local government, review of precinct structure plans, Victoria in the Future (VIF) government projections for dwellings and population, demographic advice from specialist consultants and other sources. Distribution businesses often utilise independent consultants to prepare forecasts for their networks which are then compared to the VGPR.
- Due to the large range of factors affecting gas usage forecasting, and the planning timeframes being based on a five-year cycle the industry does not undertake scenario planning on a broad range of population growth scenarios in undertaking their future network planning.

2.4.4 Existing conditions and future capacity

2.4.4.1 Gas transmission network

Due to the integrated nature of the transmission system, lack of capacity at one point will impact on the entire system, reducing capacity and reliability. The Western Outer Ring Main (WORM) project has been accepted in the regulator's access arrangement for the period 2018 to 2022, and on its completion, the project will provide the 'missing link' in the Victorian Gas Declared Transmission System (DTS) servicing Melbourne. Once the WORM project is completed the three main transmission branches making up the DTS will be linked by high pressure mains, replacing the existing low pressure connections which limit the performance of the whole system (Apa 2017).

Stakeholders have advised that when the WORM project has been completed, there will be no significant constraints caused by transmission system infrastructure for Melbourne and Geelong to meet current demand and future demand. The configuration of the transmission system will also enable an increase in dwellings at any location across Melbourne within the urban growth boundary to be equally serviced.

2.4.4.2 Gas distribution network

Stakeholders have advised that the gas distribution system is interconnected and dynamic. Should there be a local issue within the network, rather than this meaning that additional customers cannot be connected at that location, it means that the whole system will operate with more risk and less reliability. Key aspects affecting performance include:

- the age and corresponding quality of the mains pipework
- rapid increases in demand in the local area
- the closer a location is to the supply point for the subnetwork, the easier it is to service due to pressure losses which can be experienced in the system.

In Melbourne, local problematic areas are scattered across the network and there is not necessarily a consistency as to where they are located or the cause of poor system performance. The upgrade of the gas distribution network to high pressure mains commenced in 2012 (refer Section 2.4.2.4) has significantly improved the performance of the system. Winter testing is undertaken on the network annually to detect any emerging localised network constraints. Where local issues are identified due to a rapid increase in demand or infrastructure constraints, they are typically able to be resolved within the five-year capital planning cycle and do not require longer term planning, according to stakeholders.

In Melbourne, following the high pressure mains upgrade and the closure of several industrial facilities, the distribution mains system in established areas has significant residual capacity to support additional users and is unlikely to limit residential infill growth. Providing new connections in the established areas does however incur the cost of disruption (such as provision of traffic management) and travel costs due to work being done out of sequence at distributed locations. In the greenfield areas new mains are required, however this is typically not costly as mains are placed in the same trench as water mains and the costs shared. Where greenfield areas are developed and then gas is retrofitted the economy of sharing a trench with water services is not achieved. For all settings a new meter is required for each connection.

In the Melbourne CBD an alternative approach has been taken to the rest of Melbourne to deal with the existing low pressure mains system. Low pressure mains will be maintained in the CBD serving existing buildings, whilst new developments will be fed from a new high pressure main system that runs in parallel to the existing low pressure system. This approach minimises disruption and cost without introducing additional risk to the existing system. The expansion of the new high pressure system will occur incrementally, with the existing low pressure system only replaced on an as-needs basis in the event of its performance deteriorating. The main constraint on servicing growth therefore with this approach is the availability of locations to run the new high pressure mains, according to stakeholders.

2.4.4.3 Summary findings

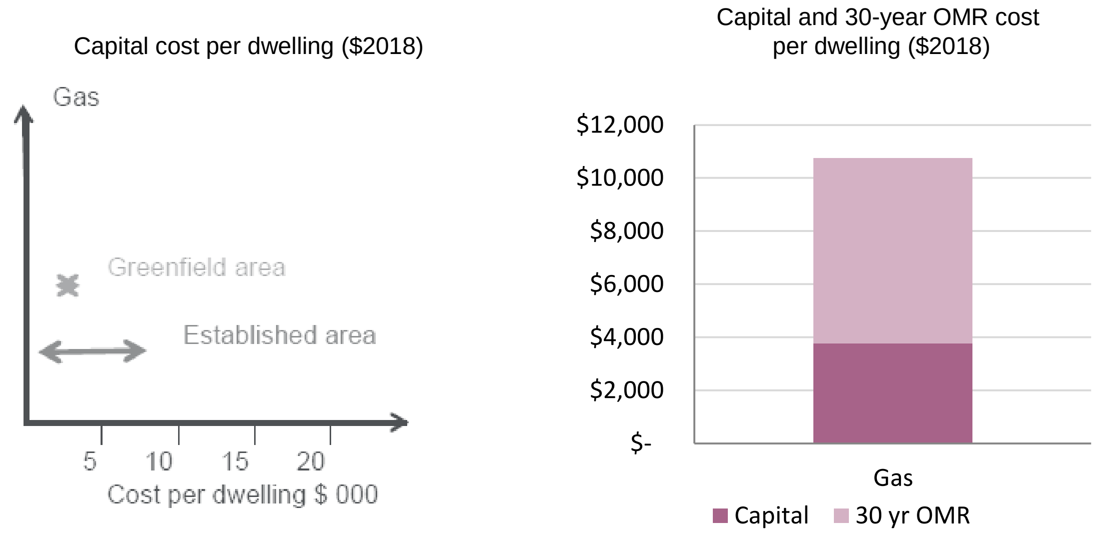
Gas services are currently adequately provided across Melbourne, with future demand able to be serviced through the incremental expansion of the system. There are not significant constraints in the system that make development in different development settings or geographically across Melbourne significantly more problematic or costly. Key issues that affect the ability for a specific location to service growth in demand for gas services include:

- whether the distribution system is has been upgraded to a high pressure system
- the distance from the location to the supply point for the city gate.

2.4.5 Gas infrastructure costs

2.4.5.1 Overview

Figure 32: Gas supply infrastructure cost variance



Costs have been determined for different development types based on the principles outlined in table 21 and in the Volume 1 Technical Paper section 2.7 and section 4.1.

The capital costs represent the cost of the infrastructure required to provide gas to a new dwelling, which includes the infrastructure to connect a dwelling into the existing network and the overall infrastructure upgrades required to the network to distribute the additional supply demand. OMR, or operational, maintenance and replacement costs represent the annual costs to manage the infrastructure, replacing or augmenting elements as they reach the end of their service life or have compliance issues. The cost of generating the gas is not included.

Table 21: Principles for assembling costs

Party	Cost element	Development type		Note
		Greenfield	Established areas	
Transmission network	Capital and OMR cost not included as they were negligible when averaged over the full customer base and with the completion of the WORM further significant transmission upgrades will not be required in Melbourne in the timeframes under consideration	NA	NA	
Distribution network	Capital cost for a new connection	Incl	Incl	
	Capital cost for extension of the existing network to service additional growth area population	Incl	NA	
	Annual operation and maintenance cost of the network (O&M)	Incl	Incl	
	Annual cost of compliance upgrades and renewal of existing aged assets	Incl	Incl	Refer Note1
Development costs within the estate	Trenching works by the developer	Incl	Incl	
	Operation, maintenance and renewal costs (OMR)	NA	NA	Refer Note 2

Key: Incl – Cost included   NA – Cost not applicable

Note:

1. As a high pressure upgrade has been undertaken across the network, renewal requirements are assumed not to vary significantly in growth areas and established neighbourhoods.
2. All OMR costs are incurred by the distributors.

2.4.5.2 Cost findings

Indicative costs for typical development settings are summarised in Table 22. The costs that are provided are indicative of the order of costs that can be experienced in the situation described, rather than definitive costs, as many factors can influence the cost of an actual development as outlined in the Volume 1 Technical Paper Section 2.3. The case studies were chosen to provide typical costs experienced, rather than extreme costs that could be experienced. However this assessment is acknowledged as subjective.

Cost findings based on the data provided in Section 0 and other sources referenced below are as follows:

- The 30-year capital and recurrent cost to provide gas infrastructure to different development types does not appear to vary significantly based on the development type. However as the OMR costs make up a significant component of the 30-year cost, if the OMR costs could be better quantified there may be greater cost variance.
- Benchmarking identified that the key operating environment characteristics that influence the OMR costs of gas distribution networks are customer density (customers per km of main), energy density (throughput per customer) and the age or condition of the distribution network pipework (Economic Insights 2016). As provision of gas is not an essential service and therefore does not need to be connected to every dwelling, customer density is not the same as dwelling density. Energy density is relatively equal across residential settings, therefore the key factors affecting the infrastructure OMR costs for gas in Melbourne are the age of the gas network supporting the dwelling and the number of customers that share the cost. We do not have the data to represent different operational costs experienced across Melbourne and therefore an average figure has been applied to all cases studies to indicate the relative cost of capital and OMR costs over a 30-year period.
- The capital cost of making a new connection in a greenfield development setting is not significantly different to the capital cost of an established area connection as the cost of the supply meter represents a significant component of the connection cost. The additional cost of providing more reticulation infrastructure in a greenfield area compared to an established area is offset by the complexity of tapping into an active main in an occupied established suburb. The cost of a connection to a small scale infill development is often more expensive than other development settings, as sub meters are required in addition to the main meter.

- Should augmentation of the distribution system be required in an established area, the per metre rate for laying pipework in inner city areas that are densely populated and have restrictions on access can be double those in middle ring areas (Ausnet Services 2016).
- The capital cost for the connection of a medium and high density dwelling when each dwelling is not separately metered is significantly lower than other development settings.
- As the gas transmission system is a pressurised system with an outer ring main (compared to a centralised system acting under gravity, such as the Melbourne Water sewerage treatment system) there is not an area of Melbourne that is more expensive to be serviced from a transmission perspective.
- Considering all of the above factors, provision of gas services to greenfield development areas does not necessarily have a higher capital cost if done when the area is initially developed and is typically easier to implement than provision in established areas in Melbourne. Extension of the gas network to greenfield areas ultimately increases the overall footprint of the gas network increasing operational costs. However the maintenance cost for servicing this larger area is not significant due to the improved asset life of pipework.

2.4.5.3 Cost data

Drawing from the Australian Energy Regulator Gas access arrangements for the three Victorian gas distributors, 2018 to 2022, the average costs for gas connection and operation for Melbourne are summarised in Table . These figures are average figures for Melbourne and do not relate to a specific location or development setting. This high level data enables us to compare the relative costs of different infrastructure elements that support residential development.

Table 22: Gas distribution infrastructure costs per dwelling

Source: D18/32432 WS: 'Summary gas utilities'	$ Jul 2018
Developer cost within development site	$0
Distribution infrastructure connection ($/dwelling)	$2,800
Transmission infrastructure connection ($/dwelling)	$900
Operation, maintenance and replacement ($/dwelling /year)	$240 pa
Capital and recurrent OMR over 30 years	$11,000

Note:

- Distribution infrastructure average costs are a weighted average of the three distribution company costs based on 2017/18 customer numbers.
- Costs within the development site are noted as zero, as the distributor undertakes all of the work except for trenching and backfilling in a shared trench with water utilities and consequently there is no additional cost to the developer for incorporating gas in a development.

Table 22 provides indicative costs for different development scenarios based on confidential cost data provided by the gas distribution businesses and compiled by Infrastructure Victoria

Table 23 Typical development setting gas costs

Connection description Source: D18/32432 WS: 'Case study locations'	Cost per dwelling ($Jul 2018) Connection capital cost	Operation, maintenance and replacement $/pa	30-year cost	Costs source
Simple connection in greenfield growth area development laid in shared preformed trench	$1,850 - $2,500	$200	$7,850 - $8,500	Connection: Confidential cost information from distributor & SMEC data OMR: AER price proposal
Simple established area connection into existing main in the street with capacity to support the service without augmentation	$900 - $2,500	$200	$6,900 - $8,500	Connection: Confidential cost information from distributor. (Developer costs within the dwelling boundary only) OMR: AER price proposal
Complex established area connection into existing main in the street with capacity to support the service without augmentation. Complexity due to traffic management or difficult ground conditions.	$3,500 - $7,500	$200	$9,500 - $13,500	Connection: Confidential cost information from distributor (Developer costs within the dwelling boundary only) OMR: AER price proposal
Inner Melbourne established area brownfield medium density development cost not requiring upstream augmentation and each dwelling separately metered (20-50 dwellings)	$1,000 - $2,100	$200	$7,000 – $8,100	Connection: Confidential cost information from distributor & SMEC data OMR: AER price proposal
Inner Melbourne established area brownfield high density development cost not requiring upstream augmentation and each dwelling separately metered (20-50 dwellings)	$750	$200*	$6,750	Connection: Confidential cost information from distributor & SMEC data OMR: AER price proposal *Note the recurrent cost listed here is higher than would be anticipated, however a more accurate figure was not identified.

If a greenfield site is built out of sequence and does not directly extend from an existing gas distribution network, then costs in the order of $300 per metre of main would be incurred to connect the development.

2.4.6 Sources

2.4.6.1 General

AEMO, *Victorian Gas Planning Report*, 2019

Apa Group, *Victorian transmission system access arrangement submission*, 2017

Ausnet Services, *Gas Access Arrangement Review*, 2018-2022

Ausnet Services, *Gas Access Arrangement Review 2018-2022, Appendix 6e Mains and Services Strategy*, 2016

Australian Gas Networks, *Final Plan*, 2017

Economic Insights, *Benchmarking the Victorian Gas Distribution Businesses' Operating and Capital Costs Using Partial Productivity Indicators*, 2016

Multinet, *Gas access arrangement 2013-17*, 2017

2.4.6.2 Melbourne average gas sector costs

The figures in the table 21 were calculated using figures from these documents publically available on the website of the Australian Energy Regulator:

Multinet:

- Multinet Gas access arrangement 2018 to 2022, Final Decision
    - Overview:
    - Attachment 6
- Multinet Gas access arrangement 2013 to 2017, Final Decision
    - Part 1:
    - Part 2:
- Multinet Gas access arrangement 2018 to 2022, Revised Proposal,

Ausnet:

- AER 2017 Final Decision AusNet Services gas access arrangement:
- Ausnet "our gas network plans 2018-2022":
- Ausnet Services Gas Access Arrangement Review 2018-2022:Access Arrangement Information, Dec 2016:
- AER 2013 final decision, part 1:
- AusNet Services - Appendix 3A - Alternative output growth calculation - 11 August 2017:
-

AGN:

- AER 2017 Final Decision AGN Services gas access arrangement:
- AER - AGN Final Decision Capex Model - November 2017 (XLSX 512.93 KB):
- Envestra 2013 final decision, part 1:

Dates of figures used

- Forecast figures for 2018-2022, forecast in 2017
- Actual and forecast figures for 2013-2017, forecast in 2013

Types of figures used

- Operating Expenditure
- Capital Expenditure
- Customer Numbers

Example calculations

$$Connection\ cost = \frac{Growth\ Capital\ Expenditure}{Final\ no.\ \ customers - Initial\ no.customers}$$

$$Annual\ Maintenance\ cost = \frac{Total\ Capital\ Exp. - Growth\ Capital\ Exp. + Operating\ Exp.}{Av.no.customers \times No.years}$$

The total cost spent over 10 years is calculated, and then this total is divided to find the average cost over the period.

Key assumptions

- All operating and capital expenditure is caused by residential customers
- In 2013-17, the number of connections is equal to the change in the number of customers over the period
- All costs $2017 real dollars

2.5 Social infrastructure

2.5.1 Education

2.5.1.1 Introduction

Education in Victoria follows a four-tier model consisting of preschool education (or kindergarten), primary education (primary schools), secondary education (secondary schools or colleges) and tertiary education (Universities and TAFE Colleges). The provision of preschool infrastructure is covered separately in this appendix in Section 0 as a component of community infrastructure, whilst schools and tertiary education facilities are covered in Section 0 of this appendix.

2.5.1.2 Education – Schools

Overview

In Victoria there are 2,240 schools, 68% of which are government schools. Of those government schools, approximately 75% are primary schools and 20% are secondary, with the balance being special schools and language schools.

Table 24: Number of schools by type in Victoria 2018

	Government	Catholic	Independent	All schools
Number of schools by school type, February 2018				
Primary	1,122	392	36	1,550
Primary–Secondary	80	12	149	241
Secondary	244	85	13	342
Special	81	5	21	107
Language	4	0	0	4
Total	1,531	494	219	2,244

Source: DET, *Summary statistics for Victorian* schools, 2018

Forecasting demand

Since 2011, Victoria has experienced rapid population growth. The Victorian Government's report *Victoria in Future 2016* projects that the school-aged population of five to 17 year olds in Victoria will increase by around 90 000 students – nearly 10%– between 2017 and 2022. Demand for individual schools is also affected by the choices that parents make. The guiding legislation for Victorian schools, the Education and Training Reform Act 2006 (the Act) provides a right for every school-age child to enrol at his or her neighbourhood government school. It also allows students to choose other government schools where there is available space. Over half of Victorian parents of school-aged children are currently choosing to send their children to schools other than their neighbourhood school. Currently, 52% of government primary school enrolments and 53% of government secondary school enrolments come from outside the local school catchment (VAGO 2017).

Costs

Findings:

- The capital cost of school infrastructure in a greenfield growth area is approximately $16,500 per dwelling.
- The capital cost of school infrastructure in established areas can range from zero cost, where existing schools have capacity, to $40,000 per dwelling in the extreme case where inner city land acquisition costs are high, resulting in the development of a multistorey development on a confined site.
- A more economical solution can be found in established areas in many cases, where land acquisition costs can be avoided through utilising existing school sites or other public land – in particular co-locating with parks and other recreational facilities. In this case the cost of an established area school can be approximately equal to a greenfield school, however the established area sites will in many instances offer less benefits than a greenfield development, for example by not providing space for future expansion or offering reduced outdoor recreational space.
- Operational costs summed over a 30-year period will be approximately equal to the capital cost of school provision.
- Operational costs of multistorey schools will be higher than a single storey school, as the multistorey building will incur additional maintenance costs. Examples of higher cost elements include windows and roof elements than cannot be

maintained from the ground, transportation systems such as lifts, central firefighting and air conditioning systems (Slattery 2018).

- The costs provided in this report are for government school provision only and do not include infrastructure costs for non-government schools, which vary significantly. If provision was made for all students to be accommodated in government schools, the cost of greenfield growth area government school provision per dwelling would increase by approximately 60% due to the increased number of government schools that would be required.
- Slattery 2018 states when considering construction cost of multistorey dwellings, excluding land "considering all the factors outlined, from planning efficiencies to more complex construction, we believe the additional [capital] cost would be in the order of 60%". This conclusion is reflected in the findings by Infrastructure Victoria, with the results in Table 24 below also indicating the additional land acquisition cost.

Table 25 Ranges of costs that could be experienced

School description (HPE CM Ref : D18/170528 School costs)	Details	Capital cost per dwelling	30-year cost
Primary School			
Greenfield growth area	P-6, 525 students, 3.5 Ha site	$8,800	$14,300
Established area	P-6, 625 students, 3 level build with no land purchase	$6,700	$10,100
Established area provision of relocatable building	2 classroom facility with additional 20% cost allowance for supplementary facilities	$1,800	$3,400
Inner Melbourne	P-6, 525 students, constrained site, multistorey build with land purchase	$21,300	$32,700
Inner Melbourne	P-6, 525 students, 2- 3 level build, constrained site with land purchase or relocation costs	$8,700 $14,300	$16,500 $19,400
Secondary School			
Greenfield growth area	7-12, 1100 students, 8.4 Ha site	$7,600	$13,100
Established area provision of relocatable building	Two classroom facility with additional 20% cost allowance for supplementary facilities	$1,500	$3,000
Established area	7-12, 650 students, specialist sports facilities with no land purchase, not multistorey	$5,000	$9,600
Inner Melbourne	7-12, 650 students, 4 level build, constrained site, shared existing grounds and no land purchase	$8000	$15,400

Capital costs have been taken from budget papers and land values have been obtained from confidential government advice. Annual recurrent operational and maintenance costs have been taken as 3% of construction cost per annum, adopting an average figure as nominated by VAGO 2017, Managing School Infrastructure.

The capital costs per dwelling are very dependent on assumptions made by Infrastructure Victoria regarding the number of school places that are required per dwelling. For consistency of comparison a greenfield ratio has been adopted for all locations and development settings, drawing on the provision rates nominated in Australian Social & Recreational Research Pty Ltd 2008 report.

2.5.1.3 Education – Tertiary

Introduction

In Victoria, tertiary education is available for students older than 17 years of age, who are no longer required to attend school. Tertiary education is delivered as Vocational Education and Training (VET) or as higher education. VET is typically offered by Technical and Further Education (TAFE) institutions or registered training organisations (RTOs) and enables students to gain qualifications for all types of employment, and specific skills to help them in the workplace. Higher education is offered by the university sector.

Universities are not distributed in residential areas but are provided at a broader subregional level located in major activity centres (GAA 2010) and therefore facilities for delivering higher education are not considered relevant to the IPIDDS project. VET facilities are however distributed more evenly throughout the community and are therefore considered further.

Forecasting demand

In 2011 the VET sector was opened up, enabling training to be provided by a broad range of RTOs in addition to TAFE. RTOs responded strongly to the offer to provide education services, resulting in TAFE now only providing training to 15% or 150,000 VET students (NCVER data website).

RTOs are responsible for providing their own facilities and consequently the need for government funded VET training facilities has significantly declined and has not been considered by the IPIDDS project. This is further verified by analysis undertaken in Section 0.

Costs

An initial high level cost analysis was undertaken for the tertiary education sector to determine if a more detailed analysis was warranted. Based on the GAA 2010 report, only TAFE facilities were considered as all other tertiary education facilities are likely to be provided at a broader subregional level.

Analysis was undertaken on the state government capital infrastructure funding for the TAFE sector from 2009/10 to 2018/19 inclusive, drawing from published budget papers. This showed that on average approximately $70,000 was spent on TAFE facility capital works per annum. These capital works were expended across Victoria (rather than just in Melbourne) and were to support the requirement for new courses and upgrade of existing facilities as well as expansion of facilities to service growth. The figure is therefore likely to overestimate the cost of infrastructure expended to support growth. When this figure is broken down to a per dwelling basis in relation to new dwellings provided in Melbourne during the same period, the per dwelling cost is less than $2 per new dwelling constructed in Melbourne. As this cost is not significant, further analysis was not undertaken on TAFE and tertiary education facilities.

2.5.2 Health, community and emergency services infrastructure

2.5.2.1 Benchmark provision

The reference document Australian Social & Recreational Research Pty Ltd, Planning for Community Infrastructure in Growth Areas 2008 (AS&RR 2008) was adopted to provide benchmark rates for health, community and emergency services infrastructure in all development settings.

The objective of this project is to enable comparison between different development settings and so for consistency of comparison between locations, benchmark greenfield rates have been adopted for all locations. We do acknowledge however that this does not necessarily reflect what is typically required, with social infrastructure requirements varying based on varied demographic mixes experienced in different development settings.

In established areas, population growth can in many circumstances be supported by existing infrastructure that has already been constructed for this purpose. Where the existing facilities do not have the capacity to service growth, other underutilised facilities can be adapted to suit new requirements (such as disused local government and community halls), or alternatively, where existing buildings do not have adequate building space to support growth, they can be expanded with permanent or relocatable buildings on existing land. In developing costs for social infrastructure in greenfield areas, benchmark figures have been adopted and costs included for land acquisition and construction. In established areas a range of costs have been identified, ranging from zero when existing facilities can be utilised, through to an upper limit figure where land must be acquired at inner city land prices, attracting a high level of cost in comparison to greenfield facilities.

2.5.2.2 Health infrastructure

In considering health infrastructure, only local health facilities were considered as the objective of the project is to identify varied infrastructure costs relating to different development settings, rather than the overall cost of infrastructure to support population growth.

To determine benchmark levels for local health infrastructure the reference sources adopted were AS&RR 2008 and DHHS 2006, 'Care in your community'. Facilities that are required at a community level consist of Level 2 and 3 community health facilities as defined by AS&RR 2008 (or Level 1 and 2 facilities as defined by DHHS 2006), which are community facilities for communities of up to a population of 100,000 people. Facilities for communities larger than 100,000 people service a subregional population and are recommended to be located within activity centres or co-located with major health facilities and so have not been included in this analysis.

Based on benchmark provision areas provided in AS&RR 2008, land acquisition costs provided in SMEC 2018 and Victorian budget capital data, the following costs were determined per dwelling for health facilities. OMR costs were developed based on benchmark industry rates of 3% of capital cost (SMEC 2018).

Table 26 Health infrastructure cost per dwelling

Development setting (HPE CM Ref: D18/170528 Sheet Health)	Cost per dwelling ($2018)		
	Capital cost	OMR	30-year OMR & capital cost
Greenfield development including land acquisition	$ 1,200	$35	$2,200
Established middle/outer ring area development utilising existing land, with capital cost increased based on constrained site	$ 1,300	$40	$2,400
Established inner ring area development utilising existing land, with capital cost increased based on constrained site	$ 2,400	$70	$4,500

2.5.2.3 Community infrastructure and emergency services infrastructure

To determine benchmark levels for community and emergency services infrastructure in different development settings we referenced AS&RR 2008 and costs were applied to these benchmarks. Refer SMEC 2018 for costing data and assumptions and Appendix 1 for a summary of benchmarks adopted.

2.5.3 Sources

Australian Social & Recreational Research Pty Ltd, *Planning for Community Infrastructure in Growth Areas*, 2008

DET, *Summary statistics for Victorian schools*, July 2018

DHHS, *Care in your community*, 2006

Growth Areas Authority, *Tertiary Education Advice for Growth Area Framework Plans Final Report*, May 2010

National Centre for Vocational Education Research (NCVER) website: https://va.ncver.edu.au/SASVisualAnalyticsViewer/VisualAnalyticsViewer_guest.jsp?reportName=Total%20VET%20students%20and%20courses%20by%20provider%20type&reportPath=/Visual%20Analytics/NCVER/vpc-total-vet-activity/Reports/3.Published&appSwitcherDisabled=true&commentsEnabled=false&reportViewOnly=true

Slattery 2018, *Kaizen Education 02*

VAGO, *Managing School Infrastructure*, May 2017

2.5.4 Social infrastructure Benchmark Provision

Table 26

	Basis of facility costing - AS&RR 2008, Planning for Community Infrastructure in Growth Areas			
	Reference	Base population	Built Form (UFA - SQM)	Site Area (SQM)
Community Infrastructure				
Level 1 Facilities (per 10,000 people)				
Kindergarten*				
4 yo Kindergarten - double room facility	AS&RR 2008	10,000	420sqm landscaped outdoor play area	3300sqm
3yo kindergarten	AS&RR 2008		100sqm floor area	incl with 4yo kinder
Child Care				
Floor space	AS&RR 2008	8000 to 10000	Facility for for 120 children	2,500
Outdoor paved area	AS&RR 2008	8000 to 10000	Facility for for 120 children	
Multipurpose Community Facilities*				
level 1 Multipurpose community facility	AS&RR 2008	8000 to 10000		8,000
level 3 Multipurpose community facility		40,0000 to 50,000		15,000
Maternal & child health - Floor area sqm	AS&RR 2008	16,000	100	
Play group - floor space	AS&RR 2008	5,000	150	
neighbourhood house	AS&RR 2008	20,000	600	
Home & community Care - planned Activity group room		40,000 to 60,000	400	
Home & commnity Care - Meals dispatch				
Meeting rooms				
200+	AS&RR 2008	20,000	250	
101-200	AS&RR 2008	8,000	185	
51-100	AS&RR 2008	8,000	90	
21-50	AS&RR 2008	8,000	50	
1-20	AS&RR 2008	4,000	75	
Occasional care, early childhood intervention				
Youth services & facilities, seniors facilities				
Library (Level 3 &4)	AS&RR 2008	30,000	1,440	10,000
Community Arts Centres				
Level 2 / Colocated Level 3 community arts centre	AS&RR 2008	40,000 to 60,000	800	
Level 3 community arts centre		40,000 to 60,000	1,250	2,750
Regional Arts Centre	AS&RR 2008	municipality		
Council Indoor Aquatice/Fitness Centre level 3/4	AS&RR 2008	40,000	Refer AS&RR 2008 for description	Refer AS&RR 2008 for description
Council Indoor recreation centres level1,2 &3		20,000 to 30,000	2000	6,000
Open space and sports fields				
Emergency services infrastructure				
Colocated facility Vic Police, Fire, VICSES & Ambulance (Greenfield only, not required in established areas)		50000		13,000
Health				
Residential Aged Care				
Level 5 Community Base Health care to support in excess of 200,000 to 250,000 people (Note level 4 DHHS 2006, Care in your community)		200,000-250,000		
Level 4 Community Base Health care to support 100,000 to 200,000 people (Note level 3 DHHS 2006, Care in your community)	AS&RR 2008	100,000 to 200,000		
Level 3 Community Base Health care to support 50,000 to 100,000 people (Note level 2 DHHS 2006, Care in your community)	AS&RR 2008	50,000 to 100,000		10,000
Level 2 Community Base Health care to support in 50,000 people (Note level 1 DHHS 2006, Care in your community)	AS&RR 2008	50,000		6,000

	Facility area scaled to a population of 10,000 people (3,500 dwellings based on GA ratios)			
	Base population	Built Form (UFA - SQM)	Site Area (SQM)	
Community Infrastructure		4,382		
Level 1 Facilities (per 10,000 people)				
Kindergarten*				
4 yo Kindergarten - double room facility	10,000	420sqm landscaped outdoor play area	3,300	1- 4yo double room/10,000
3yo kindergarten	10,000	100sqm floor area	incl with 4yo kinder	1- 3yo single room/10,000
Child Care				
Floor space	10,000	Facility for for 120 children	2,500	
Outdoor paved area	10,000	Facility for for 120 children		
Multipurpose Community Facilities*				
level 1 Multipurpose community facility	10,000		8,000	
level 3 Multipurpose community facility	10,000		3,750	
Maternal & child health - Floor area sqm	10,000	63		
Play group - floor space	10,000	300		
neighbourhood house	10,000	300		200-600 sqm range provided. Adopt 600 as assume covering all other general facilities below
Home & community Care- planned Activity group room		80		
Home & commnity Care - Meals dispatch		0		assume existing services can support or private provider
Meeting rooms				
200+	10,000	125		
101-200	10,000	231		
51-100	10,000	113		
21-50	10,000	63		
1-20	10,000	188		
Occasional care, early childhood intervention				included in shared meeting space
Youth services & facilities, seniors facilities				included in shared meeting space
Library (Level 3 & 4)	10,000	480	3,333	Level 3 library for 30,000 people assumed
Community Arts Centres				
Level 2 / Colocated Level 3 community arts centre	10,000	160		colocated on school or MPCC
Level 3 community arts centre	10,000	250	550	
Regional Arts Centre		0	-	assume already in existence for all municpalirties
Council Indoor Aquatice/Fitness Centre level 3/4	10,000	Refer AS&RR 2008 for description	Refer AS&RR 2008 for description	
Council Indoor recreation centres level1,2 & 3	10,000	800	2,400	Refer AS&RR 2008 for description
Open space and sports fields				
Emergency services infrastructure				
Colocated facility Vic Police, Fire, VICSES & Ambulance (Greenfield only, not required in established areas)	10,000		2,600	1 police station, I colocated fire/ses facility & 1 ambulance station
Health				
Residential Aged Care Not included as another form of residential dwelling				
Level 5 Community Base Health care to support in excess of 200,000 to 250,000 people (Note level 4 DHHS 2006, Care in your community)	Not included as subregional infrastructure			
Level 4 Community Base Health care to support 100,000 to 200,000 people (Note level 3 DHHS 2006, Care in your community)	Not included as subregional infrastructure			Cranbourne Integrated Care Centre Sited as a model
Level 3 Community Base Health care to support 50,000 to 100,000 people (Note level 2 DHHS 2006, Care in your community)	10,000			Western Region Health Care Centre Sited as a model - reconfirm
Level 2 Community Base Health care to support in 50,000 people (Note level 1 DHHS 2006, Care in your community)				example not provided.

About us

Infrastructure Victoria is an independent advisory body, which began operating on 1 October 2015 under the *Infrastructure Victoria Act 2015*.

Infrastructure Victoria has three main functions:

- preparing a 30-year infrastructure strategy for Victoria, which is refreshed every three to five years
- providing written advice
  to government on specific infrastructure matters
- publishing original research on infrastructure-related issues

Infrastructure Victoria also supports the development of sectoral infrastructure plans by government departments and agencies.

The aim of Infrastructure Victoria is to take a long-term, evidence-based view of infrastructure planning and raise the level of community debate about infrastructure provision.

Infrastructure Victoria does not directly oversee or fund infrastructure projects.

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This document is also available in PDF and accessible Word format at www.infrastructurevictoria.com.au