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Economic, social, and environmental impacts of alternative urban development scenarios for Victoria

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Infrastructure Victoria

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THE CENTRE FOR INTERNATIONAL ECONOMICS
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Executive Summary

Infrastructure Victoria has developed five urban development scenarios to capture a variety of outcomes for how people, dwellings and jobs growth occurs across Victoria from now to 2056. These are documented in detail in SGS 2022, Urban Development Scenarios and set out in chapter 2. The CIE has been tasked with assessing the economic, social and environmental impacts of these scenarios and the infrastructure costs associated with these scenarios.

The scenarios

The five scenarios considered have the same population, number of dwellings and jobs across Victoria in 2056, but allocate these in different ways across Victoria. The five scenarios are characterised as follows:

- **Scenario 1** — a Compact City scenario where a greater share of population and employment growth is in inner areas of Melbourne
- **Scenario 2** — a Consolidated City scenario where a greater share of population and employment growth is in middle and inner areas of Melbourne
- **Scenario 3** — a Dispersed City scenario with a higher share of growth is in greenfield areas of Melbourne
- **Scenario 4** — a Network of Cities scenario that allocates a higher share of growth to regional cities
- **Scenario 5** — a Distributed State scenario that allocates a higher share of growth to regional towns and other rural areas.

Infrastructure costs

Future urban development requires substantial additional infrastructure under all scenarios. This includes utilities, transport, local infrastructure and community infrastructure.

- Costs vary by development scenario due to differences in existing infrastructure capacity, the shares of greenfield and infill development, as well as differences in regional population density, dwelling typology and employment composition.
- Total estimated infrastructure costs by scenario are above $149 billion for all scenarios (table 1). This excludes all cost that do not differ by scenario, for example, transport projects that would have been delivered across every scenario or electricity generation costs which are the same across each scenario.

- Transport and local infrastructure have the most substantial infrastructure cost that differ across scenarios, followed by education and open space. Other utilities (e.g., gas, water and wastewater) and community facilities account only for a minor share.
- Costs are highest for scenarios with high shares of greenfield development, such as the Dispersed City scenario ($190 billion). The Consolidated City and Network of Cities scenarios have similar costs at $179 billion and $172 billion, respectively. The Compact City scenario has the lowest cost across all scenarios ($149 billion). The Distributed State has a cost of $169 billion.
- Total infrastructure cost per *new* dwelling that differ by scenario ranges from $82,000 to $105,000 across scenarios.

1 Infrastructure impacts across scenarios to 2056 – total cost ($ billions)

Sector	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$b, real	$b, real	$b, real	$b, real	$b, real
Local infrastructure	42	55	68	65	70
Education	34	23	23	20	15
Open space	18	9	6	4	3
Community facilities	13	9	6	7	2
Electricity	5	7	13	13	11
Gas	0	0	0	0	0
Water and Wastewater	9	11	13	17	20
Transport	28	57	61	52	48
Total	**149**	**172**	**190**	**179**	**169**
Difference to Dispersed City scenario	-41	-18	0	-10	-20

Note: Figures are denoted in real 2022/23 dollars. Figures have been rounded to the nearest billion and may not add up.

Data source: CIE.

The overall total costs vary only to some extent in absolute terms across scenarios. For many of these indicators it is most useful to compare across scenarios. We use the Dispersed City scenario for comparison as it represents a continuation of recent trends.

There are two main drivers of the cost differential between scenarios:

- Firstly, the Compact City and Consolidated City scenarios tend to exhibit lower costs in the transport and utilities' sectors. However, higher capital and land costs in established areas contribute to higher community and education infrastructure costs in denser regions. The lower transport/utility costs for these two scenarios are offset by the higher community/education infrastructure costs, resulting in a lower overall cost differential.
- Secondly, at least 62 percent of new dwellings are constructed in the same region across all scenarios. This means that the cost differences between scenarios is driven by 38 per cent of new relocated dwellings in which location differs in each scenario.

If we compare differences across scenarios on a cost per relocated dwelling[1] basis, the Compact City scenario has a highly material lower cost of $59 000 per new relocated dwelling compared to the Dispersed City scenario (table 2). Similarly, the Consolidated City and Distributed State scenario have a lower cost of $26 000 and $29 000 per dwelling compared to the Dispersed City scenario, respectively.

This means that the Compact City and Consolidated City scenarios offer the largest cost advantages when it comes to infrastructure cost per relocated dwelling compared to the Dispersed City scenario. The Distributed State scenario also has cost advantages per relocated dwelling; however, it has worse outcomes than the Compact City and Consolidated City scenarios when looking at economic, social and environmental impacts.

2 Total cost per new relocated dwelling to 2056 – compared to Dispersed City scenario

Sector	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$ '000, real	$ '000, real	$ '000, real	$ '000, real	$ '000, real
Local infrastructure	-37	-18	0	-4	3
Education	16	0	0	-3	-10
Open space	18	4	0	-2	-5
Community facilities	10	4	0	1	-6
Electricity	-12	-9	0	0	-3
Gas	0	0	0	0	0
Water and Wastewater	-6	-3	0	6	10
Transport	-47	-5	0	-13	-18
Total	**-59**	**-26**	**0**	**-15**	**-29**

Note: Figures are denoted in real 2022/23 dollars. Figures may not add up due to rounding.

Data source: CIE.

Economic, social and environmental impacts

There are a very wide range of possible indicators to measure for the outcomes from alternative spatial scenarios. This study has sought to focus on those that are most related to where people live and work and the type of housing they live in and those that are most material. A summary of key indicators is shown in table 3.

1 The relocated dwellings are those above the minimum across scenarios for each SA2.

3 Summary of key indicators

Indicator	Description
Housing and social indicators	
Net value of housing	This measures the value people place on housing provided by the scenario, less the cost of constructing the housing. This indicator is high if housing is located in areas that people want to live in and in types of housing people want to live in, and that is less costly to construct. This changes over time particularly reflecting the accessibility of a location to jobs. This is the main social indicator.
Share of dwellings that are detached	The share of dwellings that are detached is an indicator of housing type. Note that no normative conclusions relate to this indicator.
Accessibility metrics	The ability of people to access jobs and services close to where they live. The summary table shows access measures to jobs — access to other activities is shown in the main report.
Public transport mode share	The share of trips taken by public transport. A higher value is considered positive, as this reduces congestion on roads.
Share of dwellings that are affordable	Using sale and rent thresholds, this indicator shows the expected proportion of dwellings below a threshold as an indicator of the availability of affordable housing.
Economic indicators	
Business location productivity	Business location productivity represents the value of non-residential space less the costs of constructing it. It is higher where jobs are located in areas with high lease rates (e.g. the Melbourne CBD).
Agglomeration	Agglomeration measures spillovers from businesses being closer together. This has overlaps with business location productivity, so it is not included in total income effects.
Employment impacts	Employment impacts measures the differences in labour force participation arising from people's access to jobs. It is highest for scenarios where people have the highest access to jobs.
Income	Income measures the value per person on average over the period that comes from business location productivity and employment impacts. Note that this is not annual income, but income over the period stated.
Environmental indicators	
GHG emissions	GHG emissions covers GHG emissions from residential buildings, both the operation of the building and the embodied emissions in constructing the building, and GHG emissions from vehicles. Vehicle emissions includes tailpipe emissions from vehicles using petrol and diesel and emissions from generating electricity for electric vehicles. GHG emissions fall rapidly over time in line with a shift to electric vehicles and production of electricity becoming less carbon intensive.
Transport externalities (noise and air pollution)	Transport externalities captures the cost of noise and air pollution from transport activities.
Additional urban land take	The additional urban land take is the area required to be converted from current uses to urban uses. This is higher for scenarios with more greenfield and regional development. Additional urban land take could replace existing uses of land such as farming or areas of native vegetation.

Source: CIE.

A summary of quantitative indicators of the scenarios is shown in table 4. For many of these indicators it is most useful to compare across scenarios. **For comparison we use the Dispersed City scenario as it represents a continuation of recent trends.**

- The Compact City scenario provides the highest net value of housing. This is because it has more housing in locations that people value now and leads to the largest increase in job accessibility across scenarios. This difference is highly material at $150 000 per relocated dwelling. The Compact City scenario also has the highest business productivity and employment participation impacts. As a result, average income which is used as a summary indicator of economic impact is estimated to be $5000 higher per person compared to the Dispersed City scenario over the period 2021 to 2056. From an environmental perspective, the Compact City scenario has the third lowest combined GHG emissions and requires the least additional urban land take. The lower overall GHG emissions is due to significantly lower emissions from vehicles, offset by higher emissions from buildings, particularly embodied emissions from concrete and steel used to make apartments. The Compact City performs moderately on housing affordability measures, providing more affordable housing in Inner Melbourne but less overall compared to other scenarios.
- The Consolidated City has the second highest housing value, relatively high job accessibility and positive economic impacts compared to the Dispersed City scenario. The Consolidated City scenario has marginally higher GHG emissions compared to the Dispersed City, due to the increase in emissions from buildings (which is partly offset by lower emissions from vehicles). It also has lower transport externalities and land take compared to the Dispersed City.
- The Network of Cities has lower housing value, lower job accessibility and less positive economic impacts compared to the Dispersed City scenario. The Network of Cities has marginally lower GHG emissions, due to the lower emissions from vehicles, mostly offset by higher emissions from buildings. It also has lower transport externalities, but a higher land take compared to the Dispersed City
- At the other extreme, the Distributed State scenario is least aligned to current housing and business preferences. It has the lowest GHG emissions, due to the lower emissions associated with a higher share of detached housing (driven by using timber and brick rather than emissions-intensive concrete and steel), as well as lower emissions from vehicles. It also has the lowest transport externalities, associated with more travel in less densely populated areas. The land take, however, is the highest of the scenarios. It would lead to a higher share of housing being affordable — although this is not necessarily a positive outcome as the lower housing cost reflects that housing is located where people have a lower willingness to pay to live.

A qualitative assessment of the scenarios is shown in table 5. Scenarios are mainly differentiated by their social and economic performance, with the Compact City and Consolidated City performing more strongly than other scenarios. While important, environmental impacts are less different across scenarios, and with alternative environmental impacts suggesting different rankings of scenarios. While infill-focused scenarios perform well on efficiency metrics, a key risk is ensuring that enough housing and business space is provided, as these scenarios have a higher risk of community opposition related to infill development.

4 Summary indicators of scenarios

Indicator	Unit	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
Housing and social indicators						
Net value of housing	$b, present value relative to Dispersed City	105	52	0	-55	-107
Of which: value of improved access to jobs	$b, present value relative to Sc3	100	47	0	-37	-80
Net value of housing per relocated dwelling	$000/relocated dwelling relative to Dispersed City	152	75	0	-79	-155
Share of all dwellings that are detached, 2056	Per cent	53.9	58.0	64.6	62.1	67.1
Accessibility to jobs (car 2036)	Ratio to Dispersed City	110	104	100	101	101
Accessibility to jobs (car 2056)	Ratio to dispersed city	115	106	100	100	95
Accessibility to jobs (public transport 2036)	Ratio to dispersed city	110	104	100	98	96
Accessibility to jobs (public transport 2056)	Ratio to dispersed city	118	109	100	95	87
Public transport mode share (AM peak)	Per cent of trips	15.0	13.4	12.1	12.0	11.3
Share of dwellings for sale under $750 000 (today's value)	Per cent	47.9	49.6	55.9	56.0	62.9
Share of dwellings available for rent under $500 per week	Per cent	68.5	68.3	72.5	74.3	78.8
Economic indicators						
Business location productivity	$b relative to Dispersed City	30.8	9.0	0	- 0.6	-8.2
Agglomeration	$b relative to Dispersed City	19.7	12.3	0	-1.8	-15.5
Employment impacts	$b relative to Dispersed City	12.1	5.0	0	0.2	-2.6
Income	$/person (2021 to 2056) relative to Dispersed City	5 185	1 688	0	- 55	-1 310
Environmental indicators						
Building operational GHG emissions	Million tonnes CO2e relative to Dispersed City	0.7	0.3	0	0.1	0.0
Building embodied GHG emissions	Million tonnes CO2e relative to Dispersed City	14.8	8.0	0	1.3	-1.8
Vehicle tailpipe GHG emissions	Million tonnes CO2e relative to Dispersed City	-16.8	-7.6	0	-1.5	-10.8
Vehicle (electric) operational energy GHG emissions	Million tonnes CO2e relative to Dispersed City	-0.5	-0.2	0	-0.0	0.1
Total GHG emissions	Million tonnes CO2e relative to Dispersed City	-1.8	0.5	0	-0.1	-12.5
Environmental externalities from transport	$b relative to Dispersed City	-0.5	-0.3	0	-0.8	-1.5
Additional urban land take	Km2 relative to Dispersed City	-313	-190	0	20	241

Note: Darker teal is the most positive moving to darker orange as the most negative of the five scenarios.
Source: CIE.

5 Qualitative assessment of impacts of the scenarios

Indicator	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
Housing and social impacts	High — best aligns to where people want to live and housing types (current preferences). Highest accessibility of scenarios.	Medium/high — second closest alignment to type and location of housing with the highest value.	Medium - third closest alignment to type and location of housing with the highest value.	Medium/low — moderately poor alignment with current housing preferences. Would require large shifts in current preferences to occur.	Low — poor alignment with current housing preferences. Would require large shifts in preferences to occur. Low accessibility to jobs
Business and productivity impacts	High — business location productivity, agglomeration and employment likely highest in this scenario	Medium/high — business location productivity, agglomeration and employment higher than Scenario 3 but not as high as Scenario 1	Medium — similar business and productivity outcomes to Scenario 4	Medium — similar business and productivity outcomes to Scenario 3	Low — business productivity and employment impacts negative compared to Scenario 3
Environmental impacts	Second lowest GHG emissions Lowest land take for urban activity of scenarios	Slightly higher GHG emissions than Scenario 3 Second lowest land take	Second highest GHG emissions of scenarios Highest transport externalities Moderate land take	Slightly lower GHG emissions that Scenario 3 Slightly higher land take than Scenario 3	Lowest GHG emissions, due to transport and embodied Highest land take
Other impacts	High risk of insufficient housing supply if community opposition to infill development occurs More affordable housing in inner Melbourne locations	High risk of insufficient housing supply if community opposition to infill development occurs	Greenfield housing has lower risk of opposition to delivery	High risk that people and business preferences are not aligned to the scenario	High risk that people and business preferences are not aligned to the scenario More affordable housing in total

Source: CIE.

Glossary

Accessibility — the ease with which a person or a business can access particular services or inputs. This is calculated in most instances in this study as a weighted average of the time required to access different places, with places weighted by the quantity of the jobs or people.

Agglomeration — businesses locating closer together and gaining benefits from doing so

ATAP — Australian Transport Assessment and Planning

Business location productivity — how the location of a business impacts on its ability to use a given set of inputs to produce outputs

Climate zones — The National Construction Code (NCC) defines eight Australian climate zones and has different building code requirements for each climate zone.

Coastal water corporations – water corporations outside the metropolitan Melbourne area that have a service boundary located on the Victorian coastline.

Capital Cost or CAPEX — fixed, one-time expenses incurred on the purchase of land, buildings, construction, and equipment.

Decarbonisation — refers to the process of reducing or eliminating carbon dioxide emissions, particularly those resulting from human activities such as the burning of fossil fuels.

Demand saturation — refers to a situation where the market or consumers have reached a point where they are no longer willing or able to purchase more of a particular product or service. It means that the demand for that product or service has reached its maximum limit, and further attempts to increase sales may be challenging or result in diminishing returns.

Embodied emissions — GHG emissions related to the materials and construction processes for buildings.

GHG emissions — greenhouse gas emissions

Greenfield — development of land that is not currently urban for urban purposes. This can include land in Melbourne's New Growth Areas and in other areas.

GSP — Gross State Product

GWH — Giga Watt Hours

Infill — refers to existing urban areas that are not undeveloped greenfield sites. It includes neighbourhoods, activity centres and transport corridors in Melbourne, as well as urban renewal areas. This can be applied to Melbourne and to regional Victorian cities, such as Geelong, Ballarat and Bendigo etc., where infill development is occurring.

Inland water corporations – water corporations outside the metropolitan Melbourne area that *do not* have a service boundary located on the Victorian coastline.

Local Infrastructure — streetscape and reticulation of services within a development area to each development site

Metropolitan Centre (also called Metropolitan Activity Centres) — higher-order centres intended to provide a diverse range of jobs, activities and housing for regional catchments that are well served by public transport. These centres will play a major service delivery role, including government, health, justice and education services, as well as retail and commercial opportunities.

Occupancy rates — number of people living in a dwelling.

Other tertiary education — for example TAFE

Operating cost or OPEX — cost related to the maintenance of buildings or land. This excludes cost like teaching staff.

Opportunity cost of land — refers to the potential benefits or opportunities that are foregone or sacrificed when a particular piece of land is used for a specific purpose, instead of being used for an alternative use that could have provided greater value or returns. It represents the value of the next best alternative forgone when choosing a particular land use.

Peri-urban areas — transitional zones located on the outskirts of urban centres, characterised by a mix of urban and rural features.

Permanent capacity (relating to schools) — capacity in permanent school building buildings (i.e., bricks and mortar)

Relocatable capacity (relating to schools) — capacity in relocatable buildings (i.e., portables)

Relocated dwellings — dwellings that are in a different place in each scenario, equal to 0.7 million dwellings from 2021 to 2056. Across all scenarios Victoria grows by 1.8 million new dwellings. 1.1 million of these new dwellings are constructed in the same location across all scenarios, and 0.7 million (relocated dwellings) are in different locations.

SEIFA — Socio-Economic Indexes for Areas

Tailpipe emissions — GHG emissions from internal combustion engines in cars and other vehicles using diesel and petrol

Total cost — Sum of all capital cost and the cumulative operating cost over time.

Units of measurement — GW (Gigawatt), MW (Megawatt), kW (Kilowatt), TJ (Terajoules), MJ (Megajoules), kJ (Kilojoules), km2 (square kilometres), ha (hectares), sqm (square metres), ML (megalitre), kL (kilolitre)

UGB — urban growth boundary

VKT — Vehicle Kilometres Travelled

Well-to-tank emissions — GHG emissions related to the production of a vehicle and production of fuel used in the vehicle, such as electricity production for electric vehicles.

WTP — Willingness To Pay

1 This project

Infrastructure Victoria has developed five urban development scenarios to capture a variety of outcomes for how people, dwellings and jobs growth occurs across Victoria. These are documented in detail in SGS 2022, Urban Development Scenarios and set out in chapter 2. The CIE has been tasked with assessing the economic, social and environmental impacts of these scenarios.

Alternative urban development scenarios can have a wide range of possible impacts on Victorians. Not all impacts have been measured in this assessment. The assessment has focused on measures based on the following:

- impacts that are expected to be the most significant to people's wellbeing
- impacts that are not overlapping with other impacts — that is, they measure a distinct aspect of the performance of a scenario
- impacts that are expected to be intrinsically different across urban development scenarios, as opposed to being influenced largely by other factors, and
- impacts that are measurable.

A summary of the indicators measured and other indicators not measured is shown in table 1.1.

1.1 Summary of impacts measured for urban growth scenarios

Category	Measured	Not measured but discussed	Not considered
Environmental	GHG emissions from transport and buildings Land requirements Transport externalities (air and noise pollution)	Development of sensitive land Energy consumption Water consumption Air quality (non-transport)	Water quality Soil degradation Waste generated Noise pollution (non-transport)
Social	Housing type and suitability (alignment to housing preferences) Access to jobs Access to services Spatial distribution of housing affordability Transport metrics	Dwelling types	Housing suitability Household stress Cultural/recreational participation Youth engagement Crime
Economic	Alignment with current business preferences Labour force participation/employment Agglomeration Effective job density Individual/household income		GSP Agricultural productivity Human capital

Category	Measured	Not measured but discussed	Not considered
Costs	Most infrastructure costs, with exceptions shown to the right	Health	Ports Police Emergency services Justice Social services

Note: Measured are highlighted in teal, not measured but discussed in grey and not considered in pink.
Source: CIE.

This report continues as follows:

- Part I details the urban development scenarios
- Part II sets out infrastructure costs estimated for each scenario. It covers:
  - the method for estimating infrastructure costs
  - the types of costs assessed
  - the estimated infrastructure costs
  - details for measurement of the costs for each sector are shown in technical appendices
- Part III sets out the economic, social and environmental impacts of scenarios. It covers:
  - housing and social impacts, covering indicators such as alignment of scenarios to people's preferences about where and how they live, and accessibility
  - economic impacts, which are impacts on businesses and employment that will result in a change to income
  - environmental impacts, particularly focusing on land take and GHG emissions
  - equity impacts, focused on the distribution of outcomes spatially and housing affordability
  - the robustness and risks of different spatial scenarios.
- Part IV is technical appendices for all the different areas.

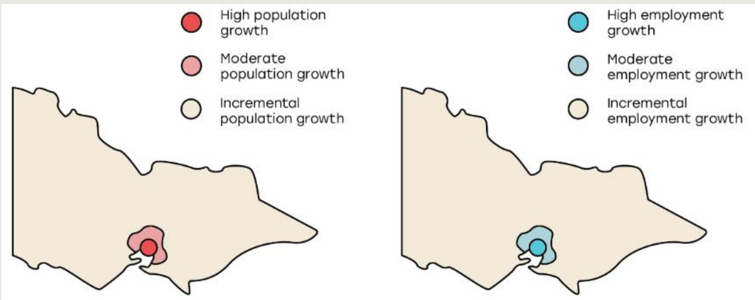
PART I

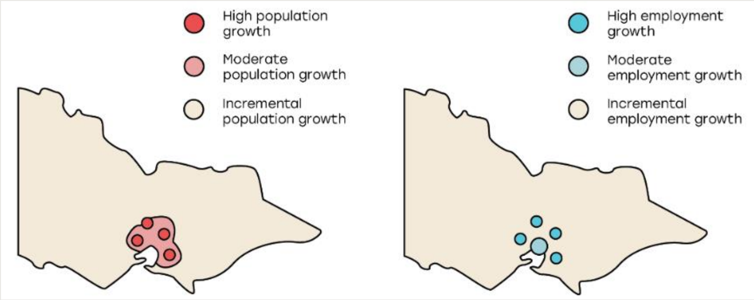
Urban development scenarios

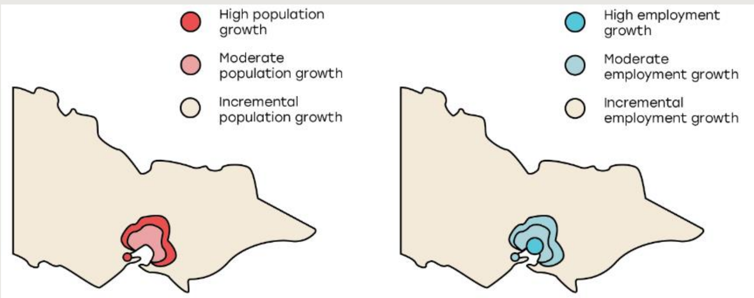
2 Urban development scenarios

Infrastructure Victoria has developed five urban development scenarios to capture a variety of outcomes for how people, dwellings and jobs growth occurs across Victoria. These are documented in detail in SGS 2022, Urban Development Scenarios. The five scenarios are set out in table 2.1, alongside some of the key implications for population and employment distributions.

2.1 The five urban development scenarios

Scenario		Description
1	Compact City	 The Compact City scenario reflects more concentrated urban development in the inner city of Melbourne and housing development in places of high transport accessibility. This structure supports sustainable city outcomes adapting to climate change impacts through policy and behavioural change. There is a consolidation of both residential and employment growth, primarily in inner Melbourne and middle Melbourne along train corridors. This means people live closer to places of employment and have greater public transport accessibility, reducing car dependency. Government also increases investment in accessible affordable housing. This trend will accelerate from 2031 and result in lower growth across outer Melbourne and regional Victoria, particularly areas at risk of adverse climate change impacts. The central city and inner urban renewal precincts experience the largest population and employment growth, reaching their aspirational residential densities while also continuing to attract a large net inflow of workers. Key Focus Areas: Focuses most heavily on inner Melbourne, with much higher employment and population growth levels than other scenarios. Outer Melbourne, Melbourne new growth areas and regional Victoria receive the lowest shares of growth under this scenario.

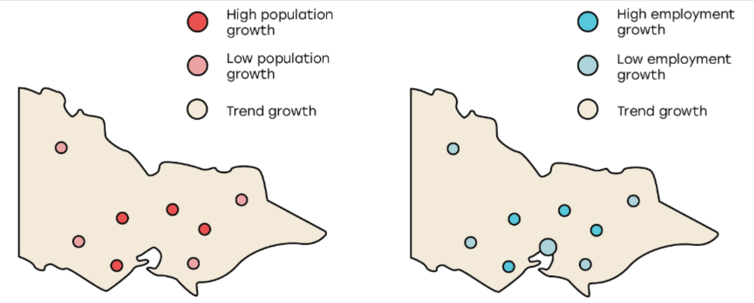
<table>
<tr><th colspan="2">Scenario</th><th>Description</th></tr>
<tr><td>2</td><td>Consolidated City</td><td>


The Consolidated City scenario reflects a response to climate change through the development of key centres across Melbourne. High density precincts are formed, providing local living and working. Population and jobs have a balanced distribution throughout these key precincts.
Population and jobs growth focuses on a select number of suburban centres outside the central city within metropolitan Melbourne. Both households and firms/workers maintain a preference for accessible and agglomerated locations, but find these needs met within key suburban precincts – Monash, La Trobe (Heidelberg), and Sunshine - which have benefitted from successful government investment.
Much of the growth in population and population-serving jobs is drawn from growth that would have otherwise occurred in outer Melbourne. However, these precincts also compete with central Melbourne for employment in knowledge intensive services and the health and education sectors.
Key Focus Areas:
Has a growth focus on middle Melbourne. Population growth for outer Melbourne, the new growth areas and regional Victoria would be relatively low, but higher than Scenario 1, with the result that Scenario 1 still forecasts slightly higher population growth overall for middle Melbourne. However, the distribution of population growth within middle Melbourne differs between the scenarios, as discussed in more detail in the following chapters. Scenario 2 also features the highest employment growth rates for middle Melbourne of any scenario.
</td></tr>
<tr><td>3</td><td>Dispersed City</td><td>


The Dispersed City forecasts a more dispersed urban structure with increased population in outer Melbourne. Melbourne's urban footprint expands as population growth spreads across outer Melbourne, peri-urban areas, and the new greenfield development areas at Melbourne's fringe.
Residential development slows across inner and middle Melbourne, with households choosing to live in outer Melbourne (including new growth areas, with the UGB needing to expand along growth corridors) and in peri-urban towns stretching along transport corridors from Melbourne to Torquay, Seymour, and Traralgon.
While population serving employment moves proximate to residents, there will be less movement of knowledge sectors, which continue to be attracted to central Melbourne. This means many people still need to live within a reasonable distance of Melbourne, limiting migration into regional areas that are further away.
Key Focus Areas:
</td></tr>
</table>

Scenario		Description
		Places substantial levels of growth in outer Melbourne and the new growth areas, drawing growth from inner Melbourne and middle Melbourne. There is also a shift towards regional centres and rural areas focused around peri-urban Melbourne compared to Scenario 1 and 2.

4 Network of Cities



The Network of Cities scenario projects a future where housing affordability in metropolitan Melbourne combined with continuing remote working leads to the development of regional cities as people choose to live regionally. Policy leads the development of these cities as higher density areas and they become consolidated centres for living regionally.

These regional cities grow and densify, attracting both population serving and higher order employment. Increased agricultural employment across the regions is also served by workers from regional cities.

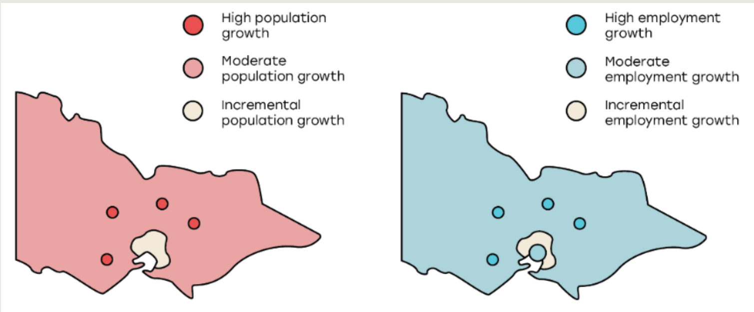
At the expense of metropolitan Melbourne, a large portion of Victoria's growth is accommodated in Geelong, Ballarat, and Bendigo.

Traralgon also experiences additional population growth to a moderate extent and smaller regional cities attract additional residents and associated population serving employment.

Key Focus Areas:

Allocates more growth to regional cities, which under this scenario would receive several times more growth than under some other scenarios. Regional centres and rural areas also receive moderately high growth rates, but less than under Scenario 3 or Scenario 4.

5 Distributed State



In the Distributed State scenario population growth decentralises from existing settlements with housing affordability in established areas leading people to settle regionally. This growth in regional areas is unmanaged and results in sprawling low density development across the state.

Residential growth slows within metropolitan Melbourne as development becomes more dispersed from existing metropolitan and regional centres across the state, initially in major regional cities and then in low density corridors which stretch from Melbourne to regional centres, and between regional centres.

Agricultural employment growth declines as farmland is used for urban sprawl. At the same time, companies return manufacturing and fabrication to Australia with industrial employment slowing the decline of manufacturing at the expense of business and government services.

Key Focus Areas:

Scenario	Description
	Places very high levels of growth in the regional centres and rural areas, reflecting employment and population growth spread broadly across regional Victoria. Regional cities also have very high growth rates, although lower than under Scenario 4.

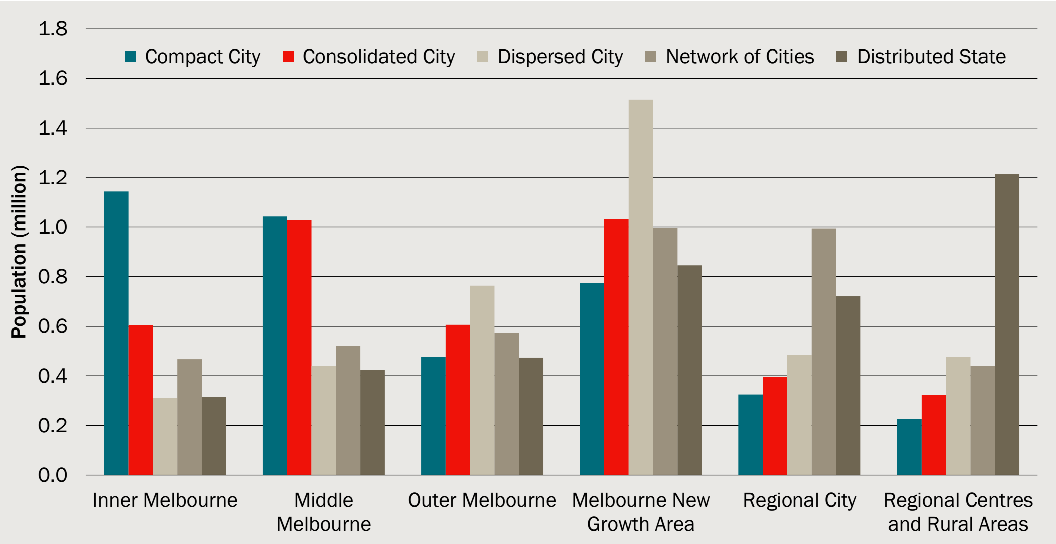
Source: SGS 2022, Urban Development Scenarios, prepared for Infrastructure Victoria.

Population growth

Under each population distribution scenario, the overall population growth in Victoria by 2056 remains the same. Total population is projected to witness a substantial growth from 6.7 million in 2021 to 10.7 million in 2056, representing an additional 4 million individuals. However, the distribution of this growth varies significantly based on spatial location (chart 2.2):

- Overall, in the Compact City, Consolidated City, and Dispersed City scenarios, more than three-quarters of the additional growth is allocated to metropolitan Melbourne. This share decreases to 64 per cent and 52 per cent in the Network of Cities and Distributed State scenarios, respectively.
- In the Compact City scenario, the majority of additional growth occurs in inner Melbourne (29 per cent) and middle Melbourne (26 per cent), followed by the Melbourne new growth areas (19 per cent) and outer Melbourne (12 per cent). Regional Victoria accounts for only 14 per cent of the growth.
- The Consolidated City scenario shows similar additional growth to the Compact City scenario in middle and outer Melbourne, as well as Regional Victoria. However, there is more growth in the Melbourne new growth areas (26 per cent) and less in inner Melbourne.
- The Dispersed City scenario allocates the highest proportion of additional growth to the Melbourne new growth areas (38 per cent), outer Melbourne (19 per cent), and Regional Victoria (24 per cent). However, there is significantly less growth in inner and middle Melbourne.
- The Network of Cities scenario primarily distributes additional growth to Regional Victoria (36 per cent), the Melbourne new growth areas (25 per cent) and outer Melbourne (14 per cent). The remaining growth is allocated to inner and middle Melbourne.
- Finally, the Distributed State scenario sees almost half of the growth occurring in Regional Victoria, mainly in regional towns. The Melbourne new growth areas account for 21 per cent of the growth, while the shares for inner Melbourne (8 per cent) and middle Melbourne (11 per cent) are the lowest among all scenarios.

2.2 Additional population, by scenario and functional urban area (2021 to 2056)



Data source: CIE, IV Population Growth forecast by scenario.

Dwelling growth

Dwelling growth follows a similar trend to population distribution. The number of dwellings is anticipated to experience a notable increase from 2.8 million in 2021 to 4.6 million in 2056, reflecting a substantial growth of 1.8 million dwellings. Of these 1.8 million additional dwellings, 1.1 million are in the same SA2s across the scenarios, and 0.7 million are relocated.

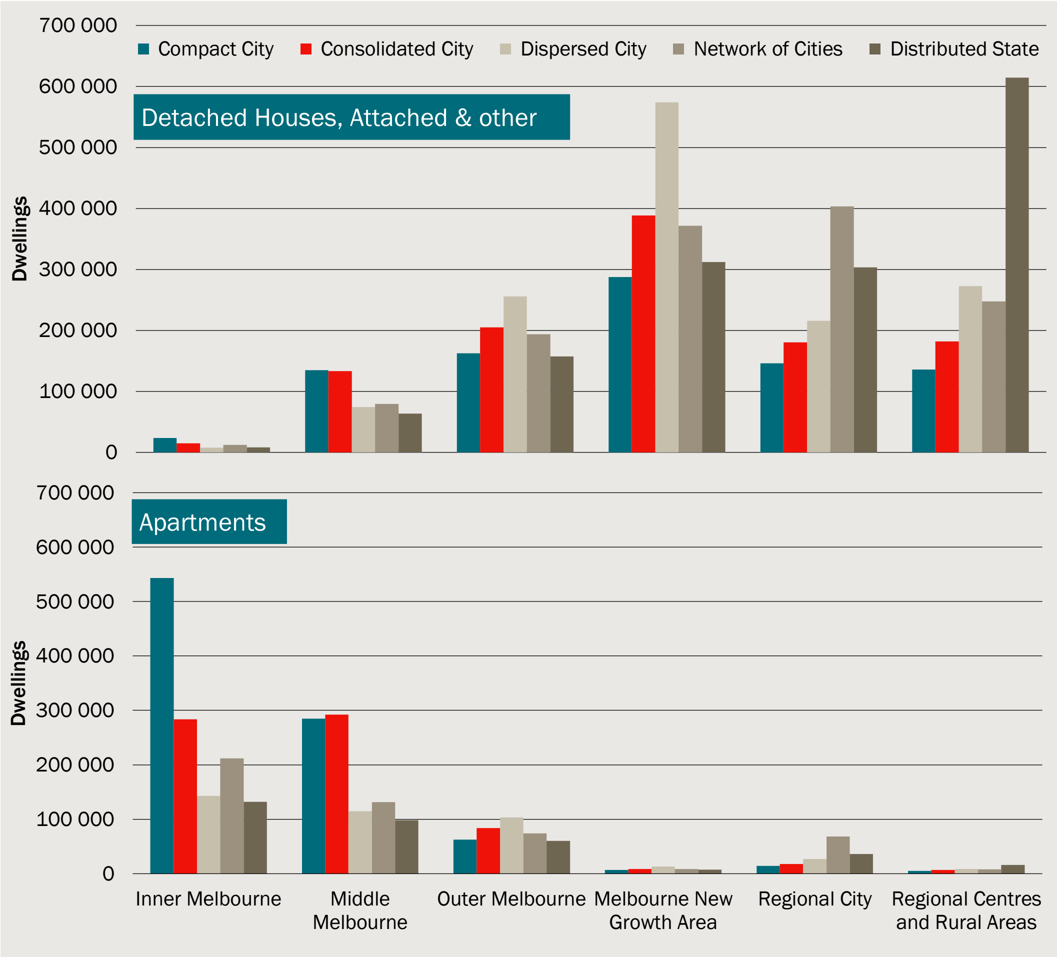
The change in average occupancy rates, which represent the number of people per dwelling, is relatively consistent across scenarios for functional urban areas from 2021 to 2056. With the exception of inner and middle Melbourne, occupancy rates generally experience a slight decrease, with the largest decline observed in outer Melbourne and the Melbourne new growth areas.

However, there are significant variations in dwelling typology among scenarios (chart 2.3). In general, the choice of dwelling types aligns with the projected population growth in urban areas. As higher-density areas are expected to accommodate more population growth, there is a greater emphasis on constructing apartments and a reduced focus on detached houses.

For instance, in the Compact City scenario, the number of new detached houses (890 000) is nearly equal to the number of apartments (916 000) being constructed. In contrast, the Distributed State scenario exhibits a significant disparity, with over four times as many houses (>1.4 million) compared to apartments. Moreover, the relative share of new detached houses in the Melbourne new growth areas (98 per cent) and the rest of Victoria (ranging from 90 to 95 per cent) remains relatively constant across all scenarios.

In summary, dwelling typology aligns with the anticipated population growth in different areas and scenarios. Higher-density areas tend to see a greater proportion of apartments, while detached houses remain prevalent in the Melbourne new growth areas and the rest of Victoria.

2.3 New dwellings, by scenario, functional urban areas and dwelling type (2021 to 2056)



Data source: CIE, IV Dwelling Growth forecast by scenario.

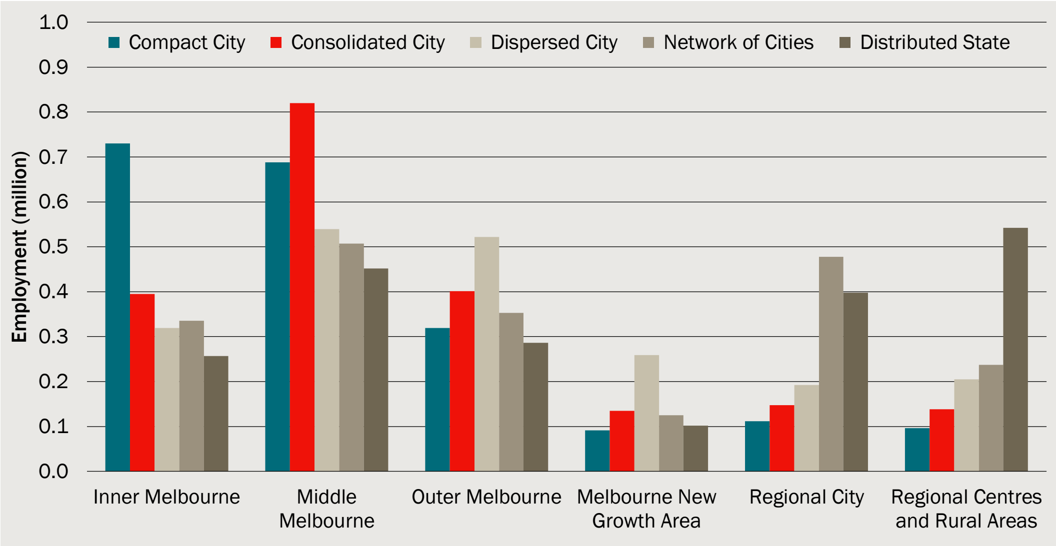
Employment growth

Employment growth aligns with the population distribution trends. Employment figures are projected to undergo significant growth, with an increase from 3.5 million in 2021 to 5.5 million in 2056, representing a substantial rise of over 2 million jobs.

Among the different scenarios, the Melbourne new growth areas exhibit the most relative growth in employment (chart 2.4). In 2021, the ratio of population to employment varies across areas, with the Melbourne new growth areas exhibiting a high ratio of 5.2, inner Melbourne showing a lower ratio of 0.9, and other areas generally falling around 2.

The relationship between population distribution and employment growth exhibits consistency across the functional urban areas in all scenarios. Inner and middle Melbourne continue to serve as the primary employment hubs, attracting a significant workforce from population and non-population driven employment. Employment growth in the Melbourne new growth areas is primarily driven by population serving employment to accommodate the population's increasing demand for essential services such as retail, hospitality, schools, and medical facilities.

2.4 Additional employment, by scenario and functional urban area (2021 to 2056)



Data source: CIE, IV Employment Growth forecast by scenario.

In terms of employment by industry, the majority of jobs are within the service sector[2] (>69 per cent) in 2021, while this share is increasing to approximately 75 per cent across all scenarios by 2056.

Although there are slight variations in additional employment by industry across the scenarios, the differences are minimal (chart 2.5):

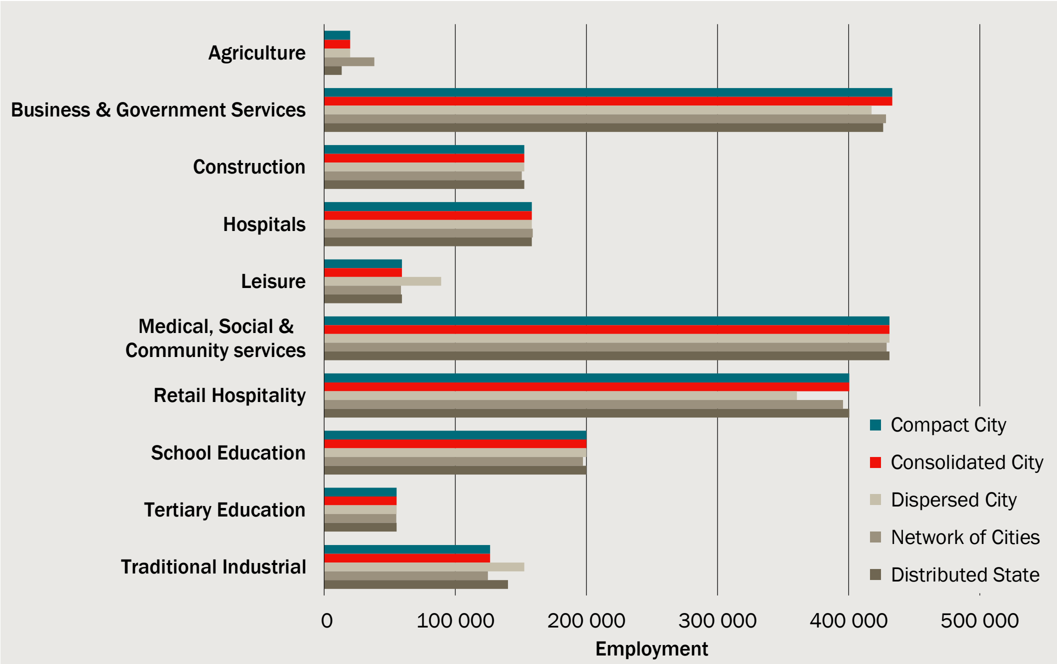
- The Compact City and Consolidated City scenarios exhibit identical patterns of additional employment by industry sector.
- The Dispersed City scenario allocates more jobs to the traditional industry[3] and leisure sectors, while reducing the allocation to the retail and hospitality sector.
- The Networks of Cities scenario sees an increase in employment within the agriculture sector and a decrease across all service sectors; and
- The Distributed State scenario has fewer additional jobs in agriculture and the Business & Government Services[4] sectors but sees an increase in employment within the traditional industry.

2 This includes Business & Government Services, Hospitals, Leisure, Medical, Social & Community services, Retail Hospitality School Education, and Tertiary Education.

3 This includes the ANZSIC 1-digit categories: Mining; Manufacturing; Electricity, Gas, Water and Waste Services; Wholesale Trade; Transport; Postal and Warehousing; Rental and Hiring Services (except Real Estate); Repair and Maintenance

4 The Business & Government Services sector is a subset of the broader service sector. It encompasses activities related to professional services, administrative support, and government

2.5 Additional employment, by scenario and industry sector (2056)



Note: More details and the industry concordance are provided in SGS 2022, *Urban Development Scenarios, Part A: Land Use Scenarios* prepared for Infrastructure Victoria, Appendix C.

Data source: CIE, IV Employment Growth forecast by scenario.

functions. Examples of industries within the Business & Government Services sector include consulting firms; legal, accounting, and advertising services; and government agencies. The service sector and the Business & Government Services sector share similarities as they both involve providing services, but the latter focuses specifically on professional services and government functions, distinguishing it from the broader service sector.

PART II

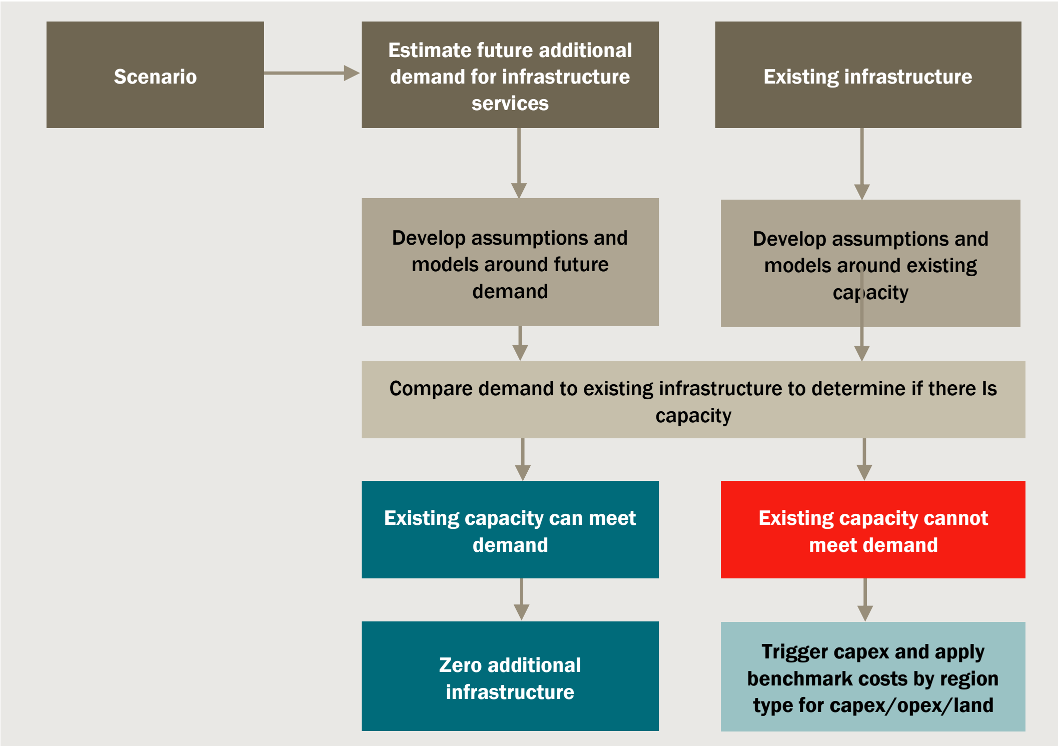
Infrastructure costs

3 *Methodological steps for measuring infrastructure costs*

General approach

The general approach to understanding infrastructure costs is shown in chart 3.1. The level of detail and specific methodology for doing this will differ for each sector.

3.1 General approach for infrastructure costs



Data source: CIE.

Infrastructure to support development can be classified in different ways depending on what the works involve.

1 On-site works — this comprises local infrastructure within the development site. For example, water pipes within a new development area. This infrastructure is typically provided and paid for by the developer. This type of cost refers to local infrastructure.

2 Extension or lead-in works — this comprises infrastructure to connect existing networks to the development area. It can comprise:

a) network extensions only to serve the new development; and

   b) Network extensions that would serve multiple areas, which could be termed 'trunk' network extensions

3 Augmentation works — this is where the capacity of existing infrastructure is required to be upgraded to meet demand generated by the new development. This could include substation upgrades, additional school and community facility capacity and 'headwork' augmentation, such as additional capacity in dams and sewerage treatment plants.

We further assume that:

- infrastructure costs will cover capital and operating expenditure
- infrastructure costs will cover land cost (where applicable)
- infrastructure costs include the sectors set out chapter 3, although not all of these will have varying costs across scenarios
- the financial cost of land is the same as the opportunity cost of land, and land used for infrastructure will be taken from some other use.

Capacity and service standards

When estimating the cost of infrastructure provision in the economic analysis it is important to consider the current existing capacity and service standards and the associated trade-offs:

- Current infrastructure capacity is the extent to which it can accommodate future growth. For example, existing school facilities need to be evaluated to determine if they can accommodate the projected increase in student numbers.
- Service standards refers to consistent levels of quality in the provision of services and ensuring that the infrastructure can accommodate the needs of the community. For example, a lower average class size in schools requires more classrooms to be built, representing a higher infrastructure service standard.

There is a trade-off between existing capacity and service standards. Lowering of a service standard allows existing infrastructure to support growth without modifications. For example, additional demand could be accommodated within existing school facilities through having larger class sizes. In this case the cost is the potential loss of value of smaller class sizes.

Our modelling approach has maintained the current service standard across all scenarios. This is because it is difficult to place a value on changing service levels. Maintaining the current service standard across scenarios means that differences across Victoria in service standards remain in our scenarios in the future. For example, current service standards in growth areas are different to inner city areas and we assume these differences will remain in the future.

Infrastructure areas assessed

The areas of infrastructure requirements to measure for comparing urban development scenarios have been assessed against the following:

- infrastructure that is more material to people's wellbeing
- infrastructure requirements that are expected to be intrinsically different across urban development scenarios, as opposed to being influenced largely by other factors, and
- infrastructure requirements that are measurable.

A summary of our assessment of impacts against these criteria is shown in table 3.2. The assessments are explained in detail in the sections below.

The costs that have not been quantified include:

- Infrastructure that serves very large catchments and, therefore, does not tend to change with scenarios — health, justice, waste and ports are examples of this, although health may vary with the regional scenarios.
- Infrastructure that serves very small catchments and tends to be highly incremental rather than having the standard infrastructure characteristic of high fixed costs — police and emergency services tend to fit into this category.

3.2 Summary of costs measured

Quantified	Qualitatively
▪ Transport[5] ▪ Utilities (including electricity, gas, water, and wastewater) ▪ Education ▪ Open Space ▪ Community facilities ▪ Local Infrastructure in development areas (utility connection, and local roads) ▪ Conversion of existing streetscapes in inner Melbourne development precincts	▪ Health ▪ Ports ▪ Police ▪ Emergency services ▪ Justice ▪ Social services ▪ Telecommunication

Source: CIE.

Note that cost related to social housing are not measured, as these will largely depend on the social housing strategy pursued rather than the spatial scenario.

5 Assessed by Arup.

4 *Estimated infrastructure costs across scenarios*

- **Future urban development requires substantial additional infrastructure. This includes utilities, transport, local infrastructure and community infrastructure.**
- **Costs vary by development scenario due to differences in existing infrastructure capacity, the shares of greenfield and infill development, as well as differences in regional population density, dwelling typology and employment composition.**
- **Total estimated additional infrastructure costs to meet the higher population in 2056 are above $776 billion for all scenarios.**
- **Transport and local infrastructure have the most substantial infrastructure cost, followed by electricity and education. Other utilities (e.g., gas, water and wastewater) and community infrastructure (community facilities and open space) only account for a smaller proportion of total cost.**
- **Overall, the Compact City and Consolidated City scenarios tend to exhibit lower costs in the transport and utilities' sectors. However, it is worth noting that community infrastructure costs are generally higher in denser areas due to higher land cost.**
- **Costs are highest for scenarios with high shares of greenfield development, such as the Dispersed City scenario ($817 billion). The Consolidated City and Network of Cities scenarios have similar costs at $800 and $807 billion. The Compact City scenario has the lowest cost across all scenarios ($776 billion).**
- **For each new dwelling that is different across scenarios we estimate that the Compact City scenario has a lower cost of $59 000 per new relocated dwelling compared to the Dispersed City scenario. Similarly, the Consolidated City and Distributed State scenario have a lower cost of $29 000 and $26 000 per dwelling compared to the Dispersed City scenario, respectively.**
- **For many of these indicators it is most useful to compare across scenarios. For comparison we use the Dispersed City scenario as it represents a continuation of recent trends.**

Table 4.1 shows the total infrastructure cost, i.e., capital, operating and land cost, across scenarios, while table 4.2 summarises only the cost which differ across scenarios. This excludes all cost that do not differ by scenario, for example, transport projects that would have been delivered across every scenario or electricity generation costs which are the same across each scenario.

4.1 Infrastructure impacts across scenarios to 2056 – absolute total cost ($ billions)

Sector	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$b, real	$b, real	$b, real	$b, real	$b, real
Local infrastructure	135	148	160	158	163
Education	55	44	44	42	37
Open space	26	17	14	13	11
Community facilities	24	21	18	18	14
Electricity	82	84	91	91	88
Gas	13	13	13	13	13
Water and Wastewater	35	38	40	44	46
Transport	405	435	438	429	426
Total	**776**	**800**	**817**	**807**	**797**
Difference to Dispersed City scenario	-41	-18	0	-10	-20

Note: Figures are denoted in real 2022/23 dollars. Cost includes cumulative operating cost until 2056. Figures have been rounded to the nearest billion and may not add up.

Data source: CIE.

4.2 Infrastructure impacts across scenarios to 2056 – total cost different across scenarios ($ billions)

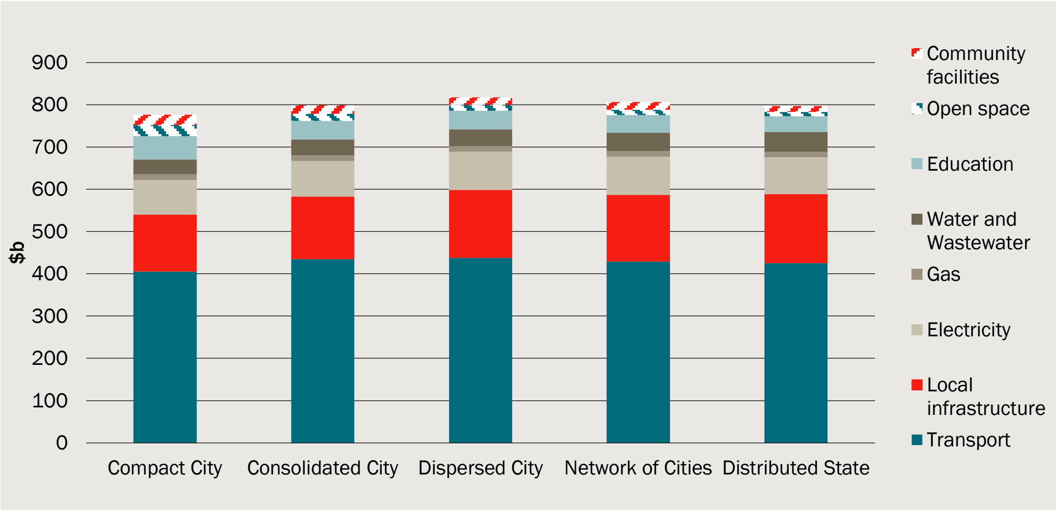
Sector	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$b, real	$b, real	$b, real	$b, real	$b, real
Local infrastructure	42	55	68	65	70
Education	34	23	23	20	15
Open space	18	9	6	4	3
Community facilities	13	9	6	7	2
Electricity	5	7	13	13	11
Gas	0	0	0	0	0
Water and Wastewater	9	11	13	17	20
Transport	28	57	61	52	48
Total	**149**	**172**	**190**	**179**	**169**
Difference to Dispersed City scenario	-41	-18	0	-10	-20

Note: Figures are denoted in real 2022/23 dollars. Cost includes cumulative operating cost until 2056. Figures have been rounded to the nearest billion and may not add up.

Data source: CIE.

Total estimated additional infrastructure costs include the additional capital, cumulative operating, and land cost associated with each scenario until 2036 and 2056. These are shown in chart 4.2. Total capital cost includes capital and land cost and is shown in chart 4.3.

4.3 Infrastructure impacts across scenarios to 2056 – total cost ($ billions)



Note: Figures are denoted in real 2022/23 dollars. Cost includes cumulative operating cost until 2056.

Data source: CIE.

4.4 Infrastructure impacts across scenarios to 2056 – only capital cost ($ billions)

Note: Excludes operating cost. Figures are denoted in real 2022/23 dollars.

Data source: CIE.

Cost per new dwelling

The additional infrastructure costs required to service the growth ranges across the scenarios from $429,000 to $452,000 per new dwelling across scenarios (table 4.5). Transport infrastructure represents more than half of these costs, followed by local infrastructure and electricity costs. Electricity costs are notably higher compared to other utility expenses, primarily due to the transformation occurring in electricity generation. Allocating all costs to growth will overstate impacts in some cases, such as electricity, where a part of the costs is related to servicing all customers not just growth.

4.5 Cost per new dwelling across scenarios to 2056 – absolute total cost ($ '000)

Sector	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$ '000, real	$ '000, real	$ '000, real	$ '000, real	$ '000, real
Local infrastructure	74	82	89	87	90
Education	31	24	24	23	20
Open space	14	9	8	7	6
Community facilities	14	11	10	10	8
Electricity	45	47	50	50	49
Gas	7	7	7	7	7
Water and Wastewater	20	21	22	24	26
Transport	224	240	242	237	235
Total	**429**	**442**	**452**	**446**	**441**
Difference to Dispersed City scenario	-23	-10	0	-6	-11

Note: Figures are denoted in real 2022/23 dollars. Cost includes cumulative operating cost until 2056. Note: Figures are denoted in real 2022/23 dollars. Cost includes cumulative operating cost until 2056. Figures may not add up due to rounding.

Data source: CIE.

Table 4.6 shows additional infrastructure costs that differ by scenarios required to service the growth ranges across the scenarios from $82,000 to $105,000 per new dwelling across scenarios. Excluding costs that are the same across all scenarios, such as transport projects which are delivered in every scenario, shows that the share of transport cost falls substantially compared to the table above and account for approximately one third of the cost of new dwellings.

4.6 Cost per new dwelling across scenarios to 2056 – total cost different across scenarios ($ '000)

Sector	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$ '000, real	$ '000, real	$ '000, real	$ '000, real	$ '000, real
Local infrastructure	23	31	38	36	39
Education	19	12	12	11	8
Open space	10	5	3	2	1
Community facilities	7	5	3	4	1
Electricity	3	4	7	7	6
Gas	0	0	0	0	0
Water and Wastewater	5	6	7	10	11
Transport	16	32	34	29	27
Total	**82**	**95**	**105**	**99**	**94**
Difference to Dispersed City scenario	-23	-10	0	-6	-11

Note: Figures are denoted in real 2022/23 dollars. Cost includes cumulative operating cost until 2056. Figures may not add up due to rounding.

Data source: CIE.

There are two main reasons for the modest per dwelling cost differentials between scenarios:

- Firstly, the Compact City and Consolidated City scenarios tend to exhibit lower costs in the transport and utilities' sectors. However, higher capital and land costs in established areas contribute to higher community and education infrastructure costs in denser regions. The lower transport/utility costs for these two scenarios are offset by the higher community/education infrastructure costs, resulting in a lower overall cost differential.
- Secondly, 1.1 million of the 1.8 million new dwellings are constructed in the same location across all scenarios. This means that the cost differences between scenarios is driven by only 0.7 million relocated dwellings.

If we instead examine cost differences per relocated dwelling[6], the differences between scenarios are larger. We estimate that the Compact City scenario has a lower cost of $59 000 per new relocated dwelling compared to the Dispersed City scenario (table 4.7). Similarly, the Consolidated City and Distributed State scenario have a lower cost of $29 000 and $26 000 per dwelling compared to the Dispersed City scenario, respectively.

This means that the Compact City and Consolidated City scenarios offer the largest cost advantages when it comes to infrastructure cost per relocated dwelling compared to the Dispersed City scenario.

4.7 Total cost per dwelling different across scenarios to 2056 – compared to Sc3

Sector	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$ '000, real	$ '000, real	$ '000, real	$ '000, real	$ '000, real
Local infrastructure	-37	-18	0	-4	3
Education	16	0	0	-3	-10
Open space	18	4	0	-2	-5
Community facilities	10	4	0	1	-6
Electricity	-12	-9	0	0	-3
Gas	0	0	0	0	0
Water and Wastewater	-6	-3	0	6	10
Transport	-47	-5	0	-13	-18
Total	**-59**	**-26**	**0**	**-15**	**-29**

Note: Figures are denoted in real 2022/23 dollars. Cost includes cumulative operating cost until 2056. Figures may not add up due to rounding.

Data source: CIE.

6 The relocated dwellings are those above the minimum across scenarios for each SA2.

Distributional impact

We have assessed on a high level the distributional impact on various stakeholders involved in funding infrastructure (table 4.8).

4.8 Funding source assumptions

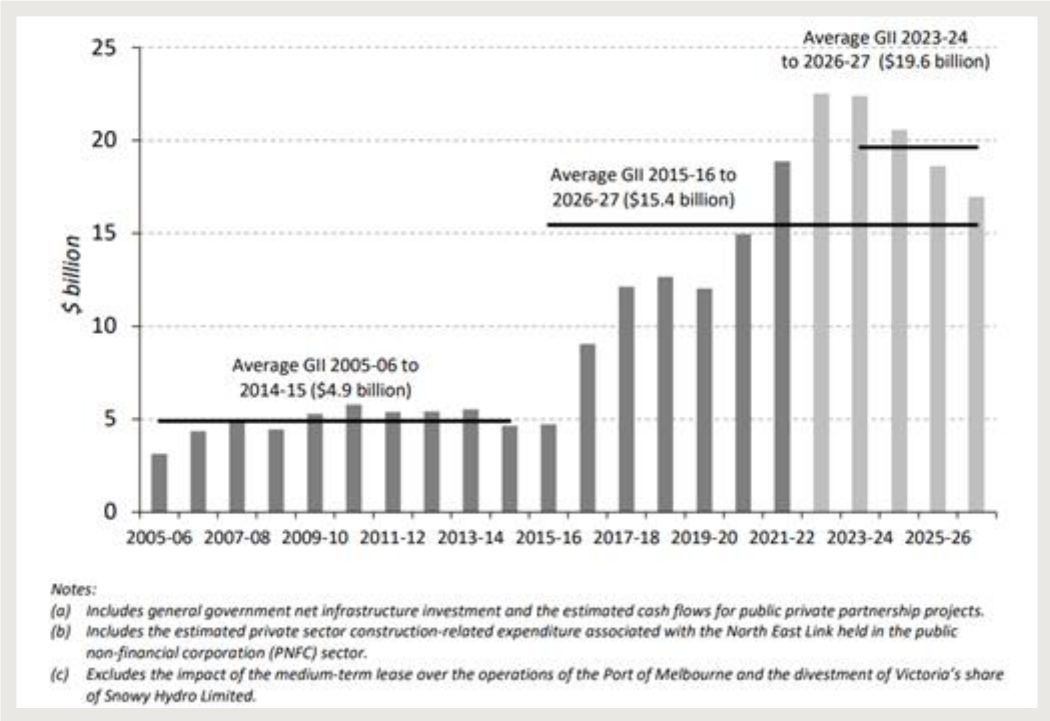
	Victorian Government	Local Government	Non-government sector (education)	Developer	User charges
Local infrastructure				CAPEX	OPEX
Education					
- Kindergarten	CAPEX & OPEX				
- Schools	CAPEX & OPEX		CAPEX & OPEX		
Open space	CAPEX	CAPEX & OPEX		CAPEX	
Community facilities	CAPEX	CAPEX & OPEX		CAPEX	
Utilities					CAPEX & OPEX
Transport	CAPEX & OPEX				

Note: We note that Victorian Government and Local Government do contribute to some local infrastructure costs when there are no development contribution plans in place or the existing development contribution plans share the cost between government and the developer. For the purpose of this analysis, a simplifying assumption was taken.

Source: CIE

Over the past two decades, there has been a notable upward trend in infrastructure investment by the Victorian Government (chart 4.9). From the late 2000s until 2015/16, investments remained relatively stable, averaging around $4.9 billion per year in nominal dollars. However, since 2016/17, there has been a consistent increase in infrastructure expenditure, with a projected peak of $22.5 billion for the 2022/23 financial year. Looking ahead, infrastructure investment is expected to maintain an average of $19.6 billion annually over the budget and forward estimates period.

4.9 Victorian Government infrastructure investment



Data source: Victorian Government (2023), Victorian Budget 2023/24 State Capital Program Budget Paper No. 4, https://s3.ap-southeast-2.amazonaws.com/budgetfiles202324.budget.vic.gov.au/2023-24+State+Budget+-+State+Capital+Program.pdf, p.2

Overall, the majority of the future infrastructure costs are borne by the Victorian Government, developers and users of services, with the Australian Government also sharing the burden (table 4.10).

We estimate that the Victorian Government is expected to bear infrastructure capital costs ranging from $371 billion (Compact City scenario) to $393 billion (Dispersed City and Consolidated City scenario), with an average annual cost of approximately $11 billion. Slight variations exist depending on the scenario (see tables 4.10 and 4.11).

The Victorian Government budget forecast for 2018 to 2026 allocates over 75 per cent of the infrastructure investments to transport and education. However, it is important to note that this costing analysis does not include investments in significant health facilities, justice or police projects, and other sectors. While the projected cost is lower than the budget forecast, it is crucial to recognise that this analysis does not capture the full extent of investments in those specific areas.

4.10 Distributional capital costs by stakeholder to 2056 ($ billions)

	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$b	$b	$b	$b	$b
Victorian Government	371	393	393	384	378
Local Government	29	21	17	17	13
Non-government sector (education)	15	10	10	10	8

	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$b	$b	$b	$b	$b
Developer	106	114	122	120	123
User charges	105	112	122	123	123
Total	**627**	**650**	**665**	**654**	**645**
Difference to Dispersed City scenario	-38	-14	0	-10	-20

Note: Please refer to the appendices on how distributional costs have been calculated by infrastructure sector. Figures are denoted in real 2022/23 dollars. Capital cost include land cost. *Figures have been rounded to the nearest billion and may not add up.*

Source: CIE.

4.11 Distributional capital costs by stakeholder per annum ($ billions)

	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$b/annum	$b/annum	$b/annum	$b/annum	$b/annum
Victorian Government	10.6	11.2	11.2	11.0	10.8
Local Government	0.8	0.6	0.5	0.5	0.4
Non-government sector (education)	0.4	0.3	0.3	0.3	0.2
Developer	3.0	3.3	3.5	3.4	3.5
User charges	3.0	3.2	3.5	3.5	3.5
Total	**17.9**	**18.6**	**19.0**	**18.7**	**18.4**
Difference to Dispersed City scenario	-1.1	-0.4	0.0	-0.3	-0.6

Note: Please refer to the appendices on how distributional costs have been calculated by infrastructure sector. Figures are denoted in real 2022/23 dollars. Capital cost include land cost. Figures have been rounded to the nearest billion and may not add up.

Source: CIE.

Sensitivity analysis in respect to land cost in established areas

For the purpose of this costing analysis, we have included land cost associated with the delivery of social infrastructure (i.e., education, open space, and community facilities) across both greenfield and infill development areas.

In this section we present cost estimates for a scenario that assumes established area land acquisition was not required for social infrastructure, based on the assumption existing government land can be repurposed. Since, repurposing existing government land still has some sort of opportunity cost, as the land could be converted to other uses or has value in its existing use, this assumption has not been used to underpin the central case estimates. This is an upside opportunity if better use can be made from Victorian Government land.

Table 4.12 shows the total infrastructure cost impact across scenario excluding land cost for established areas. This impacts only the education, open space, and community facility sectors:

- Overall cost decrease by $4 billion to $32 billion across scenarios, with the largest cost reduction for the Compact City scenario.
- There is overall increase in the cost differential for the Compact City scenario from $41 billion to $69 billion.
- The largest changes across sectors can be observed for open space as land cost is the main cost component in established areas.
- The largest changes across scenarios can be observed for the Compact City and Consolidated City scenarios which see the highest share of development in established areas across scenarios.

4.12 Infrastructure impacts across scenarios to 2056 – total cost ex. established area land cost ($ billions)

Sector	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$b, real	$b, real	$b, real	$b, real	$b, real
Local infrastructure	135	148	160	158	163
Education	43	39	43	39	36
Open space	12	12	13	11	10
Community facilities	18	16	15	16	12
Electricity	82	84	91	91	88
Gas	13	13	13	13	13
Water and Wastewater	35	38	40	44	46
Transport	405	435	438	429	426
Total ex. established area land cost	**744**	**784**	**813**	**799**	**793**
Difference to Dispersed City scenario	-69	-29	0	-13	-20
Total – central case	**776**	**800**	**817**	**807**	**797**
Difference to Dispersed City scenario	-41	-18	0	-10	-20

Note: Figures are denoted in real 2022/23 dollars. Cost includes cumulative operating cost until 2056. Figures have been rounded to the nearest billion and may not add up.

Data source: CIE.

Summary of infrastructure costs by sector

Local Infrastructure

Urban development requires substantial additional local infrastructure until 2056. This includes the streetscape and reticulation of services within a development area to each residential development and includes:

- earthworks and local roads
- civil works including drainage reticulation and connection

- sewerage reticulation and connection
- utilities including water and gas, electricity, telecommunications reticulation and connection, and
- conversion of street scapes.

Total local infrastructure cost per dwelling differs by type of development and dwelling (table 4.13). The primary source we rely on for local infrastructure costs of development is the *Infrastructure Provision in Different Development Settings Metropolitan Melbourne Costing and Analysis* report (SMEC, 2019).[7]

The cost of land for local infrastructure associated with greenfield development has been separately included in the housing model as a component of dwelling costs.[8]

4.13 Local infrastructure capital cost per dwelling assumed in the model

Dwelling type	Infill/Brownfield	Greenfield (including regional)
	$/dwelling	$/dwelling
Separate house	38 523	71 179
Attached	38 523	71 179
Low rise apartments	50 114	92 597
Medium rise apartments	31 682	58 539
High rise apartments	13 250	24 482
Other	38 523	71 179

Note: Figures are denoted in real 2022/23 dollars. This table does not include the premium of $20 985 per dwelling for converting industrial land to residential use in Arden and Fishermans Bend.

Source: CIE.

The total costs of local infrastructure including operating cost[9] of 2 per cent per annum associated with residential development are likely to be large (over $135 billion) (chart 4.14).

Costs are highest for scenarios with high shares of greenfield development, such as the Distributed State scenario ($163 billion) and the Dispersed City scenario ($160 billion), due to the higher local infrastructure cost per dwelling for greenfield development (including regional greenfield).

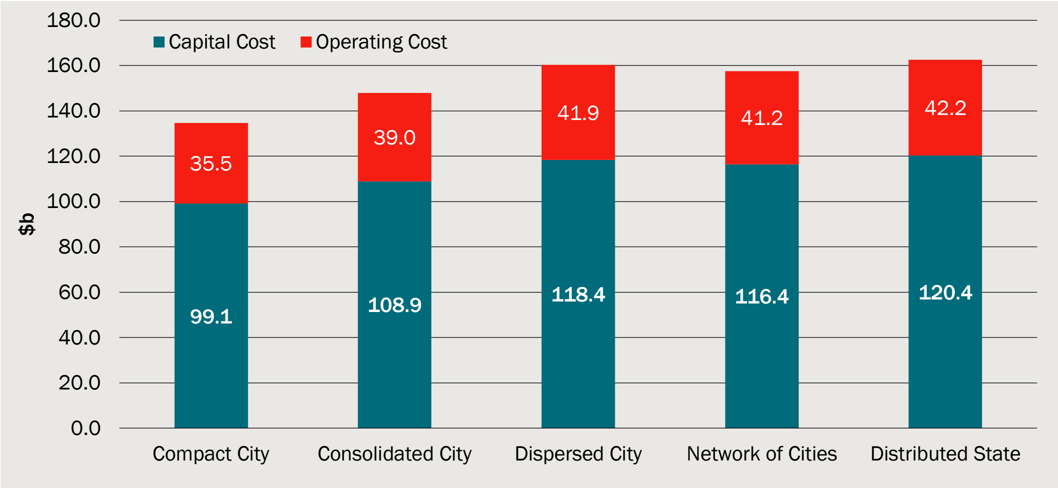
The Compact City and Consolidated City scenarios have the lowest cost ($135 billion and $148 billion) across scenarios due to the relatively high share of infill development in established areas. This is despite the additional local infrastructure costs when converting industrial land to residential use in some parts of inner Melbourne.

7 SMEC, 2019, *Infrastructure Provision in Different Development Settings Metropolitan Melbourne Costing and Analysis Report.*

8 Note, that for brownfield development in Arden and Fishermans Bend there is a premium of $13 686 per dwelling in addition to the values shown in the table below.

9 SMEC, 2019, *Infrastructure Provision in Different Development Settings Metropolitan Melbourne Costing and Analysis Report,* p.79

4.14 Local infrastructure impacts across scenarios to 2056 – total cost ($ billions)



Note: Total cost cumulative until 2056. Figures are denoted in real 2022/23 dollars.

Data source: CIE.

Open Space

Public open space (including parks, gardens, playgrounds, public beaches, riverbanks and waterfronts, outdoor playing fields and courts and publicly accessible bushland) contribute to liveability, connectivity and mitigation of urban heat impacts.

Given the large amount of public open space availability of any kind, this analysis focuses on parks & gardens, recreation corridors, and sports fields & organised recreation for Metropolitan Melbourne and parks, gardens, and sport grounds for Regional Victoria.[10] This means local councils and state government provide mixed passive and active open space for their communities.

To meet the objectives of this analysis, we have adopted a benchmarking approach, i.e., additional open space provision is a function of 'meeting the benchmark' and 'population density.'

- The benchmark is set as the current average provision rate by population density. This allows for detailed excess capacity and demand modelling at a regional area level (Statistical Area 3 level) and reflects the average open space provision and planning to date.

We modelled the cost of providing additional open space infrastructure by managing demand and excess capacity at a regional area level (SA3).

Until 2056, the additional open space requirement ranges between 2 566 and 3 031 hectares across scenarios, with the Compact City scenario requiring the most and the Distributed State scenario requiring the least additional open space. To gain a deeper understanding of the order of magnitude, it is helpful to put these results into perspective. The additional open space required in the Compact City scenario is nearly equivalent to

10 This differs from the provision of community sport and recreation hubs, which provide dedicated small-sized hubs (<0.5 hectares), such as tennis and netball courts.

the entire land area of the City of Melbourne, spanning over 3 700 hectares. In contrast, the variance between the Compact City and Distributed State scenarios represents the total expanse of open space managed by the City of Melbourne, encompassing approximately 500 hectares.

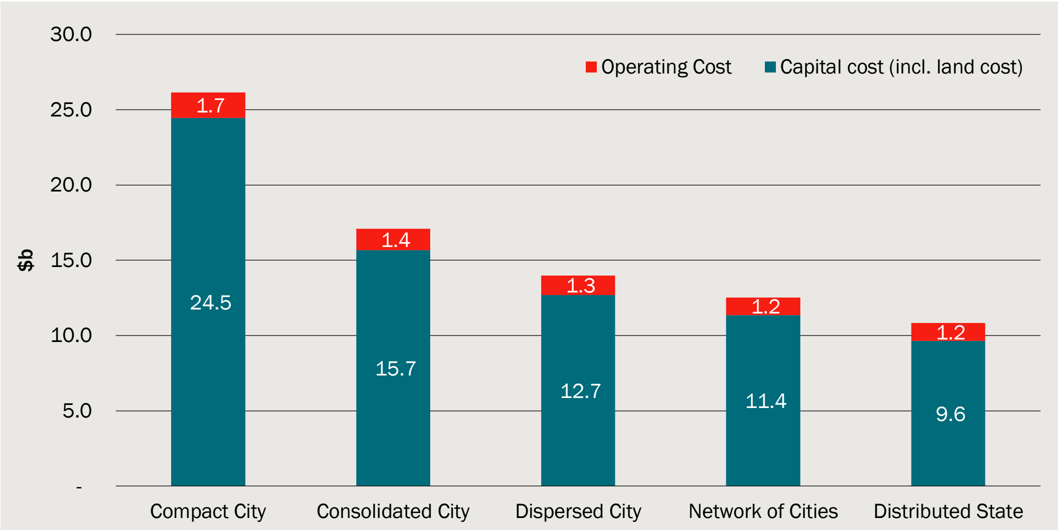
This is because there is greater capacity in existing open space in less dense areas, meaning that no or less additional open space is required. The primary factor driving the need for more open space is the change in population density and the type of development area. In greenfield areas, where there is no surplus capacity, new open spaces are typically required. On the other hand, infill development takes place in high-density regions, especially in inner and middle Melbourne, resulting in a greater demand for open space in those areas.

The cost of providing additional open space infrastructure ranges between $10.8 to $26.1 billion across the scenarios and includes capital, land, and operating cost (chart 4.15).

The total expected cost for additional open space infrastructure until 2056 is highest for the Compact City ($26.1 billion), followed by the Consolidated City scenario with $17.1 billion. The Dispersed City and Network of Cities scenarios have similar costs with $14.0 and $12.5 billion. The least cost is estimated for the Distributed State scenario with $10.8 billion.

The main cost driver is the extent of additional open space, with a significant emphasis on the land cost in scenarios involving substantial infill development. Furthermore, the expenses are influenced by the capital cost associated with open space in inner, middle, and outer Melbourne. These cost factors vary across different scenarios and notably differ from the cost drivers observed in Regional Victoria, where land and capital costs are comparatively lower.

4.15 Open space infrastructure impacts across scenarios, 2021 to 2056 – total cost ($ billions)



Note: Total cost cumulative until 2056. Figures are denoted in real 2022/23 dollars.

Data source: CIE.

Community facilities

Community infrastructure refers to the physical and social assets that are essential for communities to thrive. These facilities can include a range of amenities, such as community centres, libraries, health clinics, sports facilities, and cultural spaces. They play a critical role in fostering social cohesion, promoting public health and wellbeing, and supporting economic growth.

Community infrastructure encompasses a wide variety of facilities. Some, like large cultural and sporting facilities, serve regional catchments and are planned at the state level. The costs associated with these types of facilities are unlikely to vary significantly across scenarios and have been excluded from this analysis. This report focuses on three distinct types of community facility hubs that play a crucial role in serving local communities and are directly linked to the growth of local populations and dwellings.

Table 4.16 provides a brief description of these hubs:

- Health and wellbeing hubs
- Sport and recreation hubs[11] and additional aquatic centres, and
- Art and cultural hubs.

4.16 Community facility provision

Area	Description
Health and wellbeing hubs	Public community health, wellbeing and justice support services including services such as specialist medical treatment, nursing care, allied health, dental services, counselling services (financial, domestic violence, etc), antenatal and postnatal clinics, district nursing, primary injury, services for children (immunisation, speech therapy, etc) and community mental health.
Sport and recreation hubs and aquatic centre	Provide multipurpose courts for netball, basketball, tennis, etc, and have at least one large multipurpose room for activities such as gymnastics, dance, table tennis and fitness classes, and aquatic centres at some locations
Art and cultural hubs	Library and community gatherings spaces

Source: CIE.

We modelled the cost and demand of providing additional community facilities by managing demand and excess capacity at a regional area level (SA2) based on population. This approach ensures that facilities are appropriately scaled according to the additional population growth. It allows for a conservative estimation and subsequent aggregation of total numbers at a functional urban area level.

Until 2056, the requirement for additional community facility hubs ranges between 292 and 407 (total number of different hubs) across the different scenarios. The Compact City scenario requires the highest additional provision, while the Distributed State requires the least. The main driver for additional provision is population growth in Metropolitan Melbourne and regional cities, as we assume that there is sufficient excess capacity in regional Victoria outside of regional cities.

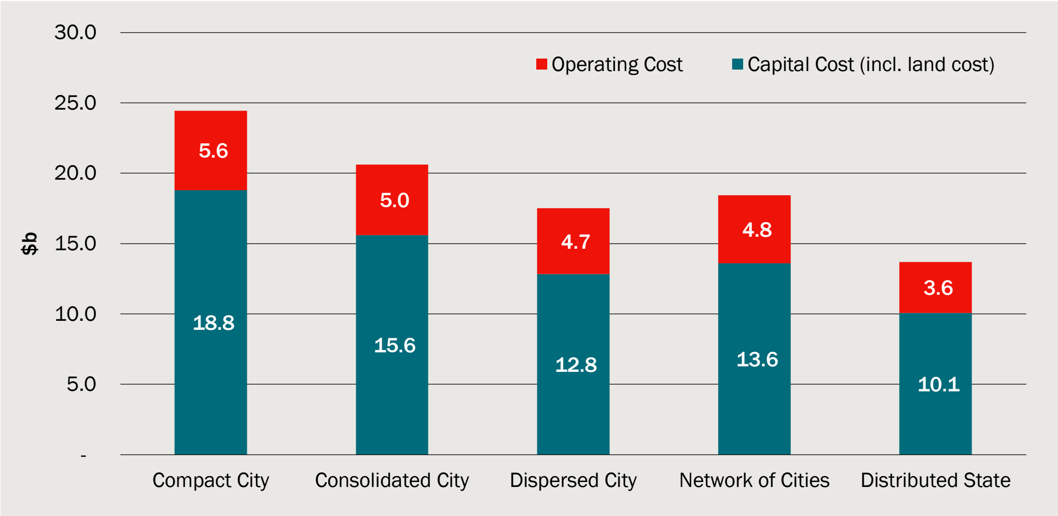
11 Sport and recreation hubs differ from high-quality open space as they offer sport pavilions, and designated facilities such as tennis or netball courts.

The cost of providing additional community infrastructure ranges between $13.7 and $24.4 billion across scenarios (chart 4.17).

The total expected costs for additional community infrastructure until 2056 are highest for the Compact City scenario (over $24.4 billion), followed by the Consolidated City scenario with over $20.6 billion and the Networks of Cities scenario with over $18.4 billion. The least cost is estimated for the Dispersed City and Distributed Stata scenarios, with over $17.5 and $13.7 billion, respectively.

Across scenarios, the total costs are mainly driven by the population growth in inner Melbourne, as these have higher construction and land costs. Scenarios with a high proportion of population growth in regional areas (outside of regional cities) generally have lower costs, assuming no capacity constraint in those areas.

4.17 Community infrastructure impacts across scenarios, 2021 to 2056 – total cost ($ billions)



Note: Total cost cumulative until 2056. Figures are denoted in real 2022/23 dollars.

Data source: CIE.

Education

In Victoria, education is compulsory for children aged from 6 to 17 years.[12] The education system consists of three main stages:[13]

- Kindergarten/preschool,
- Primary school and Secondary school, and
- Tertiary education.

12 https://www.study.vic.gov.au/en/study-in-victoria/victoria's-school-system/Pages/default.aspx

13 https://liveinmelbourne.vic.gov.au/live/education-and-childcare/melbournes-education-system

Our analysis excludes tertiary education due to the large catchments they serve, making it unlikely that costs differ by scenario.

Note that this analysis of education costs in Victoria is intended as a high-level overview. The assumptions made in this study are broad to facilitate a simplified model of infrastructure responses and their associated costs. Real-world assessments are likely to differ significantly, considering various complex inputs and decisions. It is important to acknowledge that the Department of Education may have alternative methods of addressing growth that have not been considered in this analysis. Therefore, the findings presented here may not necessarily reflect the planning approach of the Department of Education.

The Victorian Government has committed to providing free kindergarten programs for all Victorian three- and four-year-old children, leading to a surge in demand for new facilities. We assume that under current provision patterns 43 per cent of additional enrolments will be accommodated in centre-based day cares and the Victorian Government will fund, but not necessarily operates, 57 per cent of all new facilities either directly or through grants to meet the new policy reform.

Primary and secondary schools are either government-run or private. To maintain consistency with other infrastructure sectors, we model government and non-government provision together, taking a resource cost approach. This means we recognise that non-government schools receive gap funding. School infrastructure is modelled to support total Victorian school enrolments; however, the response is based on students being housed in infrastructure developed to government standards. Based on the current ratio of government to non-government school enrolments a cost to government for infrastructure provision has also been identified.

Primary and secondary schools can accommodate additional enrolments by utilising their existing permanent and relocatable capacity (within an adopted provision of total capacity). Beyond that, new additional permanent facilities or schools are required. The priority responses to meet additional enrolments differ by region. For example, schools in inner Melbourne cannot use relocatable capacity, meaning that new permanent buildings on-site or schools are needed for additional enrolments beyond a school's existing permanent capacity.

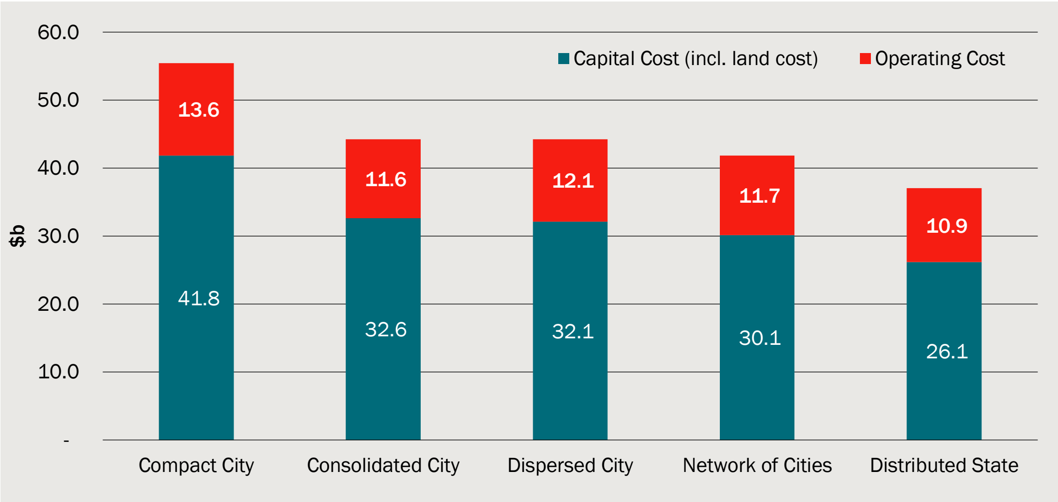
We modelled the cost of providing additional education infrastructure by managing enrolment and capacity at a regional area level (SA3). To accommodate additional enrolments by 2056:

- 832 new kindergarten facilities are needed across the state due to the new policy reform and the anticipated growth. This assumes that 57 per cent of the anticipated growth will be accommodated in new kindergartens, and the remainder in centre-based day care facilities. If all enrolment growth were to be supported in kindergarten 1 460 new kindergartens would be required.
- Between 194 and 257 new primary schools are needed, with the Compact City and the Dispersed City scenarios requiring the most and the Distributed State scenario requiring the least. Government schools account for approximately 67 per cent of these (with marginal variation by scenario).

- Between 33 and 47 new secondary schools are needed, with the Compact City and the Dispersed City scenarios requiring the most and the Distributed State scenario requiring the least. Government schools account for 44 to 54 per cent of these varying by scenario.

The cost of providing additional school infrastructure ranges from $37.0 to $55.3 billion for the total Victorian school infrastructure (chart 4.18). Scenarios that involve more additional enrolments in Metropolitan Melbourne have substantially higher costs in terms of capital and land. Growth in inner Melbourne and Melbourne new growth areas often requires new schools due to capacity constraints.

4.18 Total school infrastructure cost to 2056 – total cost ($ billions)



Note: Total cost cumulative until 2056. Figures are denoted in real 2022/23 dollars.

Data source: CIE.

Electricity

Electricity infrastructure is an essential utility service and is typically divided into three main components:

- the power generation infrastructure and transmission network,
- the distribution network, and
- the customer connection (included in local infrastructure cost and not separately estimated).

Each of these components contributes to the overall cost and planning of the electricity infrastructure.

We modelled the cost of providing additional electricity distribution infrastructure through managing operational maximum demand and excess capacity at a zone substation area level, while power generation and transmission capacity are managed at a state-level.

To estimate additional infrastructure requirements, we have adopted the following approach:

- Additional power generation and transmission network infrastructure requirements is based on the AEMO's Integrated System Plan (2022). This requirement does not differ by scenario since generation infrastructure is usually designed to ensure reliable and stable power supply.
- Additional distribution network infrastructure requirements, including zone substations, sub-transmission lines, transformers, and feeders, are based on the excess capacity in the network and the need to augment the system if capacity constraints occur.
- This differs by scenario as population growth will happen in different areas, and consumption and demand patterns vary due to various factors such as region, dwelling typology, or electric vehicle use.

Operational consumption and demand have been estimated for each zone substation and scenario, showing minimal variation across different scenarios.

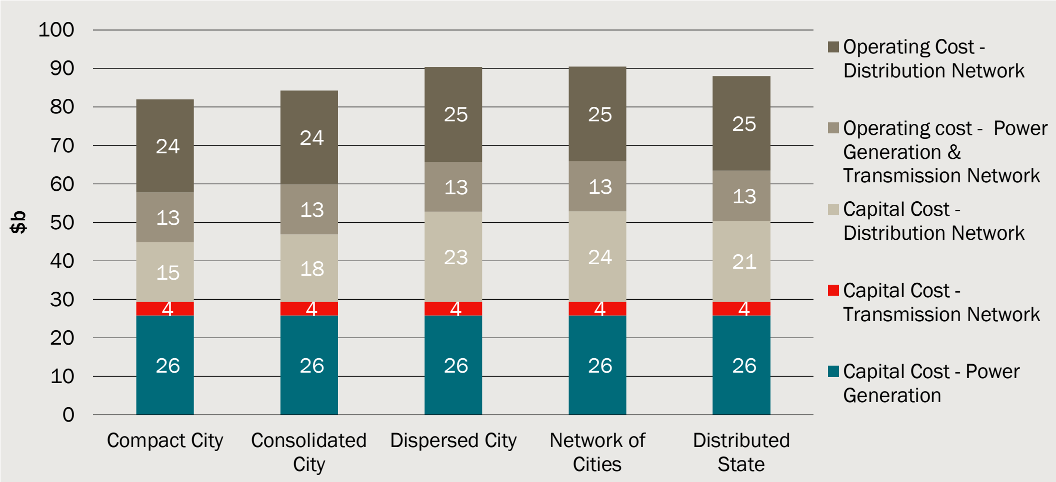
The overall cost of providing additional electricity infrastructure for future growth is more than $82 billion under all scenarios. Approximately half of the cost is attributed to installing new renewable energy power capacity and new transmission networks, totalling over $42 billion until 2056 (chart 4.19):

- Specifically, this would result in a more than doubling of the total installed power generation capacity by 2056, from 20 GW to over 56 GW, and
- the current distribution network capacity would also double from 9.6 GW to over 17 GW across all scenarios.

The cost variations across scenarios are relatively minor, with the highest difference amounting to $8 billion. The Dispersed City and Network of Cities scenarios have the greatest overall costs. These scenarios require more widespread capacity augmentations across the entire state of Victoria, whereas the other scenarios focus on augmentations either in Metropolitan Melbourne or regional Victoria, but not both. In particular, disproportional high growth in regional Victoria leads to a greater need for augmentation as the existing infrastructure is insufficient. In addition to the regional variations in capacity constraints, the total operational electricity use varies across scenarios, driven by different factors:

- The Compact City and Consolidated City scenarios exhibit the lowest operational electricity consumption among the analysed scenarios. This can be attributed to a higher proportion of apartments being developed, as apartments generally have a greater operational consumption compared to houses, mainly due to the absence of rooftop solar PV systems. However, this increased consumption is counterbalanced by a reduced number of electric vehicle (EV) kilometres travelled in these scenarios, resulting in an overall lower consumption.
- The Dispersed City, Network of Cities, and Distributed State scenarios show higher operational electricity consumption from electric vehicles. This is due to the longer distances that need to be covered in these scenarios. Electric vehicle electricity consumption is projected to account for 57 percent of total residential operational consumption by 2056, making it a significant driver of differences between scenarios.

4.19 Electricity infrastructure impacts across scenarios to 2056 – total cost ($ billions)



Note: Total cost cumulative until 2056. Figures are denoted in real 2022/23 dollars.

Data source: CIE, AEMO ISP (2022).

Natural Gas networks

The future of natural gas infrastructure in Victoria is a matter of significance as the state endeavours to achieve a more sustainable and reliable energy system. Infrastructure Victoria has undertaken a state-wide analysis of the implications of the energy transition for Victoria's extensive gas infrastructure assets.[14] The analysis provides advice and makes 11 recommendations to the Victorian Government, underpinned by extensive research, modelling and stakeholder input. The advice report informed the Victorian Government's Gas Substitution Roadmap, a policy framework that charts the strategic pathway for transitioning away from traditional natural gas usage:[15]

- A strategic plan for transitioning away from traditional natural gas towards low-carbon energy sources such as renewables, hydrogen and biogas.
- An emphasis of the importance of energy efficiency measures, promoting the use of energy-efficient appliances and systems to reduce overall energy consumption.
- A focus on strategic infrastructure planning and investment to support the transition, ensuring reliable supply and optimising existing infrastructure for new energy sources.

The Australian Energy Market Operator (AEMO) has recently published its Gas Statement of Opportunities (GSOO) report, which outlines the expected demand and supply of gas in the over the next 20 years.[16] The report indicates that natural gas

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14 Infrastructure Victoria (2021), *Towards 2050: Gas infrastructure in a zero emissions economy* https://www.infrastructurevictoria.com.au/project/infrastructure-victoria-advice-on-gas-infrastructure/#about

15 Victorian Government (2023), *Victoria's Gas Substitution Roadmap*, https://www.energy.vic.gov.au/renewable-energy/victorias-gas-substitution-roadmap

16 AEMO (2023), *Gas Statement of Opportunities March 2023 For central and eastern Australia,* https://aemo.com.au/-

demand in Victoria is expected to decline due to various factors, including increasing renewable energy generation and energy efficiency measures.

While residential properties no longer need to be connected to natural gas, the future adoption of gas remains uncertain. AEMO's forecast under the Orchestrated Step Change (1.8°C) scenario suggests that current natural gas consumption will decrease from over 200 PJ today to less than 125 PJ by 2042.[17] This indicates that natural gas will still have a role in the coming decades.

Given this decline, capacity constraints and additional large-scale infrastructure investments in the distribution network are unlikely. Therefore, we have taken a pragmatic approach to estimate the total cost. Total costs are based on the most recent AER submissions from the three distributors and linearly reduced according to gas consumption demand in Victoria.

We assume:

- Natural gas consumption and additional augmentation are expected to be consistent across scenarios due to the absence of capacity constraints.
- New industrial and commercial users requiring natural gas in their production process will be located near existing natural gas infrastructure, minimising the need for additional assets.
- Growth scenarios will not differ in terms of residential natural gas demand and the overall trend follows the AEMO forecasts.
- The decommissioning of existing assets and the cost of maintaining, replacing, and augmenting the system will align with the growth trend projected by AEMO's forecast and will be the same across scenarios.

The total cost across all scenarios is estimated at $13.2 billion (real dollars) by 2056. This includes capital cost of $7.1 billion and cumulative operating cost of $6.1 billion. It is important to note that this is a high-level estimate based on the assumption that capital and operating expenditure are directly linked to natural gas consumption.

Water and wastewater

There are 15 urban water corporations which provide water and wastewater services to residential and non-residential customers in cities and regional towns throughout Victoria.

Across Victoria there is currently limited capacity in the water supply and wastewater treatment, as well as the distribution networks, to meet future growth beyond a 5 to 10 year horizon. Additional investments will, therefore, be required to support the future population and employment growth from 2023 onward. Climate change will also place further pressure on the water security which will also bring forward the need for new

/media/files/gas/national_planning_and_forecasting/gsoo/2023/2023-gas-statement-of-opportunities.pdf?la=en

17 http://forecasting.aemo.com.au/Gas/AnnualConsumption/Total

sources of supply to manage water security risks. Different solutions are required in the different locations, depending on the local circumstance.

The level and cost of new investments will vary by water corporation. This, in part, reflects the higher water use per property in regional Victoria due to hotter and drier conditions. The costs differences will also reflect the different options available to manage water security and wastewater services. In coastal regions, for example, desalinated sea water is expected to be one viable option. New dams are unlikely to be viable due, in part, to future climate risk. Other solutions beyond these traditional approaches will be required, including recycled water will be required. Similarly, wastewater transport/treatment costs are expected to be higher in regional areas due to the higher levels of treatment required for discharge to inland waterways. This will result in higher costs in the Network of Cities and Distributed State scenarios where there is a larger share of population and employment in inland regional areas.

The precise solutions are expected to differ in different locations throughout Victoria depending on the unique options available. In some cases, for example, there may be scope to purchase water entitlements currently being used for low value agricultural use. Although these options are unlikely to be sufficient to meet the capacity required where the scenario results in a substantial increase in population/employment in that region.

The analysis conducted for this report should, therefore, be interpreted as providing high level guidance on the costs of service provision under each option.

Tables 4.20 summarise the cost outcomes separately for water supply and wastewater provision, including network distribution costs.

4.20 Estimated additional water and wastewater expenditure – total cost ($ millions)

Item	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$m	$m	$m	$m	$m
Supply augmentation/treatment to 2036					
Water - capex	1 170	1 209	1 228	1 203	1 190
Water - opex	887	927	963	985	1 000
Wastewater - capex	487	550	614	823	880
Wastewater - opex	356	441	530	765	895
Sub total	**2 900**	**3 127**	**3 334**	**3 776**	**3 964**
Supply augmentation/treatment to 2056					
Water - capex	6 910	7 130	7 313	6 841	6 773
Water - opex	5 201	5 415	5 732	5 534	5 707
Wastewater - capex	2 912	3 274	3 729	4 743	5 351
Wastewater - opex	2 149	2 628	3 296	4 384	5 557
Sub total	**17 173**	**18 447**	**20 071**	**21 502**	**23 388**
Network to 2036					

Item	Sc1	Sc2	Sc3	Sc4	Sc5
Water - capex	2 067	2 165	2 225	2 536	2 488
Water - opex	1 426	1 549	1 633	1 979	1 982
Wastewater - capex	2 461	2 478	2 436	2 511	2 504
Wastewater - opex	1 235	1 341	1 438	1 662	1 754
Sub total	**7 189**	**7 533**	**7 731**	**8 688**	**8 728**
Network to 2056					
Water - capex	5 280	5 544	5 662	6 522	6 478
Water - opex	3 617	3 911	4 156	5 137	5 284
Wastewater - capex	6 216	6 300	6 067	6 338	6 307
Wastewater - opex	3 075	3 322	3 598	4 229	4 732
Sub total	**18 188**	**19 078**	**19 482**	**22 225**	**22 801**

Source: The CIE

Note: Total cost cumulative until 2036 and 2056. Figures are denoted in real 2022/23 dollars. *Figures have been rounded to the nearest million and may not add up.*

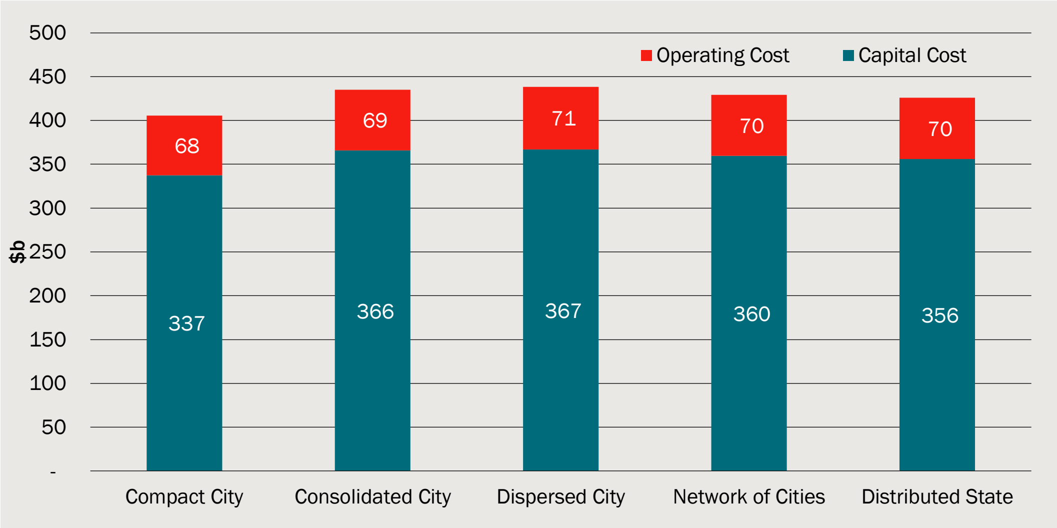
Transport

Transport infrastructure costs have been prepared by ARUP and WT Partnership and cover capital and operating costs (see ARUP and WT Partnership reports for further detail).

Total cumulative cost until 2056 are highest for the Dispersed City scenarios ($438 billion) and Consolidated City scenario ($435 billion) and followed by the Network of Cities scenario ($429 billion) and the Distributed State scenario ($426 billion) (chart 4.21). The Compact City scenario has the lowest cost across all scenarios with $405 billion, a cost differential of over $33 billion or 7 per cent compared to Dispersed City scenario.

Capital cost account for approximately 84 per cent of total cumulative cost until 2056, while the share varies only marginal across scenarios.

4.21 Transport infrastructure impacts across scenarios to 2056 – total cost ($ billions)



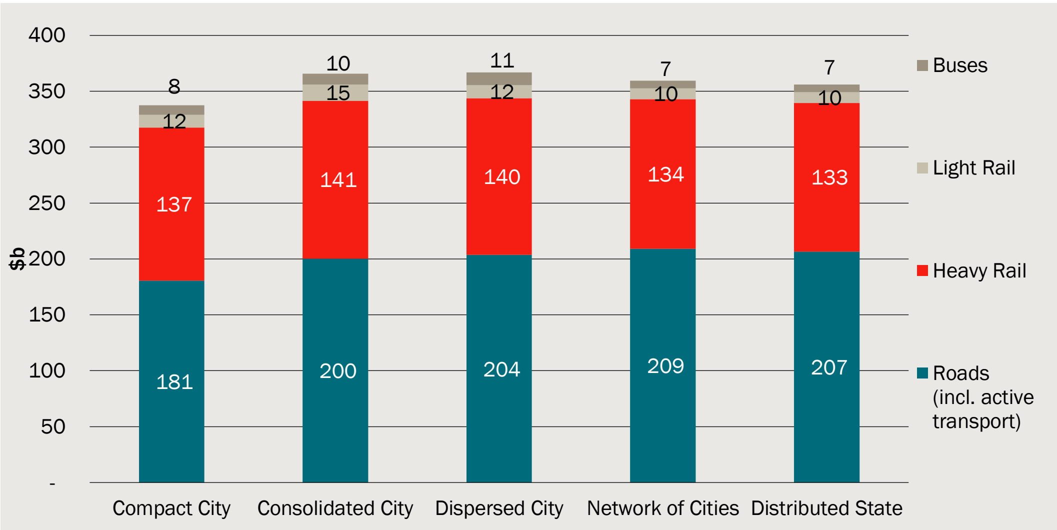
Note: Total cost cumulative until 2056. Figures are denoted in real 2022/23 dollars.

Data source: ARUP.

Main capital cost drivers are roads including active transport[18] (54 to 58 per cent) and heavy rail (37 to 41 per cent). The share of heavy rail capital cost is higher for scenarios with more development in Metropolitan Melbourne (Compact City, Consolidated City and Dispersed City scenarios), and vice versa for roads (chart 4.22).

Main operating cost driver are heavy rail (58 to 60 per cent) and buses (34 to 38 per cent). The share of operating cost for buses is higher for scenarios with more regional development (Network of Cities and Distributed State scenarios), and relatively constant for heavy rail across scenarios.

4.22 Transport capital cost by mode across scenarios to 2056 ($ billions)

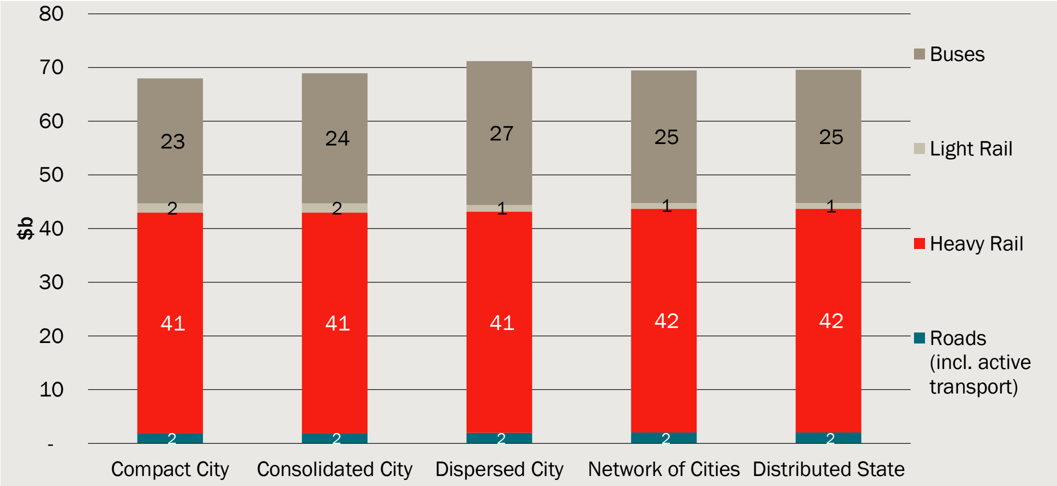


18 Additional active transport cost are only estimated for the Compact City, Consolidated City and Network of Cities scenarios and make up less than 1 per cent of the total roads capital cost.

Note: Total cost cumulative until 2056. Figures are denoted in real 2022/23 dollars.

Data source: ARUP.

4.23 Transport operating cost by mode across scenarios to 2056 – ($ billions)



Note: Total cost cumulative until 2056. Figures are denoted in real 2022/23 dollars.

Data source: ARUP.

PART III

Impacts of alternative development scenarios

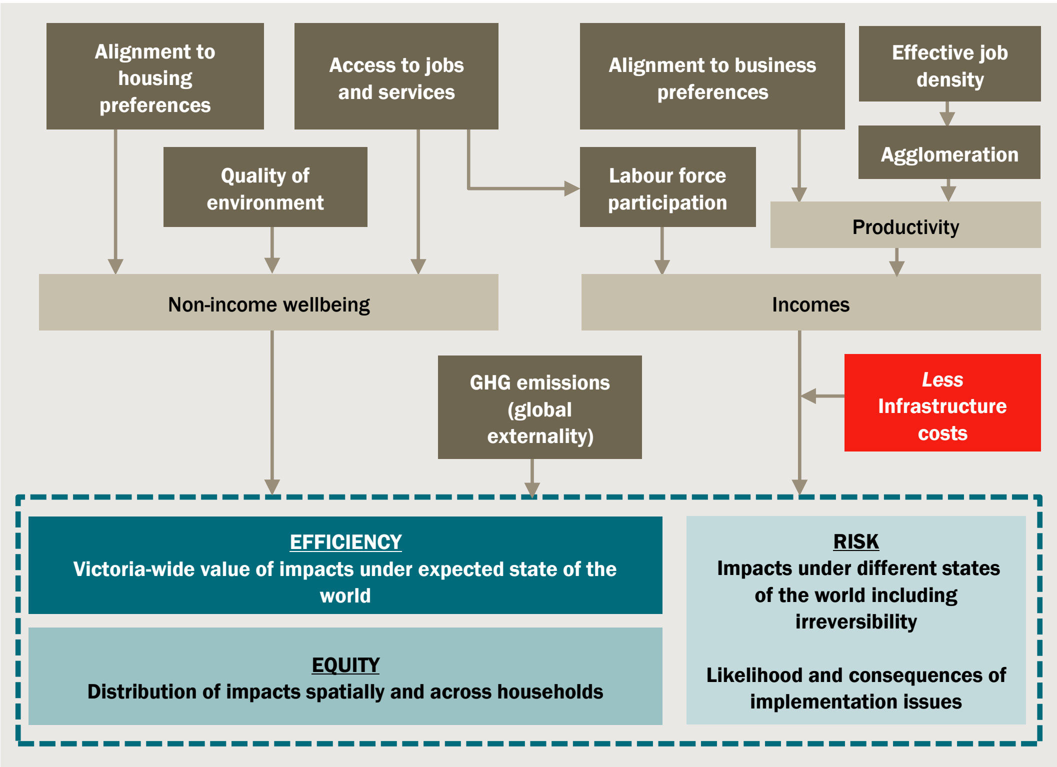
5 *Overall impacts of scenarios*

Impacts comprise a range of ways that a scenario influences the Victorian community. Impacts can include changes to accessibility, housing, business productivity and the environment. These impacts can be considered in the dimensions of:

- efficiency — the costs and benefits of the urban development scenario
- equity — how different parts of Victoria are impacted by the urban development scenario, and
- risk — which scenarios perform well in a wider range of circumstances or are less likely to have implementation risks.

The way different indicators are arranged against these dimensions in this study is shown in table 5.1.

5.1 Translating indicators into an overall framework



Data source: CIE.

The chapters below set out impacts in detail. A summary of quantitative indicators of the scenarios is shown in table 5.2.For many of these indicators it is most useful to compare across scenarios. **For comparison we use the Dispersed City scenario as it represents a continuation of recent trends.**

- The Compact City scenario provides the highest net value of housing. This is because it has more housing in locations that people value now and leads to the largest increase in job accessibility across scenarios. This difference is highly material at $150 000 per relocated dwelling. The Compact City scenario also has the highest business productivity and employment participation impacts. As a result, average income which is used as a summary indicator of economic impact is estimated to be $5000 higher per person compared to the Dispersed City scenario over the period 2021 to 2056. From an environmental perspective, the Compact City scenario has the third lowest combined GHG emissions and requires the least additional urban land take. The lower overall GHG emissions (compared to the Dispersed City) is primarily due to significantly lower emissions from vehicles, offset by higher emissions from buildings, particularly embodied emissions from concrete and steel used to make apartments. The Compact City performs moderately on housing affordability measures, providing more affordable housing in Inner Melbourne but less overall compared to other scenarios.
- The Consolidated City has the second highest housing value, relatively high job accessibility and positive economic impacts compared to the Dispersed City scenario. The Consolidated City scenario has marginally higher GHG emissions compared to the Dispersed City, due to the increase in emissions from buildings (which is partly offset by lower emissions from vehicles). It also has lower transport externalities and land take compared to the Dispersed City.
- The Network of Cities has lower housing value, lower job accessibility and worse economic impacts compared to the Dispersed City scenario. The Network of Cities has marginally lower GHG emissions compared to the Dispersed City, due to the lower emissions from vehicles and mostly offset by higher emissions from buildings. It also has lower transport externalities, but a higher land take compared to the Dispersed City
- At the other extreme, the Distributed State scenario is least aligned to current housing and business preferences. It has the lowest GHG emissions, due to the lower emissions associated with a higher share of detached housing (driven by using timber and brick rather than emissions-intensive concrete and steel), as well as lower emissions from vehicles. It also has the lowest transport externalities, associated with more travel in less densely populated areas. The land take, however, is the highest of the scenarios. It would lead to a higher share of housing being affordable — although this is not necessarily a positive outcome as the lower housing cost reflects that housing is located where people have a lower willingness to pay to live.

A summary of physical indicators of outcomes from scenarios is shown in table 5.2.

A qualitative assessment of the scenarios is shown in table 5.3. While infill-focused scenarios perform well on efficiency metrics, a key risk is ensuring that enough housing and business space is provided, as these scenarios have a higher risk of community opposition related to infill development.

5.2 Summary indicators of scenarios

Indicator	Unit	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
Housing and social indicators						
Net value of housing	$b, present value relative to Dispersed City	105	52	0	-55	-107
Of which: value of improved access to jobs	$b, present value relative to Sc3	100	47	0	-37	-80
Net value of housing per dwelling	$000/relocated dwelling relative to Dispersed City	152	75	0	-79	-155
Share of all dwellings that are detached, 2056	Per cent	53.9	58.0	64.6	62.1	67.1
Accessibility to jobs (car 2036)	Ratio to Dispersed City	110	104	100	101	101
Accessibility to jobs (car 2056)	Ratio to dispersed city	115	106	100	100	95
Accessibility to jobs (public transport 2036)	Ratio to dispersed city	110	104	100	98	96
Accessibility to jobs (public transport 2056)	Ratio to dispersed city	118	109	100	95	87
Public transport mode share (AM peak)	Per cent of trips	15.0	13.4	12.1	12.0	11.3
Share of dwellings for sale under $750 000 (today's value)	Per cent	47.9	49.6	55.9	56.0	62.9
Share of dwellings available for rent under $500 per week	Per cent	68.5	68.3	72.5	74.3	78.8
Economic indicators						
Business location productivity	$b relative to Dispersed City	30.8	9.0	0	- 0.6	-8.2
Agglomeration	$b relative to Dispersed City	19.7	12.3	0	-1.8	-15.5
Employment impacts	$b relative to Dispersed City	12.1	5.0	0	0.2	-2.6
Income	$/person (2021 to 2056) relative to Dispersed City	5 185	1 688	0	- 55	-1 310
Environmental indicators						
Building operational GHG emissions	Million tonnes CO2e relative to Dispersed City	0.7	0.3	0	0.1	0.0
Building embodied GHG emissions	Million tonnes CO2e relative to Dispersed City	14.8	8.0	0	1.3	-1.8
Vehicle tailpipe GHG emissions	Million tonnes CO2e relative to Dispersed City	-16.8	-7.6	0	-1.5	-10.8
Vehicle (electric) operational energy GHG emissions	Million tonnes CO2e relative to Dispersed City	-0.5	-0.2	0	-0.0	0.1
Total GHG emissions	Million tonnes CO2e relative to Dispersed City	-1.8	0.5	0	-0.1	-12.5
Environmental externalities from transport	$b relative to Dispersed City	-0.5	-0.3	0	-0.8	-1.5
Additional urban land take	Km2 relative to Dispersed City	-313	-190	0	20	241

Note: Darker teal is the most positive moving to darker orange as the most negative of the five scenarios.
Source: CIE.

5.3 Summary of physical impacts of scenarios

Metrics	Metrics in 2021	Metrics in 2036					Metrics in 2056				
	All	Sc1	Sc2	Sc3	Sc4	Sc5	Sc1	Sc2	Sc3	Sc4	Sc5
Number of people ('000)	6 460	8 279	8 279	8 279	8 280	8 280	8 279	10 666	10 666	10 666	10 666
Number of jobs ('000)	3 248	4 345	4 345	4 345	4 345	4 345	4 345	5 498	5 498	5 498	5 498
Number of households ('000)	2 521	3 347	3 347	3 347	3 346	3 345	3 338	4 386	4 391	4 389	4 382
Accessibility metrics											
Job density index (Car) 2018=100	100	101	100	136	125	117	136	125	117	117	110
Job density index (PT) 2018=100	100	98	96	158	146	133	158	146	133	126	113
Share of people within 45 minutes (by PT) of a metropolitan centre (per cent)	40.2	46.4	47.5	46.3	44.0	45.6	44.7	41.9	49.0	47.0	44.9
Share of people within 45 minutes (by car) of a metropolitan centre (per cent)	71.7	71.5	74.6	71.6	67.5	69.0	67.5	62.1	77.0	73.2	62.4
Average jobs accessible within 45 minutes by public transport ('000)	145	234	271	234	214	218	273	239	416	332	272
Average jobs accessible within 30 minutes by car ('000)	830	1 091	1 201	1 091	1 016	1 032	1 133	1 036	1 443	1 219	1 122
GHG emissions from transport (mt)	59.52	33.63	34.16	34.60	34.51	33.98	0.35	0.36	0.37	0.39	0.39
GHG emissions from new buildings (mt)	N/A	2.59	2.34	2.19	2.23	2.21	2.38	2.24	1.97	2.01	1.89
Total value of other transport externalities ($m)	972	1054	1059	1067	1047	1028	1020	1031	1050	1009	972
Amount of land used ('000s of hectares), cumulative since 2021	N/A	17	23	30	30	34	37	26	38	40	57

Note: The transport model has been run for 2018 rather than 2021. We have assumed that travel times are unchanged between 2018 and 2021 in order to calculate accessibility outcomes for 2021.

Source: CIE.

5.4 Qualitative assessment of impacts of the scenarios

Indicator	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
Housing and social impacts	High — best aligns to where people want to live and housing types (current preferences). Highest accessibility of scenarios.	Medium/high — second closest alignment to type and location of housing with the highest value.	Medium - third closest alignment to type and location of housing with the highest value.	Medium/low — moderately poor alignment with current housing preferences. Would require large shifts in current preferences to occur.	Low — poor alignment with current housing preferences. Would require large shifts in preferences to occur. Low accessibility to jobs

Indicator	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
Business and productivity impacts	High — business location productivity, agglomeration and employment likely highest in this scenario	Medium/high — business location productivity, agglomeration and employment higher than Scenario 3 but not as high as Scenario 1	Medium — similar business and productivity outcomes to Scenario 4	Medium — similar business and productivity outcomes to Scenario 3	Low — business productivity and employment impacts negative compared to Scenario 3
Environmental impacts	Second lowest GHG emissions Lowest land take for urban activity of scenarios	Slightly higher GHG emissions than Scenario 3 Second lowest land take	Second highest GHG emissions of scenarios Highest transport externalities Moderate land take	Slightly lower GHG emissions that Scenario 3 Slightly higher land take than Scenario 3	Lowest GHG emissions, due to transport and embodied Highest land take
Other impacts	High risk of insufficient housing supply if community opposition to infill development occurs More affordable housing in inner Melbourne locations	High risk of insufficient housing supply if community opposition to infill development occurs	Greenfield housing has lower risk of opposition to delivery	High risk that people and business preferences are not aligned to the scenario	High risk that people and business preferences are not aligned to the scenario More affordable housing in total

Source: The CIE.

6 Social impacts

For social impacts, we use changes in the value of housing as the main indicator of the value of changes in outcomes. That is, we capture the social impacts of the scenarios through estimated changes in dwelling values. This reflects the extent to which each scenario places housing where people want to live, in a type of dwelling they value, and changes the accessibility of a place. While this captures the most material social impacts, there are many ways that land use scenarios or other more detailed policies can influence people, ranging from crime, community cohesion and the liveability of a place. Given the evidence available and the strength of influence of more specific factors, we have not evaluated these other social impacts.

There are two main components of alignment with housing preferences:

- The value of housing based on current attributes of each area, net of the costs of building dwellings and the opportunity cost of land, and
- The impact of changes in attributes of each area on values. We have measured changes in accessibility for each area and how changes in job accessibility affect dwelling values.

A summary of findings is shown in table 6.1. The Compact City scenario has the highest net housing value, followed by the Consolidated City scenario. The differences are highly material, with the Compact City scenario having a higher net housing value of $152 000 per relocated dwelling compared to the Dispersed City scenario. The key assumptions and measured impacts for each of the scenarios are discussed below.

6.1 Summary of social indicators of scenarios

Scenario	Net housing value	Difference to Dispersed City	Difference to Dispersed City per relocated dwelling
	$b, present value	$b, present value	$000 per dwelling
1. Compact city	2 299	105	152
2. Consolidated city	2 245	52	75
3. Dispersed city	2 193	0	0
4. Network of cities	2 138	-55	-79
5. Distributed state	2 087	-107	-155

Source: CIE.

Approach to measuring alignment with housing preferences

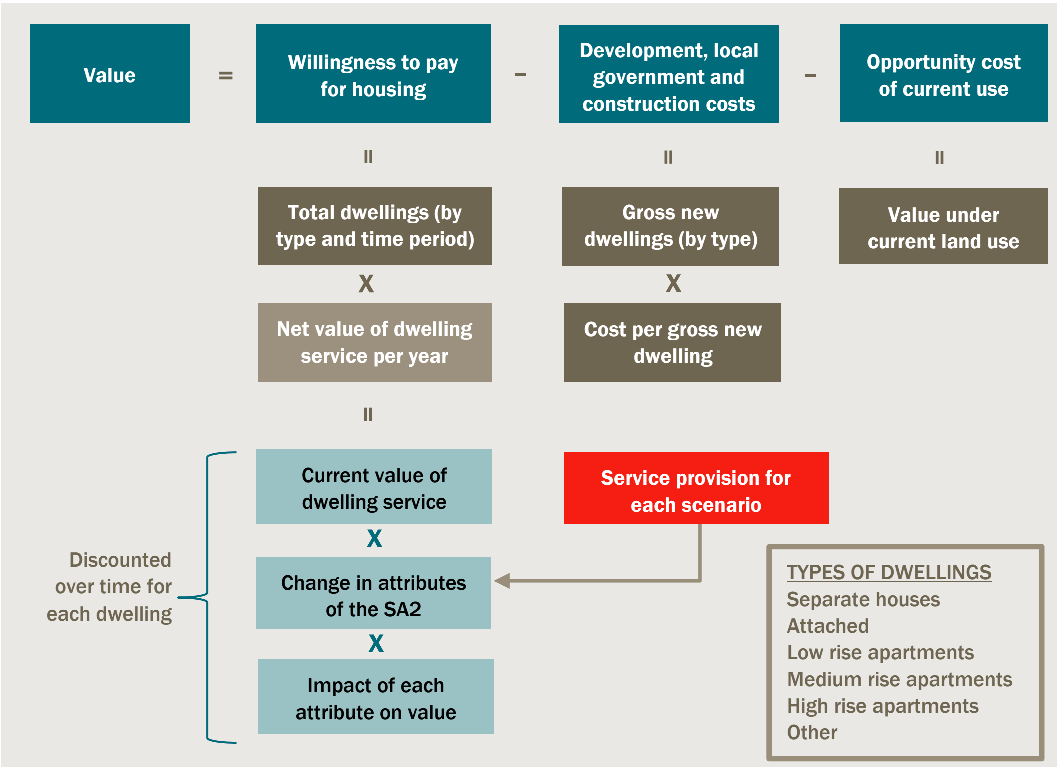
A key part of any spatial scenario is the extent to which it places housing where people want to live, in a type of dwelling they value. This is measured through the alignment of a scenario with housing preferences. Very different housing patterns have emerged from different economic and political systems, which highlights the importance of considering people's housing preferences when thinking about different urban development futures. In democratic mixed market economies such as Australia, higher urban densities have tended to occur in and close to the central city and commercial and residential land uses increasingly replace industrial land in inner city areas. These trends have been facilitated by market signals through the price of land and property.

Broadly, alignment to housing preferences is highest where housing is:

- where people want to live
- reflecting types of dwellings that people want to live in, and
- is less costly to provide.

In line with this, we have developed a model of the value of property services, which is the willingness to pay for housing net of the cost of providing dwellings (including the opportunity cost of existing use of land) (chart 6.2). This modelling approach aligns to that used in cost-benefit analysis and development feasibility analysis. The calculations have been undertaken at the SA2 level.

6.2 Approach to valuing residential property



Source: CIE.

The data and assumptions required to estimate the above are shown in table 6.3. Appendix L provides greater detail on these assumptions.

6.3 Measuring housing impacts

Item	Data source
Current willingness to pay for space (per m2 of space)	We estimate hedonic models of sale prices and rents to estimate the current value of dwellings for each combination of dwelling type and SA2. This modelling uses sales and rents data from PropTrack, which was also used in the Hedonic modelling report completed by Infrastructure Victoria.[19]
Cost of construction by space type	We use data from the ABS *Building Activity, Australia*, publication about the average construction cost for new residential dwellings in Victoria. Construction cost in 2022 dollars is equal to $392 155 for houses, $370 497 for townhouses and $463 499 for apartments. We apply real escalation to these costs of 1.03 per cent for houses and townhouses, and 0 per cent for apartments, based on average real growth in ABS Producer Price Indices for construction in Victoria since September 1998.
Space required for each scenario (m2)	ABS *Land and Housing Supply Indicators* data is combined with data from the UDP Regional Greenfield 2022 analysis to estimate lot size for new residential dwellings. We assume that there is only additional land take for greenfield development, with no increase in land take for infill.
Opportunity cost of sites	The opportunity cost of a site is the value of its existing use. This is conceptually the value of the site, which comprises the value of the building and land. We capture the opportunity cost of additional land taken in greenfield areas, assuming that it would be used for agricultural purposes in the absence of development. The value of agricultural land is based on data from the Valuer General. The opportunity cost of land that is already used for residential or employment purposes is captured through lost value of housing or employment land.
Changes in WTP exogenous to the scenarios	The central case applies no change to spatial preferences. Changes to preferences other than those that are explicitly part of the scenarios are discussed in the Risk chapter.
Changes in WTP that are part of the scenarios (eg changes in access to jobs)	These are through using a hedonic model to understand the value of differences in accessibility, controlling for characteristics of a dwelling (e.g. the number of bedrooms) and of an area (e.g. distance to the coast). We then apply this to the estimates of accessibility by scenario. We have used PropTrack data to construct a hedonic model for housing. This model is based on similar work conducted by Infrastructure Victoria and uses similar metrics for accessibility. For example, the Infrastructure Victoria hedonic modelling estimates the value of distance to a train station, while we have estimated the value of accessibility to jobs measured by effective job density. The second factor is whether and how quickly WTP declines as more space is provided in a particular type and location. We have developed estimates of the slope of the demand curve from modelling underpinning The CIE (2022) report on *Demand for housing in Victoria*.[20]

19 Infrastructure Victoria, 2023, *Measuring home price differences – How features, location and infrastructure affect Melbourne's home prices*.

20 The CIE, 2022, *Demand for housing in Victoria – Stated preference research*, Technical Appendix. https://www.infrastructurevictoria.com.au/wp-content/uploads/2023/03/Centre-for-International-Economics-Demand-for-housing-in-Victoria-stated-preference-research-technical-report.pdf

Item	Data source
Estimating present values of future housing value and dwelling costs	To estimate the present value of housing, we discount housing values to 2021 using a discount rate of 3 per cent. This is a discount rate calibrated such that the present value of future rents are similar to the sale price of a dwelling at construction.

Source: CIE.

Accounting for demand saturation

For a particular housing market, such as attached dwellings in a particular SA2, we measure the net benefit or cost of achieving a particular number of dwellings. This is the difference between how much people are willing to pay for the dwellings provided in a scenario, and what it costs to build the new dwellings required.

Changes in WTP that are part of the scenarios — such as that caused by improved accessibility of residents to jobs and services — shift demand for housing in this market from D_0 to D_1. D_0 represents projected demand for dwellings after accounting for uplift in WTP over time, consistent with the historical average rate of growth in dwelling prices.

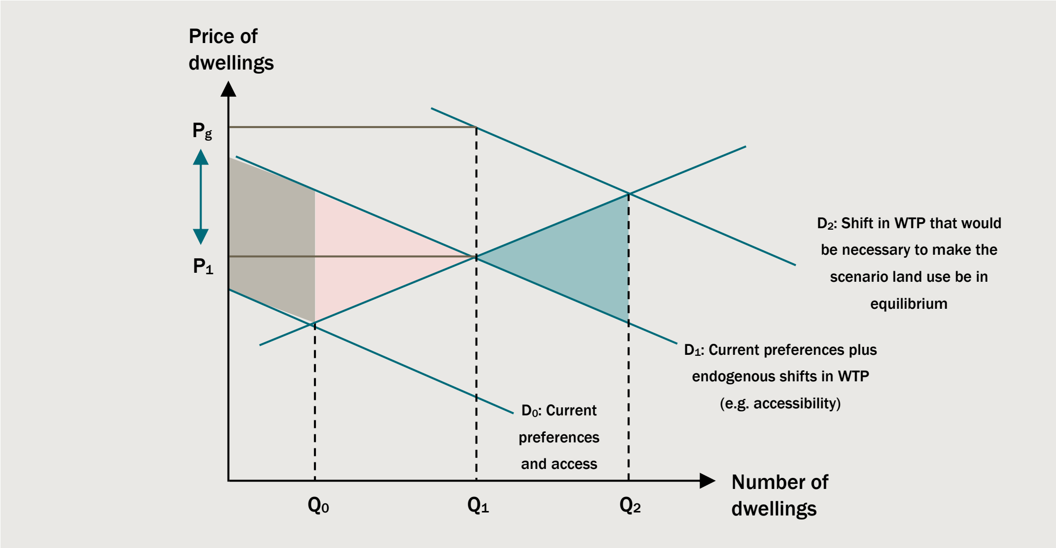
There may remain a gap between the number of people who would choose this housing type and location (Q_1) and the number of dwellings in that market prescribed by the scenario (Q_2) (chart 6.4). For example, a scenario may prescribe that there are 1000 detached dwellings in a particular SA2 under the Compact City Scenario. However, even with accessibility improvements, there is only sufficient demand for 800 detached dwellings in this SA2. As a result, there is some disbenefit to the residents of 200 dwellings who would prefer to live elsewhere, but in this scenario are prescribed to live in detached dwellings in this SA2.

The net benefit (or cost) from the scenario is:

- The brown parallelogram – this is the benefit to existing people living in the area (Q_0) such as from changes in accessibility.
- The pink triangle, which is the benefit to new dwellings
- Less, the teal triangle, which is the disbenefit from excess provision of dwellings of that type in that location. This disbenefit occurs if the cost of supplying those dwellings exceeds the amount people are willing to pay for them. The disbenefit is larger where there is a bigger gap between the number of dwellings people demand at the cost of supply and the number provided in that scenario.

Note that for simplicity the chart assumes that the price of housing is where demand meets cost (supply). There is a large body of work suggesting that the price is actually at a point well above cost at the current provision of housing, which means that new dwellings have a larger net benefit. For example, Kendall and Tulip (2018) estimate that detached house prices were 69 per cent above marginal costs of housing in 2016.[21,22]

6.4 Market for housing in an area



Note: For simplicity we show this as being in equilibrium with current preferences. Because of the significant distortions in land markets this is likely not the case.
Data source: CIE.

More development necessitates using sites that have less value for whatever reason and in targeting households that have weaker preferences for that location. This suggests that the value of land use change for each new dwelling will be lower for greater levels of development. The teal triangle above captures this effect, which we refer to as **demand saturation**.

The basis for estimating the shift in the demand curve from D_0 to D_1 is evidence about the value of accessibility to jobs, services and other factors estimated by hedonic modelling.

The basis for estimating the slope of the demand curve is evidence about housing choices for Victoria from the CIE (2022).[23] We have re-run the market share model from that study for different shocks to prices of dwellings to estimate the price elasticity of demand for broad housing regions and dwelling types (table 6.5). For each region, the price elasticity of demand shows how responsive the quantity of dwellings demanded is to changes in price. This is typically reported as a ratio of the percentage change in quantity demanded as a result of a one per cent price increase. The price elasticity of demand is

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21 Kendall, R., and Tulip, P., 2018, *The effect of zoning on housing prices*, Research Discussion Paper 2018-03, Reserve Bank of Australia, available at: https://www.rba.gov.au/publications/rdp/2018/pdf/rdp2018-03.pdf

22 Kendall and Tulip (2018) follow the approach of Glaeser and Gyourko (2003): Glaeser, E.L. and Gyourko, J., 2003, 'The impact of building restrictions on housing affordability', *Economic Policy Review*, 9(2), pp.21-39.

23 The CIE, 2022, *Demand for housing in Victoria – Stated preference research*, Technical Appendix, prepared for Infrastructure Victoria.

typically negative, reflecting that an increase in price of dwellings for a particular submarket is associated with a decrease in the quantity of dwellings demanded.

By re-running the market share model, we found that demand for housing is more price-responsive in Melbourne compared to regional areas, represented by a higher price elasticity of demand. That is, for a given increase in prices of houses (10 per cent in this case), the change in quantity demanded is larger in inner Melbourne (50.4 per cent) than it would be for the same magnitude of increase in house prices for regional areas.

Note that the market share model only includes two regional cities: Ballarat and Geelong. We have based our assumed price elasticity of demand for all regional areas on the price elasticity of demand derived for these two cities. We expect that this may overestimate the price responsiveness of housing demanded in regional towns and rural areas based on current housing preferences. If the degree of price responsiveness were lower than this estimate, it would imply a larger demand saturation effect.

6.5 Price elasticity of housing demand by submarket

Region	Dwelling type	Quantity change from a -10 per cent price shock	Implied price elasticity of demand
		Per cent	
Inner Melbourne	House/townhouse	50.4	-5.04
	Apartment	20.3	-2.03
Middle Melbourne	House/townhouse	36.3	-3.63
	Apartment	27.5	-2.75
Outer Melbourne	House/townhouse	29.2	-2.92
	Apartment	12.0	-1.20
Melbourne New Growth Area	House/townhouse	14.8	-1.48
	Apartment	8.5	-0.85
Regional (Ballarat and Geelong only)	House/townhouse	7.1	-0.71
	Apartment	33.6	-3.36

Source: Market share model developed in The CIE (2022), CIE.

Job accessibility

We have measured job accessibility using continuous metrics referred to as job access density metrics. These metrics estimate the number of jobs that residents of each area are accessible to, weighted by the travel time to get to those jobs. The calculation approach for these metrics is explained in more detail at Appendix P.

The Compact City scenario has the highest accessibility from a state-wide perspective (table 6.6). This signals that the impact of more jobs being in inner Melbourne, which is a more accessible destination than other regions, generally outweighs the value of jobs being more spread across the state.

Job accessibility by private vehicle and public transport is highest in inner Melbourne, and decreasing with distance to the CBD under all scenarios and time periods. The

Compact City scenario has the highest job access in all regions of Melbourne at both 2036 and 2056.

For Regional Cities, the Network of Cities scenario has the highest levels of accessibility. Regional centres and rural areas typically have the best accessibility under the Compact City scenario, except in 2056 by private vehicle the Network of Cities is the most accessible to jobs. This reflects that much of the accessibility of Regional Centres and Rural Areas to jobs is derived from accessibility to Melbourne CBD, which has the most jobs in the Compact City scenario.

6.6 Job access density by car and public transport, by scenario and region

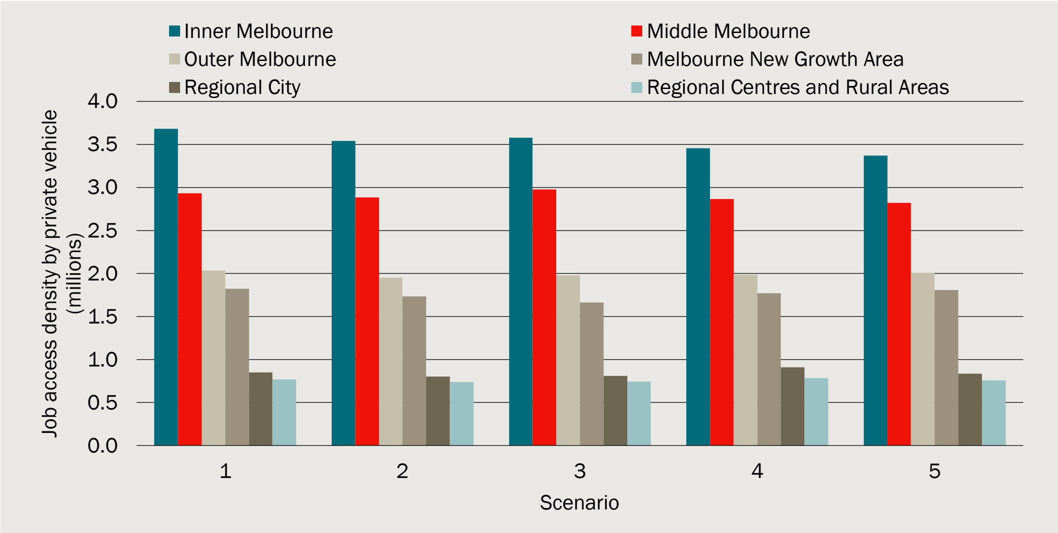
Year	Scenario	Inner Melbourne	Middle Melbourne	Outer Melbourne	Melbourne new growth area	Regional City	Regional Centres and Rural Areas	Total
		Millions	Millions	Millions	Millions	Millions	Millions	Millions
Job access density by car								
2018		2.21	1.80	1.25	1.02	0.46	0.44	**1.29**
2036	1	**2.98**	**2.46**	**1.80**	**1.57**	0.72	**0.67**	**1.85**
	2	2.94	2.45	1.74	1.47	0.69	0.64	**1.75**
	3	2.94	2.45	1.71	1.39	0.68	0.63	**1.68**
	4	2.88	2.41	1.74	1.49	**0.75**	0.65	**1.69**
	5	2.87	2.40	1.75	1.51	0.72	0.66	**1.67**
2056	1	**3.68**	**2.93**	**2.03**	**1.82**	0.85	0.77	**2.28**
	2	3.54	2.89	1.95	1.74	0.80	0.74	**2.09**
	3	3.58	2.98	1.98	1.66	0.81	0.74	**1.97**
	4	3.46	2.87	1.99	1.77	**0.91**	**0.78**	**1.96**
	5	3.37	2.82	2.01	1.81	0.84	0.76	**1.84**
Job access density by public transport								
2018		1.22	0.94	0.67	0.62	0.22	0.17	**0.68**
2036	1	**1.75**	**1.38**	**1.01**	**0.96**	0.34	**0.24**	**1.03**
	2	1.72	1.37	0.98	0.93	0.33	0.23	**0.98**
	3	1.70	1.35	0.96	0.91	0.34	0.23	**0.93**
	4	1.66	1.32	0.95	0.91	**0.35**	0.22	**0.92**
	5	1.65	1.31	0.94	0.90	0.32	0.22	**0.89**
2056	1	**2.36**	**1.89**	**1.41**	**1.32**	0.45	**0.34**	**1.47**
	2	2.27	1.87	1.38	1.26	0.44	0.33	**1.36**
	3	2.21	1.83	1.32	1.19	0.47	0.34	**1.24**
	4	2.11	1.72	1.25	1.17	**0.48**	0.33	**1.18**
	5	2.02	1.65	1.20	1.13	0.43	0.30	**1.05**

Note: The scenario with the highest accessibility for each region (by year) is shown in bold.

Source: CIE.

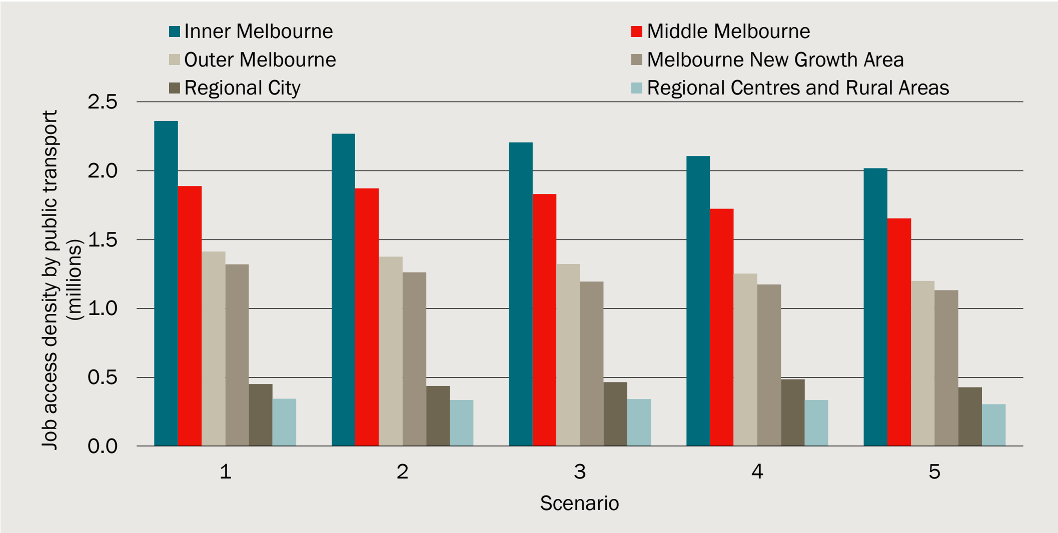
Differences in accessibility across scenarios are somewhat less for private vehicle (chart 6.7) compared to public transport (chart 6.8). Differences in accessibility across regions are much larger than differences across scenarios.

6.7 Job access density by private vehicle, 2056



Source: CIE.

6.8 Job access density by public transport, 2056



Source: CIE.

Access to infrastructure and services

Access to services has been captured through accessibility metrics, defined by whether an origin is accessible within 30 or 45 minutes to a range of destinations of interest. We have relied on estimates of the value of accessibility to services rather than straight distance from services. This will capture not only changes in where people live and where services are located, but also the effect of changes in transport network performance.

There are a wide range of services that may matter to residents. However, we have only measured accessibility to certain services (table 6.9). Accessibility to a particular type of service is only included in the modelling if:

- the service has a moderate geographical footprint, i.e. it is not a highly local service (e.g. preschools) nor a large-scale service (e.g. ports),
- the service type is a destination of significant value to residents, and
- the spatial pattern of the service in the future is relatively predictable.

For simplicity we have assumed that there are no new locations of services such as hospitals or universities. The location of each feature of interest is based on the Victoria 'Features of Interest' dataset published by Land Use Victoria.[24]

6.9 Service types for which we will measure accessibility

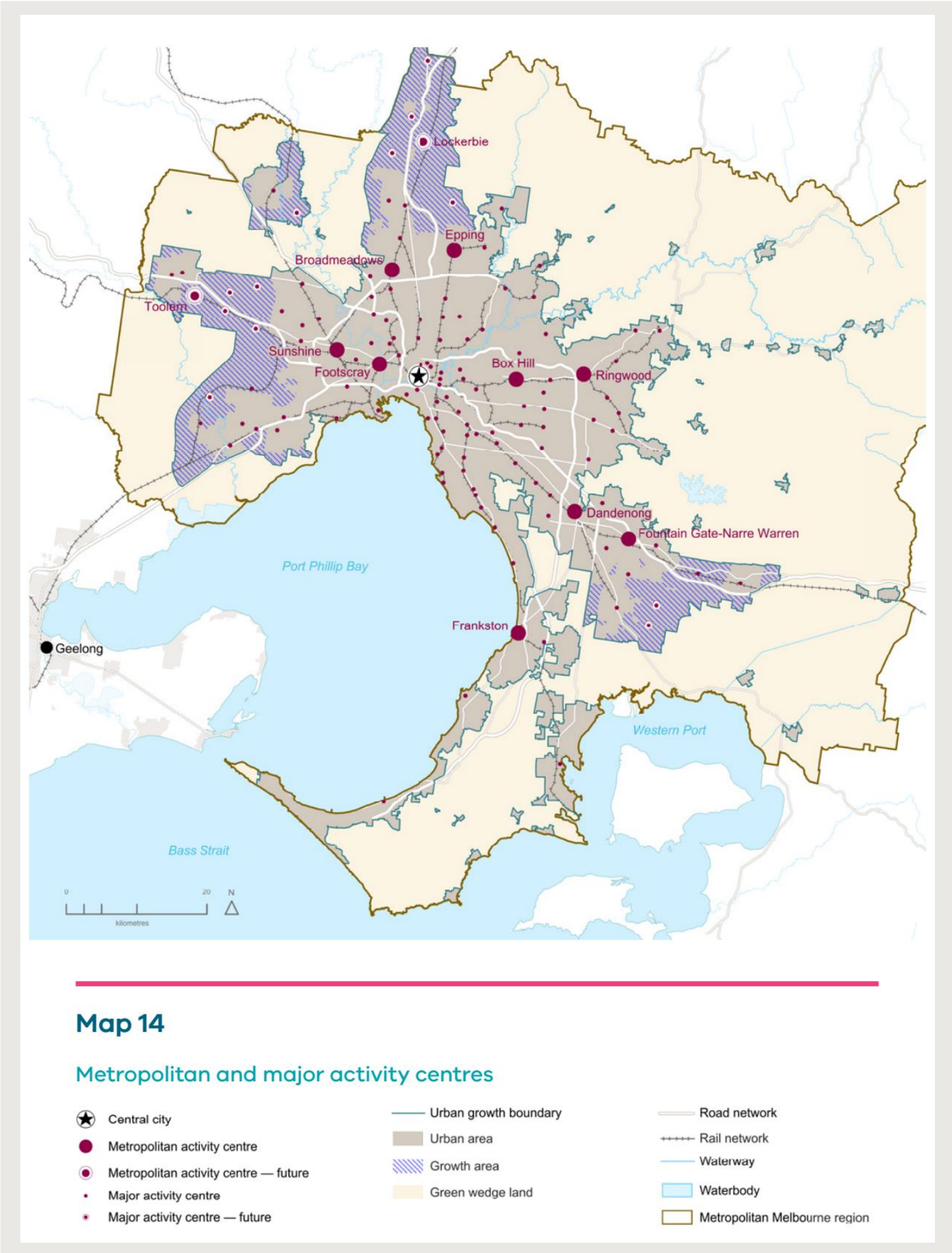
Destination type	Accessibility to this service measured in this study?	Rationale if not included
Metropolitan activity centre – higher order centres for regional catchments	✓	
Major activity centre – suburban focal points for services, etc.	✓	
Hospital	✓	Note, we focus on measuring access to hospitals with emergency departments.
Universities	✓	
Other tertiary education (e.g. TAFE)	×	Highly heterogenous services, meaning access to these sites has highly variable value depending on nature of site
Transport network points (e.g. metro train station or tram stop)	×	Intermediate input to service access, rather than a final destination. We measure accessibility instead.
Arterial roads	×	Intermediate input to accessibility, and value impact is dominated by amenity externalities. We measure accessibility instead.
Primary and secondary school	×	Typically local services
Police station	×	Hedonic modelling by Infrastructure Victoria suggests a negative effect on value
Cemeteries and landfills	×	Not a services destination, but rather a source of disamenity

Source: List of services combines those from IV (2023) hedonic modelling analysis and others identified by CIE.

24 Information about this dataset, including the specification and list of features identified, is available at: https://www.land.vic.gov.au/maps-and-spatial/spatial-data/vicmap-catalogue/vicmap-features-of-interest

The location of metropolitan and major activity centres are shown in chart 6.10. Similarly, we retain the existing classification of Metropolitan Activity Centres and Major Activity Centres with no additions.[25]

6.10 Location of activity centres in Melbourne



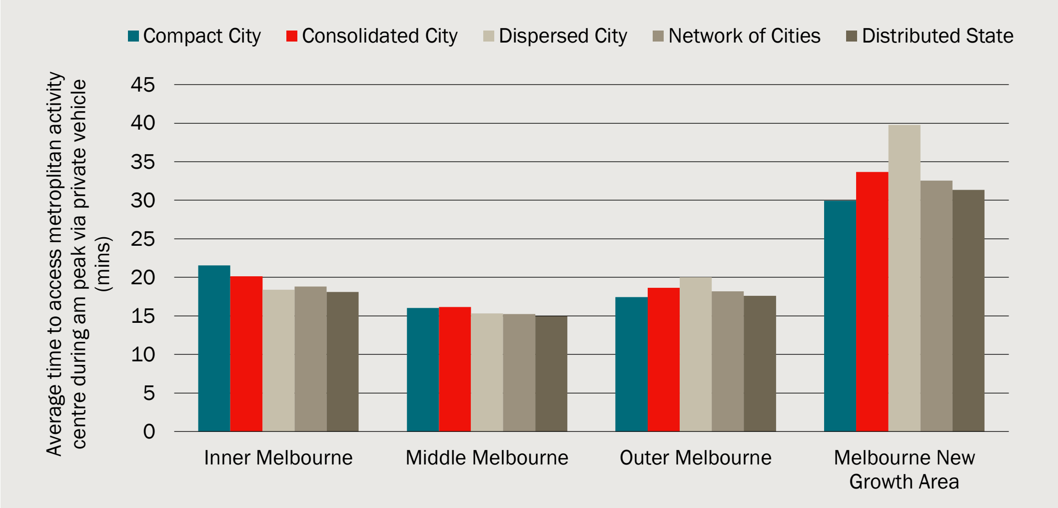
Data source: The State of Victoria Department of Environment, Land, Water and Planning 2017, available at: https://www.planmelbourne.vic.gov.au/__data/assets/pdf_file/0010/376642/Map_14_Metro_and_major_activity_centres.pdf

25 A list of current and future centres is available at: https://www.planning.vic.gov.au/policy-and-strategy/activity-centres/activity-centres-overview

The average time to access a metropolitan activity centre via car is far lower in Melbourne compared to regional areas (chart 6.11). Differences across scenarios are small relative to the size of differences across parts of Victoria. However, higher levels of congestion in scenarios with greater development in Melbourne (e.g. the Compact City) are associated with higher car travel times to a Metropolitan Activity Centre.

We do not present times to access metropolitan or major activity centres for those residing in regional areas, since this centres hierarchy is defined for Melbourne only.

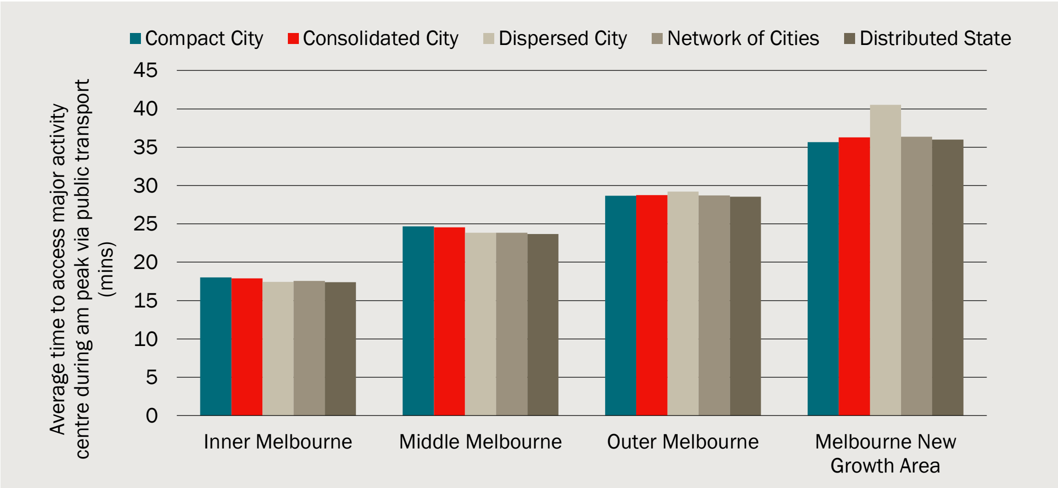
6.11 Average time to a metropolitan activity centre via private car, 2056



Data source: Transport modelling outputs supplied by Arup/IV, CIE.

Average time to a major activity centre via public transport increases as distance to inner Melbourne increases (chart 6.12). Differences across scenarios are relatively small, except in the Dispersed City, where additional congestion in the Melbourne New Growth Area leads to an increase of ~10 per cent in average time to access a major activity centre.[26]

6.12 Average time to a major activity centre via public transport, 2056



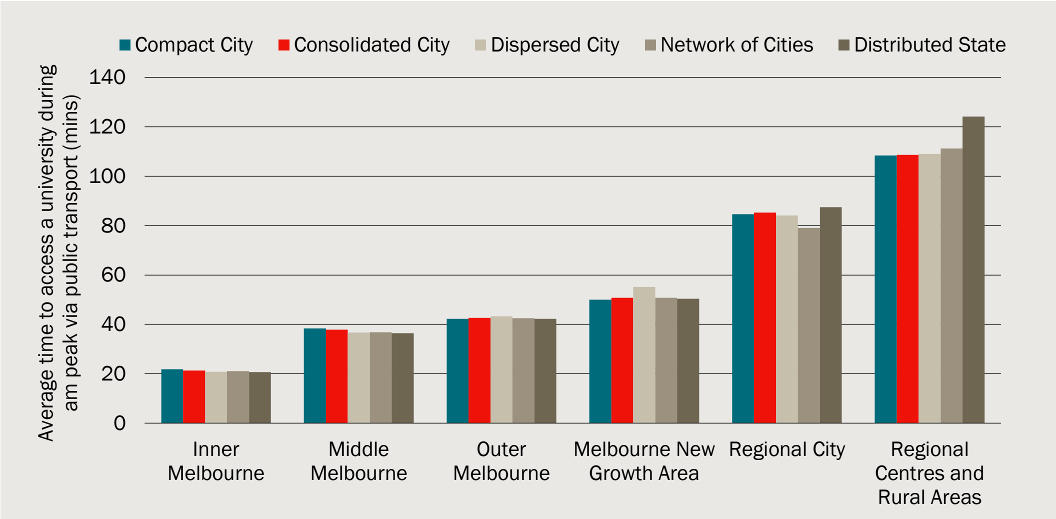
Data source: Transport modelling outputs supplied by Arup/IV, CIE.

26 We expect this reflect the impact of congestion on bus travel time.

Accessibility to universities via public transport is largely similar across scenarios (chart 6.13). Time to access a university is somewhat higher in Scenarios that have greater development in Melbourne, potentially due to the effect of changes in congestion affecting bus travel times. For example, Scenario 1 has the longest time to access universities in inner and middle Melbourne. However, accessibility remains significantly better in Melbourne compared to regional areas.

Accessibility via public transport is poor for regional areas, however, we expect that access by car is more common for people located in these areas. Differences in accessibility for regional areas between scenarios largely reflects greater development in areas that have relatively lower accessibility, which increases the population-weighted average accessibility for regional areas.

6.13 Average time to access a university via public transport, 2056

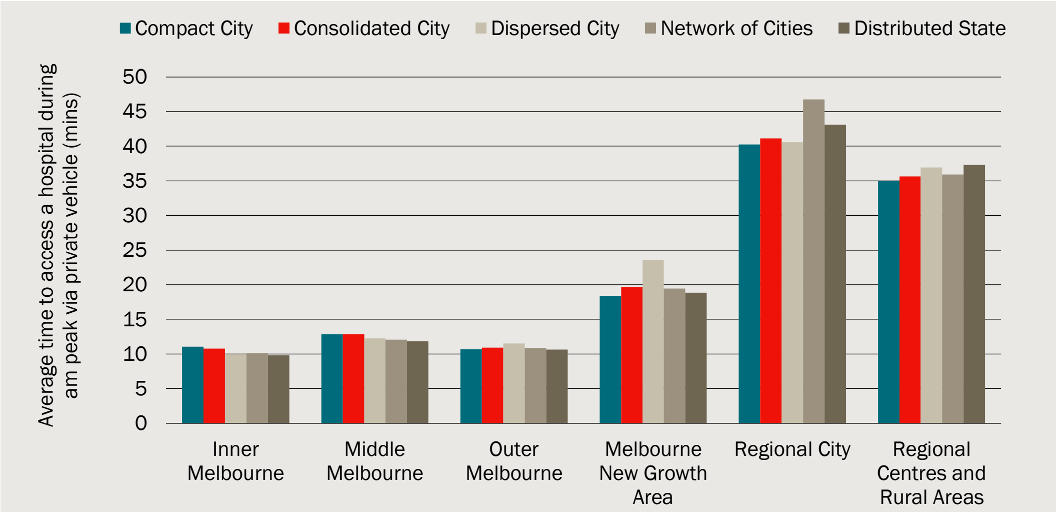


Note: The values in this chart are population-weighted averages across each region. Hence, changes in the measure reflect both changes in times due to congestion and changes in weights. The weighting process means that if more development occurs in areas with worse accessibility, the weighted average accessibility for a region will worsen even if travel times are unchanged.

Data source: Transport modelling outputs supplied by Arup/IV, CIE.

The average time to access a hospital is low in Melbourne and similar across scenarios, except for the Melbourne New Growth Area (chart 6.14). In Regional Cities, average time is slightly higher in Scenarios 4 and 5, but there is little difference overall across scenarios.

6.14 Average time to access a hospital emergency room via car, 2056



Note: The values in this chart are population-weighted averages across each region. Hence, changes in the measure reflect both changes in times due to congestion and changes in weights. The weighting process means that if more development occurs in areas with worse accessibility, the weighted average accessibility for a region will worsen even if travel times are unchanged.

Data source: Transport modelling outputs supplied by Arup/IV, CIE.

As discussed in Appendix L, we use hedonic modelling to assess the impact of services on housing values. We find consistent evidence about the magnitude of these relationships. This is likely in part due to correlation between access to hospitals and universities and access to jobs. Accessibility to centres is even more correlated with jobs. As a result, while we expect that measuring the value impact of changes in job accessibility will capture some of the impact of changing access to services, we are unable to separately estimate the value of changing access to services.

Estimates of the value of housing

Gross value of housing

We estimate that total WTP for housing is around $140-150 billion in 2036 and $260-300 billion in 2056, across scenarios (table 6.15). This represents the total value that residents of Victoria are willing to pay for all the housing provided under each scenario.

Total WTP for housing is relatively similar across scenarios in 2036, with the Compact City scenario having a $9 billion higher WTP than the Distributed State scenario. By 2056, the gap in WTP is $35 billion between the scenario with the highest WTP (Compact City) and that with the lowest (Distributed State). A higher total WTP of housing means that the housing provided is better aligned to the population's preferences for where they want to live and the type of dwellings they prefer. This suggests that housing provided in the Compact City scenario are more closely aligned with the housing types and locations that people value most highly.

Housing WTP is split into three main components:

- The value of housing at the existing attributes of each place and type of housing,

- The impact of demand saturation, which captures the downward impact on WTP from more housing being provided than the amount demanded,[27] and
- The effect of accessibility changes, which are further split by mode and into separate components for the impact with and without network changes.

The largest component is WTP for housing at existing attributes of each place. However, this varies relatively little across scenarios.

By 2056, differences in the impact of accessibility and demand saturation are more influential, particularly in decreasing the value of the Distributed State scenario.

The impacts on accessibility from network upgrades are far smaller than the impact associated with changes to the distribution of people and jobs with the reference case network.

The Distributed State scenario involves a proportionally large increase in housing for regional towns and rural areas. Such an increase necessitates using sites within each SA2 that have less value for whatever reason and in targeting households that have weaker preferences for that location. The size of this effect is significantly amplified by responsiveness to price changes being especially weak in regional areas. This means that attributes of these areas would have to improve very significantly to make them the preferred place to live for such a large group of new residents.

27 Note that these dwellings still each have positive WTP, but that the value at existing attributes will overstate that WTP due to the effect of demand saturation. Hence, the demand saturation adjustment captures the downward impact of the quantity of housing exceeding the amount demanded.

6.15 Undiscounted WTP for housing at 2036 and 2056

Year	Scenario	Value at existing attributes	Impact of demand saturation	PV job access, reference case network	PT job access, reference case network	PV job access, upgraded network	PT job access, upgraded network	Sum of value
		$b/year	$b/year	$b/year	$b/year	$b/year	$b/year	$b/year
Total impact								
2036	Sc 1	109	- 1	16	23	0	0	148
	Sc 2	108	0	15	22	0	0	144
	Sc 3	107	0	14	21	0	0	141
	Sc 4	107	0	15	19	0	0	140
	Sc 5	106	- 1	14	18	0	0	139
Relative to Sc3								
2036	Sc 1	3	0	2	2	0	0	6
	Sc 2	1	0	1	1	0	0	3
	Sc 3	0	0	0	0	0	0	0
	Sc 4	0	0	0	- 1	0	0	- 1
	Sc 5	0	0	0	- 2	0	0	- 3
Total impact								
2056	Sc 1	213	- 2	27	57	0	1	296
	Sc 2	212	0	24	53	0	2	291
	Sc 3	211	- 1	22	49	0	3	283
	Sc 4	209	- 4	23	45	0	1	273
	Sc 5	209	- 9	21	37	0	3	262
Relative to Sc3								
2056	Sc 1	2	- 1	5	9	0	- 2	13
	Sc 2	1	1	2	4	0	- 1	8
	Sc 3	0	0	0	0	0	0	0
	Sc 4	- 2	- 3	1	- 4	0	- 2	- 10
	Sc 5	- 2	- 7	- 1	- 11	0	- 1	- 22

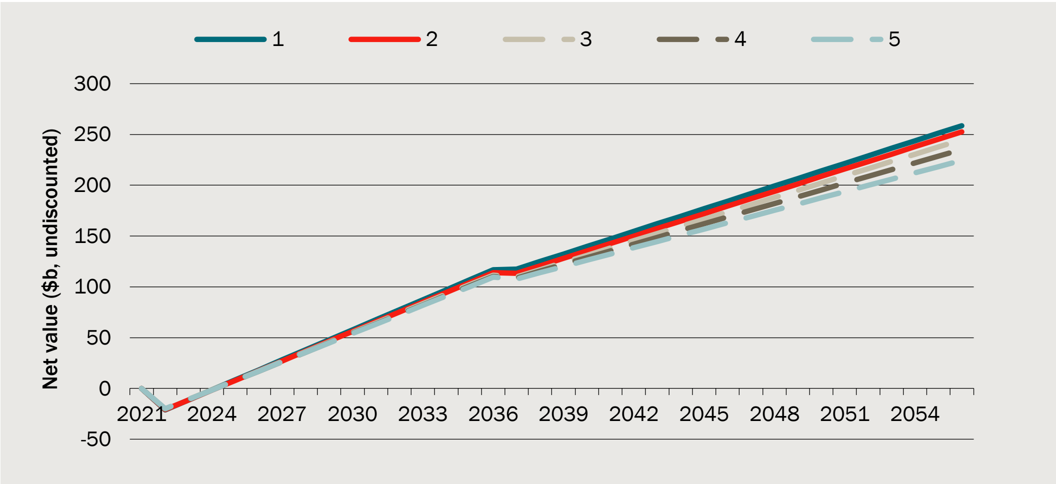
Source: CIE.

Net value of housing

In order to estimate the value of housing net of costs of construction, we need to estimate the present value of housing services. This is because construction costs occur up-front for a dwelling, while the value accrued by the dwelling is calculated as a stream of annual value (i.e. rents).[28] The present value of housing services can be estimated by applying a discount rate. We use a discount rate of 3 per cent (real), which reflects the implicit discount rate that buyers would need to have in order for sales prices and the present value of future rents to be aligned.[29]

The undiscounted value of housing, net of construction costs, is shown over time in chart 6.16. This applies a simple linear time profile to construction costs, which implicitly assumes that the same number of dwellings are constructed each year between 2021 and 2036, and then between 2036 and 2056. The value of each dwelling starts accruing once it is constructed.

6.16 Time profile of the net value of housing



Note: The net value of housing is negative in early years because the stock of new homes constructed is small relative to the number of homes being constructed, which results in net value (i.e. WTP for new dwellings minus construction costs) being negative.

Data source: CIE.

The discounted value of housing (i.e. WTP minus dwelling costs) is shown in table 6.17. Note that the opportunity cost of land is lower in scenarios with less greenfield development (e.g. Scenario 1), since we assume there is no additional land take for infill development.

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28 An alternative approach would be to estimate the sale price of each dwelling at the time of construction, but this would make it very complicated to account for future changes in attributes of a place post-construction, such as improved accessibility.

29 This is consistent with rates of rental yield observed in PropTrack data, as discussed in Appendix L. It is also consistent with the assumption made in previous work, such as The CIE (2020) *Western Sydney Place-based Infrastructure Compact*, available at: https://gsc-public-1.s3-ap-southeast-2.amazonaws.com/s3fs-public/appendix_6_-_economic_evaluation_pic_2.pdf?YI2OKoda1ZmXFIXYZH3cXVDJurKoxcM.

6.17 Discounted net value of housing across all years

Year	Scenario	Value at existing attributes	Impact of demand saturation	PV job access, reference case network	PT job access, reference case network	PV job access, upgraded network	PT job access, upgraded network	Sum of value	Dwelling construction costs	Opportunity cost of land	Total dwelling cost	Net value
		$b/year	$b/year	$b/year	$b/year	$b/year	$b/year	$b/year				
Total impact												
2021-2036	Sc 1	647	- 4	95	137	0	0	876	332	1	333	543
	Sc 2	638	0	89	129	0	0	856	322	1	324	533
	Sc 3	632	- 1	84	123	0	0	838	308	1	310	528
	Sc 4	632	- 3	86	114	0	0	829	308	1	309	520
	Sc 5	631	- 3	86	109	0	0	822	303	1	304	518
Relative to Sc3												
2021-2036	Sc 1	15	- 3	11	14	0	0	38	24	- 1	24	14
	Sc 2	6	1	5	7	0	0	18	14	0	14	5
	Sc 3	0	0	0	0	0	0	0	0	0	0	0
	Sc 4	0	- 2	2	- 9	0	0	- 9	0	0	0	- 8
	Sc 5	- 1	- 2	2	- 14	0	0	- 16	- 5	0	- 5	- 11
Total impact												
2037-2056	Sc 1	1 516	- 14	204	376	- 1	6	2 087	330	1	331	1 756
	Sc 2	1 501	- 1	186	351	- 1	10	2 046	333	1	334	1 712
	Sc 3	1 493	- 8	171	325	0	14	1 996	330	1	331	1 665
	Sc 4	1 483	- 22	175	299	1	6	1 942	323	1	324	1 618
	Sc 5	1 484	- 44	168	262	1	11	1 883	313	1	314	1 569

Year	Scenario	Value at existing attributes	Impact of demand saturation	PV job access, reference case network	PT job access, reference case network	PV job access, upgraded network	PT job access, upgraded network	Sum of value	Dwelling construction costs	Opportunity cost of land	Total dwelling cost	Net value
		$b/year	$b/year	$b/year	$b/year	$b/year	$b/year	$b/year				
Relative to Sc3												
2037-2056	Sc 1	23	- 6	33	51	- 1	- 8	91	1	- 1	0	91
	Sc 2	8	7	15	26	- 1	- 4	50	3	0	3	47
	Sc 3	0	0	0	0	0	0	0	0	0	0	0
	Sc 4	- 10	- 14	4	- 27	0	- 9	- 54	- 7	0	- 7	- 47
	Sc 5	- 10	- 36	- 3	- 63	1	- 3	- 113	- 17	0	- 17	- 96
Total impact												
All years	Sc 1	2 163	- 18	299	513	- 1	6	2 963	663	1	664	2 299
	Sc 2	2 139	- 1	274	481	- 1	10	2 902	655	2	657	2 245
	Sc 3	2 125	- 9	255	448	0	14	2 834	638	3	640	2 193
	Sc 4	2 115	- 24	261	413	1	6	2 771	631	3	633	2 138
	Sc 5	2 115	- 47	253	371	1	11	2 705	616	3	618	2 087
Relative to Sc3												
All years	Sc 1	38	- 9	45	65	- 1	- 8	129	25	- 1	24	105
	Sc 2	14	8	20	33	- 1	- 4	69	18	- 1	17	52
	Sc 3	0	0	0	0	0	0	0	0	0	0	0
	Sc 4	- 10	- 16	7	- 35	0	- 9	- 63	- 7	0	- 7	- 55
	Sc 5	- 11	- 38	- 1	- 77	1	- 3	- 129	- 22	0	- 22	- 107

Source: CIE.

Annual WTP per dwelling

Annual WTP per dwelling for the Compact City and Distributed State scenarios are shown in tables 6.18 and 6.19, respectively.

Annual WTP per dwelling can be thought of as the implied rent per dwelling, which represents the value that residents derive or how much they are willing to pay to live there. This value combines the value of dwellings at existing attributes plus the impact of changes in accessibility and demand saturation.

WTP per dwelling is highest for detached dwellings in Inner Melbourne, followed by Middle Melbourne. WTP in inner and middle Melbourne is significantly higher than in other parts of Victoria, with WTP being more than twice as high as in regional areas.

At a state-wide level, high-rise apartments have a higher WTP per dwelling in 2036 compared to other dwelling types. This is because high-rise apartments are more commonly located in inner and middle Melbourne, where demand is higher. By 2056, separate houses have a higher WTP per dwelling, reflecting a higher assumed growth rate of WTP for houses compared to apartments.[30]

WTP per dwelling across all of Victoria is lower in Scenario 5 ($56 061) compared to Scenario 1 ($63 537). This reflects:

- more dwellings being in regional areas, for which people have a lower WTP per dwelling, and
- worse accessibility outcomes in the Distributed State scenario compared to the Compact City.

Annual WTP per dwelling for separate houses in regional centres and rural areas is significantly lower under Scenario 5 compared to Scenario 1 at 2056. This reflects a combination of worse accessibility outcomes and the demand saturation effect. More intense regional development in Scenario 5 necessitates using sites that have less value for whatever reason and in targeting households that have weaker preferences for living in regional areas.

A demand saturation effect will also be present for inner Melbourne apartments, whereby intense development necessitates targeting households that have weaker preferences for apartments in inner Melbourne. However, demand for housing is more price-responsive in Melbourne, which means the size of this effect is smaller. The value of apartments in inner Melbourne is higher in Scenario 1 compared to Scenario 5, suggesting the impact of improved accessibility outweighs the demand saturation effect.

30 A higher growth rate in WTP for houses compared to apartments is consistent with historical growth. Our assumed growth rates of WTP are shown in Appendix L.

6.18 Scenario 1 housing impacts by region and dwelling type

Region	Separate house	Attached	Low rise apartments	Medium rise apartments	High rise apartments	Other	All dwelling types
	$/dwelling/year	$/dwelling/year	$/dwelling/year	$/dwelling/year	$/dwelling/year	$/dwelling/year	$/dwelling/year
Value at 2036							
Inner Melbourne	103 344	63 465	46 445	46 798	50 218	100 827	**56 979**
Middle Melbourne	67 732	47 955	42 032	42 250	42 028	70 767	**57 047**
Outer Melbourne	39 073	32 357	33 596	34 056	33 878	35 622	**37 606**
Melbourne new growth area	32 158	26 447	29 203	28 655		30 186	**31 710**
Regional City	23 734	24 013	24 594	28 249	25 991	20 753	**23 817**
Regional Centres and Rural Areas	22 776	24 931	25 181	27 082	25 029	18 131	**22 882**
All regions	**39 580**	**43 530**	**41 809**	**44 156**	**49 110**	**39 867**	**41 296**
Value at 2056							
Inner Melbourne	187 916	99 749	61 889	61 924	64 775	168 983	**75 169**
Middle Melbourne	119 214	74 664	55 257	55 036	53 191	116 540	**84 303**
Outer Melbourne	67 892	49 826	44 235	44 764	44 283	56 887	**61 560**
Melbourne new growth area	55 068	40 041	38 232	37 253		47 750	**53 695**
Regional City	39 603	35 591	32 355	38 608	32 763	32 148	**38 653**
Regional Centres and Rural Areas	38 737	36 402	32 108	34 695	28 148	28 230	**38 388**
All regions	**65 119**	**66 489**	**54 725**	**57 670**	**62 635**	**61 690**	**63 537**

Note: There are zero high rise apartments in the Melbourne new growth area, and few in regional areas.

Source: CIE.

6.19 Scenario 5 housing impacts by region and dwelling type

Region	Separate house	Attached	Low rise apartments	Medium rise apartments	High rise apartments	Other	All dwelling types
	$/dwelling/year	$/dwelling/year	$/dwelling/year	$/dwelling/year	$/dwelling/year	$/dwelling/year	$/dwelling/year
Value at 2036							
Inner Melbourne	100 043	61 496	47 105	47 332	50 255	96 943	**59 933**
Middle Melbourne	65 015	46 233	41 393	41 636	41 151	67 632	**56 081**
Outer Melbourne	37 622	31 260	32 986	33 396	33 261	34 447	**36 233**
Melbourne new growth area	30 900	25 573	28 587	28 010		28 809	**30 484**
Regional City	23 108	23 551	24 224	29 031	25 863	20 401	**23 262**
Regional Centres and Rural Areas	22 156	24 073	25 051	26 302	25 875	17 841	**22 273**
All regions	**37 442**	**39 946**	**40 752**	**43 181**	**48 504**	**38 198**	**38 753**
Value at 2056							
Inner Melbourne	170 746	91 847	61 685	61 847	64 270	153 367	**83 114**
Middle Melbourne	110 873	68 928	53 663	53 445	51 625	106 732	**86 325**
Outer Melbourne	63 404	46 650	42 848	43 286	42 824	53 100	**57 738**
Melbourne new growth area	51 803	37 829	37 154	36 338		44 403	**50 534**
Regional City	36 901	32 707	31 062	38 274	33 028	30 133	**35 809**
Regional Centres and Rural Areas	32 678	29 259	30 665	32 730	31 620	22 898	**32 351**
All regions	**56 475**	**55 520**	**50 982**	**54 596**	**61 104**	**51 429**	**56 061**

Note: There are zero high rise apartments in the Melbourne new growth area, and few in regional areas.

Source: CIE.

7 Economic impacts

Under economic impacts, we focus on indicators that will flow through to how much income Victorians have. Spatial scenarios can influence income through two mechanisms:

- productivity — where scenarios allow businesses to produce more output using the same (or fewer) inputs, which will flow through to higher incomes. There are two main theories that can be used to consider how a spatial direction impacts on productivity:
  - the first is that land and non-residential property markets are a good indicator of where businesses can be most productive. For example, a high industrial land value, such as around Port of Melbourne, reflects that businesses will face lower costs (need fewer inputs) in order to undertake production. This is because it may have lower transport costs to move goods between businesses and end users
  - the second is theories of agglomeration. These theories are based on businesses becoming more productive when they are close together. In theory, this is additional to what is measured above, however, in practice measurement of agglomeration overlaps with how land values reflect business productivity
- employment — the level of employment reflects the number of people who participate in the labour force less the share that are unemployed. If some scenarios make jobs more accessible, then this will tend to increase employment. In turn, higher employment will lead to higher household incomes.

The combination of the economic impacts above will lead to changes in average household incomes. That is, if people are working more in more productive locations, then on average their incomes should be higher.

Note that income is not a metric of welfare, as would be used in a cost benefit analysis. This is because additional work hours have an opportunity cost of the time used for work, which would need to be accounted for if it was to be a welfare calculation.

The total impacts on income and per person impacts are shown in table 7.1. Note that agglomeration impacts are shown but are not added to totals as they overlap with the business location productivity estimates. The compact city is estimated to have a positive impact on incomes of ~$5 000 per person over the period 2021 to 2056, or about $150 per person per year, relative to the dispersed city scenario. The consolidated city has an estimated positive income impact of $1 688 per person compared to the dispersed city. The network of cities has a marginal negative income impact relative to the dispersed city scenario. The distributed state scenario has a $1 310 per person income impact relative to the dispersed city scenario.

7.1 Impacts on income in total and per person

Item	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$m	$m	$m	$m	$m
Aggregated across Victoria					
Business location productivity	30 814	8 988	0	- 629	-8 222
Agglomeration	19 687	12 333	0	-1 773	-15 454
Employment impacts	12 130	4 992	0	170	-2 629
Total (excluding agglomeration)	**42 944**	**13 980**	**0**	**- 460**	**-10 852**
	$/person	$/person	$/person	$/person	$/person
Per person					
Business location productivity	3 721	1 085	0	- 76	- 993
Agglomeration	2 377	1 489	0	- 214	-1 866
Employment impacts	1 465	603	0	21	- 317
Total (excluding agglomeration)	**5 185**	**1 688**	**0**	**- 55**	**-1 310**

Source: CIE.

These alternative channels through which urban development scenarios impact on income are discussed below, alongside key assumptions and measured impacts for each of the scenarios.

Business location productivity

Measurement approach

The value for business of expansions in particular locations is conceptually similar to that for households. A scenario that provides business with space where it is both more valuable and less costly will be preferred on this measure. Key pieces of this are:

- The amount that businesses are willing to pay for sites or to lease spaces represents the **willingness to pay** for space of a given type.
- The cost of producing this space includes:
  - the opportunity cost of land and capital (the value of what it would be used for in its existing use)
  - the cost of demolishing existing activities and building new space

The private value created is the willingness to pay less the cost.

The data and assumptions used to estimate the above are shown in table 7.2 and set out in detail in Appendix M.

7.2 Measuring business location productivity impacts

Item	Data source
Current willingness to pay for space (per m2 of space)	Lease or sale rates for commercial, industrial and retail space across Victoria. We have used a range of reports from commercial real estate companies setting out net lease rates for different areas of Melbourne and for different product types (grades for commercial, industrial, retail). We have cross-checked against land valuer general valuations where possible.
Cost of construction by space type	CIE previous benchmarks, escalated to 2022 dollars. This has been tested against data from the Victorian Building Authority https://www.vba.vic.gov.au/about/data.
Opportunity cost of sites	The opportunity cost of a site is the value of its existing use. This is conceptually the value of the site, which comprises the value of the building and land. This is sourced from the Victorian Valuer General data for each local government area.
Space required for each scenario (m2)	The scenarios provide job estimates. Space estimates have been developed based on benchmarks of space per job, which are the same across areas and scenarios. Note that in practice, space will vary depending on price.
Changes in willingness to pay exogenous to the scenarios	The central case would be to apply no change to spatial preferences. As part of testing states of the world we have considered changes that would change the rank order of scenarios.
Changes in willingness to pay that are part of the scenarios (eg changes in access to labour markets)	The transport modelling has been used to generate metrics for accessibility to labour force and accessibility to other businesses. These are factored into willingness to pay through previous hedonic modelling.

Source: CIE.

In addition to the business location productivity impacts, alternative business locations can have other impacts, such as:

- transport impacts — measured in the transport analysis and also impacting on calculated accessibility
- agglomeration impacts — businesses located closer together can lead to knowledge spilling over, for example, or other productivity spillovers. This is discussed further below, but is likely to overlap with business location productivity estimates
- negative localised effects, such as noise or pollution impacts for some types of businesses. These are too specific to be measured in alternative strategic spatial scenarios.

Outcomes

The highest business productivity impacts are estimated for more compact scenarios and lowest impacts for more dispersed and regional scenarios (table 7.3). This reflects:

- a higher value of new space in areas closer to inner Melbourne, particularly commercial space
- more positive accessibility impacts for more compact scenarios, which impacts on existing space and new space.

The compact city has a $30.8 billion positive impact from space constructed from 2021 to 2056 compared to the dispersed city scenario. The consolidated city has a positive $9 billion impact. The Network of Cities scenario has a negative impact of $0.6 billion and distributed state has a negative impact of $8.4 billion.

Note that unlike for housing development, we have not included any effects from having too much non-residential space in a particular location. An example would be where continued expansion of industrial space had lower and lower value for additional businesses. Most evidence on valuations for non-residential land suggests the opposite effect — agglomeration of activities leads to higher demand. Clearly, for some types of activity, such as local serving retail space, there will be only so much space required before this is less needed. The scenario construction is based on population serving activities moving with scenarios, so we do not need to be concerned about this issue with activity serving the local population.

7.3 Estimated business location productivity impacts

	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$m	$m	$m	$m	$m
2036					
Total value					
value of new space at current prices	9 692	6 649	5 145	4 576	3 815
change in value of existing space	34 339	31 954	30 748	30 934	30 861
change in prices for new space	6 951	6 139	5 713	5 878	5 774
total 2036	50 981	44 742	41 607	41 388	40 451
Difference to dispersed city	9 375	3 135	0	- 219	-1 156
2056					
Total value					
value of new space at current prices	13 050	9 000	5 709	6 154	2 919
change in value of existing space	86 770	80 535	79 662	79 000	77 705
change in prices for new space	42 549	37 248	35 559	35 365	33 240
total 2056	142 369	126 783	120 930	120 520	113 864
Difference to dispersed city	21 439	5 852	0	- 410	-7 066
All years					
Total value all years	193 351	171 525	162 537	161 908	154 315
Difference to dispersed city	30 814	8 988	0	- 629	-8 222

Note: These are undiscounted values.
Source: CIE.

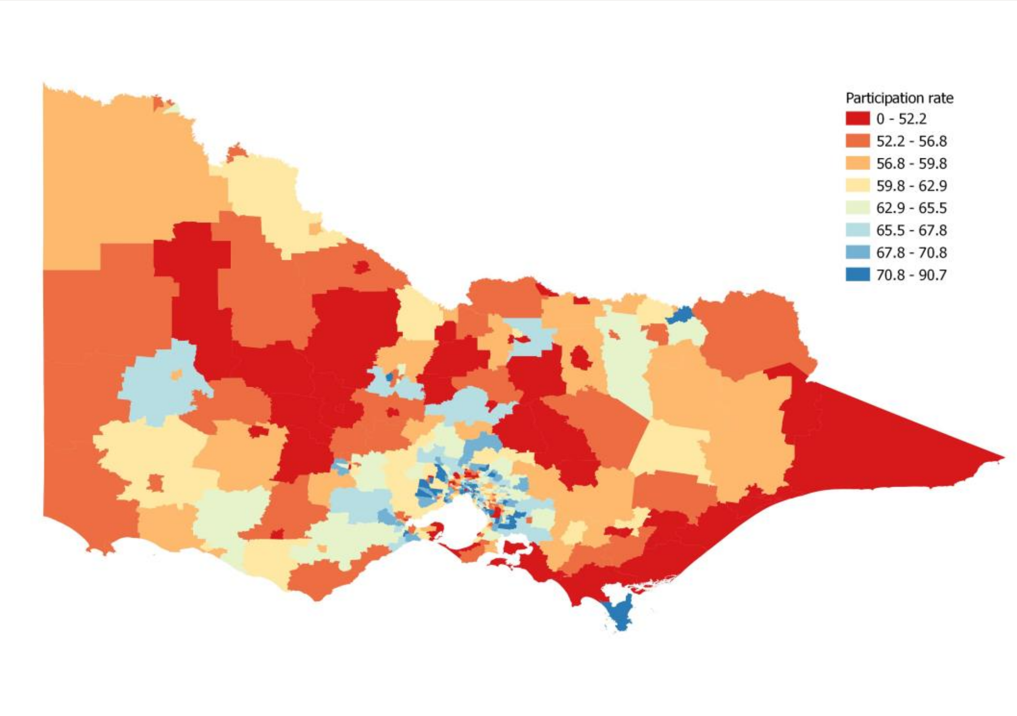
Employment impacts

Current labour force participation and employment patterns

Employment outcomes are dramatically different across parts of Melbourne and Victoria. Total employment outcomes are a combination of whether someone is participating in the labour force and, if so, whether they are able to find a job.

- Labour force participation, as measured by the share of working aged people who are in employment or are seeking employment, is lower in many of the regional areas of Victoria (chart 7.4). Within Melbourne, labour force participation is lowest in fringe areas and highest in middle areas (chart 7.5). This likely reflects affordability pushing people and families with lower participation rates to the fringe, then exacerbated by a lack of access to jobs making it more difficult to enter employment
- Unemployment rates follow a very similar pattern within Melbourne. However, outside of Melbourne unemployment rates are relatively low, for the smaller share of the population that is typically participating in the labour force (chart 7.6).

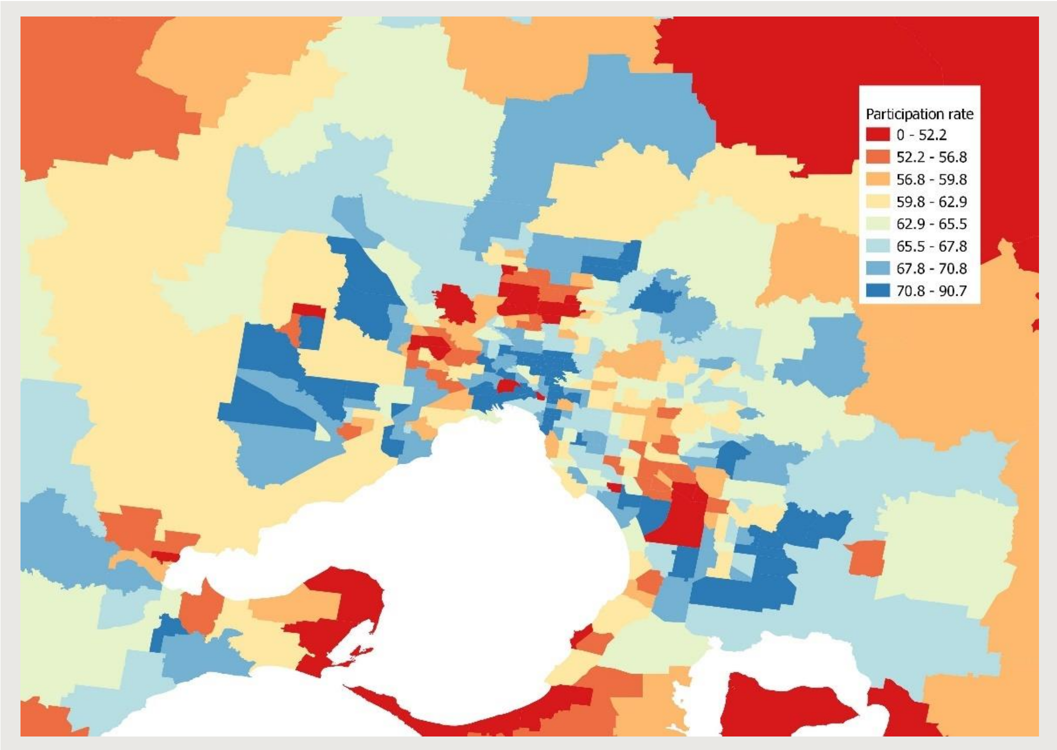
7.4 Victoria labour force participation 2021



Note: All ranges are selected so that there are an equal number of SA2s in each category.

Data source: ABS Census data.

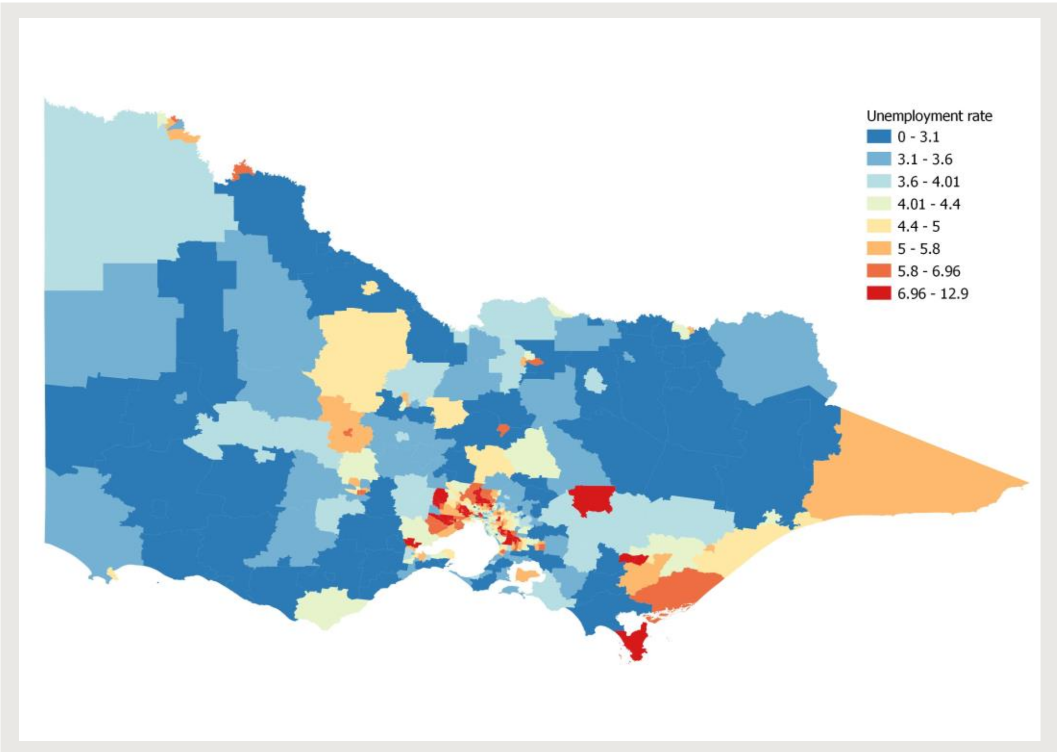
7.5 Melbourne labour force participation 2021



Note: All ranges are selected so that there are an equal number of SA2s in each category.

Data source: ABS Census data.

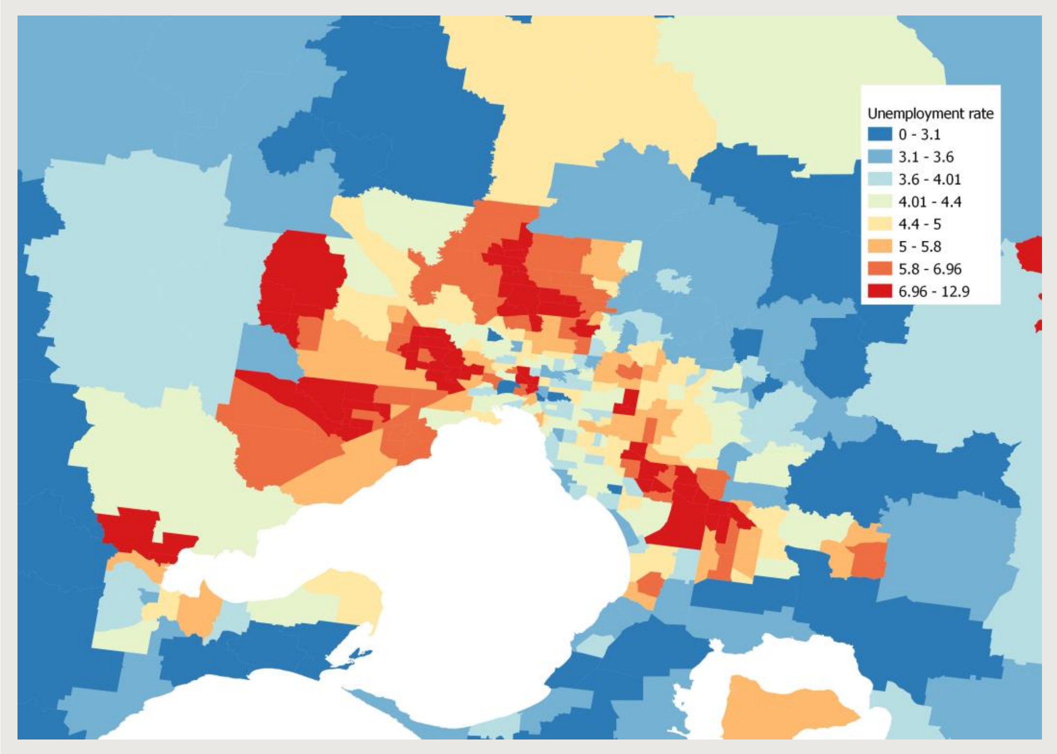
7.6 Victoria unemployment rate 2021



Note: All ranges are selected so that there are an equal number of SA2s in each category.

Data source: ABS Census data.

7.7 Melbourne unemployment rate 2021

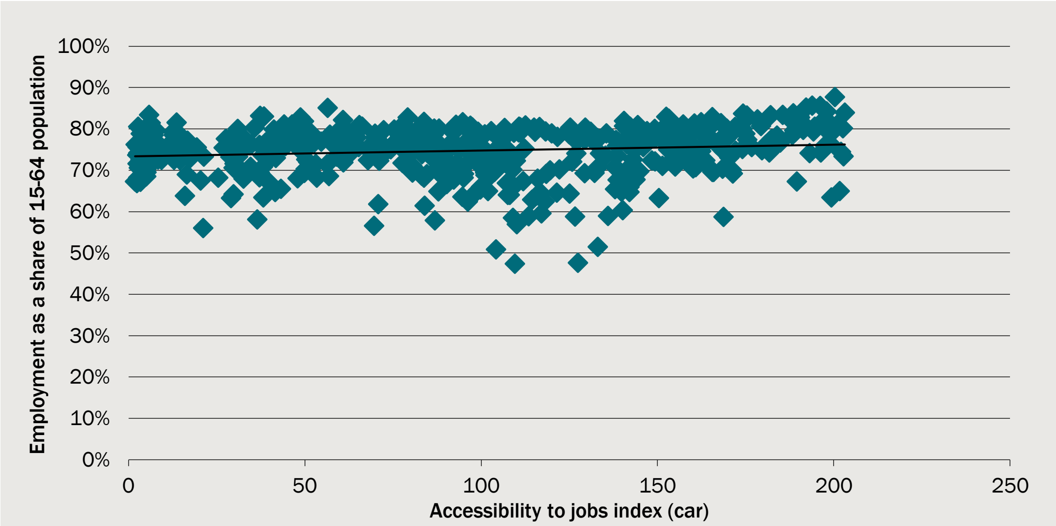


Note: All ranges are selected so that there are an equal number of SA2s in each category

Data source: ABS Census data

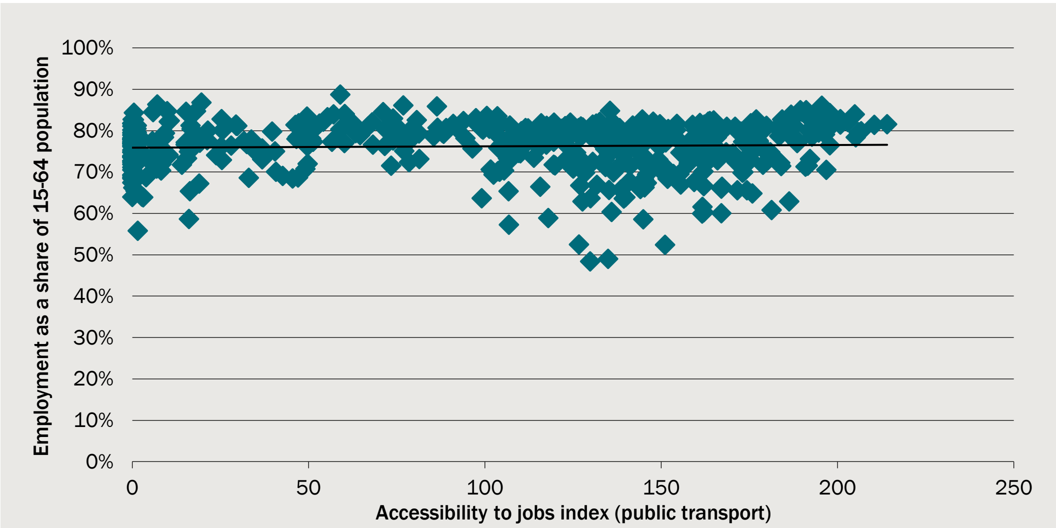
We can also examine labour market outcomes relative to the calculated measures of accessibility to jobs. Some of the areas with the lowest employment rates are on the fringe of Melbourne where accessibility to jobs is moderate (chart 7.8 shows access by car and chart 7.9 shows access by public transport). Areas with the highest accessibility to jobs do have higher employment rates in general, but there is a lot of variation and accessibility is clearly not the major driver of employment rates.

7.8 Employment rate for 15-64 year olds and accessibility to jobs by car 2021



Note: Each data point is an SA2 area in Victoria.
Data source: The CIE, based on transport accessibility metrics aggregated by travel zone for 2018 and ABS Census labour force data by place of usual residence for 2021.

7.9 Employment rate for 15-64 year olds and accessibility to jobs by public transport 2021



Note: Each data point is an SA2 area in Victoria.
Data source: The CIE, based on transport accessibility metrics aggregated by travel zone for 2018 and ABS Census labour force data by place of usual residence for 2021.

Measurement approach

The relationship between accessibility to employment and labour market outcomes is not straight forward. It does generally appear that less accessible areas have lower employment levels. In 2020, Baastiaanssen et al conducted a meta-analysis of studies on transport and employment.[31] They find that there is a (statistically) significant positive association, even where studies are able to address issues related to endogeneity. They report findings related to car ownership and commute times, but have also reviewed studies related to accessibility. They do not include the latter in the formal meta-analysis because the measures of accessibility are different across studies.

Other studies have found participation effects are particularly strong for women.[32] [33]

There are not generally consistent approaches to considering employment impacts from accessibility of transport improvements in Australia. The most used is the Australian Transport Assessment and Planning framework for wider economic benefits, specifically for labour market impacts.[34] This is based on a 1 per cent increase in the net return from working leading to a 0.18 percentage point increase in labour force participation. This method is constructed for a transport project that changes generalised costs rather than a land use strategy that changes where people live and work.

Many of the studies of accessibility and employment have difficulty in addressing causality. That is, people locate in more accessible places who are more likely to be employed. A 2011 US study used redundancies as a random event to consider how rapidly redundant workers found new jobs, and new jobs at a similar wage rate.[35] They found improvement in job accessibility reduced job search duration.

A caveat on all the studies is that there have been very significant changes in working arrangements in some industries following Covid-19. These are likely to have weakened the links between accessibility and employment, compared to pre-Covid-19. This is more likely to be relevant for accessibility impacts on higher skilled female workforce participation as opposed to accessibility impacts on lower skilled disadvantaged people's participation.

Note that there is substantial uncertainty about the pattern of impacts and the extent to which employment impacts depend on absolute versus relative access to employment, and the applicability of these findings to Melbourne. Given the patterns of labour force participation and unemployment, it is reasonable that the greatest gains would be made to improving access in more disadvantaged areas, as that is where the largest amount of

31 Bastiaanssen, J, Johnson, D and Lucas, K (2020), "Does transport help people to gain employment? A systematic review and meta-analysis of the empirical evidence", Transport Reviews, 40 (5). pp. 607-628, https://doi.org/10.1080/01441647.2020.1747569.

32 Matas A, Raymond J-L, Roig J-L 2010, *Job Accessibility and Female Employment Probability: The Cases of Barcelona and Madrid,* Urban Studies, vol. 47, no. 4, pp. 769-787, April 2010.

33 Gilfillan G and Andrews L 2010, *Labour Force Participation of Women Over 45,* Productivity Commission Staff Working Paper, Canberra.

34 ATAP, Wider Economic Benefits, https://www.atap.gov.au/tools-techniques/wider-economic-benefits.

35 Andersson, Fredrik, John Haltiwanger, Mark Kutzbach, Henry Pollakowski, and Daniel Weinberg. 2011. "Job Displacement and the Duration of Joblessness: The Role of Spatial Mismatch." Working paper.

underutilised labour is. That has also been the focus of the literature, as set out in Baastiaanssen et al (2020).[36]

While the evidence does suggest accessibility improvements will increase employment, it is also clear that it is only a small driver of labour force participation outcomes. There will be many other factors, such as education and skills, that are likely to be much more important in determining differences in participation and employment.

To develop estimates of the value of accessibility changes in terms of employment outcomes, we adopt a simple approach that reflects the evidence from the literature and existing Australian frameworks:

- overall accessibility to jobs metrics for a scenario are calculated for car and public transport for 2036 and 2056
  - these are the average accessibility to jobs faced by people of working age across Victoria
  - these are weighted by the work share of trips made by car and public transport respectively in the reference case
- the percentage change to accessibility today is estimated for each spatial scenario
- the percentage change in accessibility is converted to a percentage change in net returns from working, as follows:
  - it is assumed that the percentage change in accessibility will translate into an equal percentage change in generalised costs of transport
  - transport costs (including travel time and costs) are estimated to average 7 per cent of gross wages on average
  - the percentage change in net returns is then estimated as the percentage change in accessibility multiplied by 7 per cent
- the percentage change in net returns is multiplied by 0.18 to give a percentage point change in labour force participation, based on the ATAP parameter[37]
- the dollar value of the change in labour force participation is then estimated as the average Victorian wage multiplied by ATAP factors for additional participants to be have lower typical wages multiplied by the percentage point change in labour force participation multiplied by the working age population.
  - The ATAP approach assumed a marginal worker will typically work 70 per cent of the hours of an average worker and at a wage of 80 per cent of that of an average worker. This gives an overall annual wage of 56 per cent of average for additional people employed.

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36 Bastiaanssen, J, Johnson, D and Lucas, K (2020), “Does transport help people to gain employment? A systematic review and meta-analysis of the empirical evidence”, Transport Reviews, 40 (5). pp. 607-628, https://doi.org/10.1080/01441647.2020.1747569.

37 ATAP, Wider Economic Benefits, https://www.atap.gov.au/tools-techniques/wider-economic-benefits.

Outcomes

The estimated changes in labour force participation and how that would flow through into additional income is set out in table 7.10. Labour force participation is estimated to be highest in the Compact City scenario, because it has substantially higher accessibility to jobs through both public transport and private vehicle than other scenarios.

7.10 Labour force participation impacts from scenarios

	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	Index	Index	Index	Index	Index
2036 accessibility metrics relative to 2021					
Car	145.5	137.7	132.0	133.5	132.7
Public transport	154.1	146.2	140.1	137.8	134.9
Weighted average	146.3	138.5	132.8	134.0	132.9
2056 accessibility metrics relative to 2021					
Car	178.6	164.4	155.4	155.2	147.6
Public transport	217.7	202.3	185.0	175.9	160.1
Weighted average	182.5	168.2	158.3	157.2	148.8
	Per cent	Per cent	Per cent	Per cent	Per cent
Weighted difference to Dispersed City					
2036	10.2	4.3	0.0	0.9	0.1
2056	15.2	6.2	0.0	-0.6	-5.9
	Percentage points	Percentage points	Percentage points	Percentage points	Percentage points
Change in labour force participation					
2036	0.13	0.05	0.00	0.01	0.00
2056	0.19	0.08	0.00	-0.01	-0.07
	$m/year	$m/year	$m/year	$m/year	$m/year
Income from additional labour force participation					
2036	303	128	0	27	3
2056	697	282	0	-28	-268
Total all years	**$m**	**$m**	**$m**	**$m**	**$m**
All years to 2056	**12 130**	**4 992**	**0**	**170**	**-2 629**

Source: CIE.

Agglomeration

We have also measured agglomeration impacts associated with scenarios, although noting that this potentially overlaps with what is being measured in business location productivity. Australian Transport Assessment and Planning (ATAP) has guidelines for measuring agglomeration impacts.[38] The underlying changes in effective job density are calculated using the transport modelling results. The agglomeration elasticities the ATAP are applied to these to develop agglomeration impacts.

The estimated agglomeration impacts align closely with the business location productivity impacts (table 7.11).

- The Compact City scenario has the greater positive agglomeration impacts, estimated at almost $20 billion higher than the Dispersed City scenario. This reflects negative impacts from travel time, which are more than outweighed from positive impacts from jobs being in closer proximity.
- The Distributed State scenario has the most negative agglomeration impacts, at $15 billion less than the Dispersed City scenario.

7.11 Agglomeration impacts across scenarios

Item	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$m/year	$m/year	$m/year	$m/year	$m/year
2036	419	264	0	4	- 230
from changes to travel time	- 63	- 57	0	127	204
from changes to land use	482	320	0	- 123	- 434
2056	1 235	772	0	- 185	-1 143
from changes to travel time	- 93	- 214	0	40	340
from changes to land use	1 329	986	0	- 225	-1 483
	$m	$m	$m	$m	$m
Sum from 2021 to 2056	19 687	12 333	0	-1 773	-15 454

Note: Using ATAP's methodology at https://www.atap.gov.au/tools-techniques/wider-economic-benefits.

Source: CIE.

38 ATAP Wider Economic Benefits, https://www.atap.gov.au/tools-techniques/wider-economic-benefits.

8 Environmental impacts

The environmental impacts measured across scenarios are land take, GHG emissions from residential buildings and EV use, transport tailpipe emissions, and noise and air pollution from transport. A summary of quantitative and monetised measures is shown in table 8.1.

- The Dispersed City scenario has the highest GHG emissions. This is driven by very high transport emissions. It also has the highest air and noise pollution costs.
- The Distributed State scenario has the lowest GHG emissions in total. It also has the least noise and air pollution from transport, reflecting a lower cost of noise and air pollution in regional areas as compared to Melbourne. However, it has the highest land take of any scenario.
- The Compact City scenario has the lowest emissions from transport and the lowest land take, but high embodied emissions push its total emissions above scenario 5.
- The difference in GHG emissions between urban built form scenarios are substantially smaller than the difference in emissions brought about by faster or slower decarbonisation pathways.

8.1 Summary of environmental impacts

Item	Sc 1 Compact city	Sc 2 Consolidated city	Sc 3 Dispersed city	Sc 4 Network of cities	Sc 5 Distributed state
	ha	ha	ha	ha	ha
Land take					
Total difference to scenario 3	**-31 260**	**-18 987**	**0**	**1 972**	**24 090**
	Mt CO2e	Mt CO2e	Mt CO2e	Mt CO2e	Mt CO2e
GHG emissions					
GHG emissions from buildings	15.5	8.3	0	1.4	-1.8
GHG emissions from transport	-17.3	-7.9	0	-1.6	-10.8
Total	**-1.8**	**0.4**	**0**	**-0.1**	**-12.6**
	$m	$m	$m	$m	$m
Environmental costs					
GHG emissions from buildings	1 898	1 017	0	181	-218

Item	Sc 1 Compact city	Sc 2 Consolidated city	Sc 3 Dispersed city	Sc 4 Network of cities	Sc 5 Distributed state
GHG emissions from transport	-2 123	-965	0	-190	-1 328
GHG total	**-225**	**52**	**0**	**-9**	**-1546**
Noise and air pollution from transport	-529	-342	0	-765	-1 465
Total GHG and noise and air pollution	**-754**	**-290**	**0**	**-774**	**-3 011**

Source: CIE

Other potential sources of GHG emissions which we have not included are emissions from non-residential buildings and emissions from infrastructure development, including transport infrastructure. These were not measured due to data constraints and a lack of a standardised approach.

Land take

Measurement approach

Additional land for urban use is based on assumptions about lot sizes and floor space ratios for dwellings and non-residential development, shares of greenfield development in each type of area and land required for local infrastructure and open space. The method is set out in detail in Appendix O.

Outcomes

Residential and local infrastructure land requirements are lowest for the Compact City scenario and increase across scenarios to be highest for Distributed State, both for 2021 to 2036 and 2036 to 2056 (table 8.2 and table 8.3). The land requirements differ by type of location:

- no additional urban land is ever required in inner and middle Melbourne as these areas are assumed to have no greenfield development
- for Dispersed City, the largest land take is in Melbourne's New Growth Areas
- for Network of Cities and Distributed State, the largest additional land take is in regional cities and regional centres/rural areas respectively.

8.2 Residential and local infrastructure land requirements 2021 to 2036

Region	1 Compact city	2 Consolidated city	3 Dispersed city	4 Network of cities	5 Distributed state
	ha	ha	ha	ha	ha
Inner Melbourne	0	0	0	0	0
Middle Melbourne	0	0	0	0	0
Outer Melbourne	92	119	144	109	98
Melbourne new growth areas	6 271	9 005	11 791	8 298	7 394
Regional Cities	4 530	5 620	6 726	11 226	8 881
Regional Centres and Rural Areas	6 012	8 658	11 298	10 421	17 561
Total	**16 905**	**23 403**	**29 959**	**30 054**	**33 935**

Source: CIE.

8.3 Residential and local infrastructure land requirements 2036 to 2056

Region	1 Compact city	2 Consolidated city	3 Dispersed city	4 Network of cities	5 Distributed state
	ha	ha	ha	ha	ha
Inner Melbourne	0	0	0	0	0
Middle Melbourne	0	0	0	0	0
Outer Melbourne	123	152	201	146	110
Melbourne new growth areas	7 509	9 560	15 557	9 474	7 539
Regional Cities	6 821	8 318	9 968	19 331	14 416
Regional Centres and Rural Areas	5 916	8 101	12 278	11 037	35 292
Total	**20 369**	**26 131**	**38 005**	**39 988**	**57 357**

Source: CIE.

We have also measured non-residential land take and open space land take.

- Non-residential land take is much smaller than for residential and local infrastructure, but has a similar pattern across scenarios
- Open space land take differs as the highest land take would be for Compact City. This is because there is greater capacity in existing open space in less dense areas, meaning that additional open space would not be required
  – Note that while additional open space in inner areas is desirable to maintain open space standards, in practice it will likely be difficult to obtain and other options such as augmenting and making open space useable for longer periods (lighting, synthetics) may be used instead.

The total land differences across scenarios are moderately significant in the context of overall urban land, but less significant in the context of Victoria as a whole. For example, Compact City scenario requires 313 square kilometres less of land than the Dispersed

City scenario. This compares to a current area of Melbourne of about 2 881 square kilometres[39] and an area of Victoria of 227 000 square kilometres.

8.4 Total land requirements 2021 to 2056

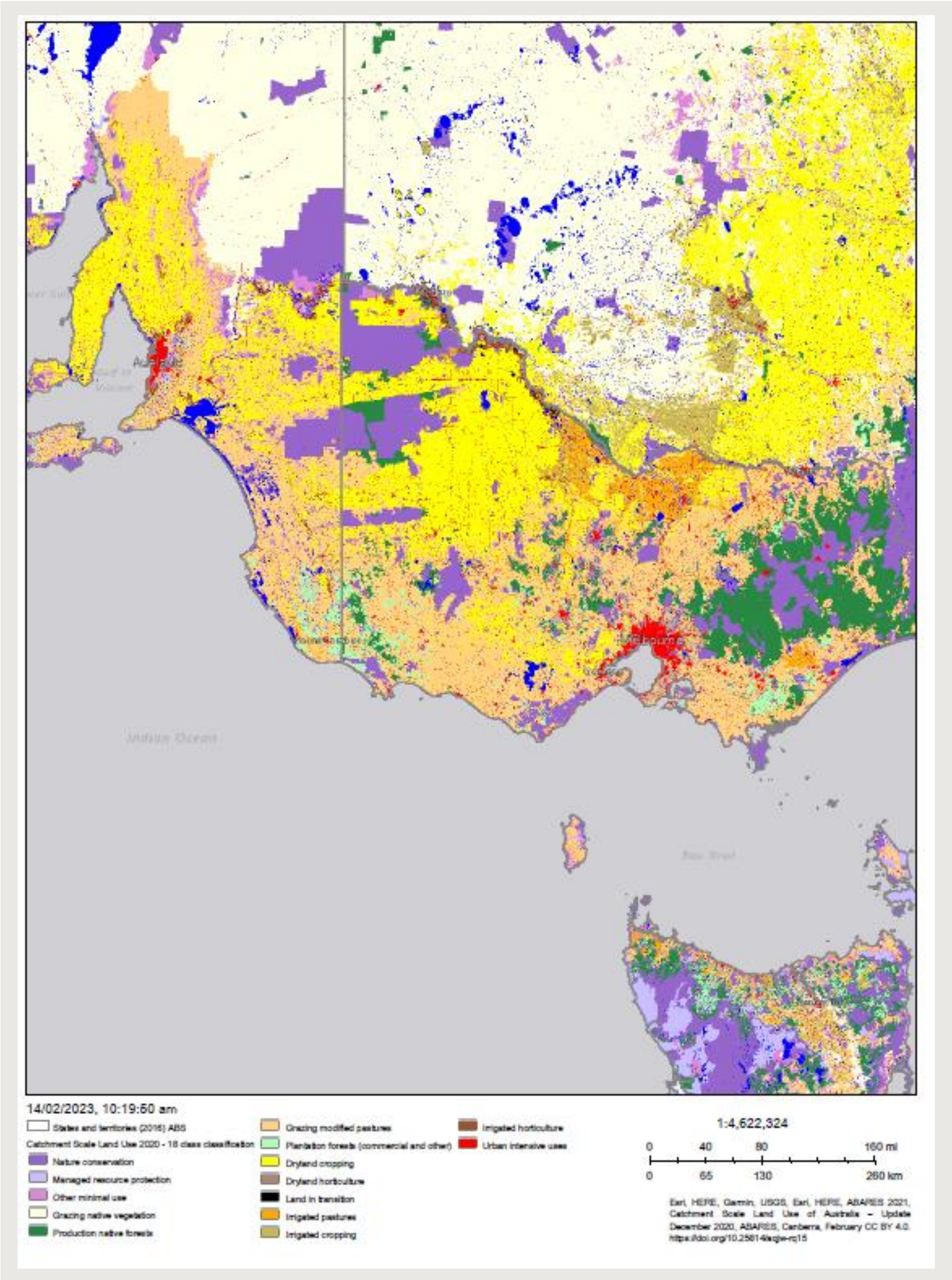
Region	1 Compact city	2 Consolidated city	3 Dispersed city	4 Network of cities	5 Distributed state
	ha	ha	ha	ha	ha
Residential and local infrastructure	37 275	49 534	67 963	70 041	91 292
Non-residential	735	939	1 549	1 782	2 533
Open space	3 031	2 841	2 789	2 451	2 566
Total	41 041	53 314	72 301	74 274	96 391
Difference to Dispersed City	-31 260	-18 987	0	1 972	24 090

Source: CIE.

Whether the additional urban land is in areas with environmental implications is difficult to know. Our expectation is that it would mainly come from agricultural land, based on current use of land in areas around Melbourne and other regional cities and towns (chart 8.5).

39 Based on the ABS urban centre and locality of Melbourne.

8.5 Catchment scale land use in Victoria



Data source: https://erin.maps.arcgis.com/apps/webappviewer/index.html?id=f401f2b81b204c82adf4d2aebe8f9a5d.

GHG emissions from buildings

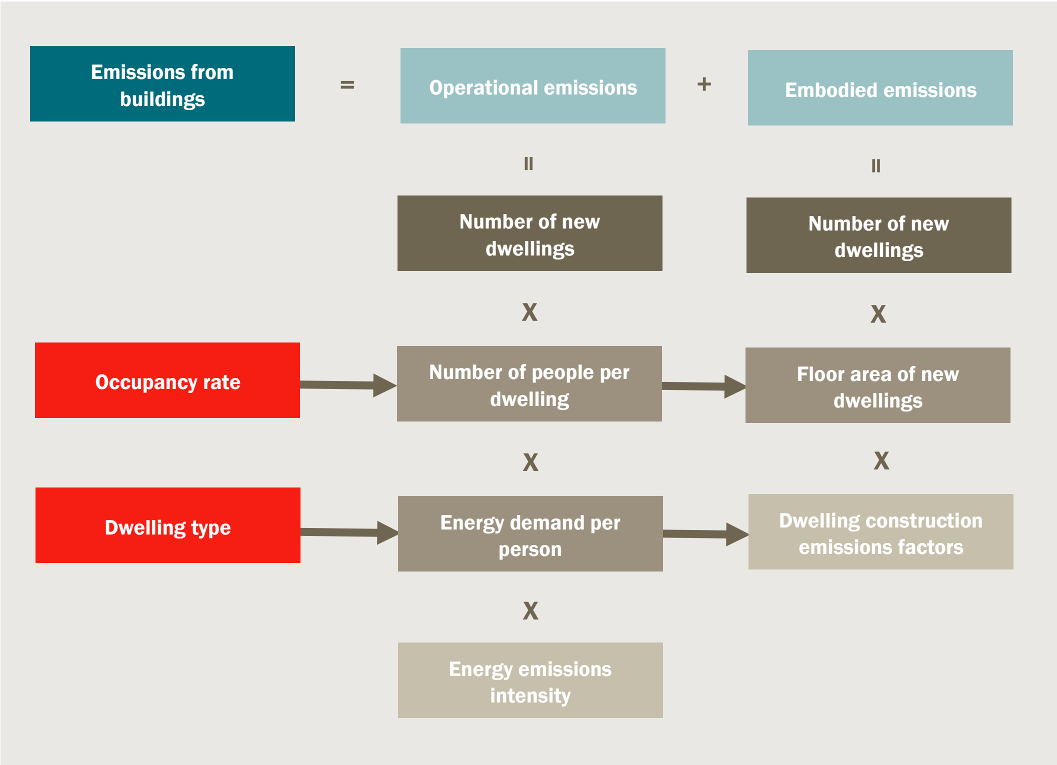
Measurement approach

New buildings are responsible for two main types of GHG emissions:

- **Operational emissions**, which refers to the emissions associated with energy use of the building's occupants. This type of emission is recurring throughout the building's lifecycle
- **Embodied emissions**, the GHG emissions incurred by the physical creation process of the building. This includes creation and transport of materials, the actual construction of the building, and demolition

These two emission types are then added to give the final construction emissions for each scenario. Chart 8.6 shows the components needed to calculate each emission type. A more detailed methodology is found in Appendix N.

8.6 Methodology for estimating GHG emissions from buildings



Source: CIE.

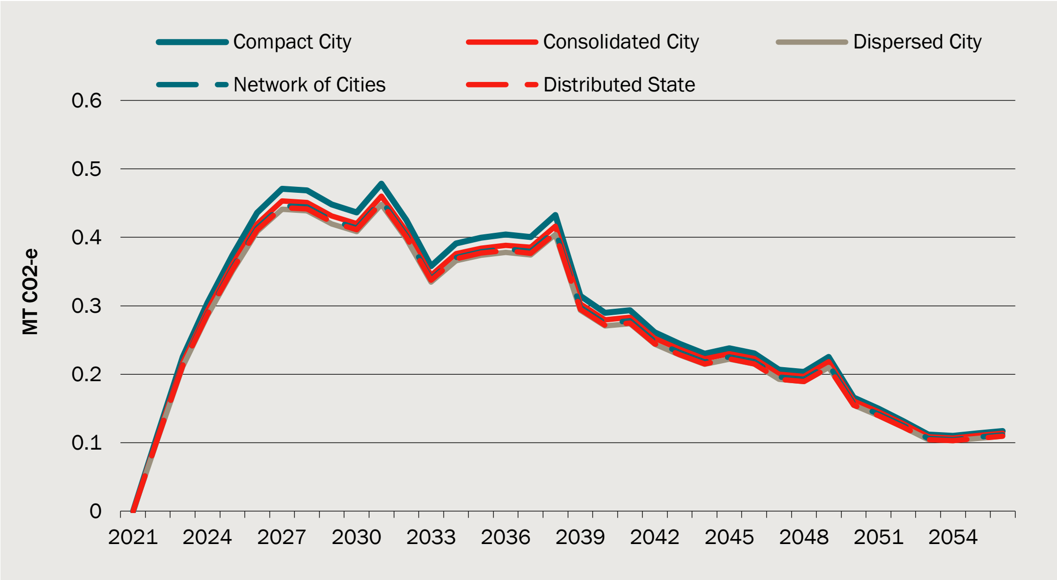
Outcomes

Charts 8.7, 8.8 and 8.9 show how operational and embodied emissions change over time for each scenario.

Grid decarbonisation beyond 2036 means that operational emissions are reduced to near zero, with very little difference between scenarios. This contributes towards the relatively minor overall differences between scenarios.

However, throughout the time when operational emissions are significant, the Compact City scenario has the highest operational emissions, due to a higher proportion of new dwellings being apartments, which use more emissions-intensive energy per person in a year. Note that the higher energy use for apartments reflects updated residential standards for energy efficiency, which allow a larger energy budget for apartments compared to detached houses. For example, a 100m2 apartment has a net energy allowance 47 per cent higher than a similar detached house.[40]

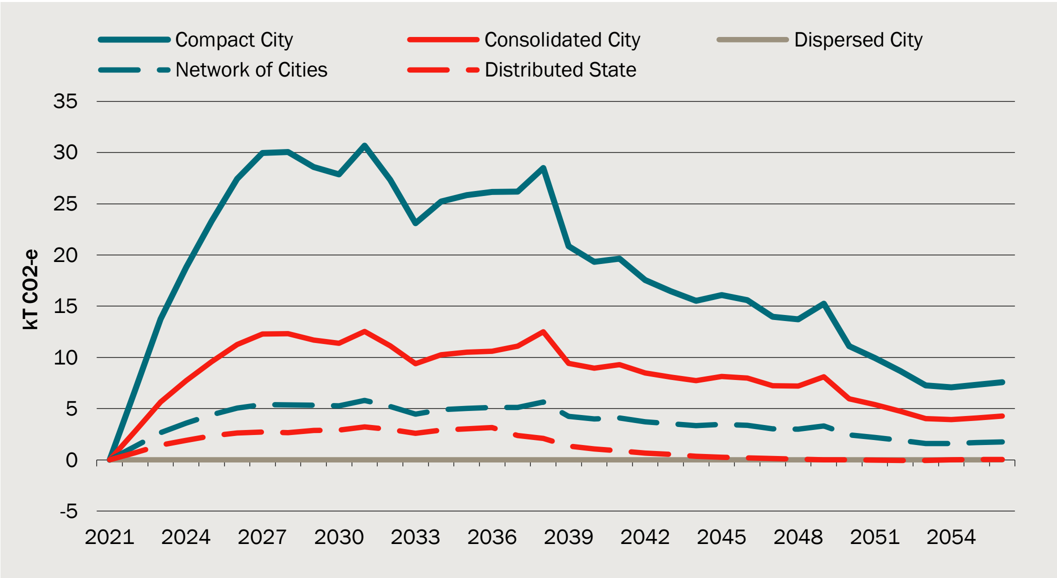
8.7 Operational emissions of new residential buildings



Note: As explained in the measurement approach, only includes operational emissions from buildings constructed in 2021 or later.

Data source: CIE.

8.8 Operational emissions relative to Dispersed City scenario



Note: New residential buildings only

Data source: CIE.

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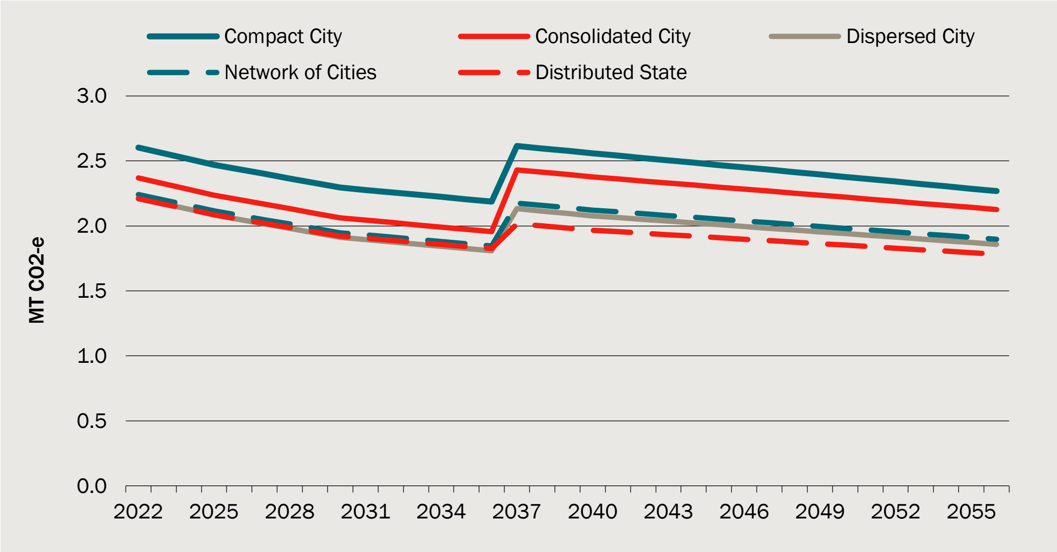
40 ABCB Whole of Home energy calculator, https://www.abcb.gov.au/resources/filter/calculators for Victoria and Climate Zone 6.

Embodied emissions slightly decrease over time as the emissions intensity decreases. The increase in the year 2037 is because of the change to dwelling numbers for the period to 2036 versus from 2037 to 2056. Unlike operational emissions, embodied emissions remain relevant for the entire evaluation period, and so have a larger overall impact on environmental costs.

8.9 Embodied emissions by scenario over time

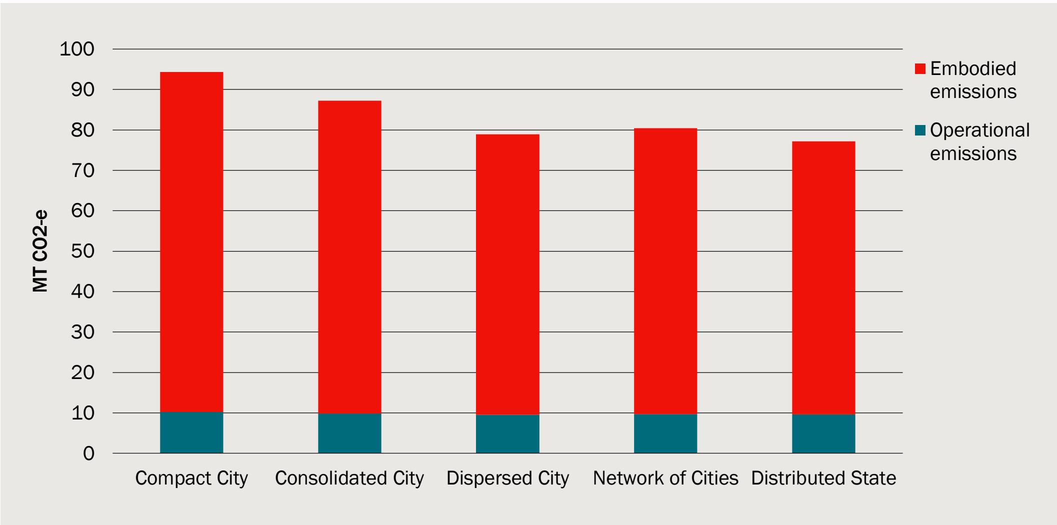


Note: 2021 was excluded, because no new buildings were constructed in 2021.

Data source: CIE.

Total operational and embodied emissions from buildings across each scenario are presented in chart 8.10. The Compact City scenario has the highest combined GHG emissions from buildings, and the Distributed State scenario has the lowest.

8.10 Total emissions from residential buildings from 2021 to 2056



Data source: CIE.

This result is driven primarily by the higher relative proportion of new class 2 residential dwellings in the Compact City scenario compared to the other scenarios.[41]

- Because embodied emissions decrease in emissions intensity more slowly than operational emissions, the higher embodied emissions of class 2 dwellings is the main driver of the overall results for building GHG emissions.
- Class 2 dwellings (apartments) lead to higher embodied GHG emissions because the materials involved in the construction of class 2 dwellings are more emissions intensive, such as steel and concrete
- This is partly offset by the smaller floor size of apartments compared to detached dwellings and townhouses, but the increase in the occupancy rate for apartments in the Compact City scenario decrease this difference over time.

While there are some differences in GHG emissions from residential buildings across the scenarios, these are very small in the context of overall GHG emissions and the variation in possible pathways to decarbonising the electricity grid and other activities.

Using an estimate for the cost of a tonne of carbon equivalent, it is possible to find the dollar value of these differences in emissions across scenarios.

- A constant cost of $123/tCO2-e was used. This is the initial value of carbon in the NSW treasury guide to carbon value in cost-benefit analysis[42]

The Compact City scenario costs $1.9b more than the Dispersed City scenario and the Distributed State scenario costs $0.2b less than the Dispersed City scenario (table 8.11).

8.11 Environmental impact from residential buildings

Scenario	Total emissions	Emissions compared to Dispersed City scenario	Cost of emissions	Costs compared to Dispersed City scenario
	Mt C02 e	Mt C02 e	$m	$m
1. Compact city	94	15.5	11 608	1 898
2. Consolidated city	87	8.3	10 727	1 017
3. Dispersed city	79	0	9 710	0
4. Network of cities	80	1.4	9 891	181
5. Distributed state	77	-1.8	9 492	-218

Note: No discount rate was applied, so all dollar values are real undiscounted.

Source: CIE.

41 Class 1 and class 2 dwellings are defined in the National Construction Code (NCC) as houses, both attached and detached, and apartment blocks respectively. A single apartment unit is referred to in the NCC as a single-occupancy unit (SOU) in a class 2 building. For conciseness, in this report a class 2 dwelling refers to a SOU rather than the entire building.

42 NSW Treasury 2023. NSW Government Guide to Cost-Benefit Analysis, Technical note. https://www.treasury.nsw.gov.au/sites/default/files/2023-03/20230302-technical-note-to-tpg23-08_carbon-value-to-use-for-cost-benefit-analysis.pdf

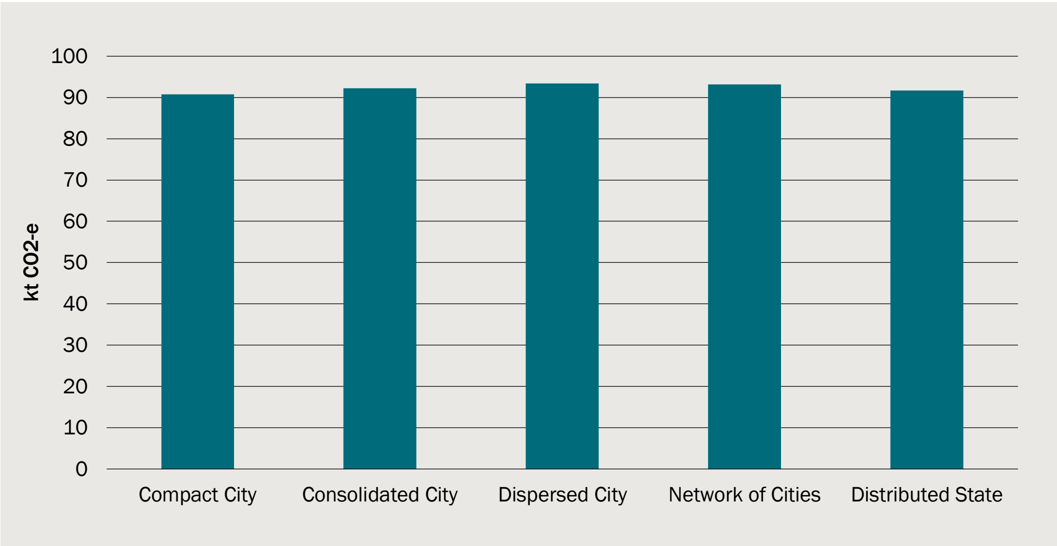
Environmental impacts of transport

Tailpipe GHG emissions

ARUP provided strategic transport modelling for the project, including tailpipe GHG emissions. Charts 8.12 and 8.13 show their results for daily CO2 emissions in 2036 and 2056. For more detail on how these were derived, see Appendix C of the ARUP report (ARUP, 2023).[43]

The scenarios with the lowest tailpipe GHG emissions in 2036 are Compact City and Distributed State, while the highest tailpipe GHG emissions are in Dispersed City and Network of Cities. This is driven by greater car use in the Dispersed City and Network of Cities scenarios, leading to more vehicle kilometres travelled (VKT) and more congestion. Note that tailpipe emissions are very small by 2056 because most vehicles are assumed to be electric.

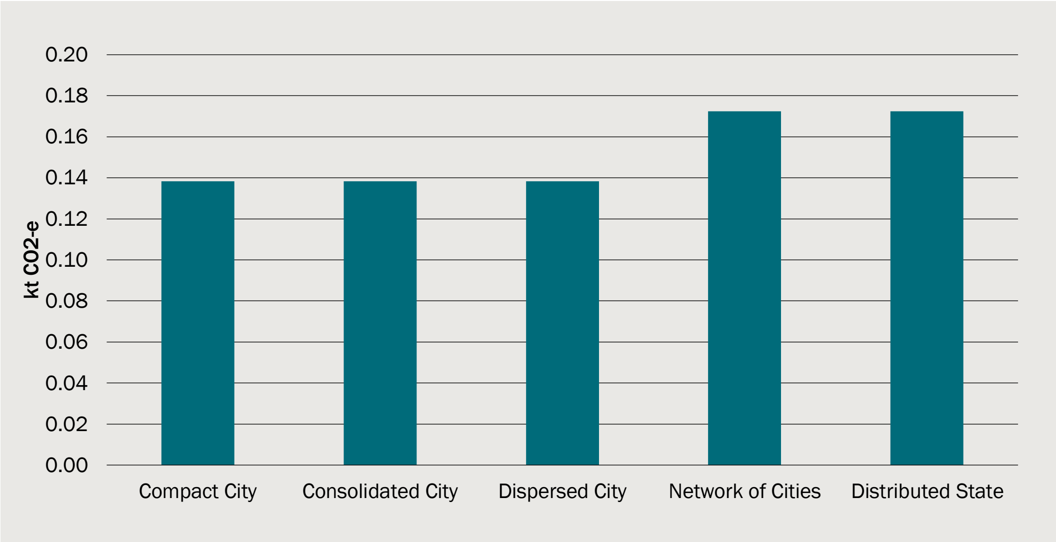
8.12 Total daily CO2 emissions in 2036



Data source: ARUP.

43 ARUP 2023, *Urban Development Scenarios: Strategic Transport Modelling*, prepared for Infrastructure Victoria

8.13 Total daily CO2 emissions in 2056



Data source: ARUP.

In 2056 the magnitude of daily CO2 emissions has fallen by over 99 per cent in every scenario. The main reason for this is that by 2056, there is an assumed 100 per cent electric vehicle (EV) uptake across the entire fleet, with no tailpipe emissions. This leaves diesel powered V/Line train services as the only GHG emitters in 2056.

The impact of this EV assumption is that by the end of the evaluation period there is very little difference between the scenarios in terms of tailpipe GHG emissions. Table 8.14 shows the difference between scenarios in tailpipe GHG emissions.

Despite this, tailpipe emissions contribute significantly to overall differences between scenarios. The Compact City scenario produces 15.4 Mt CO2-e more than the Dispersed City scenario from operational and embodied building emissions (see table 8.11) but 16.8 Mt CO2-e less than the Dispersed City scenario from tailpipe emissions, with the end result that Compact City has slightly lower overall GHG emissions. Building and tailpipe emissions pushing scenarios in opposite directions contributes to the small overall difference in GHG emissions between scenarios.

8.14 Difference in tailpipe GHG emissions across scenarios from 2021 to 2056

Scenario	Difference from Dispersed City scenario
	MT CO2-e
1. Compact city	-16.75
2. Consolidated city	-7.61
3. Dispersed city	0.00
4. Network of cities	-1.54
5. Distributed state	-10.85

Source: CIE based on data from ARUP.

GHG from EV use

While EVs do not have any tailpipe emissions, they are powered by energy from the grid, and so are responsible for the GHG emissions produced in the generation of that electricity.

As a central estimate for the amount of electricity consumed by EVs we used the step change scenario from AEMOs ISP2022 forecast, adjusted for the draft 2023 IASR.[44]

Each scenario was given an adjustment factor based on the amount of vehicle kilometres travelled relative to the base case. The central estimates were multiplied by these adjustment factors to give electricity use from EVs in each scenario for every year between 2021 and 2056.

This was then multiplied by the electricity emissions intensity factor to get final emissions associated with EV use. Table 8.15 shows the GHG outcomes from EVs.

- The Compact City scenario has the lowest emissions and the Distributed State has the highest.
- The differences between scenarios are relatively small. This is because by the time there are large differences in the amount of electricity needed to power EVs, the grid has been decarbonised enough that a lot of electricity can be produced with very little associated GHG emissions.

8.15 GHG emissions from EV operation

Scenario	Total emissions	Difference from Dispersed City scenario	Cost of emissions	Cost difference from Dispersed City scenario
	MT CO2-e	MT CO2-e	$m	$m
1 .Compact City	9.68	-0.51	1 190	-62
2. Consolidated City	9.95	-0.23	1 224	-29
3. Dispersed City	10.19	0.00	1 253	0
4. Network of Cities	10.17	-0.01	1 251	-2
5. Distributed State	10.24	0.05	1 259	6

Source: CIE.

Noise and air pollution

Use of transport incurs social costs other than GHG emissions. Most notably, transport leads to:

- air pollution, and
- noise pollution

44 AEMO Draft IASR (2023), Detailed Electric Vehicle Workbook - Draft 2023 IASR – Orchestrated Change, https://aemo.com.au/consultations/current-and-closed-consultations/2023-inputs-assumptions-and-scenarios-consultation

To estimate each of these, total daily VKT was taken for different vehicle types from the ARUP transport modelling, and then multiplied by a conversion factor from 1000 VKT to $AUD given in the 2021 ATAP guidelines.[45]

ARUP's transport modelling had kilometres travelled for the following vehicle types:

- Cars and Light Commercial Vehicles (LCVs)
- Heavy Commercial Vehicles (HCVs)
- Rail, Bus and Tram

Conversion rates used for each of these vehicle types are shown in table 8.16. For air pollution, ATAP has separate parameter values for electric vehicles compared to other vehicle types. This distinction is not made for noise pollution.

8.16 Parameter values used for air and noise pollution

	Cars and LCVs	HCVs	Rail	Bus	Tram
	$/1000 VKT	$/1000 VKT	$/1000 PKT	$/1000 PKT	$/1000 PKT
Air pollution					
Urban					
Petrol/diesel	2.78	69.92	0.06	14.04	0.13
EV	0.69	2.07	0.05	0.12	0.13
Rural					
Petrol/diesel	1.84	6.99	0.06	2.80	0.00
EV	0.70	1.500	0.06	0.09	0.00
Noise pollution					
Urban	7.57	43.72	10.30	47.11	10.3
Rural	0.10	0.44	1.03	0.02	0.00

Source: CIE, based on ATAP.

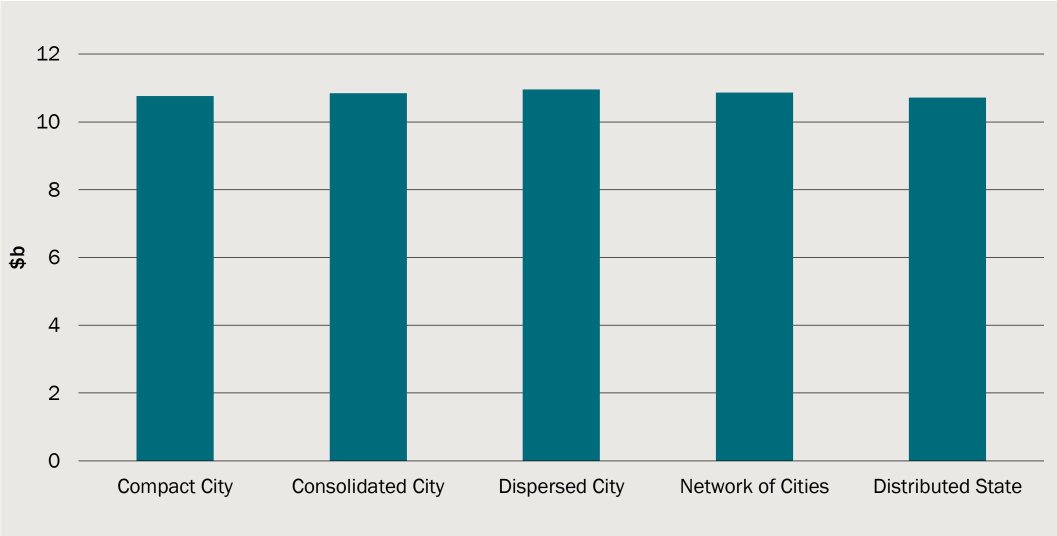
ATAP reports separate parameters for cars and LCVs, but the ARUP transport modelling grouped these together. We used an average of the two parameter values for this category.

It was further assumed that all cars and buses are medium sized, and that there are no trams outside Greater Melbourne. Finally, we used rural parameter values for the whole state outside of Greater Melbourne. This may lead to an underestimation of the externalities, particularly for the distributed state scenario.

Charts 8.17 and 8.18 show the air pollution and noise externality respectively. The dispersed city has the highest cost in both cases, with the lowest cost in the distributed state scenario. This is likely due to the impacts of air pollution and noise pollution being larger in urban centres rather than rural communities.

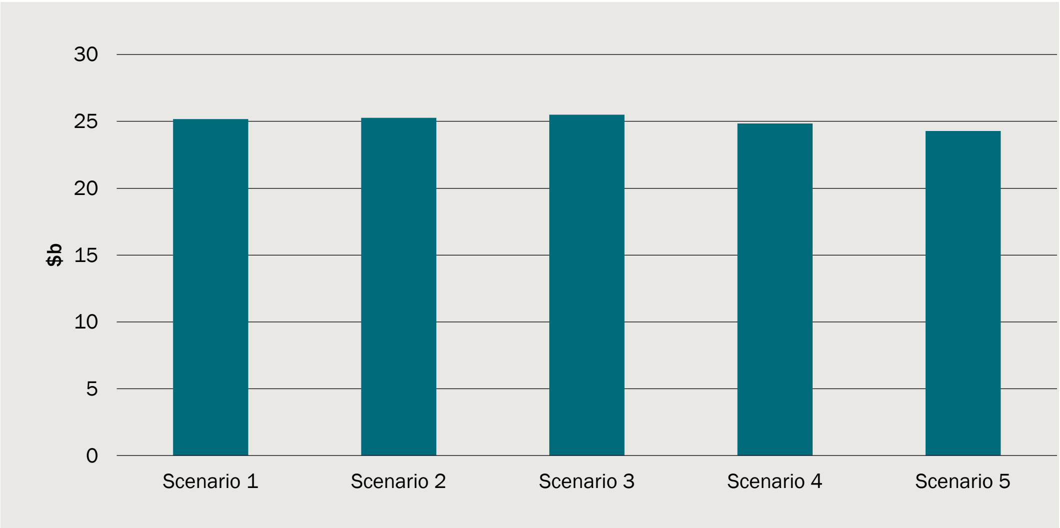
45 ATAP 2021, *Australian Transport Assessment and Planning Guidelines: PV5 Environmental parameter values*, see https://www.atap.gov.au/parameter-values/environment/index

8.17 Air pollution transport externality (2021 to 2056)



Data source: CIE, ARUP and ATAP.

8.18 Noise pollution transport externality (2021 to 2056)



Data source: CIE, ARUP and ATAP.

8.19 Air pollution and noise pollution by scenario

Scenario	Total non-GHG transport externalities	Relative to dispersed city
	$m	$m
1. Compact City	35 940	-529
2. Consolidated City	36 127	-342
3. Dispersed City	36 469	0
4. Network of Cities	35 704	-765
5. Distributed State	35 004	-1 465

Source: CIE.

Key sensitivities for GHG emissions

There are a wide variety of possible outcomes for GHG emissions estimates depending on how rapidly and how decarbonisation of energy occurs. Table 8.20 shows three alternative decarbonisation scenarios.

- A faster decarbonisation scenario in which embodied emissions intensity decreases faster. This could be achieved by, for instance, decarbonising concrete and steel production. If this occurs the overall GHG emissions (excluding tailpipe) for the scenarios falls substantially and the differences between scenarios narrow.
- A slower decarbonisation scenario, following the AEMO Slow Change scenario rather than the Step Change scenario, and with no reduction in embodied emissions intensity. This leads to much larger GHG emissions from buildings and electric vehicles, although impacts between scenarios are relatively similar
- A no decarbonisation scenario, in which neither operational or embodied emissions intensity decreases from current. This leads to very large increases in GHG emissions and makes the scenarios much more similar. This is because offsetting impacts occur. For example, the Compact City scenario has lower GHG emissions from electricity produced for powering electric vehicles. However, its building GHG emissions are higher and don't benefit from decarbonisation

Table 8.20 highlights that the GHG differences *between scenarios* (difference between rows) is much smaller than the differences *from alternative rates of decarbonisation* (differences between columns). Overall GHG emissions reduction is much more closely linked to decarbonisation pathways than it is to spatial land use scenarios and urban form.

8.20 GHG emissions (excluding tailpipe) under alternative rates of decarbonisation

Scenario	Faster decarbonisation	Current settings	Slower decarbonisation	No decarbonisation
	Mt CO2-e	Mt CO2-e	Mt CO2-e	Mt CO2-e
1. Compact City	61	104	177	578
2. Consolidated City	58	97	170	579
3. Dispersed City	55	89	162	577
4. Network of Cities	56	91	164	580
5. Distributed State	54	87	160	579

Note: Includes building and EV operation GHG emissions but excluding tailpipe emissions.
Source: CIE

Energy use

Electricity use has been measured as part of the assessment of the overall demands placed on the grid (See Appendix E). The Compact City scenario has the highest electricity use and is 2 per cent higher than the Dispersed City scenario (table 8.21). Distributed State has the lowest operational electricity use.[46] Note that operational energy use excludes solar PV generated and used on site.

8.21 Operational electricity use

	Sc 1 Compact city	Sc 2 Consolidated city	Sc 3 Dispersed city	Sc 4 Network of cities	Sc 5 Distributed state
	GWh	GWh	GWh	GWh	GWh
2036					
Residential	16 014	15 704	15 487	15 618	15 618
Non-Residential	32 736	32 710	32 926	32 730	32 761
Total	48 750	48 414	48 414	48 348	48 379
2056					
Residential	39 184	38 086	36 928	37 509	37 003
Non-Residential	46 862	46 800	47 372	46 893	47 095
Total	86 046	84 886	84 300	84 402	84 097
Difference to Sc3 (per cent)	2.1	0.7	0.0	0.1	-0.2

Source: CIE.

Other impacts not quantified

There are many other possible environmental impacts that have not been measured because they cannot be identified and linked to spatial scenarios. These include:

- waste generated and the environmental impacts from alternative ways of disposing of waste
- water use and environmental impacts from this
- air pollution outside of transport — analysis of air pollution monitoring did not show consistent issues with air pollution that would suggest differences in health impacts across scenarios, and
- GHG emissions outside of residential buildings from energy and gas use and embodied energy, including from development of infrastructure.

46 Note that table 8.24 shows energy use for the entire dwelling stock. GHG emissions were calculated for new dwellings only, excluding the existing stock of housing in 2021. This was because total electricity demand is needed to identify electricity infrastructure requirements, while GHG emissions from existing dwelling stock are identical across scenarios, and so were not needed.

9 Equity impacts of scenarios

The key metrics we think are good indicators for equity are:

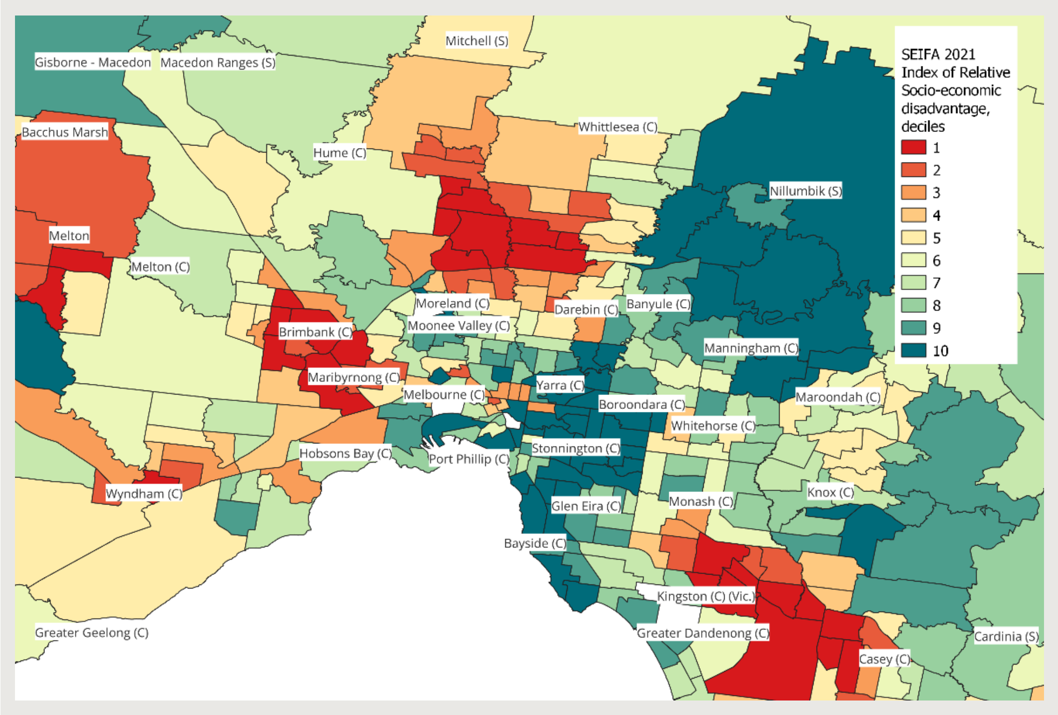
- **Spatial distribution of job accessibility** — Do areas of current disadvantage (as measured by SEIFA indices) have bigger or smaller improvements in accessibility under the scenarios?
- **Spatial distribution of housing costs** — Is there a more or less even availability of more affordable housing products spatially as a result of the scenarios?

These indicators fit within broader frameworks for considering equity, such as the socio-economic indices (SEIFA) developed by the Australian Bureau of Statistics. There is substantial spatial concentration of disadvantage in Melbourne (chart 9.1) and other Victorian cities (chart 9.2). Areas with the highest levels of disadvantage (i.e. the first decile) are typically in Melbourne's outer and growth areas.

The level of spatial distribution of disadvantage is primarily driven by inequalities in socio-economic outcomes. Socio-economic outcomes reflect inequality in income, education and socioeconomic outcomes of parents. For example, mothers' and fathers' education and occupation are both associated with their children's educational outcomes.[47] The overall spatial direction for Victoria can make some difference to spatial concentration of disadvantage.

47 Redmond, G., Wong, M., Bradbury, B. and Katz, I., 2014, *Intergenerational mobility: new evidence from the Longitudinal Surveys of Australian Youth*, NCVER research report.

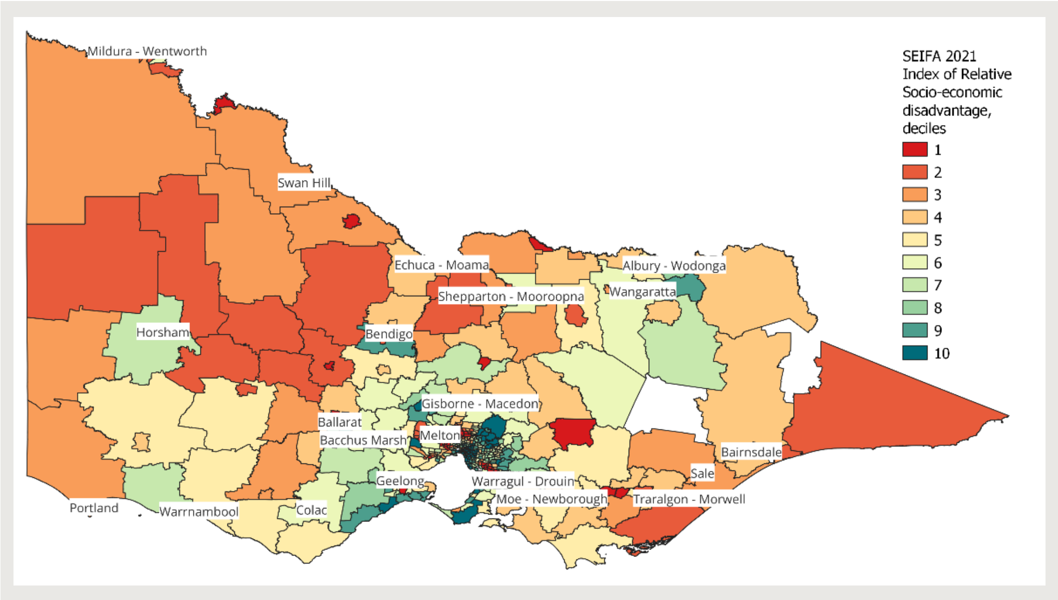
9.1 SEIFA disadvantage across Melbourne 2021



Note: Each shaded area corresponds to an SA2.

Data source: ABS, CIE.

9.2 SEIFA disadvantage across Victoria 2021



Note: Each shaded area corresponds to an SA2.

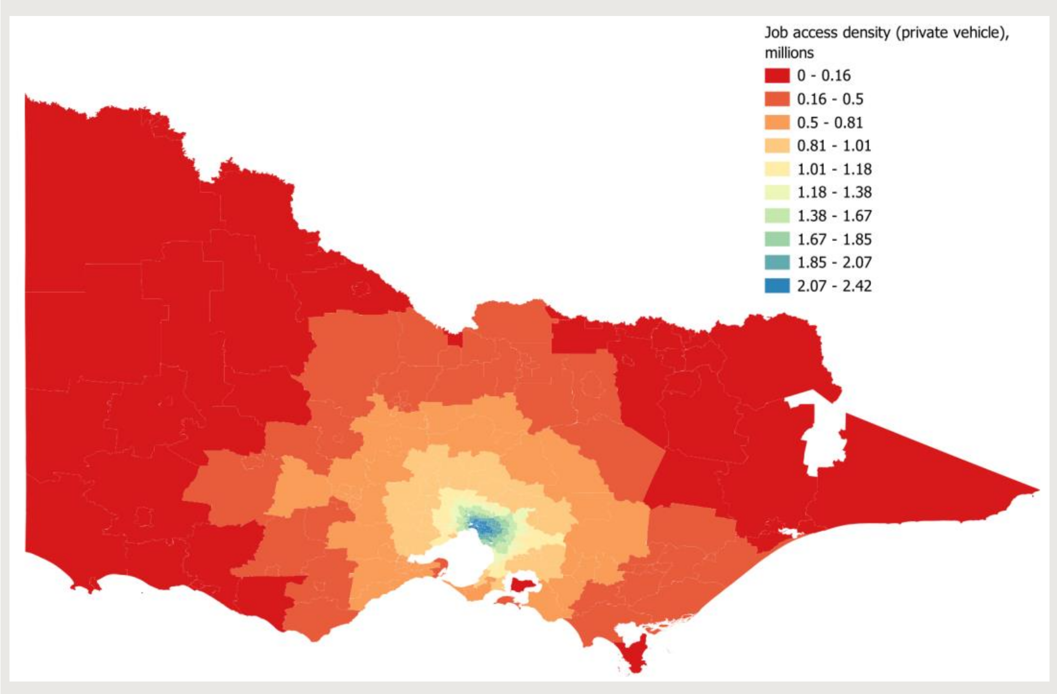
Data source: ABS, CIE.

Distribution of accessibility

Current distribution of accessibility to jobs

Accessibility to jobs by private vehicle (chart 9.3) and public transport (chart 9.4) are both much higher in Melbourne compared to regional areas. Accessibility to jobs in regional areas depends more on accessibility to Melbourne rather than to regional cities. Many of the areas with very low public transport accessibility are regional cities and rural areas, and these typically have moderate levels of disadvantage.

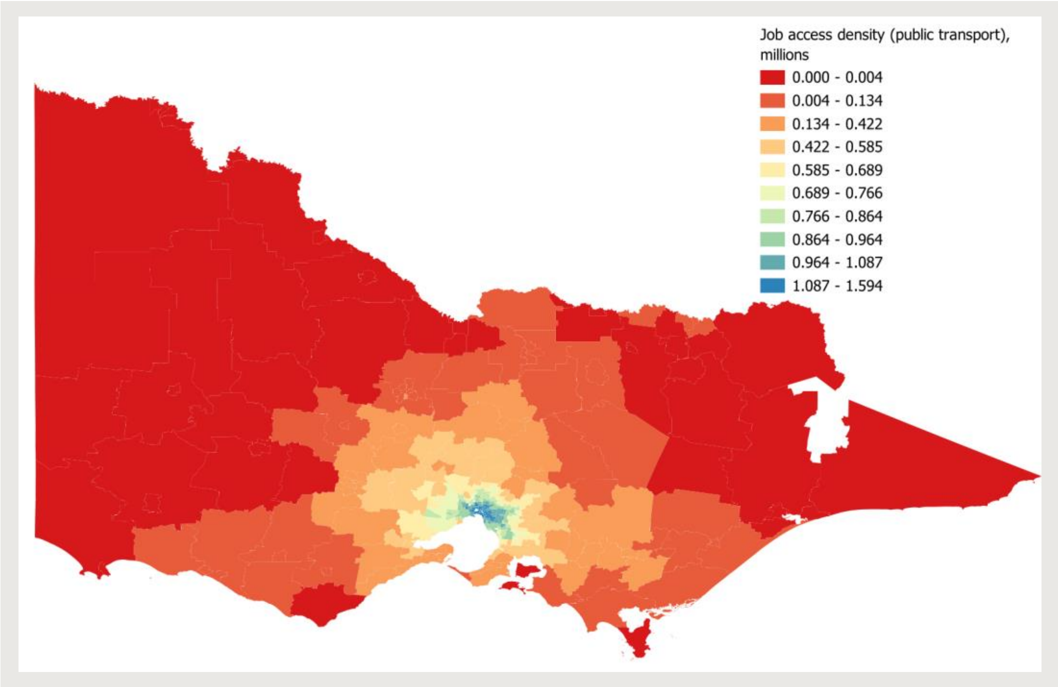
9.3 Job access density by private vehicle, Victoria in 2018



Note: Job access density metrics do not have easily interpretable units. Each shaded area corresponds to an SA2.

Data source: Transport model outputs provided by Arup via IV, CIE.

9.4 Job access density by public transport, Victoria in 2018

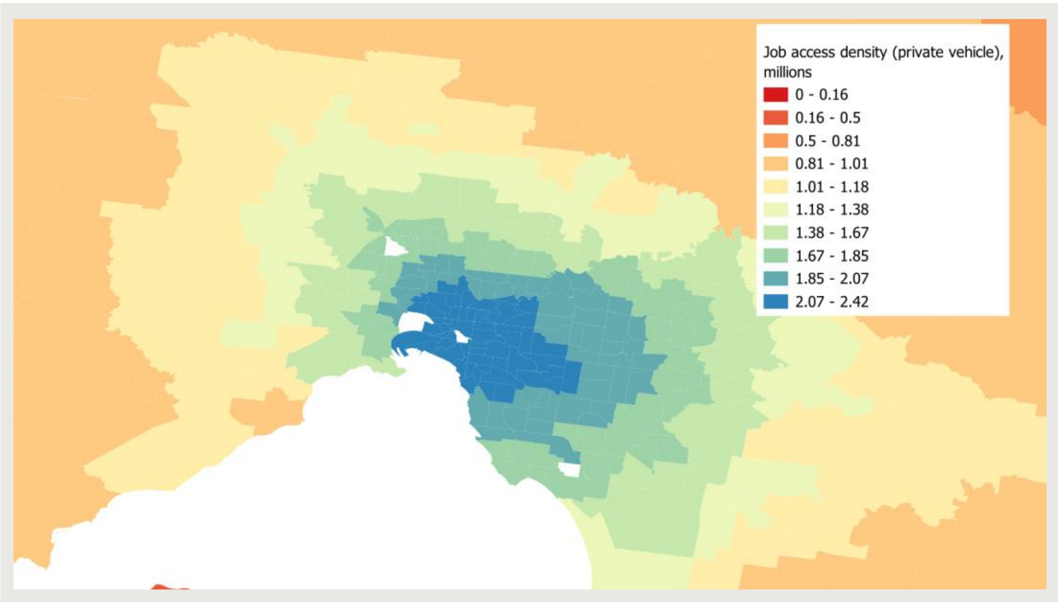


Note: Job access density metrics do not have easily interpretable units. Each shaded area corresponds to an SA2.

Data source: Transport model outputs provided by Arup via IV, CIE.

Within Melbourne, accessibility via private vehicle declines more consistently with distance from the CBD (chart 9.5). Job access density via public transport does not have as smooth of a relationship with distance to the CBD, with higher levels of accessibility visible along train lines (chart 9.6). Accessibility via both car and public transport is higher in the relatively less disadvantaged east side of Melbourne compared to the north or west.

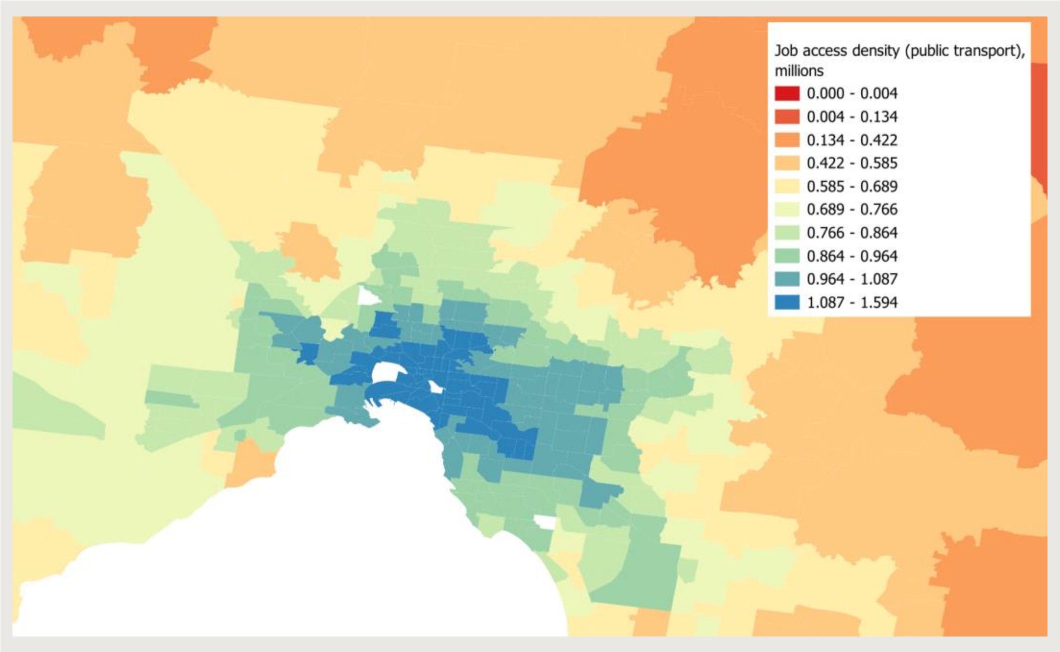
9.5 Job access density by private vehicle, Melbourne in 2018



Note: Each shaded area corresponds to an SA2.

Data source: Transport model outputs provided by Arup via IV, CIE.

9.6 Job access density by public transport, Melbourne in 2018

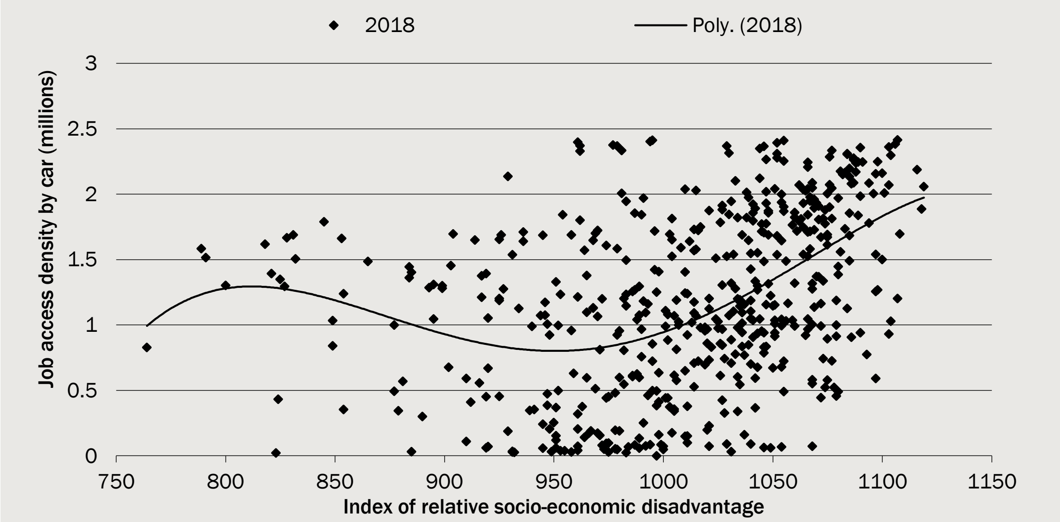


Note: Each shaded area corresponds to an SA2.

Data source: Transport model outputs provided by Arup via IV, CIE.

Accessibility by private vehicle (chart 9.7) and by public transport (chart 9.8) both tend to have a U-shaped relationship with disadvantage. That is, accessibility is high in both areas of low and high disadvantage, but accessibility is lower in areas with moderate levels of disadvantage. Much of this reflects that regional areas with low accessibility have moderate levels of disadvantage.

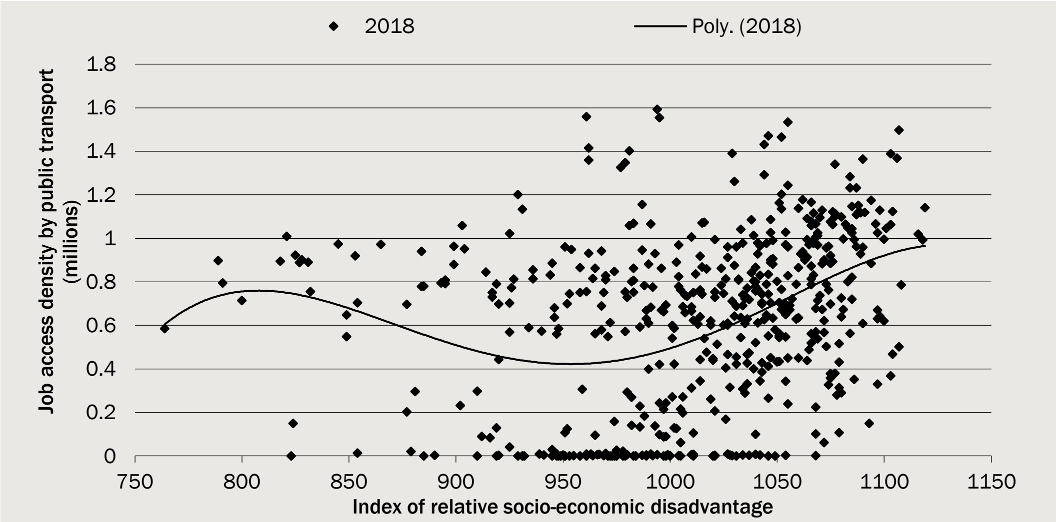
9.7 Job access density by private vehicle and disadvantage, 2018



Note: Each dot corresponds to an SA2. A higher value on the index of relative socio-economic disadvantage denotes being less disadvantaged.

Data source: CIE.

9.8 Job access density by public transport and disadvantage, 2018



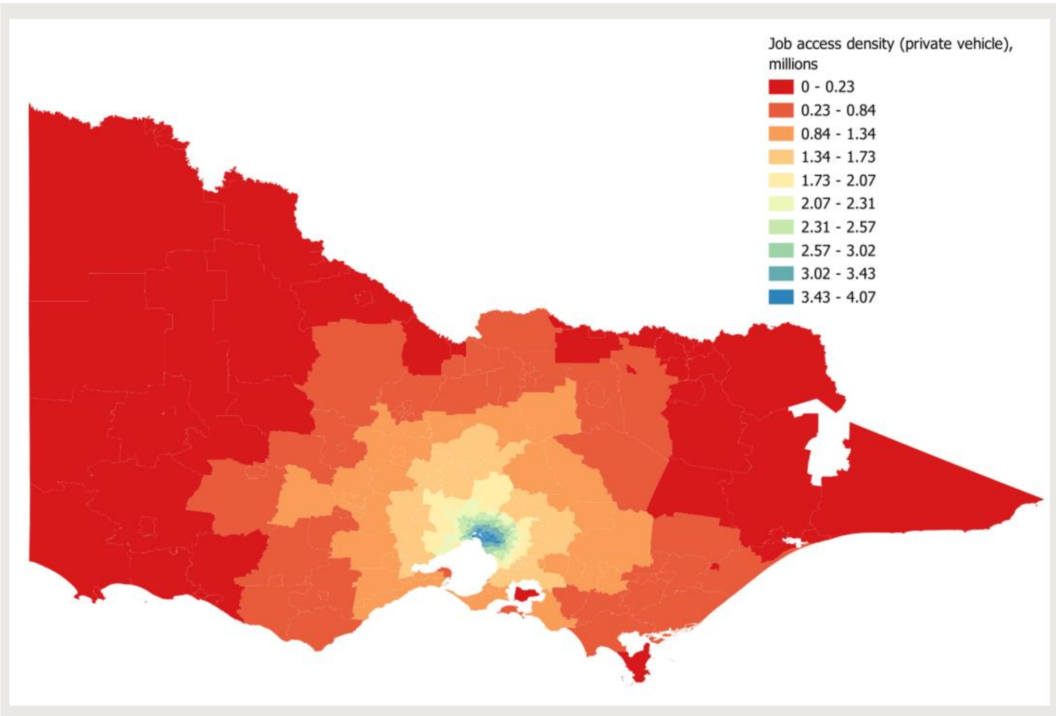
Note: Each dot corresponds to an SA2. A higher value on the index of relative socio-economic disadvantage denotes being less disadvantaged.

Data source: CIE.

Distribution of job accessibility in 2056 by scenario

Job accessibility by private vehicle differs relatively little across regional Victoria between the Compact City scenario (chart 9.9) and Distributed State scenario (chart 9.10), except that growth areas in the north of Melbourne have higher accessibility to jobs in Distributed State scenario.

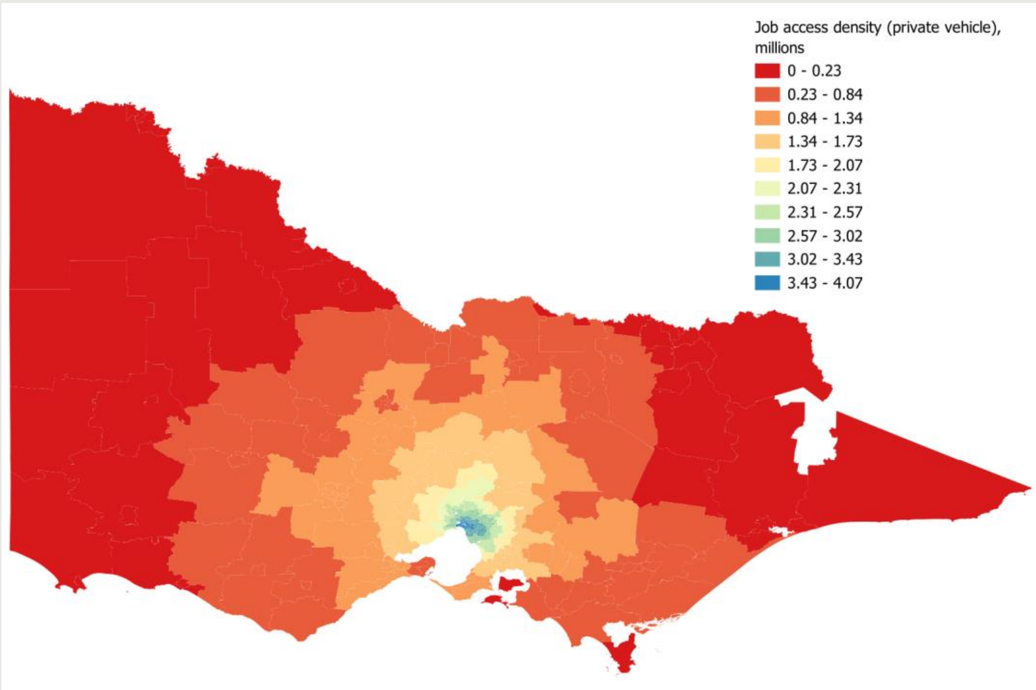
9.9 Job access density by private vehicle, Victoria in 2056, Compact City scenario



Note: Each shaded area corresponds to an SA2.

Data source: Transport model outputs provided by Arup via IV, CIE.

9.10 Job access density by private vehicle, Victoria in 2056, Distributed State scenario



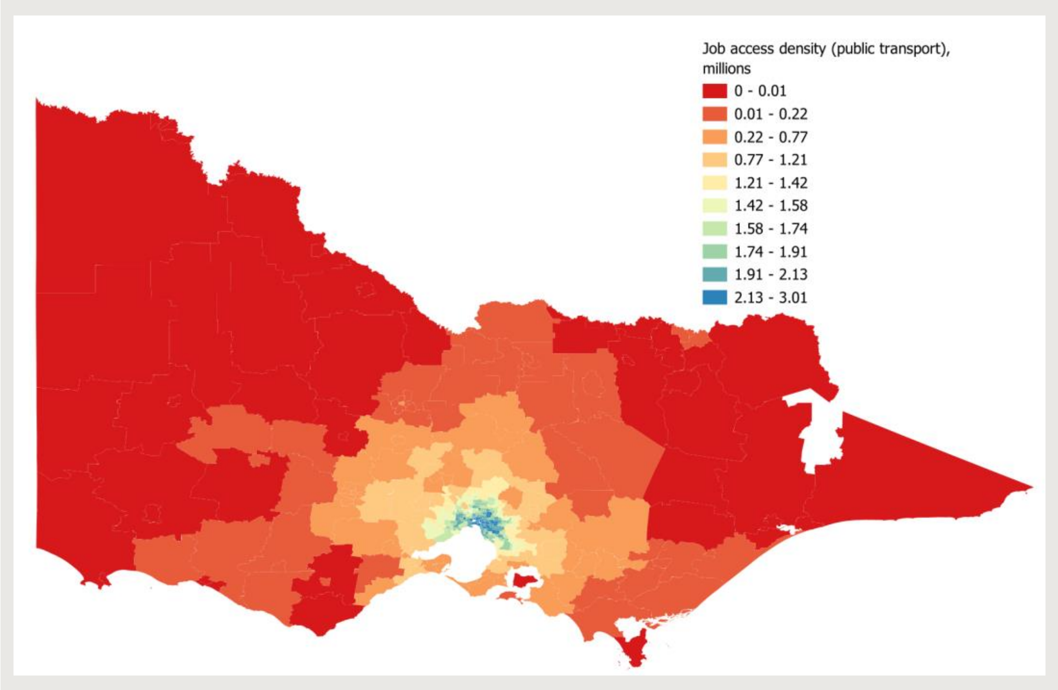
Note: Each shaded area corresponds to an SA2.

Data source: Transport model outputs provided by Arup via IV, CIE.

Differences in public transport accessibility between the Compact City scenario (chart 9.11) and Distributed State scenario (chart 9.12) are similarly small for regional areas. However, job access density via public transport is quite low (less than 500 000) in most regional areas, with some even having no jobs accessible based on this metric.[48]

48 The job access density metric applies a weighting of zero to jobs in destinations more than 180 minutes away.

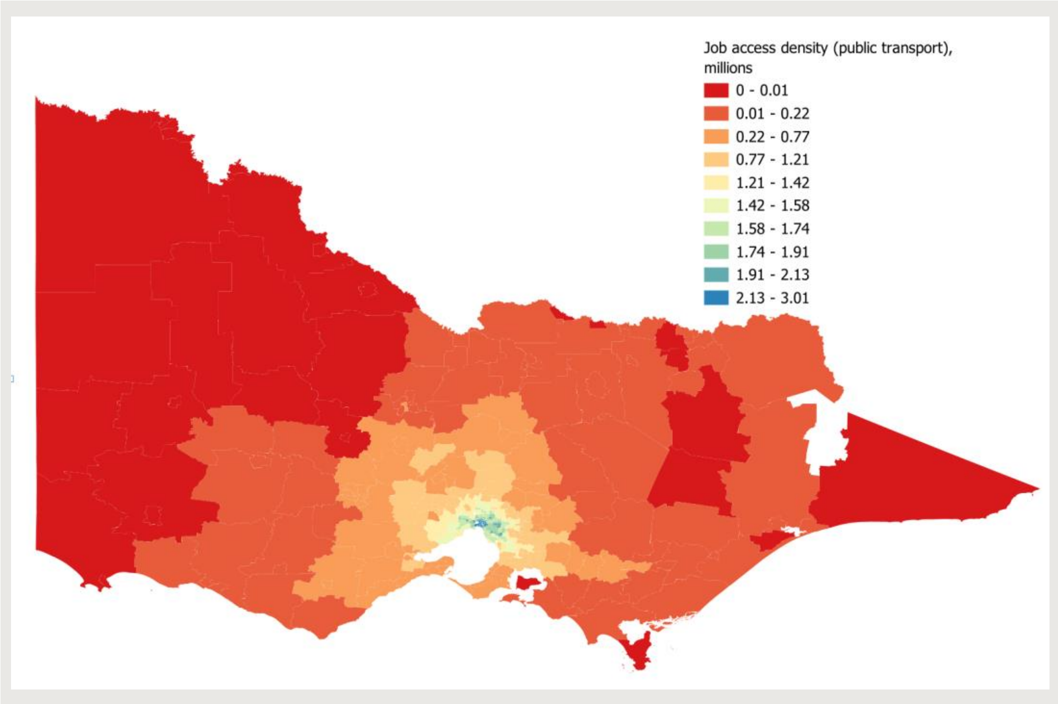
9.11 Job access density by public transport, Victoria in 2056, Compact City scenario



Note: Each shaded area corresponds to an SA2.

Data source: Transport model outputs provided by Arup via IV, CIE.

9.12 Job access density by public transport, Victoria in 2056, Distributed State scenario

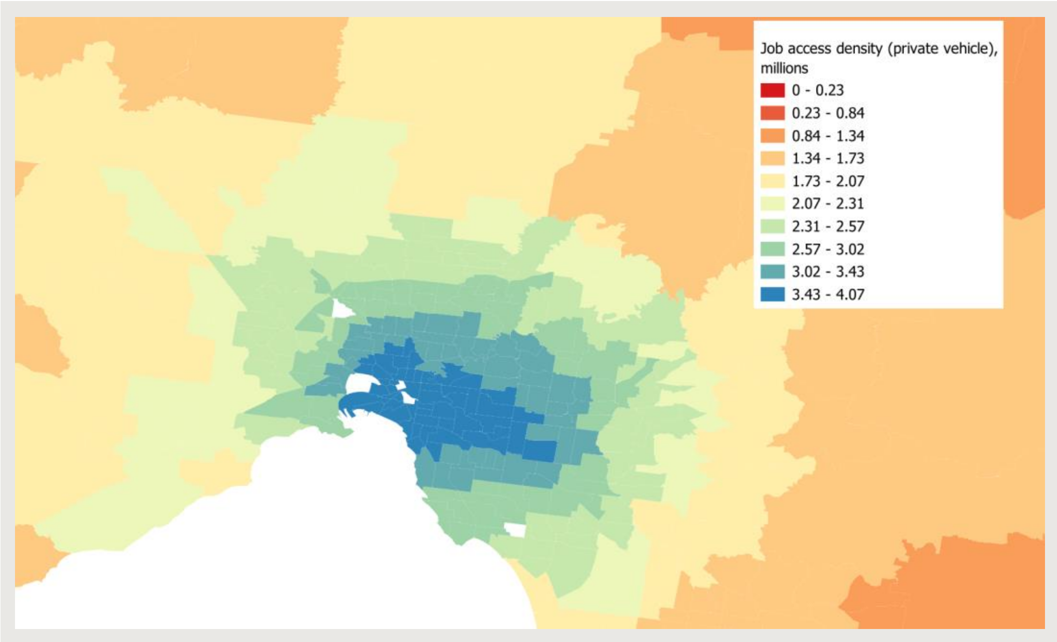


Note: Each shaded area corresponds to an SA2.

Data source: Transport model outputs provided by Arup via IV, CIE.

Job accessibility by private car differs more significantly within Melbourne across scenarios. The Compact City scenario has higher levels of accessibility to jobs via private vehicle overall (chart 9.13) compared to the Distributed State scenario (chart 9.14). This is particularly true in the eastern side of Melbourne, which is relatively less disadvantaged. It is also true for public transport accessibility (chart 9.15 and chart 9.16).

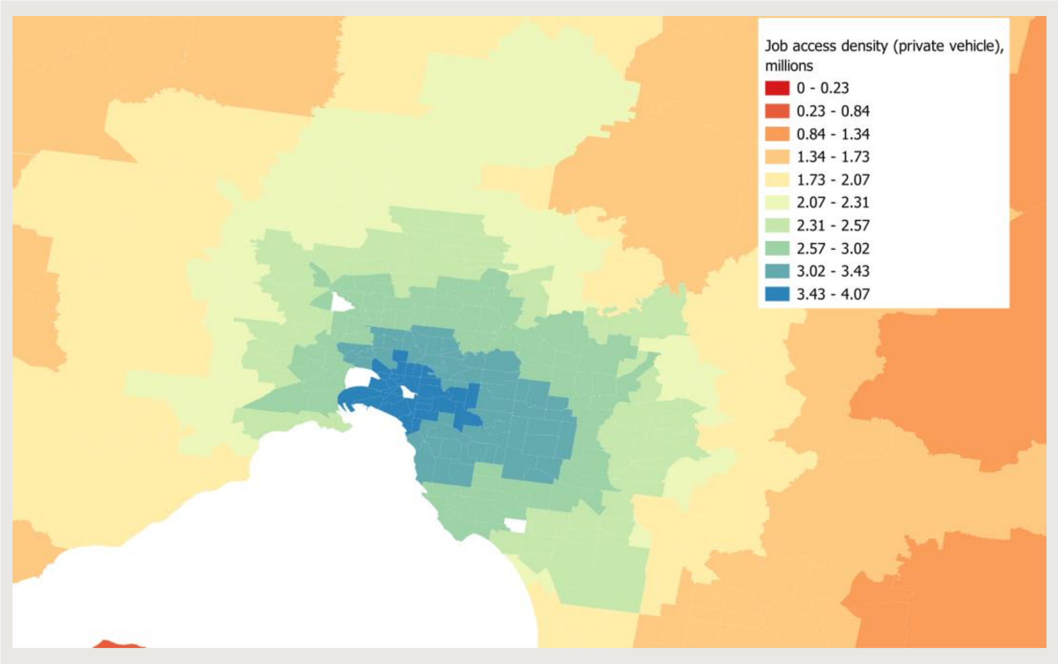
9.13 Job access density by private vehicle, Melbourne in 2056, Compact City scenario



Note: Each shaded area corresponds to an SA2.

Data source: Transport model outputs provided by Arup via IV, CIE.

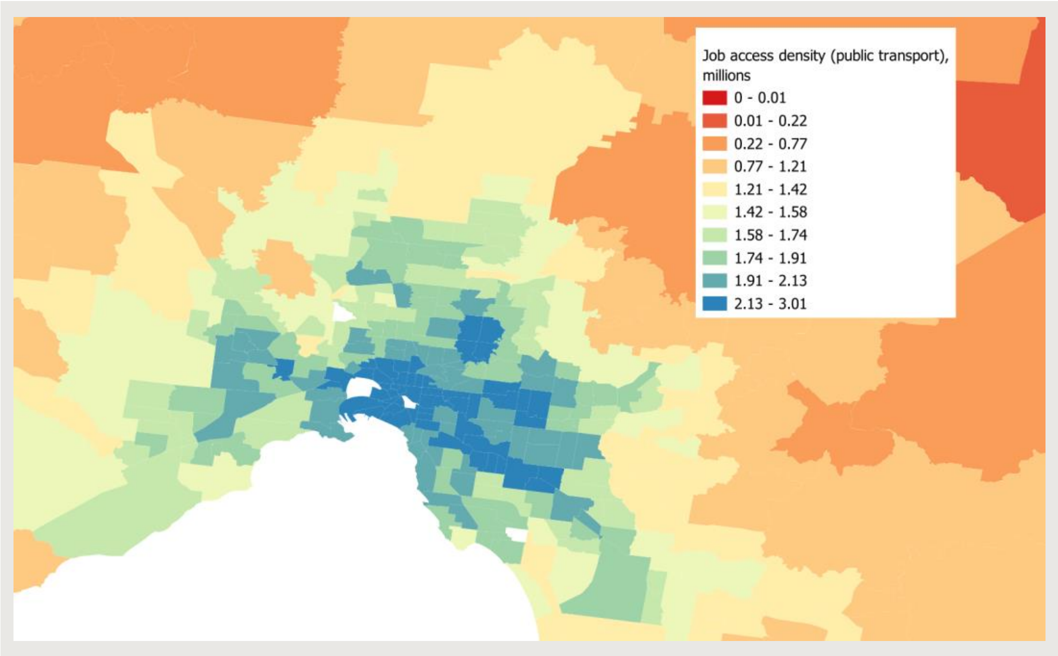
9.14 Job access density by private vehicle, Melbourne in 2056, Distributed State scenario



Note: Each shaded area corresponds to an SA2.

Data source: Transport model outputs provided by Arup via IV, CIE.

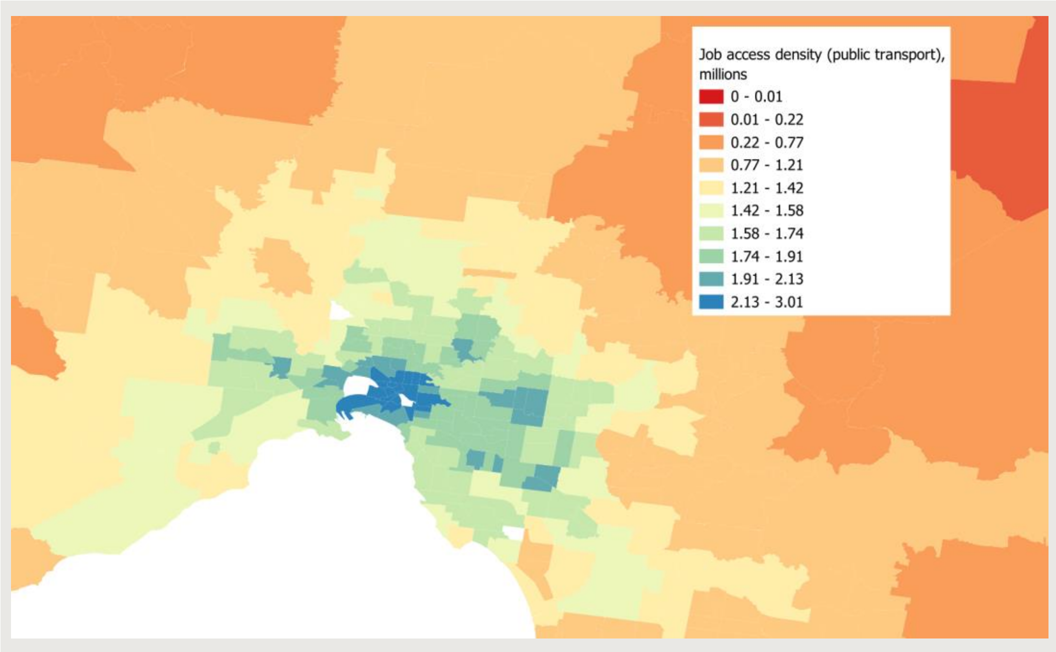
9.15 Job access density by public transport, Melbourne in 2056, Compact City scenario



Note: Each shaded area corresponds to an SA2.

Data source: Transport model outputs provided by Arup via IV, CIE.

9.16 Job access density by public transport, Melbourne in 2056, Distributed State scenario



Note: Each shaded area corresponds to an SA2.

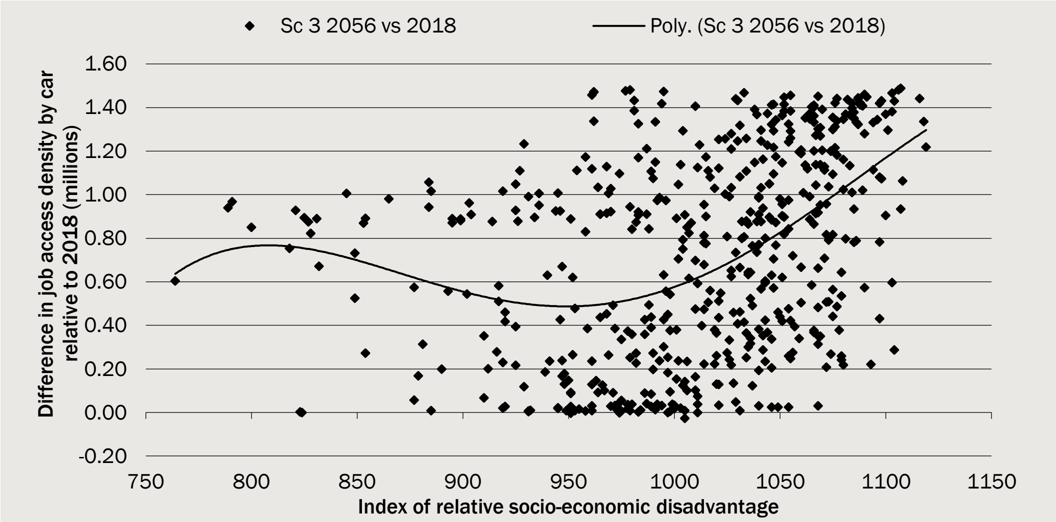
Data source: Transport model outputs provided by Arup via IV, CIE.

Differences in job accessibility by level of disadvantage

Access to jobs by private vehicle

Improvements in the job access density by private vehicle metric between 2018 and 2056 under the Dispersed City scenario are highest for areas with lower disadvantage (chart 9.17). This means that job accessibility by private vehicle would become more unequal in absolute terms over time. A similar, albeit weaker, relationship is evident when examining the distribution of percentage changes in this metric (chart 9.18)

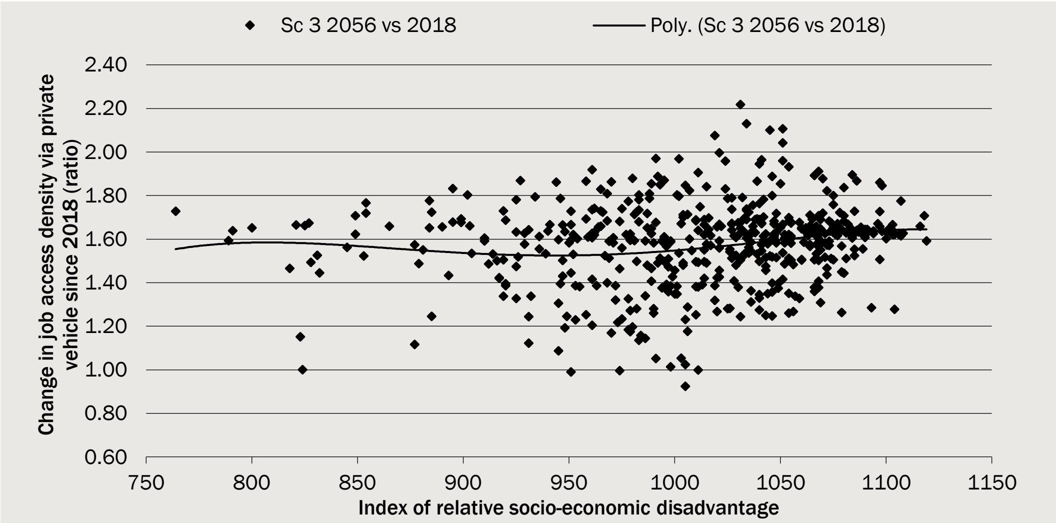
9.17 Distribution of increases in job access density by car over time, Dispersed City scenario



Note: The 'Poly' series refers to a fourth order polynomial, which is used to illustrate the broad relationship between SEIFA and accessibility. Each point corresponds to an SA2. A higher value on the index of relative socio-economic disadvantage denotes being less disadvantaged.

Data source: Transport modelling outputs provided by CIE.

9.18 Distribution of percentage increases in job access density by car over time, Dispersed City scenario



Note: The 'Poly' series refers to a fourth order polynomial, which is used to illustrate the broad relationship between SEIFA and accessibility. Each point corresponds to an SA2. A higher value on the index of relative socio-economic disadvantage denotes being less disadvantaged.

Data source: Transport modelling outputs provided by CIE.

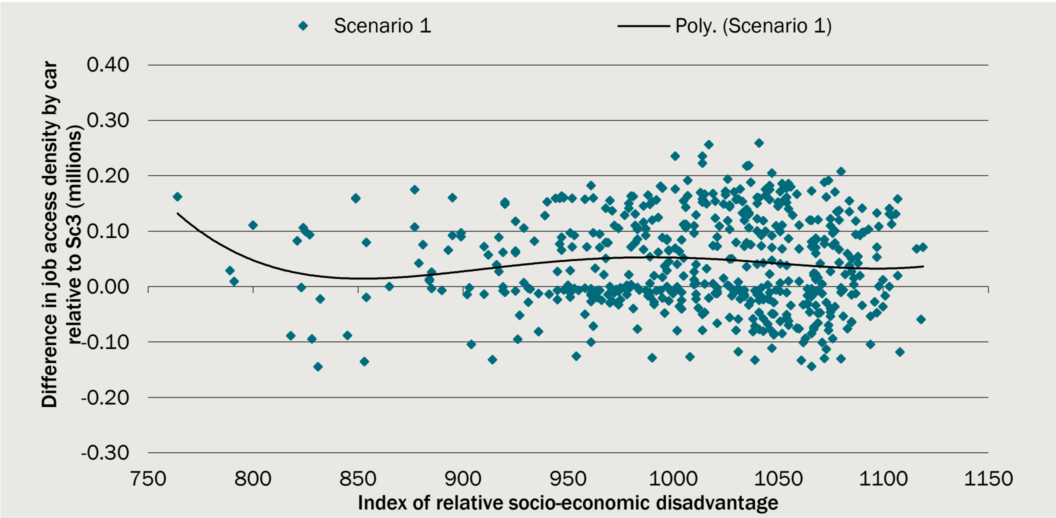
We estimate the difference in job access density between scenarios compared to the Dispersed City scenario (charts 9.19-9.22). Each chart shows how the difference in job access density relates to the level of disadvantage in each SA2, with higher values of the index suggesting a lower level of disadvantage. If there is a positive relationship between the change in job access density in each SA2 and the level of the index, this suggests that improvements in job access for that scenario are greater for areas with lower disadvantage. A line is fitted to the points in each chart, referred to as a 'Poly' series, so that the trend exhibited by all the dots can be visualised more clearly.[49]

We find that, for travel by private vehicle:

- the Compact City scenario improves accessibility across all levels of disadvantage, but most of all for areas with moderate disadvantage. That is, the value of the poly series shows that for moderate values of the index around 1000 there is a positive change in accessibility on average),
- the Consolidated City scenario has small negative impacts for areas of high and low disadvantage (i.e. values of the index around 850 and 1050 have worse accessibility in Scenario 2 compared to Scenario 3),
- the Network of Cities scenario is somewhat beneficial for accessibility of areas with moderate disadvantage, but negative for areas of low disadvantage, and
- the Distributed State scenario is similar to Network of Cities but with a more extreme fall in accessibility for areas of low disadvantage.

Impacts for each SA2 vary significantly even for a given level of disadvantage.

9.19 Distribution of difference in job access density by car, Compact City scenario compared to Dispersed City scenario

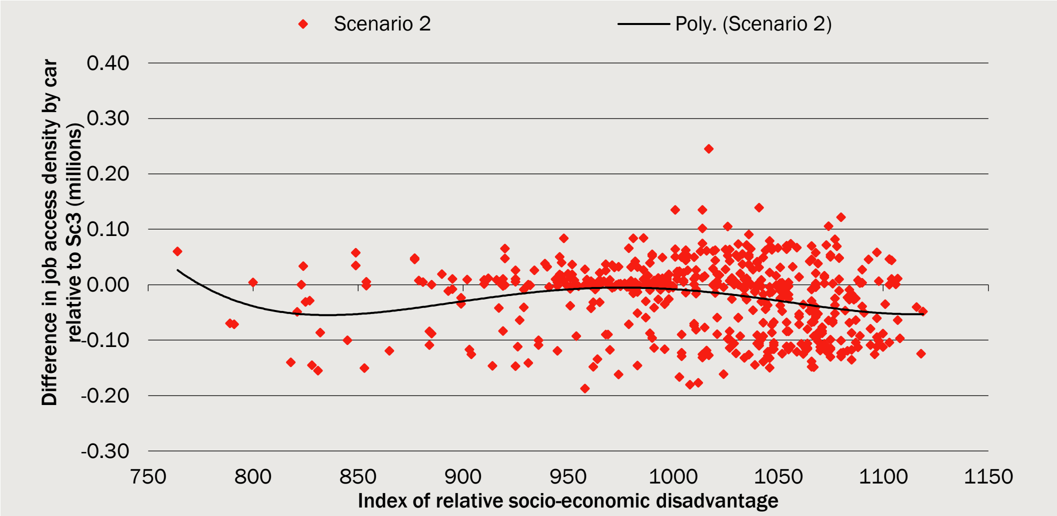


Note: The 'Poly' series refers to a fourth order polynomial, which is used to illustrate the broad relationship between SEIFA and accessibility. Each point corresponds to an SA2. A higher value on the index of relative socio-economic disadvantage denotes being less disadvantaged.

Data source: Transport modelling outputs provided by CIE.

49 'Poly' refers to polynomial, which refers to a particular type of curve being fitted to the points on each chart. An alternative would be a straight line of best fit.

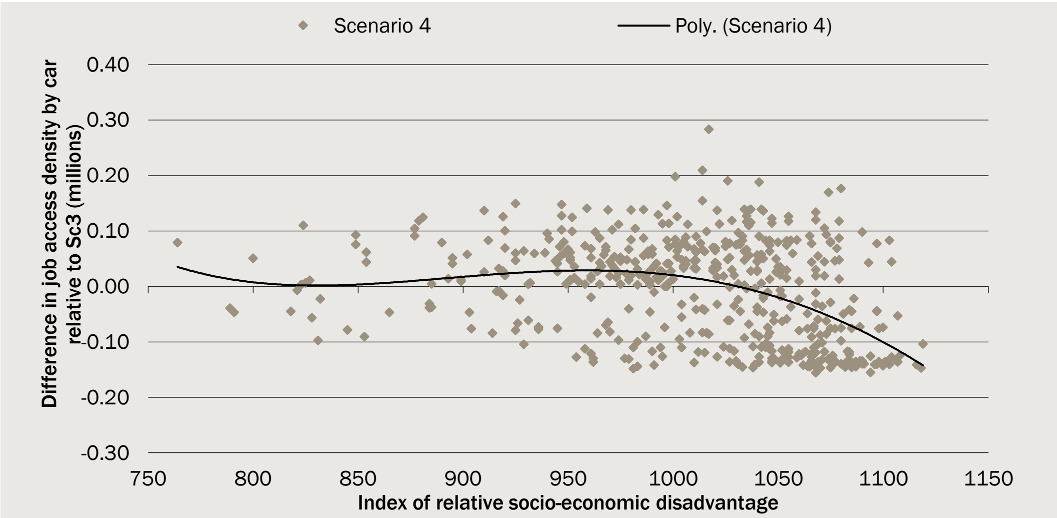
9.20 Distribution of difference in job access density by car, Consolidated City scenario compared to Dispersed City scenario



Note: The 'Poly' series refers to a fourth order polynomial, which is used to illustrate the broad relationship between SEIFA and accessibility. Each point corresponds to an SA2. A higher value on the index of relative socio-economic disadvantage denotes being less disadvantaged.

Data source: Transport modelling outputs provided by CIE.

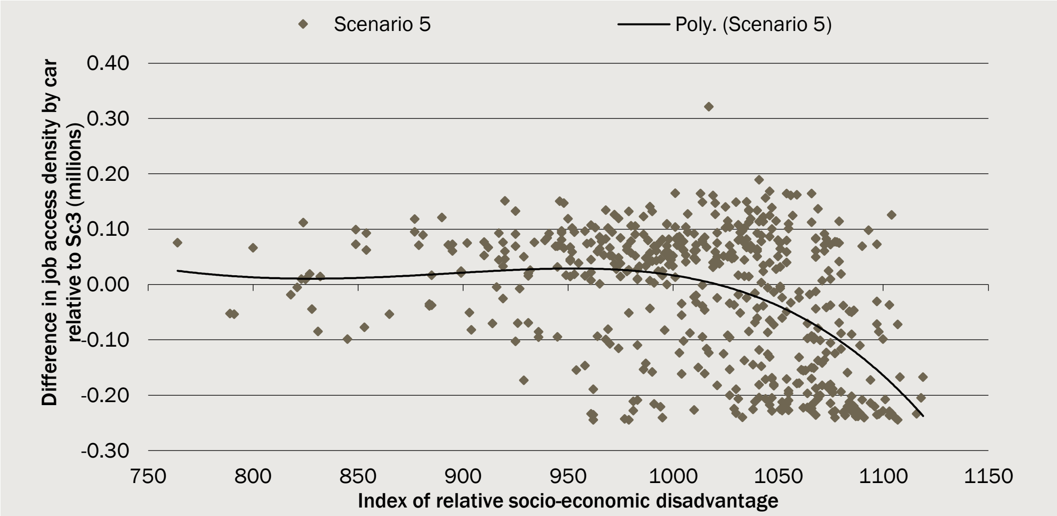
9.21 Distribution of difference in job access density by car, Network of Cities scenario compared to Dispersed City scenario



Note: The 'Poly' series refers to a fourth order polynomial, which is used to illustrate the broad relationship between SEIFA and accessibility. Each point corresponds to an SA2. A higher value on the index of relative socio-economic disadvantage denotes being less disadvantaged.

Data source: Transport modelling outputs provided by CIE.

9.22 Distribution of difference in job access density by car, Distributed State scenario compared to Dispersed City scenario



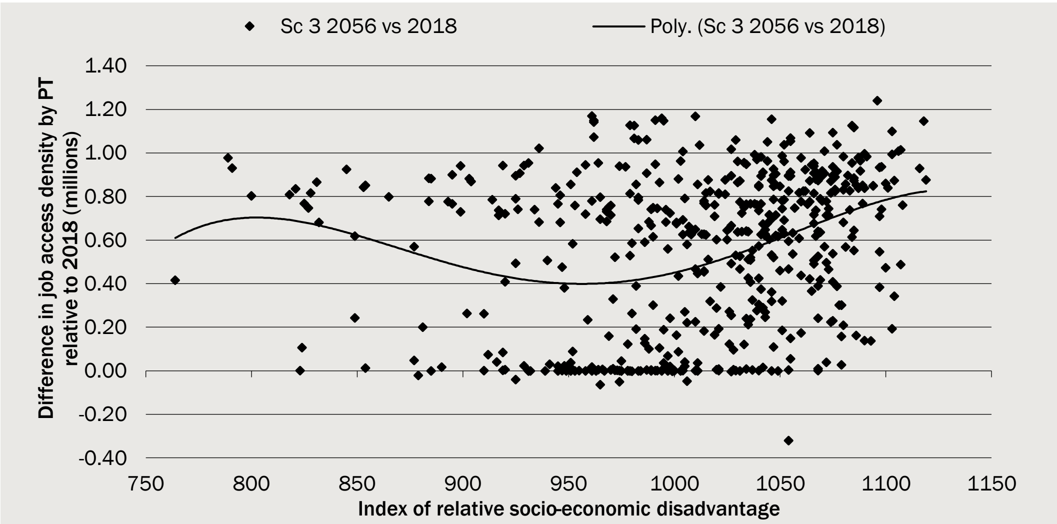
Note: The 'Poly' series refers to a fourth order polynomial, which is used to illustrate the broad relationship between SEIFA and accessibility. Each point corresponds to an SA2. A higher value on the index of relative socio-economic disadvantage denotes being less disadvantaged.

Data source: Transport modelling outputs provided by CIE.

Access to jobs by public transport

Improvements in job accessibility via public transport exhibit a U-shaped relationship with levels of disadvantage (chart 9.23) as was the case for access by private vehicle. Similarly to private vehicle accessibility, inequality of access to jobs via public transport gets slightly worse in absolute terms over time.

9.23 Distribution of increases in job access density by public transport over time, Dispersed City scenario



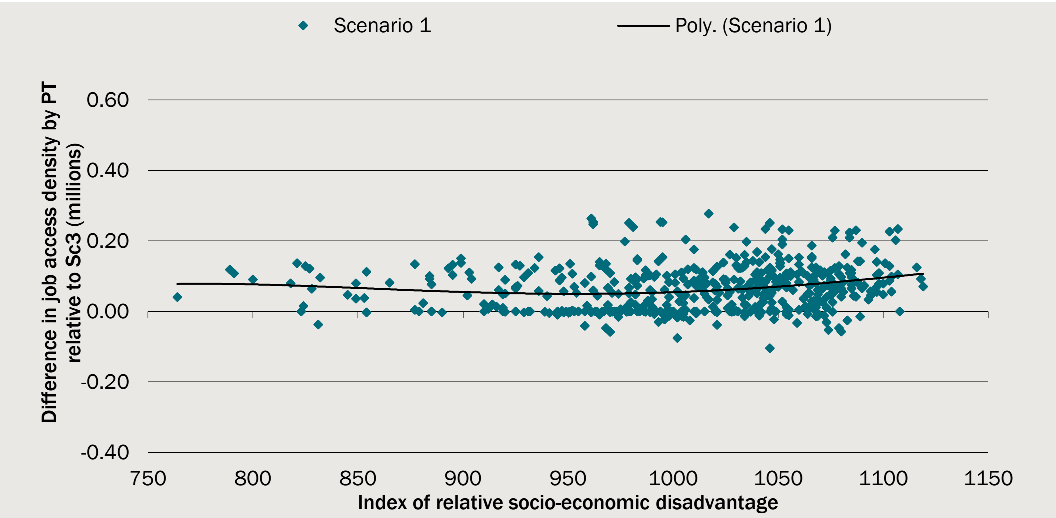
Note: The 'Poly' series refers to a fourth order polynomial, which is used to illustrate the broad relationship between SEIFA and accessibility. Each point corresponds to an SA2. A higher value on the index of relative socio-economic disadvantage denotes being less disadvantaged.

Data source: Transport modelling outputs provided by CIE.

Charts 9.24 to 9.27 compare scenarios to the Dispersed City scenario. We find that for travel by public transport:

- The Compact City and Consolidated City scenarios improve accessibility across all levels of disadvantage,
- The Network of Cities and Distributed State scenarios worsen accessibility, although somewhat less for those experiencing greater disadvantage.
- The Distributed State scenario has the greatest decrease in accessibility.

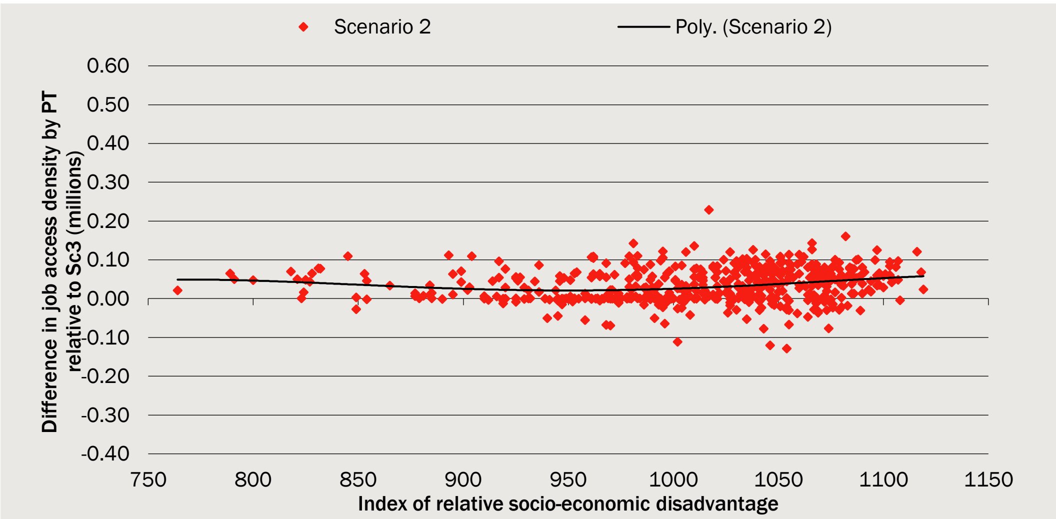
9.24 Distribution of difference in job access density by public transport, Compact City scenario relative to Dispersed City scenario



Note: The 'Poly' series refers to a fourth order polynomial, which is used to illustrate the broad relationship between SEIFA and accessibility. Each point corresponds to an SA2. A higher value on the index of relative socio-economic disadvantage denotes being less disadvantaged.

Data source: Transport modelling outputs provided by CIE.

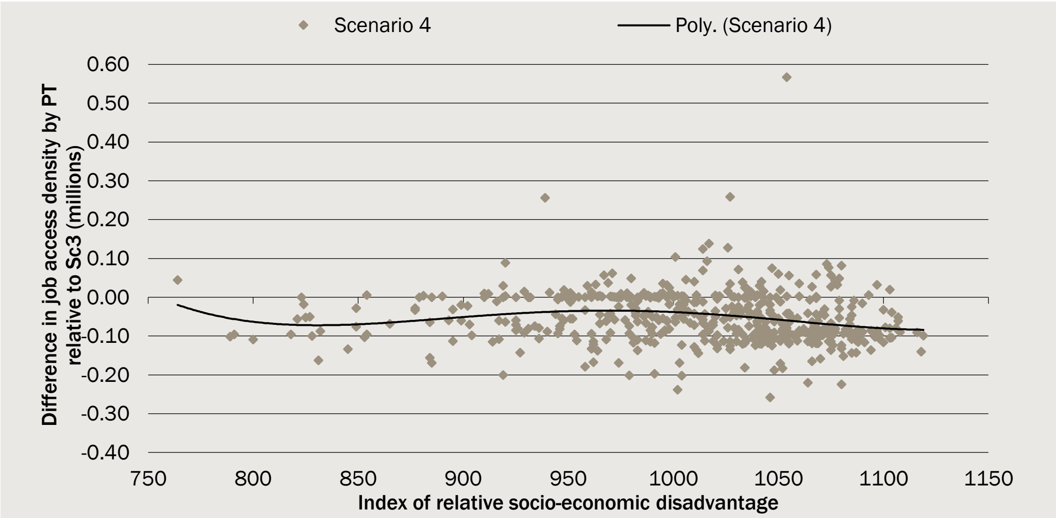
9.25 Distribution of difference in job access density by public transport, Consolidated City scenario relative to Dispersed City scenario



Note: The 'Poly' series refers to a fourth order polynomial, which is used to illustrate the broad relationship between SEIFA and accessibility. Each point corresponds to an SA2. A higher value on the index of relative socio-economic disadvantage denotes being less disadvantaged.

Data source: Transport modelling outputs provided by CIE.

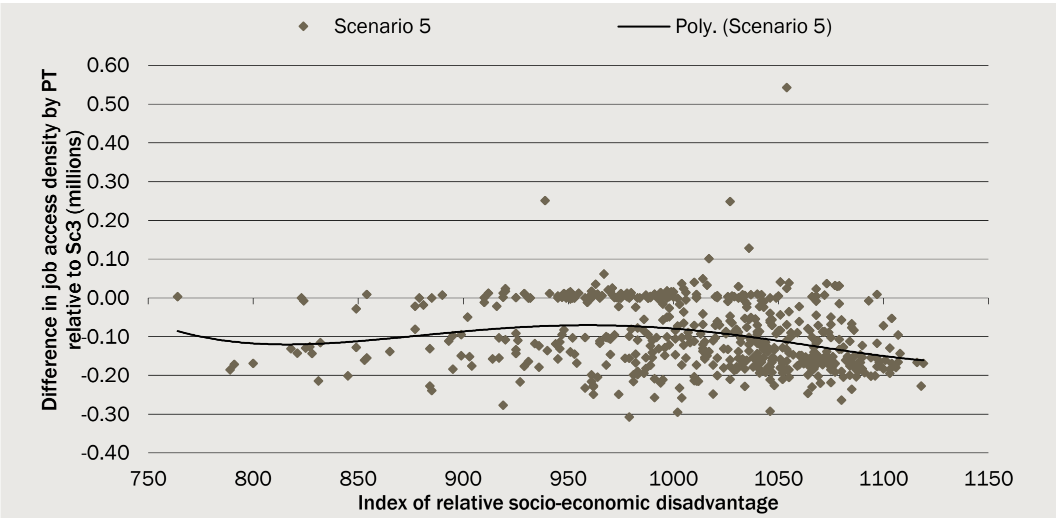
9.26 Distribution of difference in job access density by public transport, Network of Cities scenario relative to Dispersed City scenario



Note: The 'Poly' series refers to a fourth order polynomial, which is used to illustrate the broad relationship between SEIFA and accessibility. Each point corresponds to an SA2. A higher value on the index of relative socio-economic disadvantage denotes being less disadvantaged.

Data source: Transport modelling outputs provided by CIE.

9.27 Distribution of difference in job access density by public transport, Distributed State scenario relative to Dispersed City scenario



Note: The 'Poly' series refers to a fourth order polynomial, which is used to illustrate the broad relationship between SEIFA and accessibility. Each point corresponds to an SA2. A higher value on the index of relative socio-economic disadvantage denotes being less disadvantaged.

Data source: Transport modelling outputs provided by CIE.

Distribution of housing by affordability

For each scenario we estimate the distribution of housing prices, including the share of dwellings available for sale below $750 000 and dwellings available for rent below $500 per week, assuming no overall growth in prices (in today's dollars).[50]

The approach for this analysis is shown in box 6.6. In summary, we first estimate the distribution of sale prices and rents using the most recent 2 years of PropTrack data for each SA2 and dwelling type. Then we shift this distribution up or down for each scenario based on the difference in value per dwelling estimated for that scenario using the housing model.

We measure the share of dwellings within price bands. We've chosen to use arbitrary round price bands rather than estimate affordability thresholds, since it avoids needing to predict the overall trajectory for sale prices and rents, which will depend on interest rates and other external factors.

50 These values have been chosen because they are round numbers that are close to median sale prices and rents. We also present estimates of the full distribution of sale prices and rents (see charts 9.29 and 9.30).

9.28 Approach to estimating the distribution of dwelling sale prices and rents

1 **Specify the distribution of sale prices and rents in 2021:** Using PropTrack data, estimate the 5th, 10th, 20th, 30th, 40th, 50th, 60th, 70th, 80th, 90th and 95th percentiles of sale prices and of rentals for each combination of SA3 and three dwelling types in the PropTrack dataset (houses, townhouses, and apartments).

2 **Estimate the change in average prices relative to 2021:** Using the outputs of the housing model, estimate the change in average prices from 2021 to 2036 and 2056 for each combination of SA3 and the three dwelling types.

   a) This incorporates the effect of increases in accessibility, changes in the height of apartments (e.g. a higher share of high-rise apartments rather than low-rise), the effect of demand saturation, and changes in the share of dwellings within each SA2 comprising an SA3[51] under each scenario.

3 **Estimate the change in average values relative to the Victoria in Future forecasts (VIF):** Divide the increases in sales prices by the increase in sale prices of each property type across all SA3s under the Victoria in Future population projections to estimate the change in sale prices assuming 'no price growth'.

   a) For example, if prices have increased 150 per cent for houses in Ballarat by 2056 in the Distributed State scenario, but houses in Victoria increase by 125 per cent under the Victoria in Future population projections by 2056, this implies that the difference in prices in Ballarat by 2056 assuming no overall price growth is 120 per cent.

   b) The reason for this step is that it facilitates representing affordability in an approximation of current prices.

4 **Apply the change in average values relative to the VIF to shift the distribution of sale prices and rents.**

5 **Linearly interpolate the sale price and rent for each percentile from 5-95 (i.e. 5, 6, 7 … 94 and 95).**

6 **Estimate the number of dwellings that are under various sale price and rent thresholds:** Based on the interpolated distributions, we estimate the share of dwellings in each SA2 with a sale price below $250 000, $500 000, …, $1.75 million and $2 million and over.

7 **Sum up across dwelling types and SA3s to aggregate to regions or all of Victoria.**

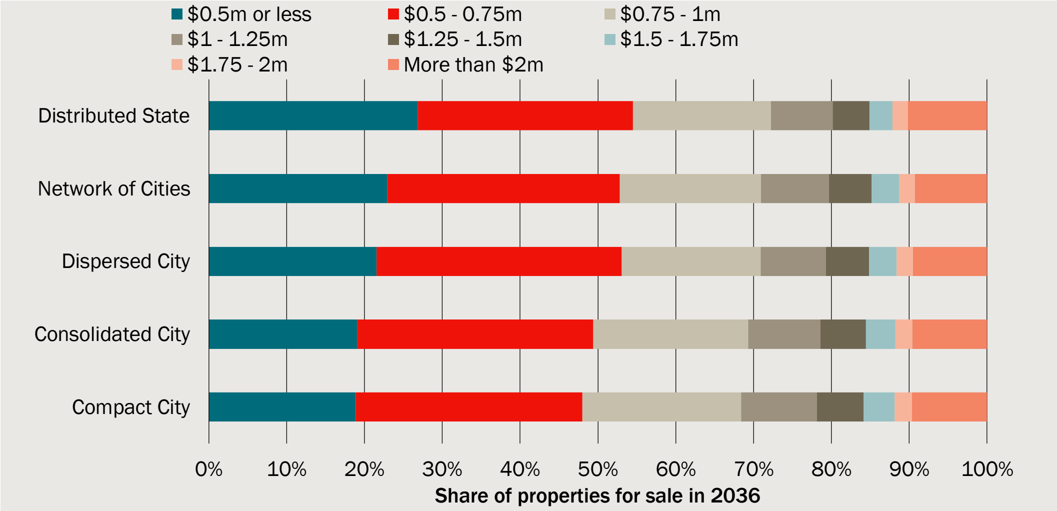
Share of housing that is affordable in 2036

The scenarios differ relatively little by 2036 in terms of the distribution of sale prices (chart 9.29) and rents (chart 9.30). The Compact City scenario has relatively more expensive dwellings, while the Distributed State scenario has relatively cheaper

51 That is, while the housing affordability modelling is conducted at the SA3 level, the housing model (which estimates the total value from housing) is built at the SA2 level.

dwellings. This reflects the value of housing being higher overall under the Compact City scenario.

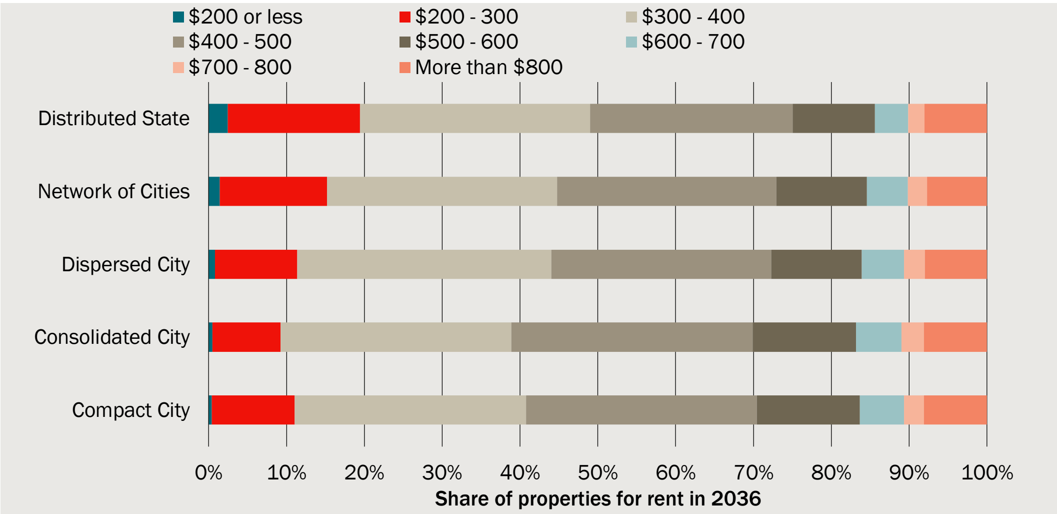
9.29 Distribution of sale prices in 2036 by scenario



Note: Prices are current as at the September quarter of 2022.

Data source: PropTrack data, CIE housing model.

9.30 Distribution of rents in 2036 by scenario



Note: Prices are current as at the September quarter of 2022.

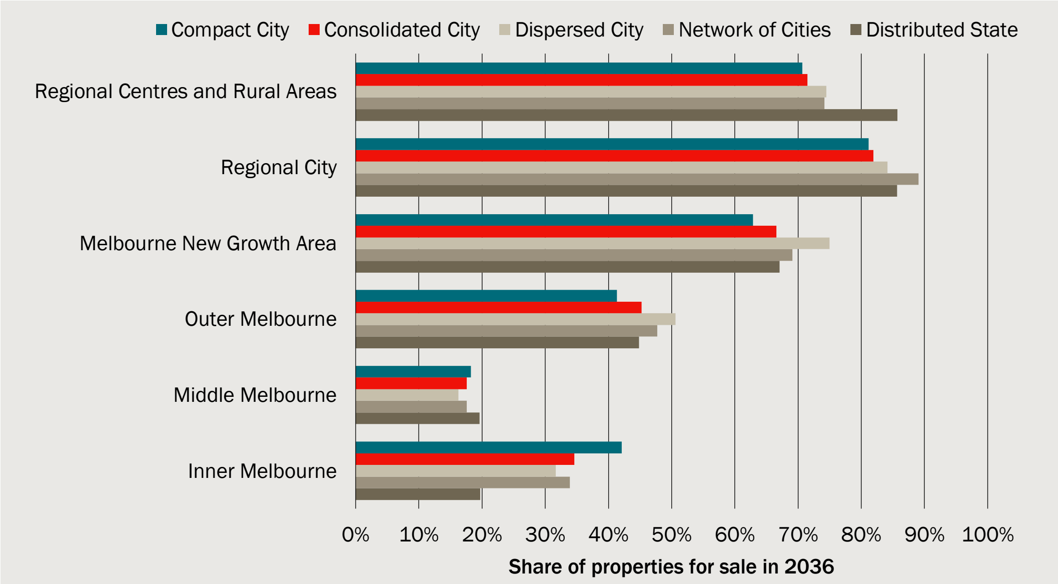
Data source: PropTrack data, CIE housing model.

By comparing the share of dwellings for sale below $750 000 (assuming no overall price growth) by region (chart 9.31), it shows affordability is highest in each region for the scenario that delivers the greatest dwelling growth. For example, while the Compact City scenario has worse affordability overall, it has a large positive impact on affordability in Inner Melbourne. Inner Melbourne has relatively worse affordability than other regions except for Middle Melbourne. This reflects a greater share of dwellings in Inner Melbourne being apartments, and, therefore, falling under these affordability thresholds.

Similarly, Sthe Dispersed City scenario has the highest share of properties under $750 000 in Outer Melbourne and Melbourne new growth areas, and the Network of Cities scenario has the best affordability outcome in Regional Cities.

Similar patterns of results are evident for rentals (chart 9.32), although, rental affordability is less variable between regions of Victoria than affordability of ownership.

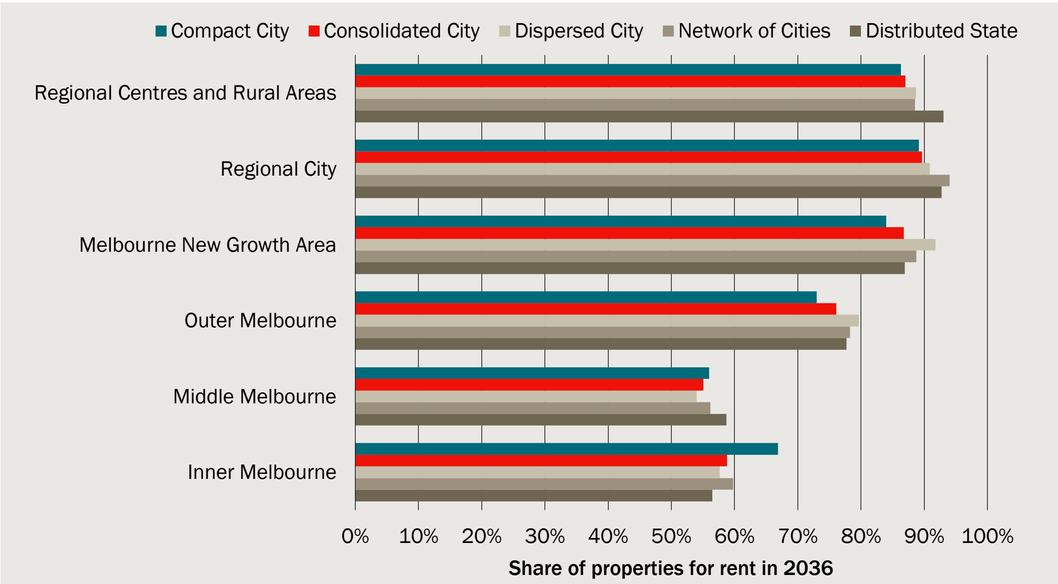
9.31 Share of properties for sale below $750 000 in 2036, assuming no price growth



Note: Prices are current as at the September quarter of 2022.

Data source: PropTrack data, CIE housing model.

9.32 Share of rental below $500/week in 2036, assuming no price growth



Note: Prices are current as at the September quarter of 2022.

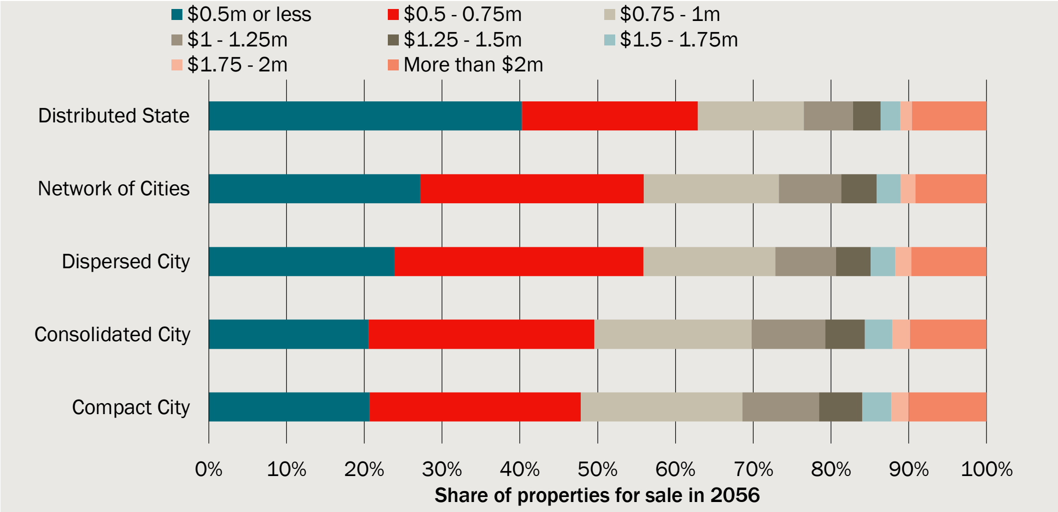
Data source: PropTrack data, CIE housing model.

Share of housing that is affordable in 2056

The differences in housing affordability between scenarios are larger in 2056, particularly for the Distributed State scenario. Almost twice as many dwellings would be available for sale under $500 000 in the Distributed State scenario 5 compared to the Compact City and Consolidated City scenarios (chart 9.33).

Rental affordability also improves most in the Distributed State scenario (chart 9.34), although much of this is an increase in the share of rentals available for less than $200/week (assuming no price growth). The improvement in affordability under the Distributed State scenario is as a result of a fall in values for regional areas due to an oversupply of dwellings in these areas.

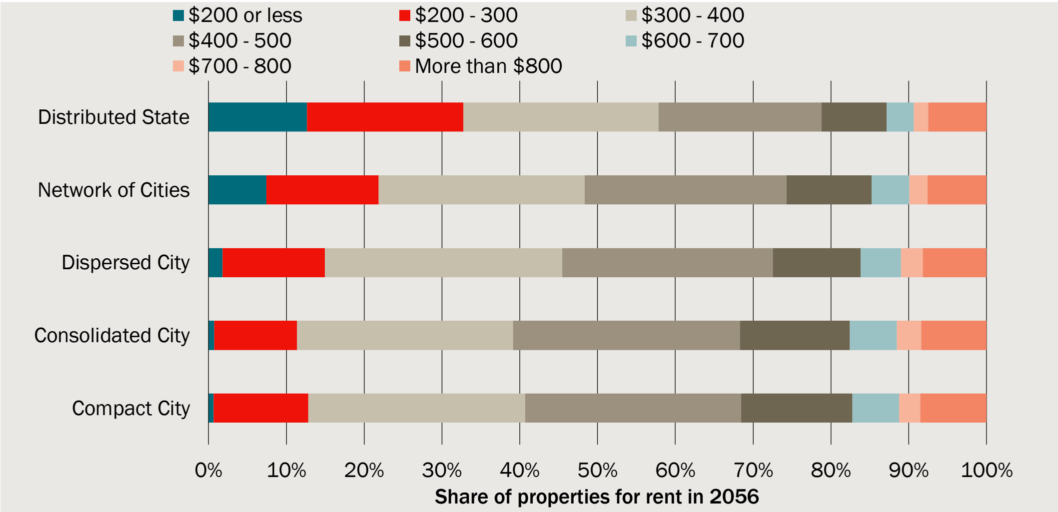
9.33 Distribution of sale prices in 2056 by scenario



Note: Prices are current as at the September quarter of 2022.

Data source: PropTrack data, CIE housing model.

9.34 Distribution of rents in 2056 by scenario



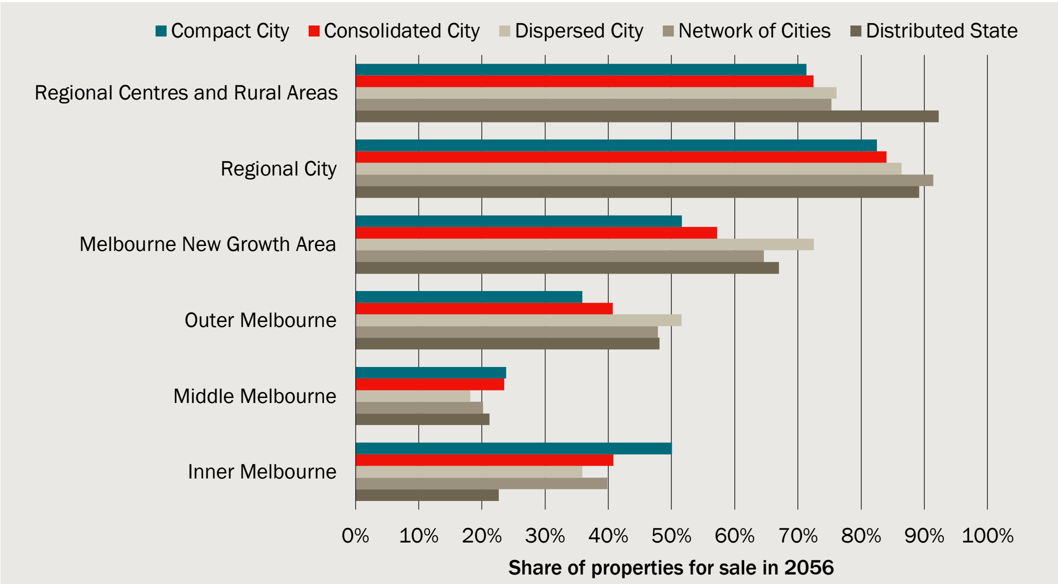
Note: Prices are current as at the September quarter of 2022.

Data source: PropTrack data, CIE housing model.

The share of properties for sale under $750 000 in 2056 (chart 9.35) and for rent under $500 per week (chart 9.36) differs significantly across scenarios:

- Inner Melbourne experiences slight improvements in affordability relative to 2036 under Scenarios 2-4. The Distributed State scenario has a significant deterioration in affordability, since far less apartments are provided in Inner Melbourne, while the Compact City scenario has a significant improvement.
- Middle Melbourne experiences relatively little change in affordability, despite it having the lowest levels of affordability out of any region.
- Outer Melbourne and Melbourne new growth areas have better affordability under Scenarios 3-5.
- Changes in affordability for regional areas are relatively smaller, except for a large improvement in ownership affordability under the Distributed State scenario for Regional Centres and Rural Areas.

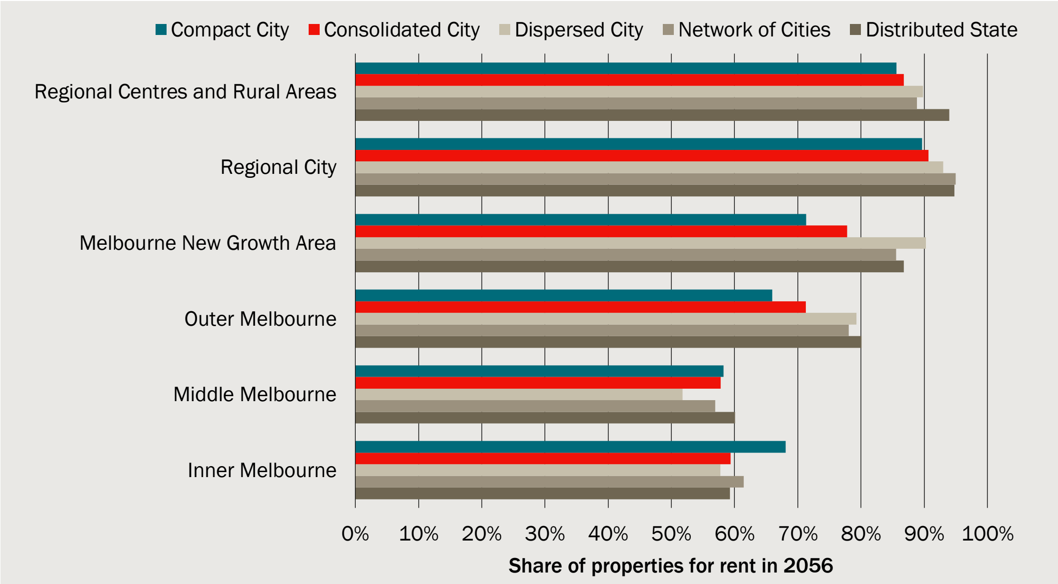
9.35 Share of properties for sale below $750 000 in 2056, assuming no price growth



Note: Prices are current as at the September quarter of 2022.

Data source: PropTrack data, CIE housing model.

9.36 Share of rental below $500/week in 2056, assuming no price growth



Note: Prices are current as at the September quarter of 2022.

Data source: PropTrack data, CIE housing model.

10 Risks and robustness of spatial scenarios

Measuring impacts for population and job scenarios for a long horizon is clearly subject to major uncertainties. Scenarios may have different impacts if changes occur that drive people and business preferences in different ways. Examples might include:

- technology changes that allow people to choose where they live with less concern to where they work, such as driverless cars or further increases in remote working and business models that suit this
- disasters such as war, natural disasters and pandemics, which alter how people want to live and work
- radical changes in industry structures that favour centralisation or decentralisation.

In this chapter we test how **robust** the estimated impacts of scenarios are to changes to people and business preferences that could arise from these types of factors.

As important, if not more, there are **risks** associated with actually delivering housing, commercial and industrial space and services in the way required for each of the scenarios. This chapter also discusses key risks and what their implications are from a policy perspective.

Robustness of scenarios

Housing preferences

The magnitude of housing preference impacts is affected significantly by alternative assumptions about the value of different dwelling types and regions (table 10.1), but the ranking of scenarios remains unchanged:

- Increases in the value for regional areas or decreases in value for apartments both worsen the impact of the Compact City and Consolidated City scenarios on housing values, but improve the Network of Cities and Distributed State scenarios. That is, if values in regional areas were higher, the Network of Cities and Distributed State scenarios would align more closely to housing preferences than if values in regional areas were lower. However, such a shift in preferences wouldn't be sufficient to change the ranking of scenarios in terms of how closely they align to housing preferences (i.e. how high the total value of housing is). Conversely, a lower value for detached dwellings decreases total housing value more for the Network of Cities and Distributed State scenarios.
- Assuming that there is no real price growth for dwellings decreases the magnitude of housing impacts significantly, but doesn't affect the comparison between scenarios as much.

- Assuming that price growth is higher in regional areas compared to Melbourne by 0.7 percentage points per annum, has relatively little impact on the overall magnitude of housing values (i.e. still between $2.0-2.3 trillion in present value terms) or the ranking of scenarios.

10.1 Housing preference impacts estimated under alternative assumptions

Alternative	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$b, PV	$b, PV	$b, PV	$b, PV	$b, PV
Total net value					
Main assumptions	2 257	2 204	2 154	2 100	2 057
20% increase in value for regional areas	2 373	2 324	2 280	2 231	2 191
20% reduction in value for apartments	2 198	2 163	2 128	2 067	2 022
20% reduction in the value for detached dwellings	2 044	1 976	1 905	1 859	1 797
No real price growth	1 841	1 773	1 706	1 668	1 616
Higher price growth for regional areas	2 257	2 204	2 154	2 100	2 057
Net value relative to Dispersed City scenario					
Main assumptions	103	50	0	- 55	- 97
20% increase in value for regional areas	93	45	0	- 48	- 88
20% reduction in value for apartments	70	34	0	- 62	- 106
20% reduction in the value for detached dwellings	139	71	0	- 46	- 108
No real price growth	135	67	0	- 38	- 90
Higher price growth for regional areas	103	50	0	- 55	- 97

Note: PV refers to present value.
Source: CIE.

Business preferences

How preferences for where businesses prefer to locate may change is uncertain. It could depend on factors such as the structure of the Victorian economy, ability to work in different locations remotely and changes to how businesses access their consumers. Moderate changes in preferences generally do not shift the ranking of alternative scenarios in terms of business location impacts (table 10.2). The exception is that a 20 per cent increase in the value of all regional space would lead to Network of Cities and Distributed State having higher business location productivity to the Dispersed City scenario. It would take quite substantial preference shifts for the estimated business location productivity of the Compact City scenario to be lower than any other scenario, given the large difference in values for space in Inner Melbourne, of which this scenario provides more.

10.2 Business preference impacts estimated under alternative assumptions

	1 Compact city	2 Consolidated city	3 Dispersed city	4 Network of cities	5 Distributed state
	$b	$b	$b	$b	$b
Main assumptions	30.8	9.0	0.0	-0.6	-8.2
20% increase in value of space for regional areas	28.7	7.5	0.0	5.4	1.5
20% reduction in value of space in inner city Melbourne	17.2	6.8	0.0	-0.1	-4.4
20% increase in value for space in Melbourne excluding inner city	27.8	10.6	0.0	-7.1	-17.4
20% increase in value for space for knowledge jobs	35.6	10.6	0.0	-0.4	-9.7
20% increase in value for space for industrial jobs	30.6	8.0	0.0	-1.9	-9.0

Source: CIE.

Decarbonisation pathways

The central analysis assumes decarbonisation of the electricity grid over time. This could happen more or less rapidly. A more rapid decarbonisation of both the grid and embodied emissions in buildings would bring scenarios closer together in terms of their overall GHG impacts. Conversely, a slower transition would make them more different (table 10.3). More importantly, **the decarbonisation pathway is much more impactful** than the land use scenario in determining overall GHG emissions from buildings.

10.3 GHG emission impacts estimated under alternative assumptions

	1 Compact city	2 Consolidated city	3 Dispersed city	4 Network of cities	5 Distributed state
	MT	MT	MT	MT	MT
Main assumptions	104	97	89	91	87
Rapid reduction in embodied emissions	61	58	55	56	54
Slower decarbonisation of grid and no reduction in embodied emissions	177	170	162	164	160
No decarbonisation of grid or reduction in embodied emissions	578	579	577	580	579

Note: Excludes tailpipe emissions, which do not vary as the grid decarbonises

Types of risks and their materiality

The discussion above is focused on changes that are outside of the scenarios, but can change the impacts that arise from scenarios. There are also **risks,** which are about the likelihood that a scenario can be delivered in the way expected. Based on the pattern of impacts the most significant risks are:

- whether some scenarios are more likely to be able to deliver the required amount of housing than others
- whether some scenarios are more likely to be able to deliver the required amount of business space than others, and
- whether it will be easier to provide increased services in some scenarios versus others.

Getting enough housing

There are constraints on achieving increases in housing supply in Melbourne, particularly in inner areas where there can be community opposition to higher densities. If these constraints act to reduce the increase in housing supply for Inner Melbourne, this would reduce the housing impacts by around $8 billion for the Compact City and Consolidated City scenarios. Impacts are larger ($10-12 billion) if middle Melbourne also had 30 per cent less housing supply increase than specified by the scenarios (table 10.4).

These estimates are likely to understate the impact of reducing housing supply since delivering less housing in inner areas of Melbourne may also affect the amount of jobs in Melbourne. To the extent it also reduces the amount of jobs in Melbourne, this would reduce accessibility to jobs throughout all of Melbourne, and thus decrease housing impacts further.

10.4 Difference in housing impacts depending on how much is delivered

Alternative	1	2	3	4	5
	Compact city	Consolidated city	Dispersed city	Network of cities	Distributed state
	$b, PV	$b, PV	$b, PV	$b, PV	$b, PV
Total net value					
Main assumptions	2 257	2 204	2 154	2 100	2 057
Only achieve 70 per cent of inner Melbourne supply increase	2 291	2 237	2 191	2 133	2 082
Only achieve 70 per cent of inner and middle Melbourne supply	2 287	2 235	2 190	2 132	2 080
Net value relative to main assumptions					
Only achieve 70 per cent of inner Melbourne supply increase	34	33	36	33	25
Only achieve 70 per cent of inner and middle Melbourne supply	30	31	35	32	23

Source: CIE.

Getting enough business space

If there are constraints on business space, these are likely to be most likely and consequential in inner areas of Melbourne. The impact of constraints on space can outweigh the differences between some of the spatial scenarios, for business location impacts (table 10.5).[52] This suggests that both ensuring that there is enough business space developed and which locations are developed are both important. It is more valuable to have space developed in a less preferred location than not at all, so long as that space can meet commercial viability requirements.

10.5 Estimated business location productivity impacts

	1 **Compact city**	2 **Consolidated city**	3 **Dispersed city**	4 **Network of cities**	5 **Distributed state**
	$b	$b	$b	$b	$b
Main assumptions	193	172	163	162	154
Only achieve 70% of inner Melbourne supply	181	165	157	157	151
Difference to main assumptions	-12	-6	-5	-5	-4
Only achieve 70% of inner and middle Melbourne supply	175	158	153	153	147
Difference to main assumptions	-18	-13	-10	-9	-7

Note: These are undiscounted values.
Source: CIE.

Providing infrastructure and services

Providing infrastructure and services such as community facilities, schools and open space is likely to be most challenging in existing urban areas where there is not sufficient capacity in existing sites. This is currently reflected in the high cost allocated to these government services in the cost assessment. It is possible that rather than resulting in higher costs for providing services, the quality of services declines, such as through more crowded spaces and more crowded schools. This risk is highest in compact city scenarios. However, Melbourne is not a dense city by international standards and other cities have found mechanisms to provide government services in higher density environments and so the risk is not considered high. Different approaches also offer the opportunity to reduce these costs in the future, such as shared use facilities.[53]

52 Note that these calculations reduce the amount of space available but do not change the accessibility metrics for scenarios.

53 For example, see Richmond High School (https://www.schoolbuildings.vic.gov.au/richmond-high-school) and Arden Community Infrastructure (https://vpa-web.s3.amazonaws.com/wp-content/uploads/2021/09/Arden-Precinct-Indicative-Cost-Plan-Report-Turner-Townsend-April-2021.pdf).

PART IV

Technical appendices

A Local infrastructure cost

- **Urban development requires substantial additional local infrastructure until 2056.**
  - **This includes the streetscape and reticulation of services within a development area to each property and includes local roads, civil works including drainage, sewerage, water supply, electricity, gas, telecommunications, and conversion of infill street scapes.**
  - **Infrastructure requirements outside of the development area are costed separately.**
- **Total expected cost of local infrastructure is likely to be large (over $135 billion).**
  - **Costs are highest for scenarios with high shares of Greenfield development, such as the Distributed State ($163 billion) and Dispersed City ($160 billion) scenarios, due to the higher local infrastructure development cost per dwelling for greenfield development (including regional greenfield)**
  - **The Compact City scenario has the least cost across scenarios due to relatively high share of Infill development in established areas. This is despite the additional local infrastructure costs when converting industrial land to residential use in inner Melbourne.**

Local infrastructure costs of residential development

Cost by development setting from Infrastructure Victoria (2019)

The primary source we rely on for local infrastructure costs of development is the *Infrastructure Provision in Different Development Settings Metropolitan Melbourne Costing and Analysis* report (SMEC, 2019).[54] Costs per dwelling have been escalated to Dec-2022 dollars and are collated in table A.1. Note that these costs assume that there is an existing residential streetscape in the development area.

54 SMEC, 2019, *Infrastructure Provision in Different Development Settings Metropolitan Melbourne Costing and Analysis Report.*

A.1 Local infrastructure rates (capital cost), by type of development

Infrastructure element within the development site	Source	Greenfield	Established		
		Separate house	Small Scale Dispersed Infill Development in Middle Established Greyfield Area (2-4 dwelling development)	Precinct Scale Brownfield Development in middle/outer established Area (medium density)	High Density Development in Inner Established Area (high density)
		$/dwelling	$/dwelling	$/dwelling	$/dwelling
Earthworks & Roads	SMEC (2019)	38 946	13 104	25 767	3 786
Drainage reticulation and connection	SMEC (2019)	11 787	11 264	7 641	2 589
Sewerage reticulation and connection	SMEC (2019)	6 375	4 390	4 445	1 410
Water and Gas Reticulation	SMEC (2019)	4 907	4 967	3 157	1 350
Electrical reticulation and connection	SMEC (2019)	4 909	3 048	5 861	2 501
Telecommunications reticulation and connection	SMEC (2019)	1 609	548	1 036	690
Landscape	SMEC (2019)	2 646	1 203	2 208	924
Residential Street Scape (only Inner Melbourne)	Arden DCP	0	20 985	20 985	20 985
Community Infrastructure	CIE				Separately estimated
Emergency services infrastructure	CIE				Not estimated
Health Infrastructure	CIE	Not estimated except for local community health Infrastructure			
Education Infrastructure	CIE				Separately estimated
Total local infrastructure costs (Inner Melbourne)		**71 179**	**59 508**	**71 099**	**34 235**
Total local infrastructure costs (all other areas)		**71 179**	**38 523**	**50 114**	**13 250**

Note: Figures are denoted in real 2022/23 dollars.

Source: CIE, SMEC, 2019, *Infrastructure Provision in Different Development Settings Metropolitan Melbourne Costing and Analysis Report, Table 2, 4, 7 and 8,* VPA (2022) *Arden Precinct WURUNDJERI WOI WURRUNG COUNTRY Development Contributions Plan, Table 15.*

Premium for conversion of industrial lands in established areas

For development in formerly industrial areas, there will be additional local infrastructure costs associated with progressively converting industrial streetscapes into residential streetscapes, whilst they remain in use. Two such areas are:

- **Arden**, a development area in the north-west of inner Melbourne providing for around 34 000 jobs and 15 000 residents. The project involves urban renewal of around 50 hectares of largely industrial land.
- **Fishermans Bend**, is an in-progress development of 480 hectares south of the Yarra River near Melbourne CBD.

For such areas, we assume that there is a higher rate of local infrastructure costs based on the costs in the Arden precinct.[55] The Development Contributions Plan (DCP)[56] for Arden reports a range of costs that are not included in SMEC (2019), such as street projects. Some of these (such as community centres) are estimated elsewhere in our analysis, and marked 'separately estimated' in table A.1. The cost for civil works including drainage in the SMEC (2019) report all relate to works within the development site. Therefore, the costs from the Arden DCP, which relate to outside the development site, are additional to the costs from SMEC (2019).

Overall, there is a cost premium of $20 985 per dwelling associated with these local infrastructure costs relative to the cost for high-density development from SMEC (2019). This premium is applied to development in the Arden and Fishermans Bend precincts, which correspond to the North Melbourne and Port Melbourne Industrial SA2, respectively.

A.2 Additional local infrastructure capital costs for urban renewal of industrial areas

Infrastructure element	Cost per residential dwelling from Arden DCP
	$/dwelling
Community Centre projects	Separately estimated
Local Park projects	Separately estimated
Sporting reserve	Separately estimated
Street projects	3 086
Pedestrian and cycling projects	239
Intersection projects	1 501
Drainage projects	16 159
Total cost	**20 985**

Note: Figures are denoted in real 2022/23 dollars. No escalation is applied to the Arden DCP figures (which are already from 2022).

Source: VPA (2022) *Arden Precinct WURUNDJERI WOI WURRUNG COUNTRY Development Contributions Plan, Table 15*, CIE.

Assumed local development cost per dwelling

We align the estimated costs from the SMEC (2019) analysis to the dwelling typology used in our housing model (table A.3), which is then used to calculate total local infrastructure costs due to residential development.

For brownfield and infill areas, the correspondence between SMEC (2019) estimates and housing model typologies we use is as follows:

55 We have not used estimates of cost per dwelling for local infrastructure in Fishermans Bend since it is less recent and we expect there has been significant cost escalation since infrastructure cost estimates were published for Fisherman's Bend.

56 Note that we use the DCP as a source for estimated local infrastructure costs, without relying on the amount of development contributions as an indicator of costs. Development contributions are not necessarily fully recovering costs, and therefore, contribution per dwelling is typically lower than infrastructure costs per dwelling.

- Separate house, attached, and Other: Small Scale Dispersed Infill Development in Middle Established Area (2-4 dwelling development)[57]
- Low-rise apartments: Precinct Scale Brownfield Development in middle/outer established Area (medium density)
- High-rise apartments: High Density Development in Inner Established Area (high density)

For medium-rise apartments, we take the average of the local infrastructure cost for low-rise and for high-rise apartments.

For greenfield areas, we have assumed estimates of greenfield local infrastructure costs from SMEC (2019) apply to separate houses. SMEC (2019) does not separately report cost estimates for medium and high-density greenfield development.

In order to estimate the costs for medium density and high-density development we assume that the relativities between housing types are the same in brownfield and greenfield areas. For example, the ratio of local infrastructure costs for medium-density development compared to small scale dispersed development in brownfield areas is 130 per cent (the ratio of $50 114 to $38 523), and we assume this relativity is the same in greenfield areas. This implies that since cost per greenfield house is $71 179, cost per medium density dwelling (e.g. low rise apartments) in greenfield areas is $92 597. The local development cost of high-density development is expected to be 34 per cent as high as for small scale dispersed development, since, for example, apartments have less street frontage per dwelling, and so lower streetscape needs.

Further, estimates from SMEC (2019) apply to metropolitan Melbourne, and we have not identified an alternative source for regional areas. Hence, we assume that local infrastructure costs per dwelling are the same in regional areas as in greenfield areas of Melbourne.

Note, that for brownfield development in Arden and Fishermans Bend we apply a premium of $20 985 per dwelling in addition to the values in table A.3.

A.3 Local infrastructure capital cost per dwelling assumed in the model

Dwelling type	Infill/Brownfield	Greenfield (including regional)
	$/dwelling	$/dwelling
Separate house	38 523	71 179
Attached	38 523	71 179
Low rise apartments	50 114	92 597
Medium rise apartments	31 682	58 539
High rise apartments	13 250	24 482
Other	38 523	71 179

Note: Figures are denoted in real 2022/23 dollars.

57 While SMEC (2019) only costed local infrastructure for houses in greenfield settings, we've taken the cost of small scale infill development as the cost of a separate house (plus attached and other dwellings). This is justified as the major costs involved are civil works.

Source: CIE based on SMEC (2019).

Cost summary

The total costs of local infrastructure including operating cost[58] of 2 per cent per annum associated with residential development are summarised in table A.4. Costs are higher for scenarios with more greenfield development, including regional greenfield development.

A.4 Local infrastructure impacts across scenarios – total cost ($ billions)

Additional from 2021 to 2056	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$b	$b	$b	$b	$b
Capital Cost	99.1	108.9	118.4	116.4	120.4
Operating Cost	35.5	39.0	41.9	41.2	42.2
Total	**134.6**	**147.9**	**160.3**	**157.5**	**162.5**

Note: Figures are denoted in real 2022/23 dollars.

Source: CIE.

Distributional impact

For the purpose of this analysis, we have assumed that the capital cost of local infrastructure is funded by developers, while the operating cost is predominantly recovered through user charges. This is a simplifying assumption given that maintenance of local roads, landscape, and residential street scape falls usually within the responsibility of the local governments. However, operating cost for those are usually quite low compared to the other infrastructure elements within the development site.

58 SMEC, 2019, *Infrastructure Provision in Different Development Settings Metropolitan Melbourne Costing and Analysis Report,* p.79

B Open space

- **Additional open space provision until 2056 ranges between 2 566 hectares and 3 031 hectares across the different scenarios, while the Compact City scenario requires the most and the Distributed State scenario the least additional open space.**
  - **The main driver of additional open space provision is change in population density as well as the type of development area (greenfield versus infill).**
- **Total expected cost for additional open space infrastructure until 2056 are highest for the Compact City scenario ($26.1 billion), followed by the Consolidated City scenario with $17.1 billion. The Dispersed City and Network of Cities scenarios have similar costs with $14.0 and $12.5 billion. The least cost is estimated for the Distributed State scenario with $10.8 billion.**
  - **Main driver of costs is the actual additional provision of open space, the land cost in scenarios with high infill development and the capital and operating cost for open space in inner, middle and outer Melbourne.**

B.1 Open space infrastructure impacts across scenarios

	Sc1	Sc2	Sc3	Sc4	Sc5
Additional from 2021 to 2056	Compact City	Consolidated City	Dispersed City	Network of Cities	Distributed State
	ha	ha	ha	ha	ha
Requirement	3 031	2 841	2 789	2 451	2 566
	$b	$b	$b	$b	$b
Capital Cost	7.4	6.3	5.7	5.2	5.2
Operating Cost	1.7	1.4	1.3	1.2	1.2
Land cost	17.1	9.4	7.0	6.2	4.4
Total	**26.1**	**17.1**	**14.0**	**12.5**	**10.8**

Note: Total may not sum up due to rounding.

Source: CIE.

Open Space Provision in Victoria

Public open space (including parks, gardens, playgrounds, public beaches, riverbanks and waterfronts, outdoor playing fields and courts and publicly accessible bushland) are a major contributory element to liveability, connectivity and mitigation of urban heat impacts.

The Victorian Planning Authority (VPA) Open Space network planning principles aims to provide accessible, high-quality open spaces for residents in Victoria.[59] Priorities of open space provision can be summarised as follows:

- Accessibility: open spaces are easily accessible to all residents, regardless of their location or socio-economic status.
- Quantity: Provide an appropriate amount of open space to cater for a range of community uses.
- Quality: provision of high-quality open spaces, including parks, playgrounds, and sporting facilities, that meet the diverse needs of the community.
- Diversity: importance of diverse open spaces, including natural areas, cultural and heritage sites, and community gardens.
- Connectivity: connectivity of open spaces, including the creation of networks and links between open spaces to provide a seamless recreational experience for residents.
- Sustainability: sustainable open spaces, including the use of environmentally friendly design principles and the preservation of natural habitats.
- Collaboration: collaboration between different stakeholders, including local councils, community groups, and developers, in the planning and delivery of open spaces.

Depending on the public open space definition, provision rates can vary largely. Conservation reserves and natural open space (such as 'Bushland') account for over 78 per cent of open space in the municipalities of the Melbourne metropolitan area, while most of that is on the fringe (table B.2). Similar, in regional Victoria conservation parks account for the majority of open space.

B.2 Distribution of existing public open space types

Type of open space	Area	
	Hectares	Per cent
Melbourne Metropolitan Area		
Parks and gardens	6 730	10.7
Transport reservations	71	0.1
Sports fields and organised recreation	6 135	9.7
Recreation corridor	934	1.5
Natural and semi-natural open space	26 383	41.8
Conservation reserves	22 772	36.1
Civic squares and promenades	28	0.0
Total	**63 051**	**100.0**
Regional Victoria		
Conservation Park	253 564	88.0
Parks	28 398	9.9

59 VPA *Metropolitan Open Space Network Provision and Distribution*, https://vpa.vic.gov.au/wp-content/uploads/2018/02/Open-Space-Network-Provision-and-Distribution-Reduced-Size.pdf , p. 4-6

Type of open space	Area	
	Hectares	Per cent
Gardens	638	0.2
Sports grounds	2 600	0.9
Other types	2 960	1.0
Total	**288 161**	**100.0**

Note: Open space for Metropolitan Melbourne includes only 'Public open space' and no restricted or private open space.

Source: VPA *Melbourne metropolitan open space network*, https://data-planvic.opendata.arcgis.com/datasets/da1c06e3ab6948fcb56de4bb3c722449_0/about,

Vic DELWP *Vicmap Features of Interest https://metashare.maps.vic.gov.au/geonetwork/srv/api/records/d257574b-6630-51f1-a53e-a9a23c0de1c8/formatters/sdm-html?root=html&output=html#tab2*

Given the large amount of public open space availability of any kind, this analysis focuses on open space such as parks & gardens, recreation corridors, and sports fields & organised recreation for Metropolitan Melbourne and parks, gardens, and sport grounds for Regional Victoria.[60] This means local councils and state government provide mixed passive and active open space for their communities.

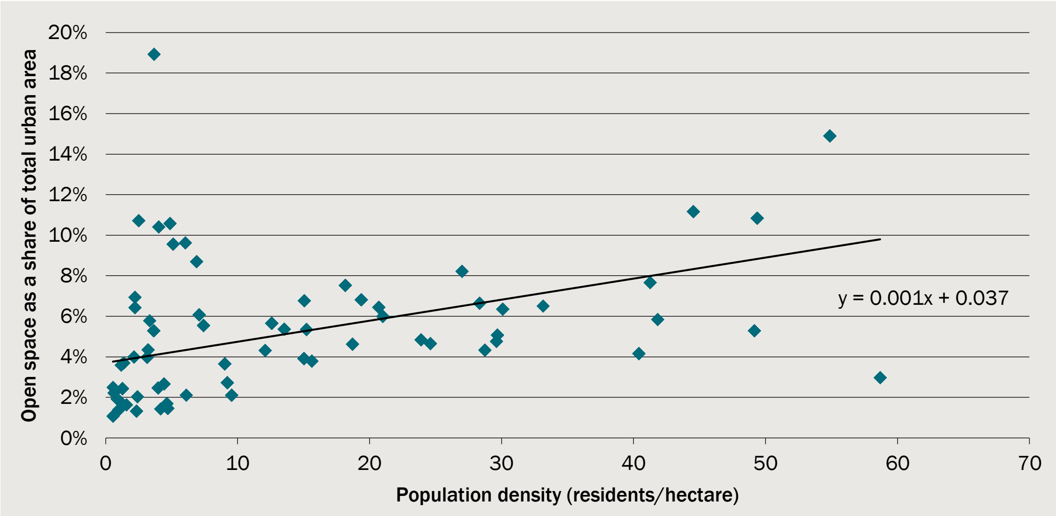
We acknowledge that the data quality regarding open space availability is more reliable and comprehensive for Metropolitan Melbourne compared to Regional Victoria. As a result, this analysis should be considered as a high-level overview rather than a detailed and precise assessment.

The amount of open space in a particular catchment is often correlated with the residential density. That is, residents in high density areas with less or no private open space (e.g., backyard) demand more recreational open space, and to mitigate the urban heat island effect more green space is required and desired in high density areas.

This pattern can be observed across Victoria (chart B.3 and table B.4) where denser areas have on average more public open space as a share of total urban area. Not surprisingly, Melbourne's Growth Areas tend to have a relatively small share of open space compared to the other functional urban areas since those are yet to be fully developed.

60 This differs from the provision of community sport and recreation hubs, which provide dedicated small-sized hubs (<0.5 hectares), such as tennis and netball courts.

B.3 Public open space provision in Victoria at a SA3 level[61]



Note: This includes Parks & Gardens, Recreation Corridors, and Sports Fields & Organised Recreation for Metropolitan Melbourne and Parks, Gardens, and Sport Grounds for Regional Victoria.

Data source: CIE.

B.4 Current open space provision by functional urban area

Functional Urban Area	Open space	Median population density	Median amount of open space as a share of urban area
	ha	Residents/ha	Per cent
Inner Melbourne	1 543	46.7	10.8
Middle Melbourne	3 956	25.7	5.0
Outer Melbourne	6 341	17.5	3.9
Melbourne New Growth Area	2 042	8.7	2.7
Regional City	8 240	6.5	5.3
Regional Centres and Rural Areas	23 107	2.4	3.7

Note: This includes Parks & Gardens, Recreation Corridors, and Sports fields & Organised Recreation for Metropolitan Melbourne and Parks, Gardens, and Sport Grounds for Regional Victoria. Open space amount based on SA3 Levels.

Source: CIE.

Approach to measure open space demand

There are several potential approaches to estimate the additional demand of open space. For the purpose of this analysis, we have adopted a benchmarking approach, i.e., additional open space provision is a function of 'meeting the benchmark' and 'population density.'

61 The analysis of open space requirements and demand have been made on a Statistical Area 3 (SA3) level, as some high density SA2's have low amounts of open space within the area but are surrounded by parks and sport fields.

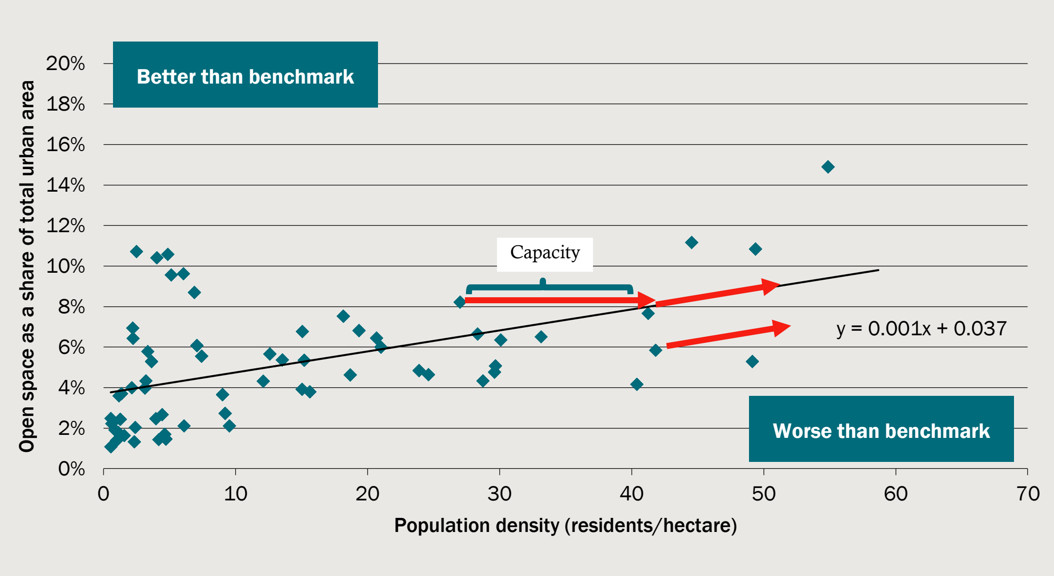
- The benchmark is then set as being the current average provision rate by population density. This allows for detailed excess capacity and demand modelling on a SA3 level and reflects average open space provision and planning to date.

The benchmarking approach also aligns well with the housing model since the current provision of open space is internalised in the value of housing to date and allows a separate modelling of Greenfield versus Infill open space provision.

The approach is visualised in chart B.5 and based on the average open space provision by population density across Victoria. It can be summarised as follows:

- Greenfield open space provision at a minimum of 1.8 per cent of total urban area in the respective area irrespective of the population density based on the y-intercept of the linear trend (i.e., benchmark curve) and increasing along the slope with increasing population density.
- Infill open space provision:
  - SA3s above the benchmark curve have sufficient open space and excess capacity to accommodate growth. There is no additional open space provision until the excess capacity is used, at which point the additional provision rate follows the slope of the curve.
  - SA3s below the benchmark curve do not have sufficient open space and provide additional open space as indicated by the slope of the benchmark curve.
- Additional open space provision equals 1.6 percentage points for an additional 10 residents per hectare based on the slope of the benchmark curve.

B.5 Conceptual open space provision by SA3



Note: Underlying data behind this chart is provided at the end of this chapter.

Data source: CIE.

Total open space provision and requirements are estimated based on the urban area within each area (SA3), while the urban area land take is increasing with development over time (see Appendix O for a detailed description of the land take methodology, and for the type of meshblocks used as urban area proxy). Box B.6 outlines the definition of ‘urban area’ used in the context of the open space analysis.

B.6 Urban Area

The open space analysis is based on estimating the share of open space in SA3 regions. As many SA3’s, in particular in regional areas, are large and not consistently populated we have defined urban areas within each SA3. We defined urban area based on ABS Meshblock data (B.7) which is the total area where people live, work and spent time, and include the following land use types:

- Education
- Commercial
- Residential
- Parkland (only if not conservation or reserves)
- Primary Production
- Other
- Industrial
- Hospital/Medical
- Transport

B.7 Urban Area by region

FUA		Urban Area	Total Area
	per cent	ha	ha
Inner Melbourne	99%	18 275	18 400
Middle Melbourne	98%	73 352	74 482
Outer Melbourne	79%	164 687	208 697
Melbourne New Growth Area	42%	111 059	262 227
Regional City	43%	129 551	303 234
Regional Centres and Rural Areas	3%	672 353	21 882 584

Source: CIE.

Capacity in Victoria’s Open Space Infrastructure

Current capacity has been estimated using the benchmarking approach outlined in the previous section. Any SA3 area which has a higher percentage of open space than the benchmark relative to the respective population density has capacity to accommodate future population growth up to the benchmark level. Based on the benchmarking approach, there is considerable capacity outside of Metropolitan Melbourne, while inner and middle Melbourne have overall no excess capacity. While there is no excess capacity within most of Metropolitan Melbourne (as some SA3s are below the benchmark), some SA3s can still serve some additional population (table B.8).

B.8 Current excess capacity and allowance for additional population

Functional Urban Area	Weighted excess capacity (Difference between actual open space provision and benchmark)	Additional population (That can be served by existing open space)
	Per cent	No.
Inner Melbourne	0.2	2 444
Middle Melbourne	-0.9	2 590
Outer Melbourne	-0.9	7 148
Melbourne New Growth Area	-1.3	4 686
Regional City	1.8	94 199
Regional Centres and Rural Areas	1.2	55 335

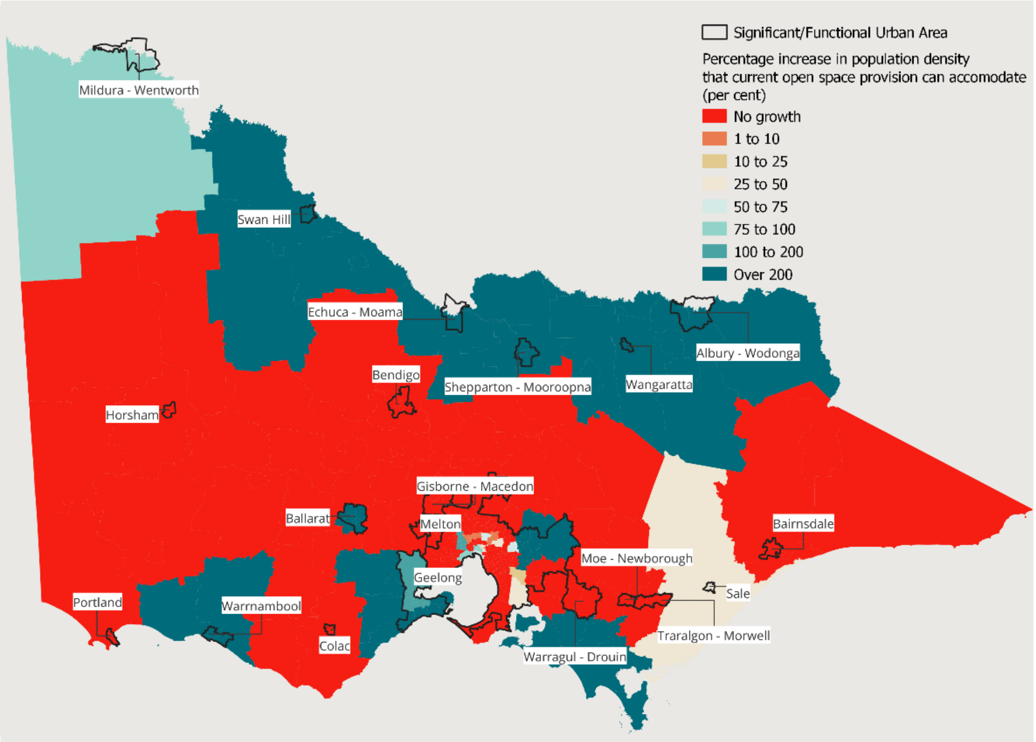
Source: CIE.

Maps B.9 and B.10 show how much additional population growth each SA3 can accommodate relative to today:

- A large share of regional areas and cities have no open space excess capacity to accommodate an increase in population density assuming a constant urban area.
  - Some exceptions include the North of Victoria, Warrnambool, Ballarat and Geelong
- There is generally no excess capacity in North Growth, West Growth, and Sunbury/Diggers Rest Corridor and outer Melbourne infill areas.
- The remainder of the Melbourne Growth area (South-East corridor) has capacity for additional 10 to 50 per cent relative to the current population density.
- Inner Melbourne and middle Melbourne generally have very low excess capacity, except for Melbourne City which has a high share of open space that can accommodate increases in population density.

Overall, additional open space is needed across all scenarios and functional urban areas as population density until 2036 and 2056 will exceed current available provision by far (chart B.11).

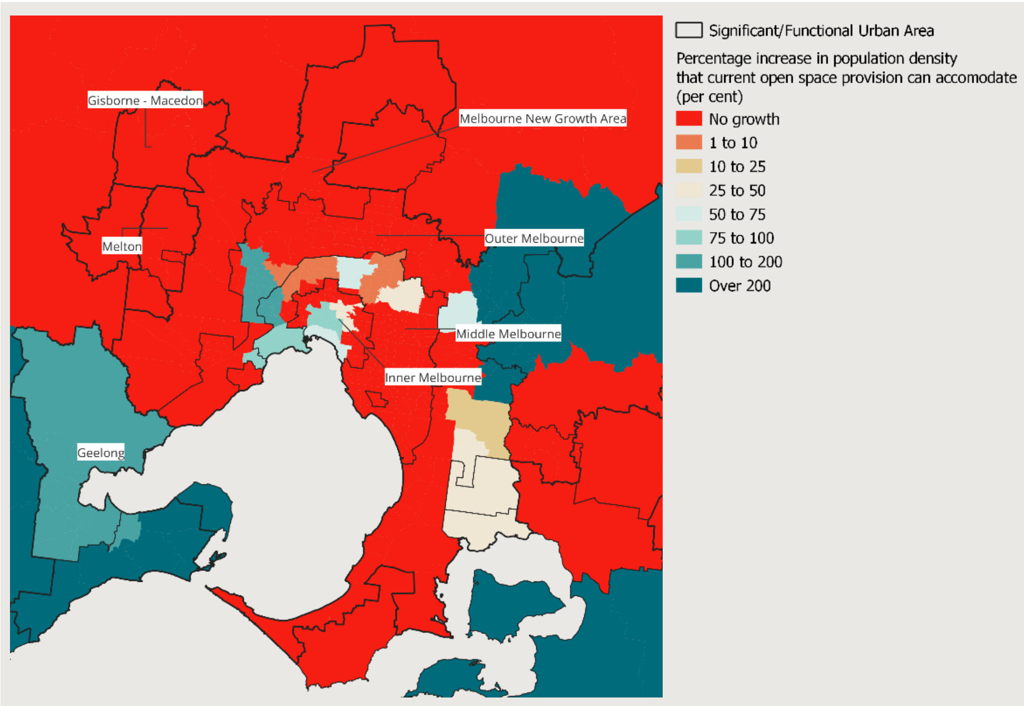
B.9 Significant and functional urban areas that can accommodate increase in population density by SA3



Note; Analysis is done on a SA3 level.

Data source: CIE.

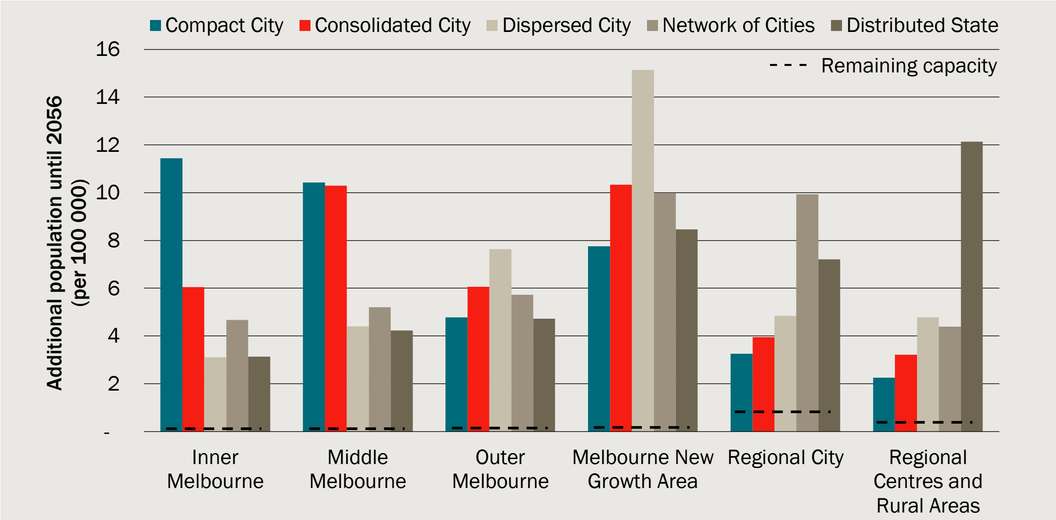
B.10 Metropolitan Melbourne urban areas that can accommodate increase in population density by SA3



Note; Analysis is done on a SA3 level.

Data source: CIE.

B.11 Additional population until 2056 and open space capacity by functional urban area and scenario



Data source: CIE.

Additional open space requirement by population scenario

Under each population distribution scenario, the additional population is the same, however, population densities vary considerably. On average across the scenarios, 5.5 to 7 per cent more open space is needed to accommodate the increase in population density, while this share is higher the less dispersed the population scenario is. There are two main drivers for additional requirement:

- Change in population density, and
- Share of Infill versus Greenfield area.

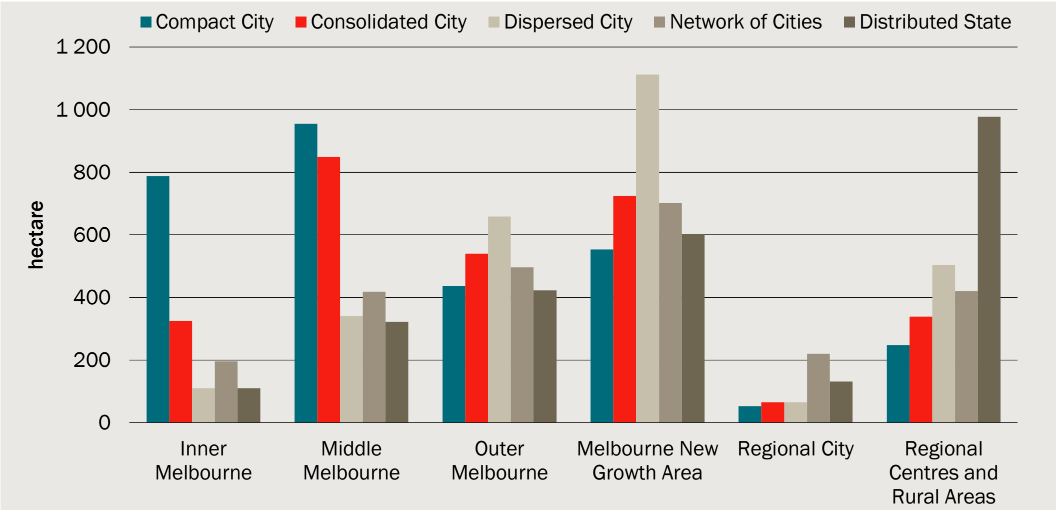
The latter is highly relevant as there is a minimum open space provision for Greenfield independent of population density. This means scenarios which see extensive Greenfield development will ultimately require more open space than scenarios with development in infill areas. Infill areas are largely the inner, middle, and outer Melbourne functional urban areas.

In summary (chart B.12):

- The Compact City scenario sees the highest additional requirement in open space with 3 031 hectares, as over 67 per cent of the growth is happening in infill areas. Those areas see a large increase in population density which leads to additional open space requirements. In particular, inner and middle Melbourne account for more than half of the additional open space requirement as those areas see a 55 to 162 per cent increase in population density until 2056.
- The Consolidated City scenario differs only slightly from the Compact City scenario, with less growth in infill areas (56 per cent). The additional provision in open space equates to 2 841 hectares, while the difference to the Compact City scenario is driven by more Greenfield open space requirement.

- The Dispersed City scenario has the highest population growth in Melbourne's New Growth Areas across all scenarios with 38 per cent, followed by Infill areas with 38 per cent. This means that more open space must be provided in Greenfield areas across Victoria, but less is required in highly dense areas. In total 2 789 hectares of additional open space is needed, with the majority being where the population growth is occurring, in Melbourne's New Growth Areas and Regional Victoria.
- The Network of Cities scenario sees a very similar share of Greenfield development across Victoria as the Dispersed City scenario. As open space capacity is slightly higher in some parts of Regional Victoria, total additional open space requirement equals 2 451 hectares, which is the lowest across all scenarios.
- The Distributed State scenario assumes 49 per cent of population growth outside of Metropolitan Melbourne and 70 per cent in Greenfield areas across Victoria. Additional open space requirements are marginally higher than the Network of Cities scenario at 2 566 hectares.

B.12 Additional open space requirements, by scenario (2056)



Costs of additional open space infrastructure provision

Total cost for providing more open space includes the land cost, capital and operating costs. Costs have been assumed to vary by regions, while the land cost differs by region and by type of development area. In addition, we have assumed:

- Greenfield areas: Land will be repurposed to open space, and
- Infill areas, which are usually land constrained:
  - Where there **is** already natural and semi-natural open space, this open space will be embellished. This is usually land in government ownership and will be the preferred method compared to acquiring new land in infill areas.[62]
  - Where there **is not** enough natural and semi-natural open space to be embellished, existing land will be transformed into open space.

62 https://www.planning.vic.gov.au/__data/assets/pdf_file/0020/103169/3.1-Open-Space-Resource-Guide.pdf, p.1

Land costs per square metre of required land are summarised in table B.13.

B.13 Land cost for open space provision

Functional Urban Area	Greenfield	Infill	Infill
	Purchase land	Embellishment of government-owned natural open space	Purchase land
	$/sqm	$/sqm	$/sqm
Inner Melbourne	NA	0	5 322
Middle Melbourne	NA	0	2 517
Outer Melbourne	692	0	1 095
Melbourne New Growth Area	530	0	NA
Regional City	161	0	480
Regional Centres and Rural Areas	20	0	24

Note: Land cost values are based on a weighted average of number of sales, median price per area, and median block size by region in Victoria. Greenfield values are based on the weighted average of land uses classified as Res Dev Site, Res Land (WithBuild), Vac Res A, Vac Res B, Vac Res C, Vac Res Englobo Other, Vac Res Rural style, Infill new only on ac Res A, Vac Res B, Vac Res C..

Source: Valuer-General Victoria *Property sales statistics* (2021), https://www.land.vic.gov.au/valuations/resources-and-reports/property-sales-statistics

Capital and operating cost for public open space varies generally depending on the quality of open space. For example, establishing a small local park will be significantly less costly than providing active open space.

We have, therefore, based estimates for Greenfield areas, i.e., Melbourne New Growth Area and most of Regional Victoria, on VPA's Benchmark Infrastructure Costings for a 5-to-6-hectare park with sports and recreation facilities, which reflects a mixed passive and active open space park (table B.14).[63] Cost estimates for the remainder of Metropolitan Melbourne have been based on Developer Contributions Plans.

B.14 Capital expenditure for open space provision

Functional Urban Area	Capital expenditure
	$2023/sqm
Inner Melbourne	357.3
Middle Melbourne	214.6
Outer Melbourne	214.6
Melbourne New Growth Area	188.0
Regional City	188.0
Regional Centres and Rural Areas	188.0

Note: Rates have been escalated using the ABS Heavy and civil engineering construction Australia Index.

Source: Victorian Planning Authority *Benchmark Infrastructure Report* Table 2-1 (2019), https://vpa-web.s3.amazonaws.com/wp-content/uploads/2019/10/Review-of-Benchmark-Infrastructure-Costings-Report-11-April-2019-FINAL-VERSION.pdf, VPA (2021) Arden Precinct Draft Development Contributions Plan https://vpa-web.s3.amazonaws.com/wp-content/uploads/2021/09/Arden-Precinct-Draft-Development-Contributions-Plan-August-2021.pdf, VPA (2018) East-Village Development Contribution Plan https://www.gleneira.vic.gov.au/media/5189/07-east-village-development-contribution-plan.pdf

63 Victorian Planning Authority *Benchmark Infrastructure Report* (2019), https://vpa-web.s3.amazonaws.com/wp-content/uploads/2019/10/Review-of-Benchmark-Infrastructure-Costings-Report-11-April-2019-FINAL-VERSION.pdf

Operating expenditure is based on Frankston Council's open space asset management plan as the report provides management rates for turf, bushland, vegetation, and council facilities surrounds per hectare per year and converted to an operating cost per capital cost figure (table B.15). Total operating expenditure assumes that additional open space requirement is increasing linearly over time.

B.15 Operating expenditure for open space provision

Functional Urban Area	Operating expenditure	
	% of CAPEX	$2023/sqm
Inner Melbourne	1.3	4.6
Middle Melbourne	1.3	2.8
Outer Melbourne	1.3	2.8
Melbourne New Growth Area	1.3	2.4
Regional City	1.3	2.4
Regional Centres and Rural Areas	1.3	2.4

Note: Rates have been escalated using the ABS Heavy and civil engineering construction Australia Index.

Source: Frankston Council's *Open Space Asset Management Plan* Table 10 (2017), https://www.frankston.vic.gov.au/files/assets/public/planning-and-building/pdfs/open_space_asset_management_plan_2017.pdf

The accuracy of the management rate has been verified by comparing total operating expenditure from the model for open space under the current provision to the total Victorian Local Government expenditure data from 2018-19 to 2020-21.[64]

Cost summary

We model the cost of providing additional open space infrastructure through managing demand and excess capacity at an SA3 area level.

The cost of providing additional open space infrastructure ranges between $10.8 to $26.1 billion across the scenarios.

The Compact City scenario has considerably higher cost than any other scenario with over $26.1 billion mainly driven by the high land cost. On the other hand, the Consolidated City scenario requires only 7 per cent less open space, but costs are 35 per cent lower compared to the Compact City scenario at $27.1 billion. The Dispersed City and Network of Cities scenarios have similar cost around $14 and $12.5 billion, followed

64 Average recurrent expenditure for Sports Grounds & Facilities and Parks & Reserves has been $1.2 billion per year in 2023-dollars from 2018-19 to 2020-21. Applying the rates outlined in the table to our model of current open space provision, we estimate total operating expenditure at $1.1 billion in 2023-dollars. While our figure is marginally lower, we have been advised by the Open Space for Everyone team at DEECA that publicly available data does not fully capture all available open space, which would lead to a slight underestimation of total available open space and therefore operating expenditure in our model.

Local Government *Consultation & Council Data Recurrent expenditure for Sports Grounds & Facilities and Parks & Reserves,* https://www.localgovernment.vic.gov.au/funding-programs/victoria-grants-commission/consultation-and-operations by the Distributed State scenario which sees the lowest additional open space requirement and costs of $10.8 billion.

As additional open space provision increases between scenarios, so do the cost. However, the open space requirement does not differ as much as the costs between scenarios. This is mainly driven by land cost, and to a smaller degree by capital and operating cost.

New open space in infill areas has a very high cost of land. In particular in the Compact City scenario large land areas are repurposed to open space. In contrast, in the Consolidated City scenario a larger share of additional open space can be met by embellishing existing natural and semi-natural open space which has no additional land cost.

B.16 Open space infrastructure impacts across scenarios, 2021 to 2056

	Sc1	Sc2	Sc3	Sc4	Sc5
Additional from 2021 to 2056	Compact City	Consolidated City	Dispersed City	Network of Cities	Distributed State
	ha	ha	ha	ha	ha
Requirement	3 031	2 841	2 789	2 451	2 566
	$b	$b	$b	$b	$b
Capital Cost	7.4	6.3	5.7	5.2	5.2
Operating Cost	1.7	1.4	1.3	1.2	1.2
Land cost	17.1	9.4	7.0	6.2	4.4
Total	**26.1**	**17.1**	**14.0**	**12.5**	**10.8**

Note: Total may not sum up due to rounding.

Source: CIE.

Overall, capital and land cost equate on average to $275 million (Distributed State scenario) to $699 million (Compact City scenario) per annum. This is in a similar order of magnitude what councils have spent in the past years. From 2018/19 to 2020/21, Local governments spent on average $323 million on capital and land per year for parks and reserves.[65]

Distributional impacts

The variety of owners and managers of open space means the financing of those spaces and funding sources for them are inevitably complex. Funding streams include:[66]

- General revenues, council rates, trusts, and levies,
- Local open space contributions,

65 Local Government *Consultation & Council Data Capital Asset Outlays for Sports Grounds & Facilities and Parks & Reserves,* https://www.localgovernment.vic.gov.au/funding-programs/victoria-grants-commission/consultation-and-operations

66 Victorian Government (2021), Open Space Strategy for Metropolitan Melbourne https://www.environment.vic.gov.au/__data/assets/pdf_file/0025/520594/Metro-Open-Space-Strategy-FA4-book-WEB.pdf, p.43

- Developers' contributions, and
- Other fees, charges and grants.

Additional open space is provided and funded through different ways:[67]

- Land contributions by the Victorian government to create new Capital City open space.
- Municipal open space for new communities to be funded by the Victorian government, Local Government and developers.
- Open space contributions by developers to provide for the demand created by forecast residents and workers. This includes land contributions from developers to create new Neighbourhood, Local and Small Local open space, and cash contributions for land purchase, open space establishment and upgrades.
- Allocations by the Local Government including land conversion or purchase to expand the open space network, and annual budget expenditure for open space establishment and upgrades.

To meet the objective of this analysis, we have assumed there are two groups of stakeholders that are responsible for funding open space:[68]

- Largely by developers, and
- Local and State Governments.

Developers have to contribute to the establishment of new open space and improvements of open space as part of the Developer Contribution Plans. These contributions are typically intended to mitigate the impact of new developments on the surrounding community and infrastructure, including the need for additional open space. As part of these requirements, developers may be obligated to provide land or cash contributions.

For example, under the Subdivision Act a developer who applies to subdivide land may be required to:[69]

- set aside up to 5 per cent of the land for public open space, or
- pay up to 5 per cent of the site value of the land, or
- a combination of both.

However, those rates can differ by council and can go up to 10 per cent.

We have assumed that 23 per cent of capital works and land cost will be funded by developers and 14 per cent by the State Government. This is based on the average share of (non-recurrent) contributions relative to the capital outlays for parks and reserves by

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67 City of Melbourne Open Space Strategy (2012) https://www.melbourne.vic.gov.au/SiteCollectionDocuments/open-space-contributions-framework.pdf, p.1

68 Australian Social & Recreation (ASR) Research Pty Ltd (2009), Guide to social infrastructure planning, Appendix 3, available at: https://vpa-web.s3.amazonaws.com/wp-content/uploads/2016/07/Guide-to-Social-Infrastructure-Planning.pdf

69 https://www.planning.vic.gov.au/policy-and-strategy/infrastructure-contributions

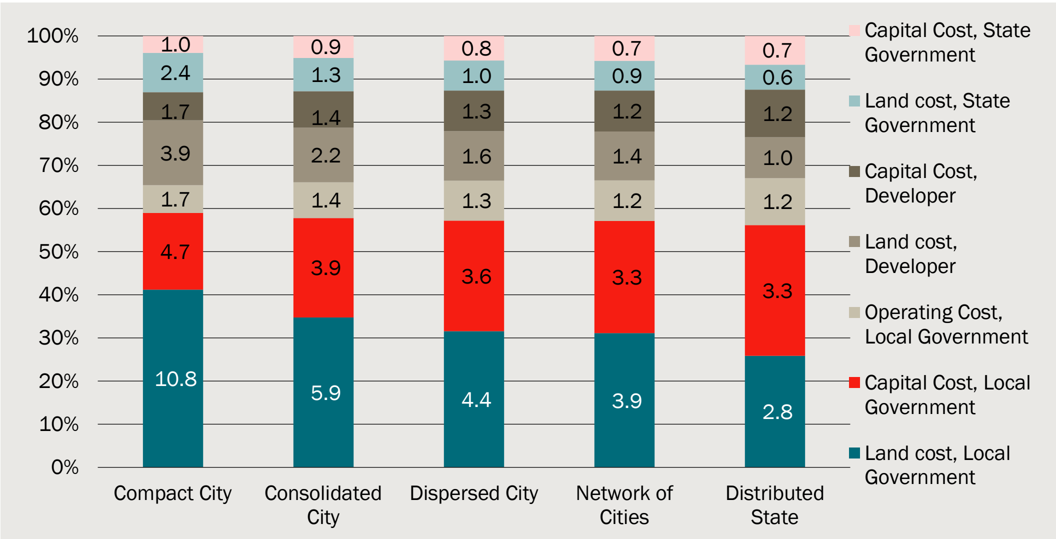
Local Governments from 2018/19 to 2020/21.[70] Operating expenditures are funded solely by the Local Government. Table B.17 and chart B.18 summarise the costs funded by stakeholder.

B.17 Open space infrastructure impacts across scenarios 2021 to 2056, by stakeholder

Cost item	Stakeholder	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
		$b	$b	$b	$b	$b
Capital Cost	Developer	1.7	1.4	1.3	1.2	1.2
	State Government	1.0	0.9	0.8	0.7	0.7
	Local Government	4.7	3.9	3.6	3.3	3.3
Operating Cost	Local Government	1.7	1.4	1.3	1.2	1.2
Land cost	Developer	3.9	2.2	1.6	1.4	1.0
	State Government	2.4	1.3	1.0	0.9	0.6
	Local Government	10.8	5.9	4.4	3.9	2.8
Total	**Developer**	**5.6**	**3.6**	**2.9**	**2.6**	**2.2**
	State Government	**3.4**	**2.2**	**1.8**	**1.6**	**1.4**
	Local Government	**17.1**	**11.3**	**9.3**	**8.3**	**7.3**
Grand Total		**26.1**	**17.1**	**14.0**	**12.5**	**10.8**

Source: CIE.

B.18 Share of funding by stakeholder



Data source: CIE.

70 Local Government *Consultation & Council Data Recurrent expenditure Parks & Reserves,* https://www.localgovernment.vic.gov.au/funding-programs/victoria-grants-commission/consultation-and-operations

Detailed current open space provision by SA3

B.19 Current open space provision by SA3

SA3 Code	SA3 Name	Urban area (2021)	Open space	Pop' density	Open space share
		km²	km²	Pop/ha	Per cent
20101	Ballarat	319.1	16.9	3.6	5.3
20102	Creswick - Daylesford - Ballan	259.8	9.3	1.2	3.6
20103	Maryborough - Pyrenees	307.1	5.9	0.9	1.9
20201	Bendigo	263.0	6.5	4.0	2.5
20202	Heathcote - Castlemaine - Kyneton	956.2	10.4	0.5	1.1
20203	Loddon - Elmore	212.8	5.3	0.5	2.5
20301	Barwon - West	65.3	3.8	3.3	5.8
20302	Geelong	288.1	16.0	7.4	5.5
20303	Surf Coast - Bellarine Peninsula	131.1	11.4	6.9	8.7
20401	Upper Goulburn Valley	464.5	11.3	1.3	2.4
20402	Wangaratta - Benalla	214.4	13.8	2.2	6.4
20403	Wodonga - Alpine	344.3	23.9	2.2	6.9
20501	Baw Baw	235.8	4.8	2.4	2.0
20502	Gippsland - East	499.9	7.0	1.0	1.4
20503	Gippsland - South West	135.3	12.9	5.1	9.6
20504	Latrobe Valley	242.7	9.7	3.1	4.0
20505	Wellington	211.0	8.4	2.1	4.0
20601	Brunswick - Coburg	20.4	1.1	49.1	5.3
20602	Darebin - South	14.0	0.8	41.8	5.9
20603	Essendon	18.2	1.4	41.2	7.7
20604	Melbourne City	30.5	4.5	54.9	14.9
20605	Port Phillip	25.5	2.8	44.5	11.2
20606	Stonnington - West	11.9	0.4	58.7	3.0
20607	Yarra	20.6	2.2	49.4	10.8
20701	Boroondara	60.0	3.1	29.7	5.1
20702	Manningham - West	48.7	3.1	20.7	6.4
20703	Whitehorse - West	38.1	1.8	29.6	4.8
20801	Bayside	37.2	1.6	28.7	4.3
20802	Glen Eira	40.7	1.7	40.4	4.2
20803	Kingston	69.3	3.2	18.7	4.6
20804	Stonnington - East	13.7	0.9	33.1	6.5
20901	Banyule	62.6	3.8	21.0	6.0
20902	Darebin - North	39.3	3.2	27.0	8.2

SA3 Code	SA3 Name	Urban area (2021)	Open space	Pop' density	Open space share
		km2	km2	Pop/ha	Per cent
20903	Nillumbik - Kinglake	297.4	4.0	2.3	1.3
20904	Whittlesea - Wallan	551.4	8.1	4.7	1.5
21001	Keilor	42.4	2.3	15.2	5.3
21002	Macedon Ranges	214.2	3.5	1.6	1.6
21003	Moreland - North	30.3	2.0	28.3	6.7
21004	Sunbury	75.6	1.6	6.1	2.1
21005	Tullamarine - Broadmeadows	214.4	4.5	9.5	2.1
21101	Knox	109.4	4.3	15.0	3.9
21102	Manningham - East	64.6	0.9	4.2	1.4
21103	Maroondah	61.2	4.2	19.3	6.8
21104	Whitehorse - East	26.6	1.2	24.6	4.7
21105	Yarra Ranges	224.3	13.6	7.1	6.1
21201	Cardinia	267.8	7.2	4.4	2.7
21202	Casey - North	104.4	5.6	13.5	5.4
21203	Casey - South	181.4	10.3	12.6	5.7
21204	Dandenong	128.6	4.9	15.6	3.8
21205	Monash	79.5	3.9	23.9	4.8
21301	Brimbank	106.8	8.0	18.2	7.5
21302	Hobsons Bay	61.1	4.1	15.0	6.8
21303	Maribyrnong	31.2	2.0	30.1	6.4
21304	Melton - Bacchus Marsh	221.3	8.1	9.0	3.7
21305	Wyndham	321.6	8.8	9.2	2.7
21401	Frankston	118.5	5.1	12.1	4.3
21402	Mornington Peninsula	366.0	6.2	4.6	1.7
21501	Grampians	434.5	16.1	1.4	3.7
21502	Mildura	174.2	7.6	3.2	4.3
21503	Murray River - Swan Hill	91.4	9.5	4.0	10.4
21601	Campaspe	151.5	16.2	2.5	10.7
21602	Moira	49.6	4.8	6.0	9.6
21603	Shepparton	137.9	14.6	4.9	10.6
21701	Glenelg - Southern Grampians	571.2	12.7	0.6	2.2
21703	Colac - Corangamite	337.4	6.0	1.1	1.8
21704	Warrnambool	143.9	27.2	3.6	18.9

Source: CIE, ABS Meshblocks (2021), VPA *Melbourne metropolitan open space network*, https://data-planvic.opendata.arcgis.com/datasets/da1c06e3ab6948fcb56de4bb3c722449_0/about,

Vic DELWP *Vicmap Features of Interest* *https://metashare.maps.vic.gov.au/geonetwork/srv/api/records/d257574b-6630-51f1-a53e-a9a23c0de1c8/formatters/sdm-html?root=html&output=html#tab2*

C Community facilities

- **Requirement for additional community facility hubs until 2056 ranges between 292 and 407 (total number of hubs) across the different scenarios, which includes Health & Wellbeing hubs, Sport & Recreation hubs, Aquatic Centres, and Art & Cultural hubs. The Compact City scenario sees the highest additional provision and the Distributed State scenario the least.**
  - **The main driver of additional provision is population growth in urban areas, i.e., Metropolitan Melbourne and Regional Cities, as the central case assumes that there is sufficient excess capacity in regional Victoria.**
- **Total expected costs for additional community infrastructure until 2056 are highest for the Compact City scenario (over $24.4 billion), followed by the Consolidated City scenario with over $20.6 billion and the Network of Cities scenario with over $18.4 billion. The least cost is estimated for the Dispersed City and Distributed State scenarios with over $17.5 and $13.7 billion, respectively.**
  - **The main driver of costs is the additional provision of community facilities. For scenarios with high infill development the main drivers are also land cost, and higher construction costs in inner Melbourne due to greater complexity.**

C.1 Community infrastructure impacts across scenarios

Additional from 2021 2056	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	No.	No.	No.	No.	No.
Facilities / Hubs	407	382	375	379	292
	$b	$b	$b	$b	$b
Capital Cost	11.8	10.5	9.7	10.1	7.6
Operating Cost	5.6	5.0	4.7	4.8	3.6
Land Cost	7.0	5.1	3.1	3.5	2.5
Total	**24.4**	**20.6**	**17.5**	**18.4**	**13.7**

Note: Total may not sum up due to rounding.

Source: CIE.

Community infrastructure refers to the physical and social assets that are essential for communities to thrive. These facilities can include a range of amenities community centres, libraries, health clinics, sports facilities, and cultural spaces. They play a critical role in fostering social cohesion, supporting economic growth, and promoting public health and wellbeing.

The provision of local community infrastructure in Victoria is also informed by a range of guidelines and standards developed by government agencies such as the Department of Health[71], Sport and Recreation Victoria[72], and Creative Victoria[73]. These guidelines provide best practices for designing and delivering community facilities that meet the needs of diverse communities and promote social inclusion.

Community infrastructure covers a wide range of different facilities, many of them such as large cultural and sporting facilities will serve big catchments and will be planned on a state level. In this report, we will focus on local community infrastructure and three different types of community facility hubs as outlined in the Fishermans Bend Community Infrastructure Plan and delivery models:[74]

- Health and wellbeing hubs
- Sport and recreation hubs and additional aquatic centre, and
- Art and cultural hubs.

Sport and recreation hubs differ from open space as they offer sport pavilions, and designated facilities such as tennis or netball courts.

A short description of the hubs is provided in table C.2 and a summary of the key provision and size assumptions in table C.3. Note that inner Melbourne provision is generally assumed to be two-storey facilities due to site constraints, while for other functional urban areas the provision will be a one-storey building. Each facility has a carpark and is usually based on the floor to site area ratio from the VPA Benchmark Infrastructure & Cost Guide.

C.2 Community facility provision

Area	Description
Health and wellbeing hubs	Public community health, wellbeing and justice support services including services such as specialist medical treatment, nursing care, allied health, dental services, counselling services (financial, domestic violence, etc), antenatal and postnatal clinics, district nursing, primary injury, services for children (immunisation, speech therapy, etc) and community mental health.
Sport and recreation hubs and aquatic centre	Provide multipurpose courts for netball, basketball, tennis, etc, and have at least one large multipurpose room for activities such as gymnastics, dance, table tennis and fitness classes, and aquatic centres at some locations
Art and cultural hubs	Library and community gatherings spaces

71 https://www.health.vic.gov.au/community-health/community-health-services and https://www.health.vic.gov.au/community-health/community-health-integrated-program-chip-guidelines

72 https://sport.vic.gov.au/our-work/infrastructure/community-infrastructure and https://sport.vic.gov.au/__data/assets/pdf_file/0020/188021/13363-CSVE-Active-Vic-Strategic-Framework_Sport-and-Rec_FA2_WEB.pdf

73 https://creative.vic.gov.au/__data/assets/pdf_file/0005/2099678/Creative-State-2025-1.pdf

74 Department of Environment, Land, Water and Planning (2017), *Fishermans Bend Community Infrastructure Plan*, p. 63-77, https://www.fishermansbend.vic.gov.au/__data/assets/pdf_file/0018/31671/Community-Infrastructure-Plan_-FB-Taskforce_Sep-2017.pdf

Source: IV Education guidance note

C.3 Provision and Size assumptions for inner Melbourne and other regions

Functional Urban Area (FUA)	Provision Rate	Floor Area	Site Area[a]	Description
	per additional residents	hectares	hectares	
Inner Melbourne				
Health & wellbeing hub	40 000[75]	0.40[76]	0.53	2 Storeys with Carpark
Sport & recreation hub	20 000[77]	0.30[78]	0.45	2 Storeys with Carpark
Aquatic centre	65 000[79]	NA	1.60[80]	Centre with Carpark
Art and cultural hub	30 000[81]	0.15[82]	0.41	2 Storeys with Carpark
Middle, outer and Melbourne new growth area, and regional cities				
Health & wellbeing hub	40 000	0.40	0.73	1 Storey with Carpark
Sport & recreation hub	20 000	0.30	0.60	1 Storey with Carpark
Aquatic centre	65 000	NA	2.50	Centre with Carpark
Art and cultural hub	30 000	0.15	0.48	1 Storey with Carpark

[a] Includes outside area and carpark.

Source: CIE.

Capacity in Victoria's Community Infrastructure

Estimating the excess capacity of community infrastructure in Victoria can be a complex task due to various factors. One of the primary reasons is that community infrastructure encompasses a wide range of facilities, such as community centres, libraries, and sports

75 Department of Environment, Land, Water and Planning (2017), *Fishermans Bend Community Infrastructure Plan*, p. 21

76 Victorian Government 2017, Fishermans Bend Community Infrastructure Plan, Community-Infrastructure-Plan_-FB-Taskforce_Sep-2017.pdf (fishermansbend.vic.gov.au) page 72 – Average Health and Wellbeing size

77 Infrastructure Victoria (2019) *Infrastructure Provision in Different Development Settings: Metropolitan Melbourne, Volume 2 Technical Appendix,* p.70 – Council Indoor recreation centre provision

78 Ibid., p.70 – Council Indoor recreation centre site area, and VPA Benchmark Infrastructure & Cost Guide – Appendix 3: Sports Pavilions - Site to Floor Area ratio

79 Infrastructure Victoria 2021 Background paper - Social infrastructure in Melbourne's new growth areas (infrastructurevictoria.com.au) Page 19 – Average existing provision in 2021.

80 Australian Social & Recreational Research Pty Ltd, Planning for Community Infrastructure in Growth Areas 2008, p.35 – Minimum size for Inner Melbourne and Average Size for remainder, https://vpa.vic.gov.au/wp-content/Assets/Files/Planning_for_Community_Infrastructure_in_Growth_Areas_Apr08.pdf

81 Infrastructure Victoria (2019) *Infrastructure Provision in Different Development Settings: Metropolitan Melbourne, Volume 2 Technical Appendix,* p.70 – Library Level 3 & 4 provision

82 VPA Benchmark Infrastructure & Cost Guide – Appendix 3: Community Facilities - Level 3 with Library

facilities, each with its unique capacity and usage patterns. As a result, it is challenging to develop a standardised methodology to estimate excess capacity across these different types of facilities.

For the purpose of this analysis the various types have been aggregated in three high-level types. The aggregation of various community facilities can result in a loss of granularity and may not fully capture the nuances of the infrastructure's excess capacity. Furthermore, there are data gaps in terms of reliable data on usage patterns and capacity by facility.

For the reasons outlined above high-level assumptions have been made about the currently existing excess capacity (table C.4). Those will be tested and revisited in the sensitivity analysis.

C.4 Excess capacity assumptions

Area	Excess capacity assumption
Inner Melbourne	0 per cent[83]
Middle & outer Melbourne	20 per cent, with sensitivity of 0 and 30 per cent
Melbourne new growth areas	5 per cent
Regional cities	20 per cent, with sensitivity of 0 and 30 per cent
Regional centres and rural areas	No capacity constraint, with sensitivity of 50 per cent

Source: CIE.

Cost of additional community facilities

Total cost for providing additional community facilities includes the opportunity cost of land, capital, and operating costs. Costs have been assumed to vary by regions, while the land cost differs by region and by type of development area.

Land cost per square metre of required land is summarised in table C.5.

C.5 Land cost for community facilities

Functional Urban Area	Greenfield	Infill
	$/sqm	$/sqm
Inner Melbourne	NA	5 322
Middle Melbourne	NA	2 517
Outer Melbourne	692	1 095
Melbourne New Growth Area	530	NA
Regional City	161	480
Regional Centres and Rural Areas	20	24

83 Victorian Government 2017, Fishermans Bend Community Infrastructure Plan, Community-Infrastructure-Plan_-FB-Taskforce_Sep-2017.pdf (fishermansbend.vic.gov.au) page 9

Note: Land cost values are based on a weighted average of number of sales, median price per area, and median block size by region in Victoria. Greenfield values are based on the weighted average of land uses classified as Res Dev Site, Res Land (WithBuild), Vac Res A, Vac Res B, Vac Res C, Vac Res Englobo Other, Vac Res Rural style, Infill new only on ac Res A, Vac Res B, Vac Res C..
Source: Valuer-General Victoria *Property sales statistics* (2021), https://www.land.vic.gov.au/valuations/resources-and-reports/property-sales-statistics

Capital and operating cost for community facilities vary by type and area of development. Cost estimates used in this analysis are summarised in table C.6. Capital cost for developments in inner Melbourne have been escalated by 42 per cent, recognising the complexity of development in high density areas as well as the potential demolition cost.[84] Total operating expenditure assumes that additional community infrastructure requirement is increasing linearly over time.

C.6 Capital expenditure by type of community facility

Functional Urban Area (FUA)	CAPEX	OPEX	
	$m, 2023	$m/annum, 2023	% of CAPEX
Inner Melbourne			
Health & wellbeing hub	90.79[85]	2.49	2.7[86]
Sport & recreation hub	13.39[87]	0.37	2.7
Aquatic centre	78.82[88]	2.16	2.7
Art and cultural hub	17.27[89]	0.47	2.7
Middle, Outer and Growth Area Melbourne, and Regional Cities			
Health & wellbeing hub	63.99	1.75	2.7
Sport & recreation hub	9.60	0.26	2.7
Aquatic centre	55.55	1.52	2.7
Art and cultural hub	14.65	0.47	2.7

Note: Estimates from sources have been escalated to $2023 dollars with the ABS Heavy and civil engineering construction index.
Source: CIE.

84 This is based on the relative cost difference between greenfield and infill construction and development cost. Infrastructure Victoria (2019) *Infrastructure Provision in Different Development Settings: Metropolitan Melbourne, Volume 2 Technical Appendix,* p.4-5

85 Victorian Government 2021-22 Budget Paper 3 page 69 https://s3-ap-southeast-2.amazonaws.com/budgetfiles202122.budget.vic.gov.au/2021-22+State+Budget+-+Service+Delivery.pdf – Average cost per community hospital

86 Asset Management and Maintenance by Councils, https://www.audit.vic.gov.au/report/asset-management-and-maintenance-councils?section=32425

87 Based on VPA Benchmark Infrastructure & Cost Guide – see appendix B and tables 9.11 and 2.2 for design and costing detail

88 Infrastructure Victoria 2021 Background paper - Social infrastructure in Melbourne's new growth areas (infrastructurevictoria.com.au) Page 8 & 11 – Average cost for Aquatic Centres based on two case studies

89 Based on VPA Benchmark Infrastructure & Cost Guide – Community Facilities Level 3 with Library - see appendix B and tables 8.9 for design and costing detail

Cost summary

We model the cost and demand of providing additional community facilities through managing demand and excess capacity at a population level by SA2. This implies that facilities are scaled to the appropriate size conditional on the additional population growth. This approach has been taken as it allows to estimate conservatively and subsequently to aggregate total numbers on a functional urban area level.

The cost of providing additional community infrastructure ranges between $13.7 and $24.4 billion across scenarios.

Across scenarios, total costs are mainly driven by the population growth occurring in inner Melbourne, as those facilities are more costly in terms of construction and land cost. Scenarios with a high share of population growth in regional areas (outside of regional cities) have generally lower costs given the central assumption of no capacity constraint in those areas.

C.7 Community infrastructure impacts across scenarios

Additional from 2021 2056	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	No.	No.	No.	No.	No.
Facilities / Hubs	407	382	375	379	292
	$b	$b	$b	$b	$b
Capital Cost	11.8	10.5	9.7	10.1	7.6
Operating Cost	5.6	5.0	4.7	4.8	3.6
Land Cost	7.0	5.1	3.1	3.5	2.5
Total	**24.4**	**20.6**	**17.5**	**18.4**	**13.7**

Note: Total may not sum up due to rounding.

Source: CIE.

Sensitivity analysis

As noted, excess capacity assumptions have not been verified by actual data. The sensitivity analysis accounts for that uncertainty by testing alternative excess capacity rates:

- No change for inner Melbourne and Melbourne new growth areas
- Middle & outer Melbourne: 0 and 30 per cent
- Regional cities: 0 and 30 per cent
- Regional centres and rural areas: 50 per cent

Overall, the ranking of the results does not change. However, the Dispersed City scenario has the highest variability in cost due to the included capacity constraint in the sensitivity analysis.

C.8 Community infrastructure impacts across scenarios, sensitivity analysis

Additional from 2021 2056	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	No.	No.	No.	No.	No.
Facilities / Hubs – Central	407	382	375	379	292
Facilities / Hubs – Lower excess capacity	530	516	507	505	490
Facilities / Hubs – Higher excess capacity	373	345	346	350	265
	$b	$b	$b	$b	$b
Total Cost – Central	24.4	20.6	17.5	18.4	13.7
Total Cost – Lower excess capacity	29.4	26.0	22.9	23.6	21.9
Total Cost – Higher excess capacity	22.6	18.7	16.1	17.0	12.5

Note: Total may not sum up due to rounding.

Source: CIE.

Distributional impacts

The variety of owners and managers of community facilities means the financing of those facilities and funding sources for them are inevitably complex.

To meet the objective of this analysis, we have assumed there are three groups of stakeholders that are responsible for funding community facilities:

- Government (Victorian and Local), and
- Developers.

We have assumed that 8 per cent of capital works and land cost will be funded by developers and 21 per cent by the State Government. This is based on the average share of (non-recurrent) contributions relative to the capital outlays for recreation & culture and family & community services by Local Governments from 2018/19 to 2020/21.[90] Operating expenditures are funded solely by the Local Government.

Table C.9 and chart C.10 summarise the costs funded by stakeholder.

C.9 Community infrastructure funding by stakeholder (2056)

Cost item	Stakeholder	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
		$b	$b	$b	$b	$b
Capital Cost	Developer	0.9	0.8	0.8	0.8	0.6
	Local Government	8.4	7.4	6.9	7.2	5.4
	State Government	2.5	2.2	2.0	2.1	1.6

90 Local Government *Consultation & Council Data Recurrent expenditure Parks & Reserves,* https://www.localgovernment.vic.gov.au/funding-programs/victoria-grants-commission/consultation-and-operations

Cost item	Stakeholder	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
		$b	$b	$b	$b	$b
Operating Cost	Local Government	5.6	5.0	4.7	4.8	3.6
Land cost	Developer	0.6	0.4	0.2	0.3	0.2
	Local Government	5.0	3.6	2.2	2.5	1.8
	State Government	1.5	1.1	0.7	0.7	0.5
Total	**Developer**	**1.5**	**1.2**	**1.0**	**1.1**	**0.8**
	Local Government	**19.0**	**16.1**	**13.8**	**14.5**	**10.8**
	State Government	**3.9**	**3.3**	**2.7**	**2.9**	**2.1**
Grand Total		**24.4**	**20.6**	**17.5**	**18.4**	**13.7**

Note: Figures are denoted in real $2022/23 dollars.

Source: CIE

C.10 Share of funding by stakeholder ($b)

Data source: CIE.

Community Facility design

C.11 Sport and Recreation hub, 0.45-hectare site area

Group	Sub Item	Qty	Unit	Rate (P50)	Amount (P50)	Rate (P90)	Amount (P90)
				$2019	$2019	$2019	$2019
Buildings	Site Preparation	3,000	m2	-	-	-	-
	Change Rooms With Toilets and Showers X 6	687	m2	2,408	1,654,385	2,445	1,679,895

Group	Sub Item	Qty	Unit	Rate (P50)	Amount (P50)	Rate (P90)	Amount (P90)
				$2019	$2019	$2019	$2019
	Umpire Change Rooms with Toilets	172	m2	2,519	432,694	2,595	445,677
	Storage Rooms	344	m2	2,414	829,288	2,406	826,526
	Multipurpose Room/ Social Room	429	m2	2,365	1,015,690	2,330	1,000,516
	Office/ First Aid Room	86	m2	2,352	201,952	2,360	202,696
	Canteen and Kitchen	115	m2	2,515	287,963	2,525	289,108
	Public Toilet	172	m2	1,239	212,742	1,586	272,375
	Netball Court	1	No	83,143	83,143	98,076	98,076
	Tennis Court	1	No	65,423	65,423	72,602	72,602
	Lighting Netball Court	1	No	22,803	22,803	24,396	24,396
	Lighting Tennis	1	No	21,416	21,416	24,493	24,493
Landscaping	Landscaping Construction	1,253	m2	20	25,419	26	32,827
	Landscaping Establishment (12wk)	1,253	m2	1	1,404	1	1,617
	Landscape maintenance-1 year/2 summers	1,253	m2	3	3,635	3	3,685
Car Parking	Pavement	247	m2	95	23,360	109	26,939
	Kerb and Channel	40	m	55	2,180	60	2,380
	Drainage Pipes	45	m	177	7,987	193	8,663
	Drainage Pits	2	No	2,612	5,172	2,803	5,549
	Car Park Lighting	231	m2	15	3,502	17	4,007
	Linemarking/ Signage	247	m2/pavement	3	804	4	1,004
Site Works	Site Preparation	4,500	m2	4	16,560	5	21,195
	Footpaths and paved areas	68	m2	64	4,296	72	4,857
Canopy & Veranda	Canopy & Veranda	120	m2	762	91,420	863	103,500
	Concrete Paths	0	m2	-	-	-	-
	Lighting	0	m2	-	-	-	-
	Gates/entrances	0	m2	-	-	-	-
	Other-Miscellaneous	0	m2	-	-	-	-
	Stormwater	1	%	3	165,437	3	170,035
	Sewer	1	%	2	101,769	2	104,597
	Water	1	%	2	99,262	2	102,021
	Gas	1	%	1	44,116	1	45,343
	Fire Protection	1	%	1	33,087	1	34,007
	Light & Power	1	%	2	119,315	2	122,631
	Communication	1	%	1	25,066	1	25,763
Miscellaneous	Sub-standard site conditions	0	% of area	-	-	-	-

Group	Sub Item	Qty	Unit	Rate (P50)	Amount (P50)	Rate (P90)	Amount (P90)
				$2019	$2019	$2019	$2019
	Council Fees	1	%	3	162,930	3	167,459
	Authority Fees	1	%	1	50,132	1	51,526
	Traffic Management	1	%	2	100,265	2	103,052
	Environmental Management	1	%	1	25,066	1	25,763
	Survey/Design	1	%	5	250,662	5	257,629
	Supervision & Project Management	1	%	9	451,191	9	463,733
	Site Establishment	1	%	3	125,331	3	128,815
	Environmentally Sustainable Design	1	%	2	100,265	2	103,052
	Contingency	1	%	15	751,986	15	772,888
Total	**Excluding Delivery**				**5,013,239**		**5,152,583**
	Including Delivery				**7,619,120**		**7,830,896**

Source: VPA Benchmark Infrastructure & Cost Guide – Appendix 3

C.12 Sport and Recreation hub, 0.6-hectare site area

Group	Sub Item	Qty	Unit	Rate (P50)	Amount (P50)	Rate (P90)	Amount (P90)
				$2019	$2019	$2019	$2019
Buildings	Site Preparation	3,000	m2	4	11,040	5	15,540
	Change Rooms With Toilets and Showers X 6	687	m2	2,408	1,654,385	2,445	1,679,895
	Umpire Change Rooms with Toilets	172	m2	2,519	432,694	2,595	445,677
	Storage Rooms	344	m2	2,414	829,288	2,406	826,526
	Multipurpose Room/ Social Room	429	m2	2,365	1,015,690	2,330	1,000,516
	Office/ First Aid Room	86	m2	2,352	201,952	2,360	202,696
	Canteen and Kitchen	115	m2	2,515	287,963	2,525	289,108
	Public Toilet	172	m2	1,239	212,742	1,586	272,375
	Netball Court	1	No	83,143	83,143	98,076	98,076
	Tennis Court	1	No	65,423	65,423	72,602	72,602
	Lighting Netball Court	1	No	22,803	22,803	24,396	24,396
	Lighting Tennis	1	No	21,416	21,416	24,493	24,493
Landscaping	Landscaping Construction	2753.4	m2	20	55,839	26	72,112
	Landscaping Establishment (12wk)	2753.4	m2	1	3,084	1	3,552

Group	Sub Item	Qty	Unit	Rate (P50)	Amount (P50)	Rate (P90)	Amount (P90)
				$2019	$2019	$2019	$2019
	Landscape maintenance-1 year/2 summers	2753.4	m2	3	7,985	3	8,095
Car Parking	Pavement	328.8	m2	95	31,147	109	35,918
	Kerb and Channel	52.8	m	55	2,906	60	3,174
	Drainage Pipes	60	m	177	10,649	193	11,551
	Drainage Pits	2.64	No	2,612	6,896	2,803	7,399
	Car Park Lighting	308.64	m2	15	4,670	17	5,343
	Linemarking/ Signage	328.8	m2/pavement	3	1,072	4	1,338
Site Works	Site Preparation	6000	m2	4	22,080	5	28,260
	Footpaths and paved areas	90	m2	64	5,729	72	6,476
Canopy & Veranda	Canopy & Veranda	120	m2	762	91,420	863	103,500
	Concrete Paths	0	m2	-	-	-	-
	Lighting	0	m2	-	-	-	-
	Gates/entrances	0	m2	-	-	-	-
	Other-Miscellaneous	0	m2	-	-	-	-
	Stormwater	1	%	3	167,707	3	172,874
	Sewer	1	%	2	103,165	2	106,344
	Water	1	%	2	100,624	2	103,725
	Gas	1	%	1	44,722	1	46,100
	Fire Protection	1	%	1	33,541	1	34,575
	Light & Power	1	%	2	120,952	2	124,679
	Communication	1	%	1	25,410	1	26,193
Miscellaneous	Sub-standard site conditions	0	% of area	-	-	-	-
	Council Fees	1	%	3	165,166	3	170,255
	Authority Fees	1	%	1	50,820	1	52,386
	Traffic Management	1	%	2	101,640	2	104,772
	Environmental Management	1	%	1	25,410	1	26,193
	Survey/Design	1	%	5	254,101	5	261,931
	Supervision & Project Management	1	%	9	457,381	9	471,476
	Site Establishment	1	%	3	127,050	3	130,965
	Environmentally Sustainable Design	1	%	2	101,640	2	104,772
	Contingency	1	%	15	762,302	15	785,793
Total	**Excluding Delivery**				**5,082,016**		**5,238,618**

Group	Sub Item	Qty	Unit	Rate (P50)	Amount (P50)	Rate (P90)	Amount (P90)
				$2019	$2019	$2019	$2019
	Including Delivery				**7,723,647**		**7,961,652**

Source: VPA Benchmark Infrastructure & Cost Guide – Appendix 3.

C.13 Art and Cultural hub, 0.24-hectare site area

Group	Sub Item	Qty	Unit	Rate (P50)	Amount (P50)	Rate (P90)	Amount (P90)
				$2019	$2019	$2019	$2019
Buildings	Library	1,500	m2	2,302	3,452,955	2,441	3,661,350
	Small commercial Kitchen	45	m2	2,855	128,462	3,109	139,910
	Consulting Suite	200	m2	2,464	492,806	2,568	513,528
	Multipurpose community Spaces	450	m2	2,302	1,035,887	2,441	1,098,405
	Storage External	-	m2	1,830	-	2,040	-
	Specialist Community Space	250	m2	2,302	575,493	2,441	610,225
	Disabled toilet/ Parent's Change room	-	m2	3,040	-	3,462	-
	Toilets/ Change Rooms	-	m2	2,853	-	3,109	-
	Administration	-	m2	2,245	-	2,290	-
	Cleaners	-	m2	2,149	-	2,325	-
Canopy & Veranda	Canopy & Veranda	-	m2	1,106	-	1,299	-
	Pavement	3,327	m2	97	323,218	106	352,329
Car park	Kerb and Channel	473	m	55	25,925	62	29,350
	Drainage Pipes	282	m	180	50,718	201	56,786
	Drainage Pits	10	Item	2,565	25,654	2,851	28,515
	Linemarking/Signage	3,327	Item	3	10,347	4	14,206
	Car Park Lighting	3,456	m2	15	52,116	18	63,418
	Other	-		-	-	-	-
Outdoor Play	Kindergarten outdoor playspaces	-	m2	530	-	610	-
	Playground	-	m3	794	-	1,131	-
Site works	Site Preparation	8,777	m2	4	32,299	5	45,640
	Paths	180	m2	68	12,175	81	14,625
	Landscaping	500	m2	26	13,090	30	14,905
	Lighting	-	Item	-	-	-	-
	Boundary Fencing	-	m	89	-	116	-
	Gates	1	Item	615	615	707	707
	Other	-		-	-	-	-
Services	Stormwater	1	%	3	205,648	3	219,249

Group	Sub Item	Qty	Unit	Rate (P50)	Amount (P50)	Rate (P90)	Amount (P90)
				$2019	$2019	$2019	$2019
	Sewer	1	%	2	126,505	2	134,871
	Water	1	%	2	123,389	2	131,549
	Gas	1	%	1	54,839	1	58,466
	Fire Protection	1	%	1	41,130	1	43,850
	Light & Power	1	%	2	148,316	2	158,125
	Communication	1	%	1	31,159	1	33,219
Miscellaneous	Sub-standard site conditions	-	% of area	-	-	-	-
	Council Fees	1	%	3	202,532	3	215,927
	Authority Fees	1	%	1	62,318	1	66,439
	Traffic Management	1	%	2	124,635	2	132,878
	Environmental Management	1	%	1	31,159	1	33,219
	Survey/ Design Fees	1	%	5	311,588	5	332,195
	Supervision and Project Management	1	%	9	560,858	9	597,951
	Site Establishment	1	%	3	155,794	3	166,097
	Environmentally Sustainable Design	1	%	2	124,635	2	132,878
	Contingency	1	%	15	934,764	15	996,585
Total	**Excluding Delivery**				**6,231,759**		**6,643,899**
	Including Delivery				**9,471,028**		**10,097,398**

Source: VPA Benchmark Infrastructure & Cost Guide – Appendix 3

D Education

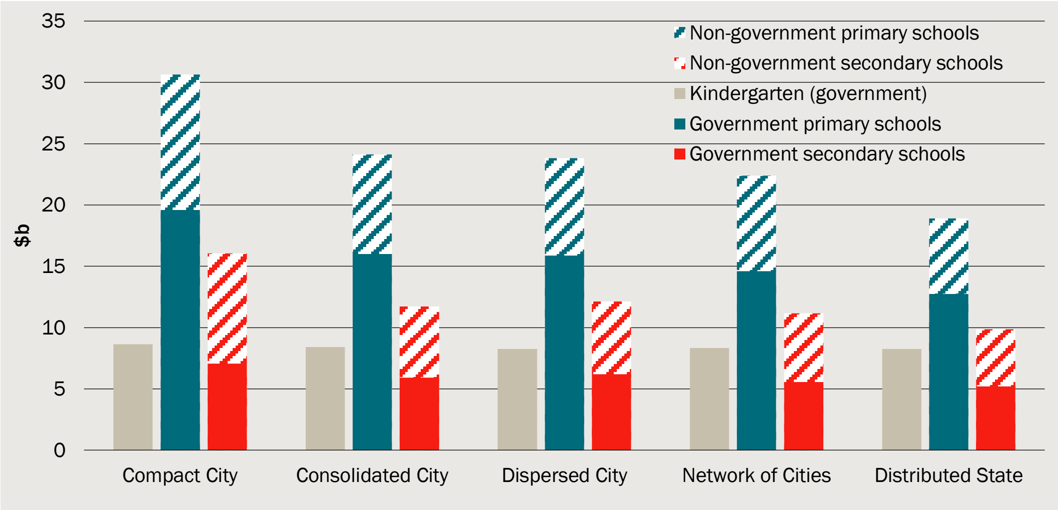
- **Please note that this analysis of education costs in Victoria is intended as a high-level overview. The assumptions made in this study are broad to facilitate a simplified model of infrastructure responses and their associated costs. Real-world assessments are likely to differ significantly, considering various complex inputs and decisions. It is important to acknowledge that the Department of Education may have alternative methods of addressing growth that have not been considered in this analysis. Therefore, the findings presented here may not necessarily reflect the planning approach of the Department of Education.**
- **Need for additional education infrastructure is estimated for kindergarten, primary and secondary schools based on modelled existing capacity and a range of priority responses to meet additional enrolments until 2036 and 2056.**
  - **School and kindergarten infrastructure is modelled to support total Victorian school enrolments; however, the response is based on students being housed in infrastructure developed to government standards. Based on the current ratio of government to non-government school enrolments a cost to government for total infrastructure provision has also been identified.**
  - **The Victorian Government has committed to free Kindergarten programs for all Victorian three- and four-year-old children, which will lead to an increase in demand for new facilities, and**
  - **Primary and secondary schools can meet additional enrolments by utilising their existing permanent and relocatable capacity (within an adopted provision), and beyond that new schools are required.**
- **To meet additional kindergarten enrolments between 2021 and 2056:**
  - **832 new kindergarten facilities are needed across the state due to the new policy reform and the anticipated growth. This assumes that 57 per cent of the anticipated growth will be accommodated in new kindergartens, and the remainder in centre-based day care facilities. If all enrolment growth were to be supported in kindergartens 1 460 new kindergarten would be required.**
- **To meet additional primary school enrolments between 2021 and 2056:**
  - **Under our model, primary schools can accommodate between 40 to 54 percent of the additional enrolments until 2056 in existing permanent and relocatable buildings with surplus capacity on-site. This share is the highest for the Distributed State scenario and the lowest for the Dispersed City scenario, which experiences the largest growth in the Melbourne New Growth Areas across all scenarios, an area with a relatively low share of existing permanent capacity.**

  - Existing relocatable capacity is very high across all regions and exceeds our modelled limit (40 per cent of permanent capacity) in some regions, such as the Melbourne New Growth Areas. As a result, no new relocatable buildings are being provided to accommodate enrolment in our model.
  - Across scenarios new permanent buildings on exiting school sites are constructed to accommodate 68,150 (Dispersed City scenario) to 84,101 (Distributed State scenario) enrolments:
    - Those include 46,570 or 8.3 per cent of existing enrolments which are moved from existing relocatable buildings to new permanent buildings, and 21,580 (Dispersed City scenario) to 37,531 of additional enrolments (Distributed State scenario).
  - Beyond this, 133 to 172 new governmental primary schools and 194 to 257 total new primary schools are needed to meet the additional enrolments across scenarios.
- To meet additional secondary school enrolments between 2021 and 2056:
  - Under our model, secondary schools can accommodate between 57 to 62 percent of the additional enrolments until 2056 in existing permanent and relocatable buildings with surplus capacity on-site. This share is the highest for the Distributed State scenario and the lowest for the Dispersed City scenario, which experiences the largest growth in the Melbourne New Growth Areas across all scenarios, an area with a relatively low share of existing permanent capacity.
  - Existing relocatable capacity is high across all regions and exceeds our modelled limit (40 per cent of permanent capacity) in some regions, such as the Melbourne New Growth Areas. As a result, only a small share of 4,405 to 6,781 of additional enrolments are accommodated in relocatable buildings.
  - Across scenarios new permanent buildings on exiting school sites are constructed to accommodate 44,156 (Dispersed City scenario) to 51,674 (Distributed State scenario):
    - Those include 10,589 or 2.5 per cent of existing enrolments which are moved from existing relocatable buildings to new permanent buildings, and 33,567 to 41,085 of additional enrolments.
  - Beyond this, 18 to 24 new governmental secondary schools and 33 (Distributed State scenario) to 47 (Dispersed City scenario) total new secondary schools are needed to meet the additional enrolments across scenarios.
- Total capital and infrastructure operating cost of providing additional school infrastructure ranges from $26.2 (Distributed State scenario) to $35.3 billion (Compact City scenario) for government schools and kindergarten infrastructure, and $37.0 to $55.3 billion for the total Victorian school infrastructure including non-government schools and centre-based day care facilities.
  - Scenarios which see more additional enrolments in Metropolitan Melbourne have substantially higher costs in terms of capital and land cost. In particular growth in Inner Melbourne and Melbourne New Growth Areas is often met with

new schools rather than additional relocatable or additional permanent capacity, adding land cost.

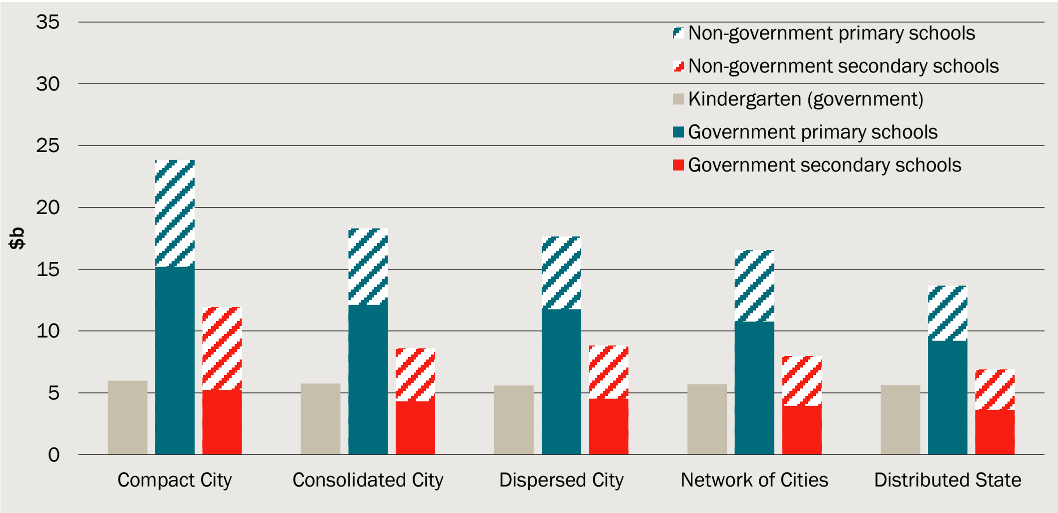
- **In all scenarios, the cost of total additional primary school infrastructure is almost double the cost of total additional secondary school infrastructure. This is driven by two factors; new primary schools are somewhat more expensive per student than new secondary schools and relatively more additional enrolments in secondary schools can be accommodated on existing school sites.**
- **The Capital and land cost account for the majority of cost with approximately 70 per cent (Distributed State scenario) to 75 per cent (Compact City scenario).**

D.1 Total school infrastructure cost until 2056



Data source: CIE.

D.2 Total capital cost until 2056



Note: Includes land cost

Data source: CIE.

Education Provision in Victoria

In Victoria, education is compulsory for children aged from 6 to 17 years.[91] The education system consists of three main stages:[92]

- Kindergarten/preschool
- Primary school and secondary high school
- Tertiary education.

Kindergarten/Preschool

Kindergarten/preschool education in Victoria covers preschools, kindergartens, or preschool programs in long day care centres. It is typically a one-to-two-year program for children before they start primary school. While not mandatory in Victoria, it is advised that children participate in kindergarten/preschool education to foster their social, mental, and physical skills in readiness for school.[93]

Preschool is offered in designated preschools, as preschool programs within centre-based day care, or in preschools collocated with primary schools for 3- and 4-year-old children across the state. The provision of kindergarten/preschool education in Victoria is available through both government and non-government entities:[94]

- **Government** provision is around 14 per cent.
- **Non-government** provision accounts for 86 per cent, while the majority of those were community preschools, followed by independent preschools.
- Governmental and non-governmental provision rates vary only somewhat by region, with governmental providers accounting for 12 per cent in Major Cities and ~17 per cent in inner and outer regional areas, while remote and very remote areas are only serviced by non-governmental providers.
- In 2022, 43 per cent of enrolled children visited a preschool program delivered by centre-based day care services.[95]

The Victorian Government has committed to expand kindergarten programs across the state. This entails:[96]

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91 https://www.study.vic.gov.au/en/study-in-victoria/victoria's-school-system/Pages/default.aspx

92 https://liveinmelbourne.vic.gov.au/live/education-and-childcare/melbournes-education-system

93 https://liveinmelbourne.vic.gov.au/live/education-and-childcare/melbournes-education-system

94 ABS Preschool Education, Australia, 2021, Table 2 and Table 9 Children enrolled, https://www.abs.gov.au/statistics/people/education/preschool-education-australia/latest-release

95 ABS Preschool Education, Australia, 2022, Graph 2, Children enrolled by sector, https://www.abs.gov.au/statistics/people/education/preschool-education/latest-release#enrolments-by-sector

96 https://www.vic.gov.au/give-your-child-the-best-start-in-life

- Free Kindergarten programs for all Victorian three- and four-year-old children at participating services in both standalone (sessional) services and long day care (childcare) settings,
- Over the next decade, Four-Year-Old Kindergarten will transition to 'Pre-Prep' – increasing to a universal 30-hour a week program of play-based learning for every four-year-old child in Victoria.

Primary and Secondary Schools

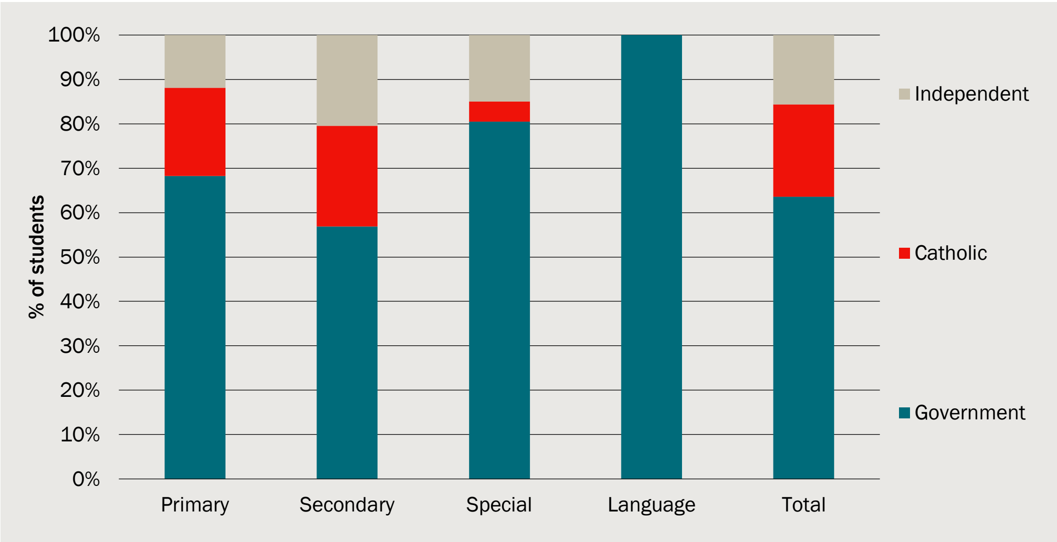
Primary school students are aged between 5 and 12 years old with classes divided into Prep and Years 1 to 6. Secondary school students are aged between 12 and 20 years old, while classes are divided into Years 7 to 12.[97]

The Victorian primary and secondary school system has 3 main providers (chart D.3):[98]

- **Government schools** provision ranges around 68 per cent in primary and 57 per cent in secondary schools and for all schools at ~64 per cent and dominates special and language schools.
- **Catholic schools** account overall for 21 per cent and
- **Independent schools** for 16 per cent of all students.

In addition, the number of children registered for home schooling is continuing to grow in recent years, however, makes up less than ~1 per cent of all children.[99]

D.3 Victorian education system, by school type and provider (2022)



Note: Primary includes preparatory, year 1 to 6 and ungraded students. Secondary includes year 7 to 12 and ungraded students. Data as of February 2021.

Data source: Table 1 Summary Statistics on Victorian Schools, available here: https://www.vic.gov.au/statistics-victorian-schools-and-teaching

97 https://www.study.vic.gov.au/en/study-in-victoria/victoria's-school-system/Pages/default.aspx

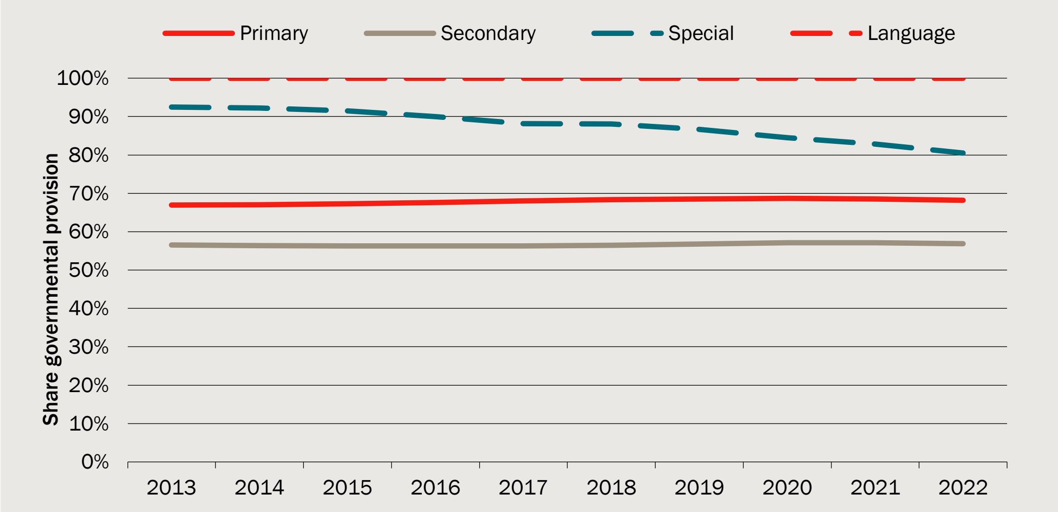
98 Victorian Government (2022), *Statistics on Victorian schools and teaching,* Schools and enrolments 2022.xlsx, available at: https://www.vic.gov.au/statistics-victorian-schools-and-teaching

99 https://www.vrqa.vic.gov.au/aboutus/Pages/homeschoolingstatistics2020.aspx

The share of government school provision for primary, secondary and language schools has been constant in the past 10 years, while the role of non-governmental special schools has been increasing over the past years (chart D.4).

Government versus non-government provision varies only slightly by the administration regions. Government provision tends to be higher in areas with low enrolments, such as regional areas (chart D.5).

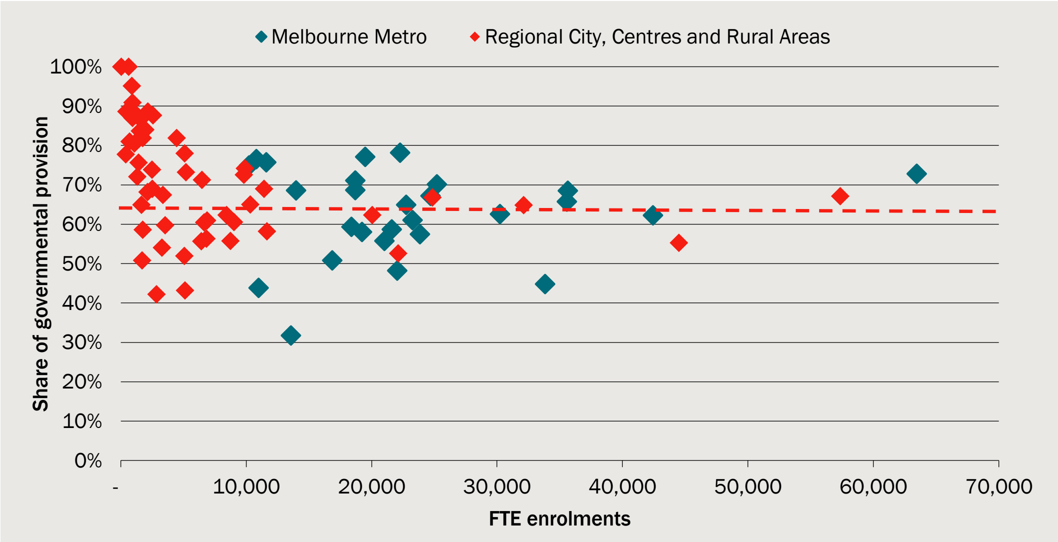
D.4 Share of governmental provision by school type, 2013 to 2022



Note: Primary includes preparatory, year 1 to 6 and ungraded students. Secondary includes year 7 to 12 and ungraded students. Data as of February 2021.

Data source: Schools and enrolments 2022, available here: https://www.vic.gov.au/statistics-victorian-schools-and-teaching and enrolments 2022, available here: https://www.vic.gov.au/statistics-victorian-schools-and-teaching'

D.5 Governmental provision by LGA enrolment size



Note: Both primary and secondary. Red dashed line shows the overall Victorian Government share.

Data source: Schools and enrolments 2022, available here: https://www.vic.gov.au/statistics-victorian-schools-and-teaching

Tertiary Education

Victoria's post-secondary education system comprises 10 universities, a network of vocational training institutions called TAFEs, and numerous private colleges and training institutes that provide a broad selection of career skills and qualifications, as well as English language, executive, and professional development programs.

This analysis has excluded the tertiary education sector as it serves larger catchments, thereby, resulting in minor variations in additional provision and cost across the different population scenarios.

Summary of assumptions

For the purpose of this analysis, we have made a suite of general modelling assumptions summarised in table D.6, that enable us to calculate infrastructure provision and cost to meet the objectives of this project. Broad assumptions have been made to support a simplified model of infrastructure responses and associated costs and that real world assessments would likely be quite different considering multiple complex inputs and decisions.

We recognise the actual situation may vary across the state and might not be fully represented in our assumption. For example, the Victorian Government has announced a major funding initiative to increase attendance and quality provision of preschools/kindergartens across the state as part of their Early Childhood Reform Plan.[100]

Some of the key assumptions include:

- Additional kindergarten enrolment space for every four-year old and every two three-year old is required in line with the 2033 goal.[101]
  - This is based on 3-year-olds attending for 15 hours, and 4-year-olds attending for 30 hours. This allows for the possibility of holding two sessions a day for 3-year-olds. Consequently, only one kindergarten space is required for every two three-year-olds, while one space is needed for every 4-year-old.

  As this policy intervention will lead to a surge in demand, we have assumed that there is no existing building capacity and any additional enrolments moving forward are met with new kindergarten funded by the Victorian Government and not for profit and private providers. Facilities funded by government are assumed to be co-located with primary schools or multi-purpose community facilities requiring no extra land[102], except for some areas in Inner Melbourne where there is no land available to co-locate new kindergartens.
  - The assumptions made are quite conservative, considering that currently, approximately 43 percent of all enrolled children are attending a preschool

100 Victorian Government (2017), *Early Childhood Reform Plan,* https://www.education.vic.gov.au/Documents/about/educationstate/ec-reform-plan.pdf

101 https://www.vic.gov.au/give-your-child-the-best-start-in-life

102 https://www.schoolbuildings.vic.gov.au/building-blocks-grants-capacity-building

program delivered by centre-based day care services, and there might still be available capacity in the system. As a result, we have incorporated sensitivities to explore scenarios with a lower share of governmental provision (only 57 percent) and to test the impact of existing capacities.

- Special and language schools, and home-schooling are not modelled separately due their small overall share.
- School infrastructure is modelled to support total Victorian school enrolments; however, the response is based on students being housed in infrastructure developed to government standards. Based on the current ratio of government to non-government school enrolments a cost to government for infrastructure provision has also been identified.
- Note that the analysis presented in this report covers the period from 2021 to 2056; however, it is important to clarify that schools funded in 2021 will not be operational until 2023. Therefore, to ensure consistency and accuracy in calculating infrastructure provision and costs over the entire time frame, we have adopted the 2023 enrolment figures as the baseline figure from which to project infrastructure needs and expenses from 2021 to 2056. This approach accounts for the delay in school openings and ensures that the projections are aligned to the actual operational timeline of the funded schools.

D.6 General Assumptions

Metric	To be included in model
Type of school	
Kindergarten/Preschool	Yes, separate demand modelling and no excess capacity assumed.
Primary/	Yes
Secondary Schools	Yes
Special Schools	No, demand will be allocated to primary and secondary schools due to small quantity (<5 per cent of all schools and <2 per cent of all students)
Language Schools	No, demand will be allocated to primary and secondary schools due to small quantity (<0.2 per cent of all schools and <0.2 per cent of all students)
Home Schooling	No, demand will be allocated to primary and secondary schools due to small quantity (<1 per cent of all students)
TAFE	No, as they serve large catchments and unlikely to have large cost differential across scenarios.
University	No, as they serve large catchments and unlikely to have large cost differential across scenarios.
Providers	
Government Schools and Preschool/Kindergarten	Yes. To be consistent with other infrastructure sectors, we model government and non-government provision together, ie taking a resource cost approach, recognising that non-government schools receive gap funding. This means that we assume that all increased school enrolments are supported in new schools built to the standard and cost of government schools. Also, we assume that existing non-government schools have the same surplus capacity as government schools.
Catholic/Independent/Community Schools and Preschool/Kindergarten	

Metric	To be included in model
	Kindergarten facilities are assumed to be fully funded by the Victorian Government through directly funding them on school or community sites, or allocating grants to local government, or private entities.

Source: CIE.

Approach to measure additional school infrastructure provision

Broad assumptions have been made to support a simplified model of infrastructure responses and associated costs and that real world assessments would likely be quite different considering multiple complex inputs and decisions. Our high-level approach to estimate additional school infrastructure provision needed follows a three-step process:

1 Calculate additional enrolments for preschools/kindergarten, primary and secondary schools for each region (SA3) by 2036 and 2056

2 Calculate the current school capacity in terms of existing capacity in permanent buildings (i.e., bricks and mortar) and in relocatable buildings (i.e., portables)

   a) For primary and secondary schools existing relocatable capacity has been capped. This means that existing enrolments are moved from existing relocatable buildings into new permanent buildings on the same school site, where the share of students based in relocatable buildings is higher than 40 per cent of total enrolments. This assumption is tested in the sensitivity analysis.

   b) For preschools/kindergarten we have been assumed that there is no existing capacity. We have also reported results assuming a 25 per cent capacity.

3 Calculate additional education infrastructure to accommodate additional enrolments.

   a) This based on iterative process of increasing capacity at existing school sites with *adopted*[103] additional relocatable and additional permanent capacity.[104]

   b) Once existing school site have no expansion capacity within the *adopted* provision, new schools are required.

IV's population projection is provided on a regional level (SA3) and by age groups 0-14 and 15-24.[105] These are redistributed into the age groups relevant for education infrastructure (i.e., 3 to 4, 5 to 11 and 12- to 17-year-old). The redistribution is based on

103 'adopted' relates to response assumptions which have been developed as part of the consultation of Infrastructure Victoria with the Department of Education and do not reflect state government policy. For example, existing schools might already have a higher existing relocatable capacity than indicated by the response assumptions. For areas outside of Inner Melbourne adopted relocatable capacity is assumed as 20 per cent of the total permanent capacity.

104 In consultation with the Department of Education, Infrastructure Victoria has provided a methodology to calculate the recommended responses to additional enrolments.

105 Developed by SGS.

the VIF (2019) population projection distribution of ages for major regions (Greater Melbourne GCCSA and regional SA4s).[106]

Based on this, children are allocated to the respective school types as shown in table D.7. There are some overlaps between some ages and the school type:

- 48 per cent of 5-year-old children are enrolled in preschools/kindergarten while the remainder is enrolled in the preparatory year of primary schools,
- 46 per cent of 12-year-old children are enrolled in primary schools while the remainder are enrolled in secondary schools.
- Note that we have used actual enrolments for kindergarten in 2023. The enrolment shares are currently lower than the one shown in the table below. With the kindergarten policy reform, a higher share of children is expected to need enrolment spaces compared to today. This means that additional capacities are also needed for children who are currently not enrolled.

D.7 School type by age and share of enrolment

Age	Type of education	Comment	Share of children
			Per cent
3	Kindergarten		50
4	Kindergarten		100
5	Kindergarten	Split share due to transition	48
5	Primary	Split share due to transition	52
6	Primary		100
7	Primary		100
8	Primary		100
9	Primary		100
10	Primary		100
11	Primary		100
12	Primary	Split share due to transition	46
12	Secondary	Split share due to transition	54
13	Secondary		100
14	Secondary		100
15	Secondary		100
16	Secondary		100
17	Secondary		100
18	Secondary		53

106 Victoria in Future (2019), Official state government projection of population and households, available at: https://www.planning.vic.gov.au/land-use-and-population-research/victoria-in-future#:~:text=Victoria%20in%20Future%202019&text=VIF2019%20shows%20Victoria%20remains%20the,Total%20population

[a] Kindergarten offered to 3- and 4-year-old children is not mandatory. Data on enrolled children is take from the ABS Census for education. Participation rates of enrolled preschool/kindergarten students across Victorian LGA's are high but vary between 72 and 100 per cent, while the Victorian average lies at ~92 per cent in 2019.[107]

Note: Whilst students may attend up until the age of 20 (as you have noted earlier), there are not significant enrolments for students over 18 years of age.

Source: ABS Education data.

In consultation with the Victorian Department of Education and Infrastructure Victoria we have developed a methodology to calculate existing capacity and priority responses for additional enrolments (table D.8). Flow chart (D.9) shows the allocation process of additional enrolments beyond existing capacity:

Additional enrolment is first absorbed by existing surplus capacity at a school. If possible, additional relocatable buildings are used to meet the additional enrolments. This, however, is not possible in every region (e.g., Inner Melbourne). After that, if ongoing demand is maintained and it is a practical solution, additional permanent capacity is added. Note that some of the existing enrolment is moved from relocatables into new permanent buildings (within the adopted provision) where the share of students based in relocatable buildings is higher than 40 per cent of total permanent capacity.

After this allocation process, if the ongoing demand is maintained and exceeds those measures, new schools are required.

For kindergarten any additional demand is assumed to be met by constructing new designated facilities which will be co-located with primary schools or multi-purpose community facilities. Based on those priority responses additional school infrastructure demand is compared to the additional enrolments by school type and region (SA3).

D.8 Priority responses for additional primary and secondary school enrolments

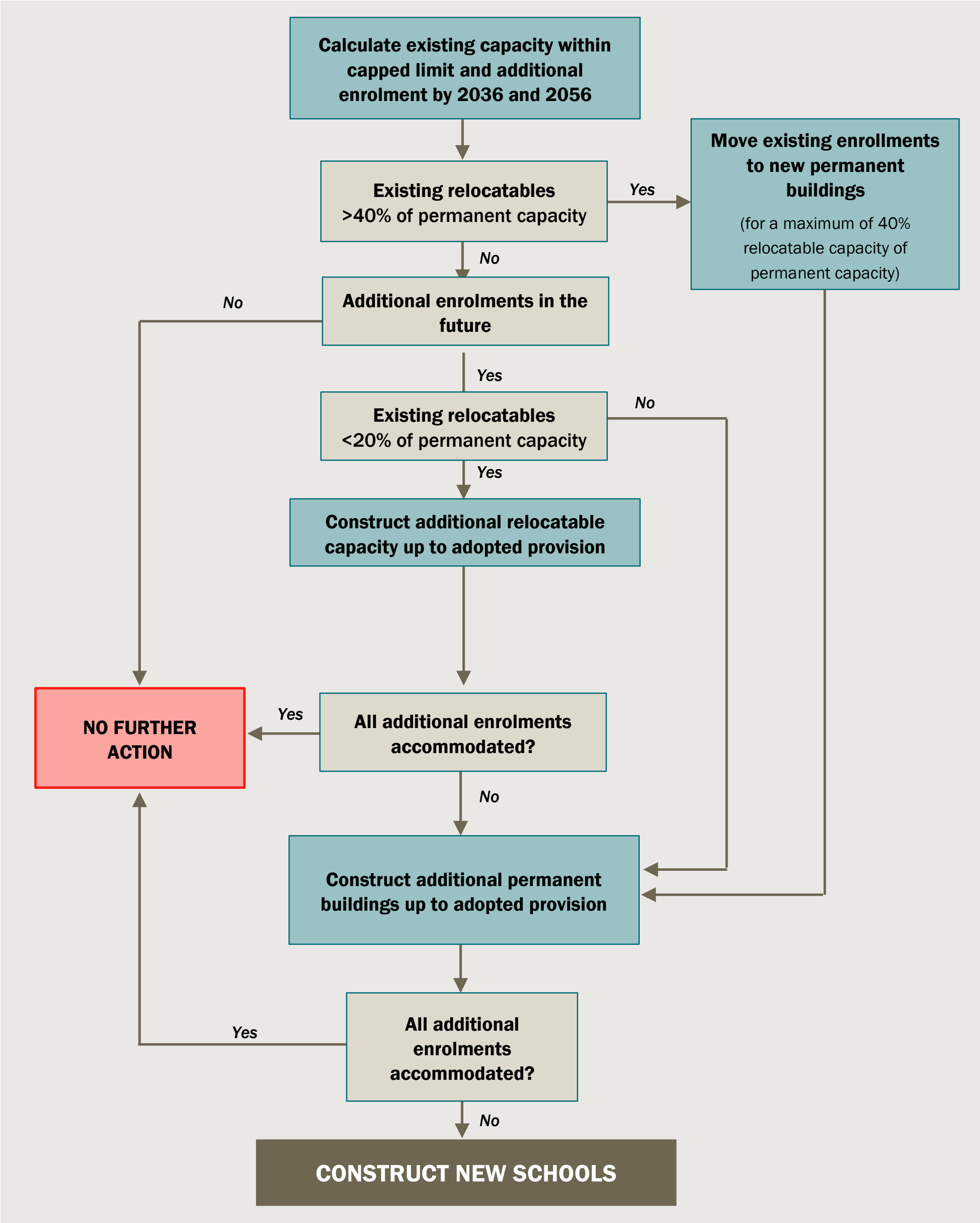
<table>
<tr><th></th><th colspan="5">Priority Responses (left to right)</th></tr>
<tr><th>Geographic Setting</th><th>Absorb existing surplus</th><th>Additional relocatable buildings</th><th>Additional permanent buildings</th><th>New primary school</th><th>New secondary school</th></tr>
<tr><td>Inner (high density) Melbourne</td><td rowspan="6">Yes – excess existing permanent capacity + excess existing relocatable capacity (up to 40%)</td><td rowspan="2">No</td><td>No</td><td rowspan="6">Yes – for up to 525 enrolments[a]</td><td rowspan="6">Yes – for up to 1200 enrolments[a]</td></tr>
<tr><td>Inner (other) Melbourne</td><td rowspan="3">Yes – up to 25% of existing permanent capacity</td></tr>
<tr><td>Middle and Outer Melbourne</td><td rowspan="4">Yes – up to 20% of existing permanent capacity</td></tr>
<tr><td>Melbourne New Growth Areas</td></tr>
<tr><td>Regional (cities and major towns)</td><td rowspan="2">Yes – up to 50% of existing permanent capacity</td></tr>
<tr><td>Regional (other)</td></tr>
</table>

[a] New school capacity is a mix of permanent and relocatable and can be adjusted to local requirements.

107 Department of Education, VCAMS Kindergarten participation rate https://discover.data.vic.gov.au/dataset/vcams-kindergarten-participation-rate

Source: CIE in consultation with Infrastructure Victoria and Department of Education

D.9 Flow chart of additional enrolment allocation beyond existing capacity



Data source: CIE.

Excess Capacity in Victoria's school infrastructure

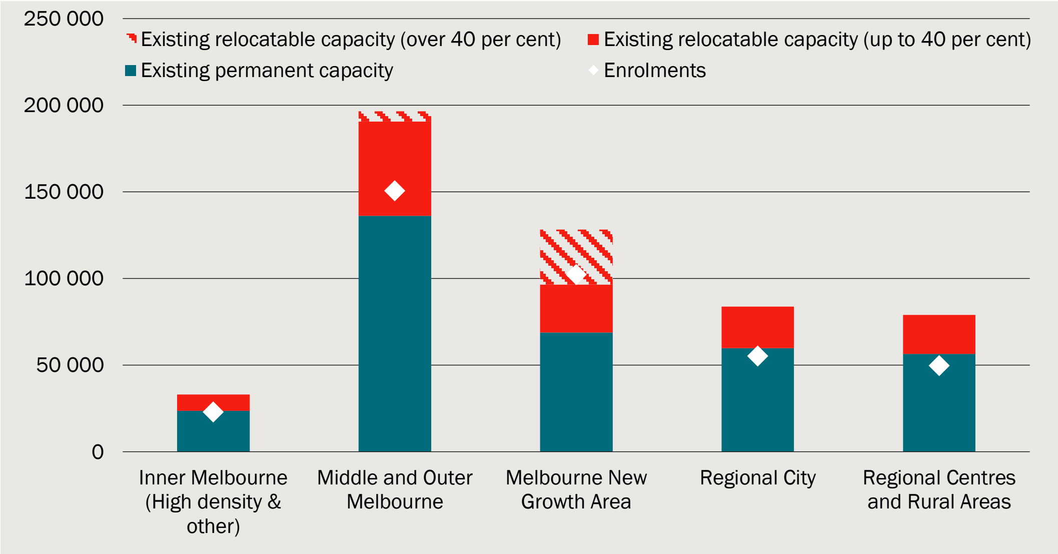
Data on primary and secondary enrolments and existing government school capacity by region (SA3) for February 2023 have been provided by Infrastructure Victoria based on consultations with the Department of Education. At a high level (aggregated by region) the data indicates, when considered at an SA3 level, with the modelling assumptions adopted that (chart D.10 and D.11):

- Primary and secondary schools in Regional Victoria have some existing permanent surplus capacity, while Inner, Middle and Outer Melbourne and Melbourne New Growth Areas have no surplus permanent capacity and manage current enrolments with relocatable capacity.
  - Middle and Outer Melbourne and Melbourne New Growth Areas have also some existing relocatable capacities above the adopted provision.
- In addition, primary schools in the Melbourne New Growth Areas use some of the relocatable capacity which is above the upper limit of 40 per cent provision to manage current enrolments. This means that going forward allowance will be made in the model for new additional permanent capacity to replace some of the existing relocatable capacity.
- Overall, the capacity for additional enrolments from existing permanent surplus and relocatable capacity within the adopted provision is:
  - approximately 81,000 enrolments or 21 per cent of current enrolments within the government primary school system and 78,000 enrolments or 32 per cent of current enrolments within the government secondary school system, or
  - approximately 128,000 enrolments within the total Victorian primary school system and 149,000 enrolments within the total Victorian secondary school system, respectively.[108]
- For kindergarten facilities we assume that there is no excess capacity at all due to the recent policy shift which will see a surge in demand. This assumption will be relaxed in the sensitivity analysis, assuming a 25 per cent existing capacity (~32,000 enrolments).

Note that we have aggregated the data, and this pattern does not hold for every region (SA3) within Victoria.

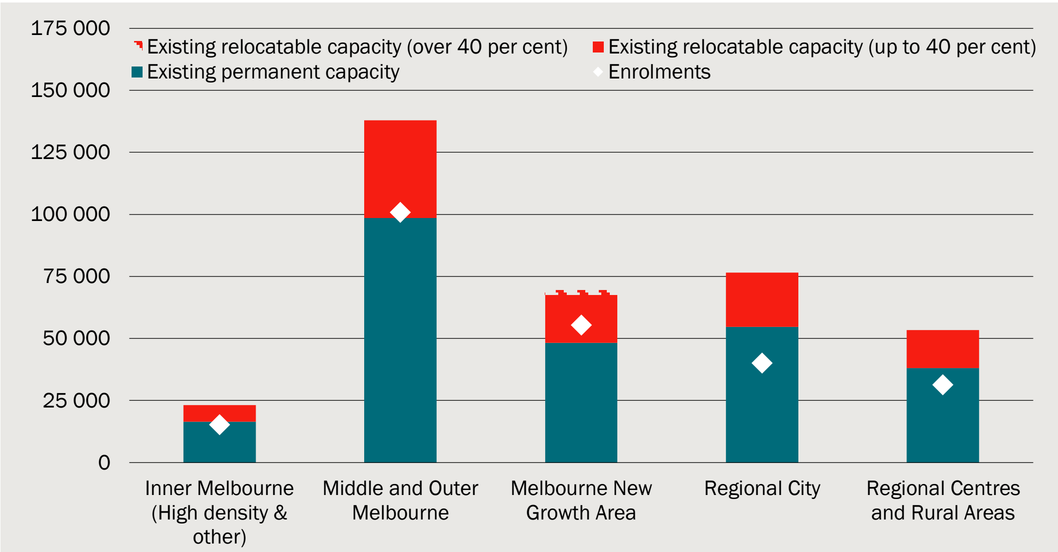
108 This estimate is based on the calculated enrolment figures for the whole state and by the data from 2021 to 2023 and assuming that non-government schools have the same capacity (constraints) and responses to additional enrolments as government schools.

D.10 Government primary school enrolments and capacity (2023)



Source: CIE in consultation with Infrastructure Victoria and Department of Education

D.11 Government secondary school enrolments and capacity (2023)



Source: CIE in consultation with Infrastructure Victoria and Department of Education

Additional provision by population scenario

Until 2056, we estimate that:

- Total additional preschool/kindergarten enrolments are approximately 96,000. Directly funded governmental provision accounts for 12 per cent in 2023.[109] This

109 This is based on the ABS Preschool Education (2022) data which split out preschool education by provider and remoteness area.

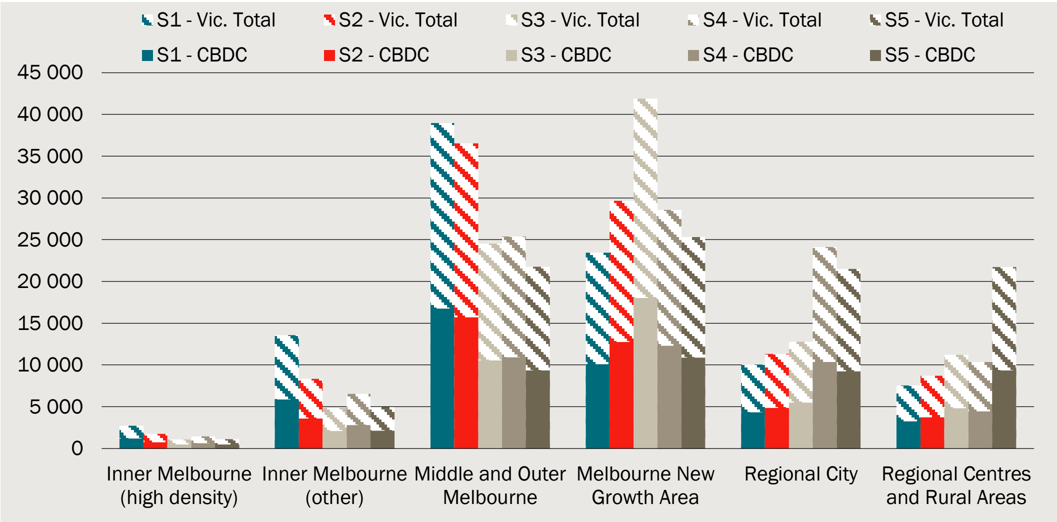
allocation may vary in the future with the current reforms in preschool education[110], however for the purpose of this analysis we have assumed that all additional enrolment spaces will be funded by the Victorian Government but not necessarily operated.

  – This assumption is quite conservative, considering that currently, approximately 43 percent of all enrolled children are attending a preschool program delivered by centre-based day care services. Applying this share to the estimated kindergarten enrolments indicates that approximately 41,000 additional enrolments will be accommodated in centre-based day care services.

- Total additional primary school enrolments are approximately 210,000 – a 55 per cent increase compared to 2023. Government schools account for 65 to 66 per cent of enrolments varying by scenario. For example, when more population is allocated to regional areas the level of governmental provision will be higher since those areas are predominantly serviced by government schools.
- Total additional secondary school enrolments are approximately 176,000 – almost double compared to 2023. Government schools account for 49 to 55 per cent, varying by scenario.

Chart D.12, D.13 and D.14 illustrate how these additional enrolments are distributed between the region in Victoria under each scenario.

D.12 Additional enrolment in the Victorian kindergarten system, 2023 to 2056

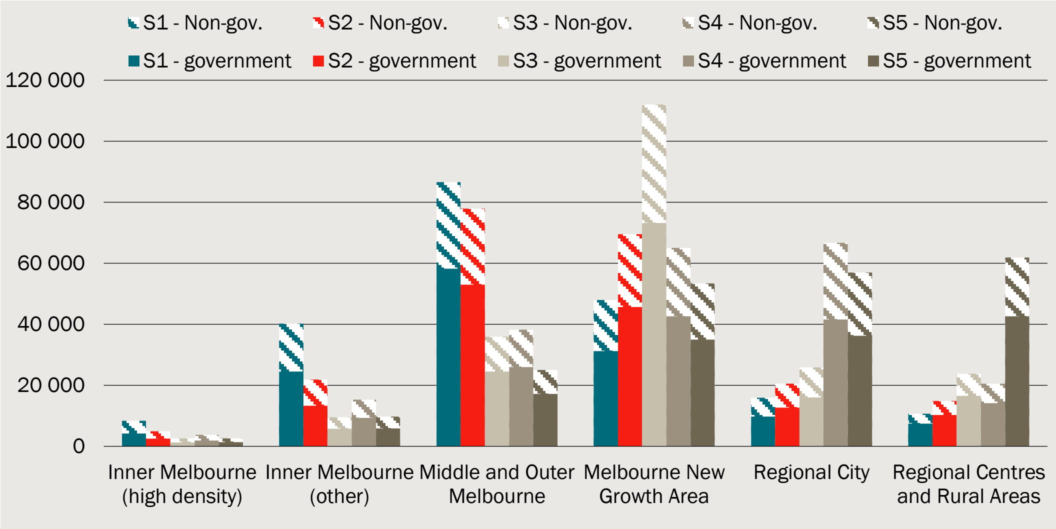


Note: CBDC – Centre-based day care

Data source: CIE Education Model based on consultation with Infrastructure Victoria and Department of Education, ABS Preschool Education, 2022.

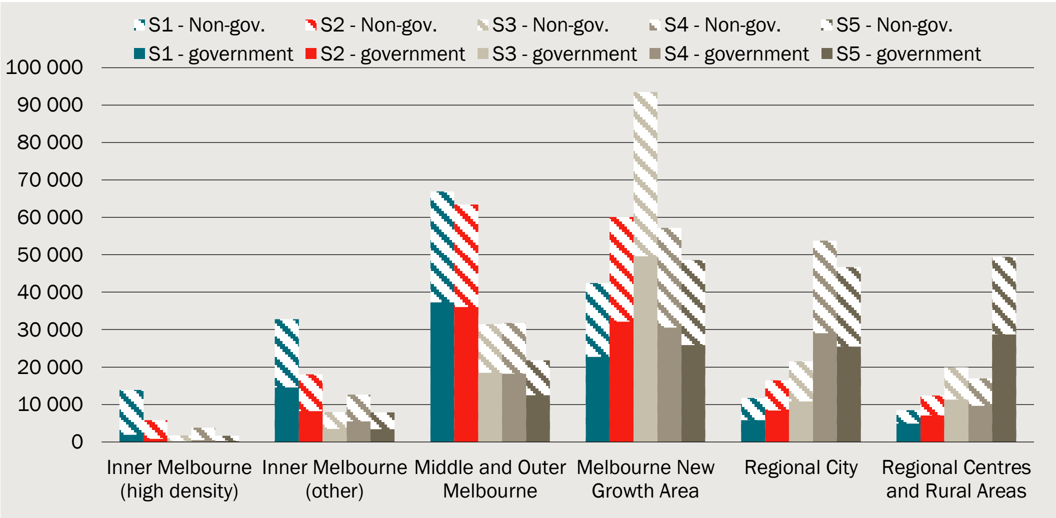
110 Victorian Government (2017), *Early Childhood Reform Plan,* https://www.education.vic.gov.au/Documents/about/educationstate/ec-reform-plan.pdf

D.13 Additional enrolment in government (solid) and non-government (pattern) *primary* schools, 2023 to 2056



Data source: CIE Education Model based on consultation with Infrastructure Victoria and Department of Education

D.14 Additional enrolment in government (solid) and non-government (pattern) *secondary* schools, 2023 to 2056



Data source: CIE Education Model based on consultation with Infrastructure Victoria and Department of Education

Priority response to additional enrolments

Additional enrolments until 2036 and 2056 are met with the priority responses developed in consultation with Infrastructure Victoria and Department of Education.

Table D.15 describes in detail the various indicators reported in the following result tables.

D.15 Description of indicators for result tables

Indicator	Description
2023	
Total enrolments (to date)	Total school enrolments in 2023 (Prep to Year 12).
Existing permanent capacity	Existing school capacity in permanent buildings (i.e., bricks and mortar) of all school campuses.
Existing relocatable capacity	Existing school capacity in relocatable buildings (i.e., portables) of all school campuses where students based in relocatable buildings is lower or equal to 40 per cent of permanent capacity.
Total existing capacity	Sum of existing permanent and relocatable capacity.
Excess capacity	Total existing capacity less of total enrolments to date.
Expansion capacity	Additional relocatable buildings (up to 20% existing permanent capacity) + additional permanent capacity (25% or 50%).
Total potential capacity on existing school campuses	**Sum of excess capacity and expansion capacity.**
2023 to 2056	
Additional enrolments	Additional enrolments that need to be accommodated by 2056 based on population data. This figure matches the sum of: *'Additional enrolments met by excess capacity (within adopted provision)'* + *'Additional enrolments in relocatable building (within adopted provision)'* + *'Additional enrolments in new schools'*
Additional enrolments met by excess capacity	Number of additional enrolments that can be accommodated by the existing excess capacity.
Additional enrolments in relocatable buildings	Number of additional enrolments that can be accommodated by providing additional relocatable buildings on existing school sites. For the great majority of SA3 areas this is 0 as most SA3 areas have already a higher relocatable building provision than our adopted provision.
Existing enrolments moved from existing relocatable into new permanent buildings	Number of existing enrolments which are moved from existing relocatable buildings into new permanent buildings on the same school site, where the share of students based in relocatable buildings is higher than 40 per cent of total enrolments.
Additional enrolments in new permanent buildings	Number of additional enrolments which are accommodated in new permanent buildings on existing school sites.
Additional enrolments in new schools	Number of additional enrolments that cannot be accommodated in existing capacity, new relocatable or permanent buildings. Those enrolments require new schools.

Note: Allocation of additional enrolments follows the adopted provision outlines in the previous sections. For new relocatable buildings this is up to 20 per cent of the existing permanent capacity and for new permanent buildings 0 up to 50 per cent of the existing permanent capacity.

Source: CIE.

Tables D.16 to D.21 summarise the adopted existing permanent and relocatable capacity that can be utilised in 2023 and the additional school infrastructure needed from 2023 to 2056 for only the governmental and total Victorian provision and for kindergarten, primary and secondary schools:

- Kindergarten facilities are assumed to have no excess capacity and future additional enrolments are met with new facilities. While the number of additional enrolments is the same, the number of facilities needed varies somewhat by scenario due to regional enrolment differences. For example, total enrolments are lower in one regional area in one scenario in 2056 compared to 2023.
  - To meet the additional enrolments created by new policy reform around 1 460 new kindergarten facilities are calculated to be needed across the state. Under current provision patterns this would require 628 additional centre-based day care centres, and 832 additional kindergartens.
  - The capacity assumption is quite conservative. Consequently, we have explored various capacity scenarios. For instance, assuming a 25 percent existing capacity across all regions, the required additional kindergarten facilities amount to 563 to 569.
- Primary schools have existing capacity; however, under the model use of this capacity is limited due to a mismatch of where additional enrolments occur and where capacity exists.
  - Primary schools can accommodate between 40 to 54 percent of the additional enrolments until 2056 on-site in existing buildings. This share is the highest for the Distributed State scenario, as Regional Victoria has disproportionately high existing permanent and relocatable capacity. Conversely, the share is the lowest for the Dispersed City scenario, which experiences the largest growth in the Melbourne New Growth Areas across all scenarios, an area with a relatively low share of existing permanent capacity.
    - We note that, in reality, additional enrolments could be reallocated more efficiently to school campuses with existing capacity by adjusting the school boundaries, especially in medium and high-density areas. This would increase the proportion of additional enrolments accommodated in existing buildings.
  - Total existing capacity under the model consist predominantly of relocatable capacity and is in some regions at or above the modelled limit of 40 per cent. This means that in those areas existing enrolments in relocatable buildings are moved to new permanent buildings on-site.
    - Across all scenarios 8.3 per cent of existing enrolments are moved from relocatable to new permanent buildings. This amounts to 31,819 of existing government primary school enrolments and 46,570 of the total Victorian primary school enrolments.
  - Beyond this, 133 to 172 new governmental primary schools and 194 to 257 total new primary schools are needed to meet the additional enrolments.
- Secondary schools have relatively more existing capacity than primary schools and can utilise a larger share of that.
  - Secondary schools can accommodate between 57 to 62 percent of the additional enrolments until 2056 on-site in existing buildings. This share is the highest for the Distributed State scenario, as Regional Victoria has disproportionately high existing permanent and relocatable capacity. Conversely, the share is the lowest for the Dispersed City scenario, which experiences the largest growth in the

Melbourne New Growth Areas across all scenarios, an area with a relatively low share of existing permanent capacity.

  - We note that, in reality, additional enrolments could be reallocated more efficiently to school campuses with existing capacity by adjusting the school boundaries, especially in medium and high-density areas. This would increase the proportion of additional enrolments accommodated in existing buildings.

- Total existing capacity under the model consist predominantly of relocatable capacity and is in some regions at or above the modelled limit of 40 per cent. This means that in those areas existing enrolments in relocatable buildings are moved to new permanent buildings on-site.
  - Across all scenarios 2.5 per cent of existing enrolments are moved from relocatable to new permanent buildings. This is a substantially lower share compared to the primary school system. This amounts to 6,180 of existing government secondary school enrolments and 10,589 of the total Victorian secondary school enrolments.
- Beyond this, 18 to 24 new governmental secondary schools and 33 to 47 total new secondary schools are needed to meet the additional enrolments.

- Results across scenarios show:
  - The Dispersed City, Network of Cities, and Compact City scenarios require the most additional schools under the model as in particular the primary school sector cannot utilise existing capacity where it is needed.
    - A larger driver is growth in the Melbourne New Growth Areas, as current capacity is managed with a larger share of relocatable buildings, often above the modelled upper limit.
    - In addition, for the Compact City scenario, this is due to the high share of additional enrolments in Inner Melbourne, which cannot be serviced solely by relocatable capacity and, to a lesser extent, by additional permanent capacity.
  - The Consolidated City scenario has a similar pattern as the Compact City scenario, but to a lesser extent.
  - The Distributed State scenario sees additional population in particular in areas which are better suited to accommodate additional enrolments and able to utilise the existing capacities and additional permanent capacity the best across all scenarios. This leads to a comparatively lower requirement for new schools.

D.16 Additional infrastructure for Victorian KINDERGARTEN (excl. CENTRE-BASED DAY CARE)

Year	Sc1 Compact City	Sc2 Consolid. City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	No.	No.	No.	No.	No.
2023					
Total enrolments (to date)	71 080	71 080	71 080	71 080	71 080
Total existing excess capacity	**0**	**0**	**0**	**0**	**0**

Year	Sc1 Compact City	Sc2 Consolid. City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	No.	No.	No.	No.	No.
2023 to 2056					
Additional enrolments	54 904	54 904	54 904	54 904	54 904
New kindergarten	**832**	**832**	**832**	**832**	**832**
New kindergarten – 25 per cent existing capacity	**569**	**568**	**569**	**565**	**563**

Source: CIE.

D.17 Additional infrastructure for Victorian CENTRE-BASED DAY CARE

Year	Sc1 Compact City	Sc2 Consolid. City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	No.	No.	No.	No.	No.
2023					
Total enrolments (to date)	53 622	53 622	53 622	53 622	53 622
Total existing excess capacity	**0**	**0**	**0**	**0**	**0**
2023 to 2056					
Additional enrolments	41 419	41 419	41 419	41 419	41 419
New kindergarten	**628**	**628**	**628**	**628**	**628**
New kindergarten – 25 per cent existing capacity	**429**	**428**	**429**	**426**	**425**

Source: CIE.

D.18 Additional school infrastructure for government PRIMARY schools

Year	Sc1 Compact City	Sc2 Consolid. City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	No.	No.	No.	No.	No.
2023					
Total enrolments (to date)	380 577	380 577	380 577	380 577	380 577
Existing permanent capacity	344 975	344 975	344 975	344 975	344 975
Existing relocatable capacity	164 602	164 602	164 602	164 602	164 602
Total existing capacity	**509 577**	**509 577**	**509 577**	**509 577**	**509 577**
Excess capacity	81 193	81 193	81 193	81 193	81 193
Expansion capacity	115 318	115 318	115 318	115 318	115 318
Total potential capacity on existing school campuses	**196 511**	**196 511**	**196 511**	**196 511**	**196 511**

Year	Sc1 Compact City	Sc2 Consolid. City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	No.	No.	No.	No.	No.
2023 to 2056					
Additional enrolments	135 160	137 205	137 268	135 377	138 111
Additional enrolments met by existing capacity	36 992	40 557	32 830	38 412	43 580
Additional enrolments in new relocatable buildings	0	0	0	0	0
Existing enrolment in relocatable buildings converted into new permanent buildings	31 819	31 819	31 819	31 819	31 819
Additional enrolments in new permanent buildings	21 690	21 223	14 039	18 556	24 772
Additional enrolments in new schools	76 478	75 425	90 399	78 409	69 758
New schools	**146**	**144**	**172**	**149**	**133**

Note: The sum of 'Additional enrolments met by existing capacity', 'Additional enrolments in new relocatable buildings', 'Additional enrolments in new permanent buildings', and 'Additional enrolments in new schools' equals 'Additional enrolments.'

Source: CIE.

D.19 Additional school infrastructure for total Victorian PRIMARY schools

Year	Sc1 Compact City	Sc2 Consolid. City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	No.	No.	No.	No.	No.
2023					
Total enrolments (to date)	570 111	570 111	570 111	570 111	570 111
Existing permanent capacity	522 319	522 319	522 319	522 319	522 319
Existing relocatable capacity	244 833	244 833	244 833	244 833	244 833
Total existing capacity	**767 152**	**767 152**	**767 152**	**767 152**	**767 152**
Excess capacity	128 016	128 016	128 016	128 016	128 016
Expansion capacity	174 163	174 163	174 163	174 163	174 163
Total potential capacity on existing school campuses	**302 178**	**302 178**	**302 178**	**302 178**	**302 178**
2023 to 2056					
Additional enrolments	209 568	209 568	209 568	209 568	209 568
Additional enrolments met by existing capacity	61 192	66 452	53 147	62 213	69 948
Additional enrolments in new relocatable buildings	0	0	0	0	0
Existing enrolment in relocatable buildings converted into new permanent buildings	46 570	46 570	46 570	46 570	46 570
Additional enrolments in new permanent buildings	33 857	33 019	21 580	28 850	37 531
Additional enrolments in new schools	114 519	110 097	134 840	118 505	102 089
New schools	**218**	**210**	**257**	**226**	**194**

Note: The sum of 'Additional enrolments met by existing capacity', 'Additional enrolments in new relocatable buildings', 'Additional enrolments in new permanent buildings', and 'Additional enrolments in new schools' equals 'Additional enrolments.'

Source: CIE.

D.20 Additional school infrastructure for government SECONDARY schools

Year	Sc1 Compact City	Sc2 Consolid. City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	No.	No.	No.	No.	No.
2023					
Total enrolments (to date)	243 029	243 029	243 029	243 029	243 029
Existing permanent capacity	255 975	255 975	255 975	255 975	255 975
Existing relocatable capacity	64 850	64 850	64 850	64 850	64 850
Total existing capacity	**320 825**	**320 825**	**320 825**	**320 825**	**320 825**
Excess capacity	77 796	77 796	77 796	77 796	77 796
Expansion capacity	97 946	97 946	97 946	97 946	97 946
Total potential capacity on existing school campuses	**175 743**	**175 743**	**175 743**	**175 743**	**175 743**
2023 to 2056					
Additional enrolments	87 061	92 635	93 920	93 401	96 176
Additional enrolments met by existing capacity	42 995	48 329	44 458	46 120	48 534
Additional enrolments in new relocatable buildings	1 936	2 563	2 168	2 540	3 375
Existing enrolment in relocatable buildings converted into new permanent buildings	6 180	6 180	6 180	6 180	6 180
Additional enrolments in new permanent buildings	19 878	20 604	18 005	22 120	22 900
Additional enrolments in new schools	22 252	21 139	29 288	22 620	21 366
New schools	**19**	**18**	**24**	**19**	**18**

Note: The sum of 'Additional enrolments met by existing capacity', 'Additional enrolments in new relocatable buildings', 'Additional enrolments in new permanent buildings', and 'Additional enrolments in new schools' equals 'Additional enrolments.'

Source: CIE.

D.21 Additional school infrastructure for total Victorian SECONDARY schools

Year	Sc1 Compact City	Sc2 Consolid. City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	No.	No.	No.	No.	No.
2023					
Total enrolments (to date)	445 285	445 285	445 285	445 285	445 285
Existing permanent capacity	477 222	477 222	477 222	477 222	477 222
Existing relocatable capacity	116 698	116 698	116 698	116 698	116 698
Total existing capacity	**593 920**	**593 920**	**593 920**	**593 920**	**593 920**
Excess capacity	148 635	148 635	148 635	148 635	148 635
Expansion capacity	179 696	179 696	179 696	179 696	179 696
Total potential capacity on existing school campuses	**328 331**	**328 331**	**328 331**	**328 331**	**328 331**

Year	Sc1 Compact City	Sc2 Consolid. City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	No.	No.	No.	No.	No.
2023 to 2056					
Additional enrolments	176 253	176 253	176 253	176 253	176 253
Additional enrolments met by existing capacity	84 709	92 734	82 010	86 469	88 925
Additional enrolments in new relocatable buildings	4 183	5 389	4 405	4 940	6 781
Existing enrolment in relocatable buildings converted into new permanent buildings	10 589	10 589	10 589	10 589	10 589
Additional enrolments in new permanent buildings	37 457	36 904	33 567	39 922	41 085
Additional enrolments in new schools	49 904	41 226	56 271	44 921	39 463
New schools	**42**	**34**	**47**	**37**	**33**

Note: The sum of 'Additional enrolments met by existing capacity', 'Additional enrolments in new relocatable buildings', 'Additional enrolments in new permanent buildings', and 'Additional enrolments in new schools' equals 'Additional enrolments.'

Source: CIE.

Cost of additional education infrastructure

Total cost for providing additional school infrastructure includes the land cost, capital and operating costs.

New schools differ in the amount of land they require by type of school and region. Table D.22 summarises our assumed land requirement by school type and region in Victoria.

D.22 Land requirement for new kindergarten and schools, by region in Victoria

School type	Inner Melbourne (high density)	Inner Melbourne (other)	Middle and Outer Melbourne	Melbourne New Growth Area	Regional City	Regional Centres and Rural Areas
	ha	ha	ha	ha	ha	ha
Kindergarten	0.0	0.5	0.0	0.0	0.0	0.0
Primary School	2.0	2.0	2.0	3.5	3.5	3.5
Secondary School	2.0	2.0	5.0	8.4	8.4	8.4

Note: Figures show land requirement for government kindergarten and schools, however, we have assumed the same land requirements apply to non-government centre-based day car and schools.

Source: CIE in consultation with Infrastructure Victoria.

Land cost per square metre of required land differs by region and the type of development area and is summarised in table D.23.

D.23 Land cost for new schools

Functional Urban Area	Greenfield	Infill
	$/sqm	$/sqm
Inner Melbourne (high density and other)	NA	5322
Middle and Outer Melbourne	NA	1806
Melbourne New Growth Area	530	NA
Regional City	161	480
Regional Centres and Rural Areas	20	24

Note: Land cost values are based on a weighted average of number of sales, median price per area, and median block size by region in Victoria. Greenfield values are based on the weighted average of land uses classified as Res Dev Site, Res Land (WithBuild), Vac Res A, Vac Res B, Vac Res C, Vac Res Englobo Other, Vac Res Rural style, and Infill only on ac Res A, Vac Res B, Vac Res C.

Source: Valuer-General Victoria *Property sales statistics* (2021), https://www.land.vic.gov.au/valuations/resources-and-reports/property-sales-statistics

We have adopted the following capital costs based on information provided by Infrastructure Victoria (table D.24 and D.25):

- For additional relocatable capacity the cost per module ranges from $0.35 million to $1.95 for capacities of either 50, 100 or 150 students. The cost per student ranges from $7,032 to $12,992 depending on the size.
  - We have assumed that only module with a capacity for 50 students are used, as higher capacity modules have multiple storeys which are most likely considered for highly constrained sites.
- For additional permanent capacity at primary schools the cost ranges from $8.11 million to $15.54 million for capacities of 150 to 300, and $14.25 million to $21.21 million for secondary schools, respectively.
  - Cost per primary school student is similar for the different capacities ranging between $51,817 to $54,498.
  - Cost per secondary school student differs by capacity and becomes less costly the higher the capacity. Cost ranges from $70,687 (300 capacity) to $95,016 (150 capacity) per student.
- There are cost differences for 'new schools' depending on the type of school and location of development.
  - New schools in Inner Melbourne are assumed to be 'vertical/multi storey' schools due to highly constrained sites, and therefore, more complex and costly.
  - Across all other regions in Victoria capital cost for schools by type are the same,
- Kindergarten facilities come at a cost of $6.5 million per facility (66 capacity).

Annual operating cost have been estimated as a percentage of total capex at 3 per cent.[111] This includes only the cost of physical infrastructure maintenance, and not the cost of delivering educational services such as teaching and ICT software and devices. Operating costs are estimated from 2023 to 2036 and subsequent from 2036 to 2056 and

111 IV (2019), Infrastructure Provision in Different Development Settings, Metropolitan Melbourne Volume 2 Technical Appendix, p.67, available at https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/08/IPIDDS-Metro-Melbourne-Vol-2-Technical-appendix_Aug-2019.pdf.pdf

divided by two. This assumes that on average additional infrastructure is provided halfway through both time periods.

D.24 Capital expenditure (excl. land cost) by type of expansion on existing sites

Response type						Enrolment Capacity
	50	100	150	200	250	300
	$m	$m	$m	$m	$m	$m
Primary Schools						
Additional relocatable capacity	0.35	1.15	1.95	NA	NA	NA
Additional permanent capacity	NA	NA	8.11	10.90	13.60	15.54
Secondary Schools						
Additional relocatable capacity	0.35	1.15	1.95	NA	NA	NA
Additional permanent capacity	NA	NA	14.25	17.12	18.62	21.21

Note: Figures show cost for government schools, however, we have assumed the same cost apply to non-government schools.

Source: Provided by Infrastructure Victoria.

D.25 Capital expenditure (excl. land cost) for new kindergarten and schools

Response type	Inner Melbourne (high density and other)	Rest of Victoria
	$m	$m
New kindergarten	6.44	6.44
New primary school	86.58	43.57
New secondary school	173.64	86.36

Note: Figures show cost for government schools, however, we have assumed the same cost apply to non-government schools.

Source: Provided by Infrastructure Victoria.

Cost summary

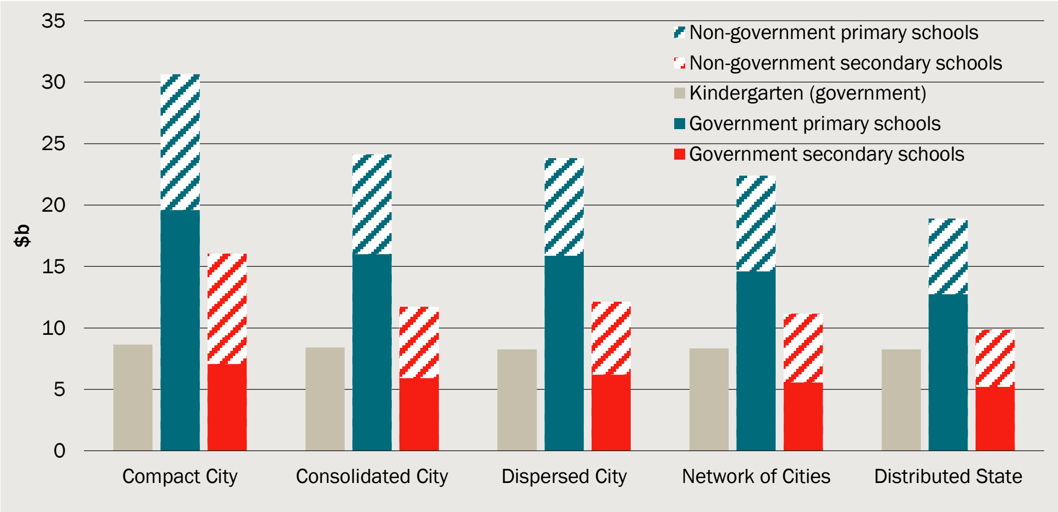
We model the cost of providing additional education infrastructure through managing enrolment and capacity at a regional area level (SA3).

The cost of providing additional school infrastructure ranges from $26.2 to $35.3 billion for government schools and kindergarten infrastructure (assuming that 43 per cent of enrolments in non-government centre-based day care), and $37.0 to $55.3 billion for the total Victorian school infrastructure.

Capital and land cost account for the majority of cost with approximately 70 (Distributed State scenario) to 75 per cent (Compact City scenario). The difference between scenarios is largely driven by land cost. While land cost makes up only 10 per cent of the total cost in the Distributed State scenario, it amounts to 24 per cent in the Compact City scenario.

In all scenarios, the cost of additional primary school infrastructure is almost double the cost of additional secondary school infrastructure. The main driver of this is the capacity constraints in the primary school infrastructure in some regions.

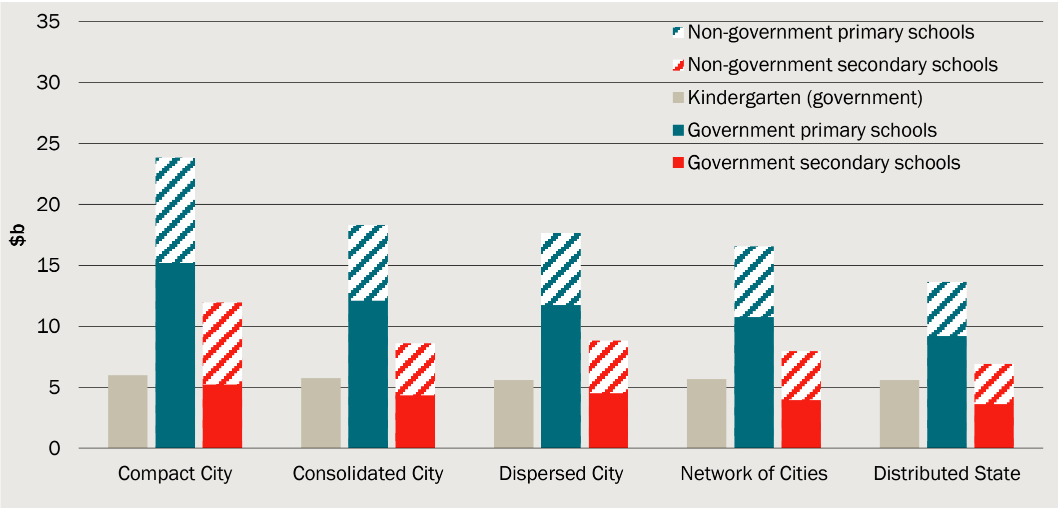
D.26 Total education infrastructure cost until 2056



Note: Kindergarten (government) figure assumes that 43 per cent of kindergarten programs are held in non-government centre-based day care.

Data source: CIE.

D.27 Total capital cost until 2056



Note: *Includes land cost.* Kindergarten (government) figure assumes that 43 per cent of kindergarten programs are held in non-government centre-based day care.

Data source: CIE.

Scenarios which see more additional enrolments in Metropolitan Melbourne have substantially higher costs in terms of capital and land cost. In particular growth in Inner Melbourne and Melbourne New Growth Areas is often met with new schools rather than additional relocatable or additional permanent capacity.

Tables D.28 and D.29 summarise the different cost components by school type and scenario for only additional government school infrastructure and total Victorian school infrastructure.

D.28 Government education infrastructure impact across scenarios until 2056

Cost	Type of cost	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
		$b	$b	$b	$b	$b
Kindergarten						
Capital Cost	New kindergarten	5.4	5.4	5.4	5.4	5.4
Operating Cost		2.7	2.7	2.7	2.7	2.7
Land Cost		0.6	0.4	0.2	0.3	0.3
Total		**8.6**	**8.4**	**8.3**	**8.3**	**8.3**
Primary Schools						
Capital Cost	Additional relocatable	0.0	0.0	0.0	0.0	0.0
	Additional permanent	1.1	1.1	0.7	1.0	1.3
	New school	7.8	6.8	7.6	6.8	5.9
Operating Cost		4.4	3.9	4.1	3.8	3.5
Land Cost		6.3	4.3	3.4	3.0	2.0
Total		**19.6**	**16.0**	**15.9**	**14.6**	**12.8**
Secondary Schools						
Capital Cost	Additional relocatable	<0.1	<0.1	<0.1	<0.1	<0.1
	Additional permanent	1.4	1.5	1.3	1.6	1.6
	New school	2.3	1.7	2.1	1.7	1.6
Operating Cost		1.8	1.6	1.7	1.6	1.6
Land Cost		1.5	1.1	1.1	0.6	0.4
Total		**7.1**	**5.9**	**6.2**	**5.6**	**5.2**
All infrastructure						
Capital Cost	Additional relocatable	<0.1	<0.1	<0.1	<0.1	<0.1
	Additional permanent	2.6	2.6	2.0	2.5	2.9
	New school/kindergarten	15.4	13.8	15.1	13.8	12.8
Operating Cost		8.9	8.1	8.5	8.1	7.8
Land Cost		8.5	5.8	4.8	4.0	2.7
Grand Total		**35.3**	**30.3**	**30.3**	**28.5**	**26.2**

Note: Assumes that 43 per cent of kindergarten programs are held in non-government centre-based day care

Data source: CIE.

D.29 Total Victorian education infrastructure impact across scenarios until 2056

Cost	Type of cost	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
		$b	$b	$b	$b	$b
Kindergarten						
Capital Cost	New kindergarten	5.4	5.4	5.4	5.4	5.4
Operating Cost		2.7	2.7	2.7	2.7	2.7
Land Cost		0.6	0.4	0.2	0.3	0.3
Total		**8.6**	**8.4**	**8.3**	**8.3**	**8.3**
Primary Schools						
Capital Cost	Additional relocatable	0.0	0.0	0.0	0.0	0.0
	Additional permanent	1.8	1.7	1.1	1.5	1.9
	New school	12.0	10.1	11.4	10.4	8.7
Operating Cost		6.8	5.8	6.2	5.9	5.2
Land Cost		10.1	6.5	5.2	4.7	3.1
Total		**30.7**	**24.1**	**23.8**	**22.4**	**18.9**
Secondary Schools						
Capital Cost	Additional relocatable	<0.1	<0.1	<0.1	<0.1	<0.1
	Additional permanent	2.7	2.6	2.4	2.8	2.9
	New school	5.6	3.7	4.2	3.6	3.0
Operating Cost		4.1	3.1	3.3	3.2	3.0
Land Cost		3.6	2.3	2.2	1.5	0.9
Total		**16.0**	**11.7**	**12.1**	**11.2**	**9.9**
All Schools						
Capital Cost	Additional relocatable	<0.1	<0.1	<0.1	<0.1	<0.1
	Additional permanent	4.4	4.3	3.5	4.3	4.9
	New school/kindergarten	23.0	19.1	21.0	19.3	17.0
Operating Cost		13.6	11.6	12.1	11.7	10.9
Land Cost		14.4	9.2	7.6	6.5	4.2
Grand Total		**55.3**	**44.3**	**44.2**	**41.9**	**37.0**

Source: CIE.

Distributional impact

In Victoria, education expenditure is funded by three main streams:[112]

- The Australian Government (the Commonwealth) provides recurrent funding for every student enrolled at any type of school and construction grants to non-government schools,
- The Victorian Government provides capital and recurrent funding for every student enrolled at any type of school as well as (construction) grants to non-government schools, and
- User charges for non-government schools.

The funding responsibilities between the Commonwealth and the Victorian Government are outlined in The Australian Education Act 2013 (the Act) and National School Reform Agreement - Victoria Bilateral Agreement (the Agreement).[113]

In order to meet the objective of this analysis, we have assumed:

- Kindergarten infrastructure costs are fully funded by the Victorian Government, with 43 per cent of preschool enrolments supported by non-government long day care centres.
- Capital, infrastructure operating and land costs for government schools are fully directly funded or through grants by the Australian Government and Victorian Government. The Australian Government is supporting construction of new schools mostly through grants which are provided to the Victorian Department of Education. We have assumed for the purpose of this analysis that all government school funding is allocated to the Victorian Government.
- Capital, infrastructure operating and land costs for non-government schools are funded through various streams, such as State and Australian Government, user charges and fundraising. We have assumed for the purpose of this analysis that all non-government school funding is allocated to the non-government sector.

Table D.30 and chart D.31 summarise the costs funded by stakeholder.

D.30 Education infrastructure funding by stakeholder (2021 to 2056)

		Sc1	Sc2	Sc3	Sc4	Sc5
		Compact City	Consolidated City	Dispersed City	Network of Cities	Distributed State
		$b	$b	$b	$b	$b
Kindergarten						
Capital Cost	Government	5.4	5.4	5.4	5.4	5.4
Operating Cost	Government	2.7	2.7	2.7	2.7	2.7
Land cost	Government	0.6	0.4	0.2	0.3	0.3

112 Parliamentary Budget Office (2020), Figure 1, available at: https://pbo.vic.gov.au/response/461

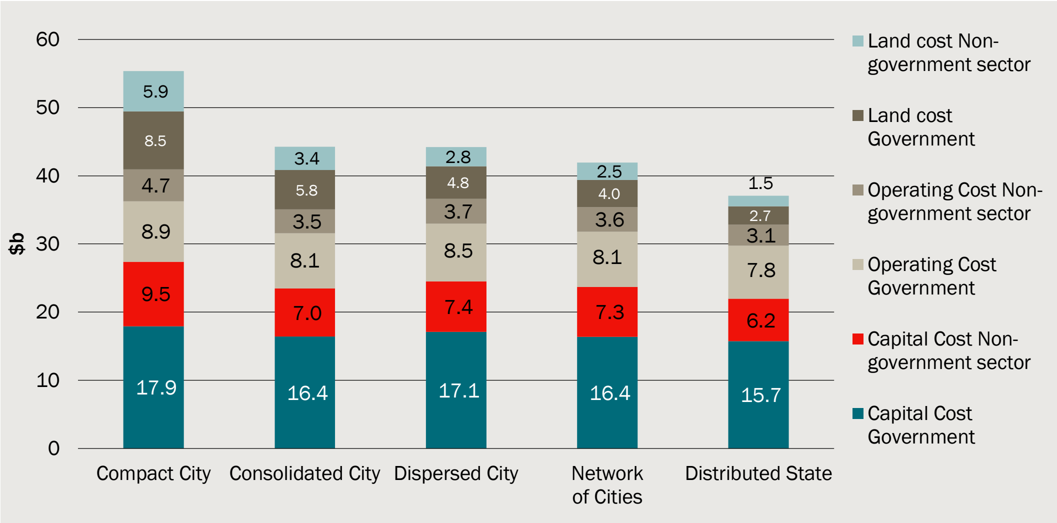
113 Parliamentary Budget Office (2020), https://pbo.vic.gov.au/response/461

		Sc1	Sc2	Sc3	Sc4	Sc5
		Compact City	Consolidated City	Dispersed City	Network of Cities	Distributed State
		$b	$b	$b	$b	$b
Total	**Government**	**8.6**	**8.4**	**8.3**	**8.3**	**8.3**
Primary schools						
Capital Cost	Government	8.9	7.9	8.3	7.7	7.2
	Non-government sector	4.9	3.9	4.2	4.1	3.4
Operating Cost	Government	4.4	3.9	4.1	3.8	3.5
	Non-government sector	2.4	1.9	2.1	2.0	1.7
Land cost	Government	6.3	4.3	3.4	3.0	2.0
	Non-government sector	3.8	2.3	1.7	1.7	1.0
Total	**Government**	**19.6**	**16.0**	**15.9**	**14.6**	**12.8**
	Non-government sector	**11.1**	**8.1**	**8.0**	**7.8**	**6.2**
Secondary Schools						
Capital Cost	Government	3.7	3.2	3.4	3.3	3.2
	Non-government sector	4.6	3.1	3.2	3.2	2.8
Operating Cost	Government	1.8	1.6	1.7	1.6	1.6
	Non-government sector	2.3	1.5	1.6	1.6	1.4
Land cost	Government	1.5	1.1	1.1	0.6	0.4
	Non-government sector	2.1	1.2	1.1	0.9	0.5
Total	**Government**	**7.1**	**5.9**	**6.2**	**5.6**	**5.2**
	Non-government sector	**9.0**	**5.8**	**5.9**	**5.6**	**4.7**
All infrastructure						
Capital Cost	Government	17.9	16.4	17.1	16.4	15.7
	Non-government sector	9.5	7.0	7.4	7.3	6.2
Operating Cost	Government	8.9	8.1	8.5	8.1	7.8
	Non-government sector	4.7	3.5	3.7	3.6	3.1
Land cost	Government	8.5	5.8	4.8	4.0	2.7
	Non-government sector	5.9	3.4	2.8	2.5	1.5
Total	**Government**	**35.3**	**30.3**	**30.3**	**28.5**	**26.2**
	Non-government sector	**20.1**	**13.9**	**13.9**	**13.4**	**10.8**

Note: Figures are denoted in $2022/23 dollars.

Source: CIE

D.31 Education infrastructure funding by stakeholder (2021 to 2056)



Note: Figures are denoted in $2022/23 dollars.

Source: CIE

E Electricity

- **Additional electricity infrastructure requirements under the urban development scenarios are two-fold and include:**
  - **power generation and transmission networks, and**
  - **distribution networks.**
- **Operational consumption and demand estimates show minimal variation across different scenarios.**
- **By 2056, approximately 60 GW of power generating capacity will be installed, an increase of 39 GW compared to today.**
  - **The transformation to more renewable energy is estimated to cost ~$42 billion for the anticipated growth, which is the same across scenarios. This includes the installation of utility-scale wind and solar farms as well as storage solutions. Note that private rooftop solar PV provision and costing have not been included in the analysis.**
- **Overall, scenarios do not differ significantly in terms of maximum demand, which is driven by the somewhat marginal differences in residential and non-residential consumption relative to the AEMO ISP (2022) consumption and demand forecast**
  - **By 2056, the distribution network will need a maximum (peak) demand capacity ranging between 17 089 to 17 597 MW depending on the scenario, which is almost double the current capacity.**
  - **Population and employment growth are the main drivers of this increase. Other drivers include changes in the dwelling typology, occupancy rates, rooftop solar PV uptake, climate zones, EV uptake and industry sector composition across scenarios, which lead to varying demand profiles.**
- **The total expected cost for augmenting the distribution network is estimated at a zone substation level. The additional distribution network costs are $40 to $48 billion across all scenarios - the highest being the Dispersed City and Network of Cities scenarios, with the Compact City scenario being the lowest.**

Table E.1 summarises the total installed capacity and the total operational maximum demand by 2056 and table E.2 the cumulative capital and operating cost for the power generation, transmission network and distribution network by 2056.

E.1 Electricity infrastructure across scenarios by 2056

	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	MW	MW	MW	MW	MW
Total Installed Capacity by 2056	59 494	59 494	59 494	59 494	59 494
Total Dispatchable Capacity by 2056	15 589	15 589	15 589	15 589	15 589
Additional installed capacity (2056 vs. 2021)	39 050	39 050	39 050	39 050	39 050
	MW	MW	MW	MW	MW
Total Maximum demand by 2056	17 089	17 290	17 597	17 536	17 552
Additional Maximum (Peak) Demand (2056 vs. 2021)	8 185	8 386	8 693	8 632	8 648

Source: *CIE* Model, AEMO ISP (2022), 2022 Final ISP results workbook – Step Change, https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp

E.2 Cumulative electricity infrastructure costs across scenarios by 2056

Cumulative cost from 2021 to 2056	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$b	$b	$b	$b	$b
Additional Power Generation and Transmission Network infrastructure					
Capital Cost – Power Generation	25.8	25.8	25.8	25.8	25.8
Capital Cost – Transmission Network	3.5	3.5	3.5	3.5	3.5
Operating and maintenance cost – Power Generation & Transmission Network	13.0	13.0	13.0	13.0	13.0
Sub-total	**42.3**	**42.3**	**42.3**	**42.3**	**42.3**
Additional Distribution Network Infrastructure					
Capital Cost – Distribution Network	15.5	17.5	23.4	23.6	21.1
Operating Cost – Distribution Network	24.1	24.3	24.7	24.6	24.6
Sub-total	**39.6**	**41.9**	**48.1**	**48.1**	**45.7**
Total Additional Electricity Infrastructure					
Capital Cost	44.8	46.9	52.8	52.9	50.4
Operating and maintenance cost	37.1	37.3	37.6	37.5	37.6
Grand Total	**81.9**	**84.2**	**90.4**	**90.5**	**88.0**

Source: *CIE* Model, AEMO ISP (2022), 2022 Final ISP results workbook – Step Change, https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp

Electricity infrastructure in Victoria

Electricity infrastructure is an essential utility service and is typically divided into three main components:

- the power generation infrastructure and the transmission network, which transports electricity over long distances from power generation sources to local distribution networks,
- the distribution network, which delivers electricity to homes and businesses in urban and regional areas, and
- the customer connection, which involves the installation of metering and other equipment to connect individual premises to the distribution network.

Each of these components contributes to the overall cost and planning of the electricity infrastructure.

In recent years, Victoria has progressed in transitioning towards a cleaner and more sustainable electricity system. This transition has been driven by various factors, including increasing demand for renewable energy, the emergence of new technologies such as electric vehicles and energy storage, and changing consumer preferences.

In order to meet these challenges and capitalise on the opportunities presented by the transition to a clean energy future, the Australian Energy Market Operator (AEMO) has developed the Integrated System Plan (ISP) 2022[114] and Electricity Statement of Opportunities (ESOO) 2022.[115]

AEMOs ISP is a comprehensive long-term planning document that provides a roadmap for the future development of the national electricity market.[116] The ISP is updated regularly and provides projections and scenarios for generation and transmission investments until 2050.

Some of the key development that can be expected over the coming decades include:

- Growth of renewable energy sources, such as solar and wind power, with Victoria expected to have over 28GW of solar capacity (both solar farms and distributed PV) and 12GW of wind capacity by 2050.[117]
- Increasing adoption of electric vehicles (EVs), with Victoria expected to have around 2.2 million EVs on the road by 2035 and 6.5 million by 2050, up from the current number of around 18 000.[118]

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114 https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf?la=en

115 https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/nem_esoo/2022/2022-electricity-statement-of-opportunities.pdf?la=en

116 https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf?la=en

117 AEMO ISP (2022), Final ISP results workbook - Step change scenario, https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp

118 AEMO Draft IASR (2023), Detailed Electric Vehicle Workbook - Draft 2023 IASR – Orchestrated Change, https://aemo.com.au/consultations/current-and-closed-consultations/2023-inputs-assumptions-and-scenarios-consultation

- Significant investment in energy storage, grid modernisation, and demand response technologies to support the growth of renewable energy and EVs.
- The need to balance electricity supply and demand in real-time to maintain the stability and reliability of the electricity system.
- Increasing use of distributed energy resources, such as rooftop solar and battery storage, which will require changes to the traditional electricity network and business models.
- The continued retirement of aging coal-fired power plants and the need for replacement with cleaner and more flexible sources of energy.
- Increasing demand for energy management services, including energy efficiency and demand response, to help consumers and businesses manage their electricity consumption and costs.

The following chapter summarises our approach and estimates of the future provision and costs of the electricity infrastructure in Victoria for different populations scenarios and is structured as follows:

- Residential and non-residential consumption and demand,
- Approach to estimate the additional infrastructure needed,
- Cost of additional infrastructure, and
- A summary of cost by scenario.

Box E.3 summarises the terminology that will be used throughout this report to describe electricity consumption, demand and supply.

E.3 Definitions used throughout this chapter

There are four main concepts in relation to the electricity network relevant for this analysis:[119]

- **'Operational'**: Refers to the electricity used by residential, commercial and large industrial consumers, as supplied by scheduled, semi-scheduled and significant non-scheduled generating units.
  – Significant non-scheduled generating units include, for example, large-scale wind or solar generators greater than or equal to 30 MW, but not rooftop solar PV.
- **'Consumption'**: Refers to electricity used over a period of time (kWh, MWh, or GWh). Consumption can also be disaggregated into:
  – 'Operational consumption' which describes consumption which is supplied by 'operational' generating units (see above). For example, 'Operational consumption' decreases as rooftop solar PV generation increases.

119 AEMO (2021), Operation Consumption Definition, available at: https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/demand-forecasts/operational-consumption-definition.pdf

- **'Demand'**: Describes electricity used at a particular time (kW, MW, or GW). This is relevant when discussing peak or maximum electricity demand. In the context of this analysis, we will refer to peak or maximum *operational* demand.
- **'Installed capacity'**: Represents the theoretical maximum generation capacity.
- **'Electrification':** The process of powering by electricity by changing over from an earlier fossil fuel power source, such as natural gas.

Residential electricity use in Victoria

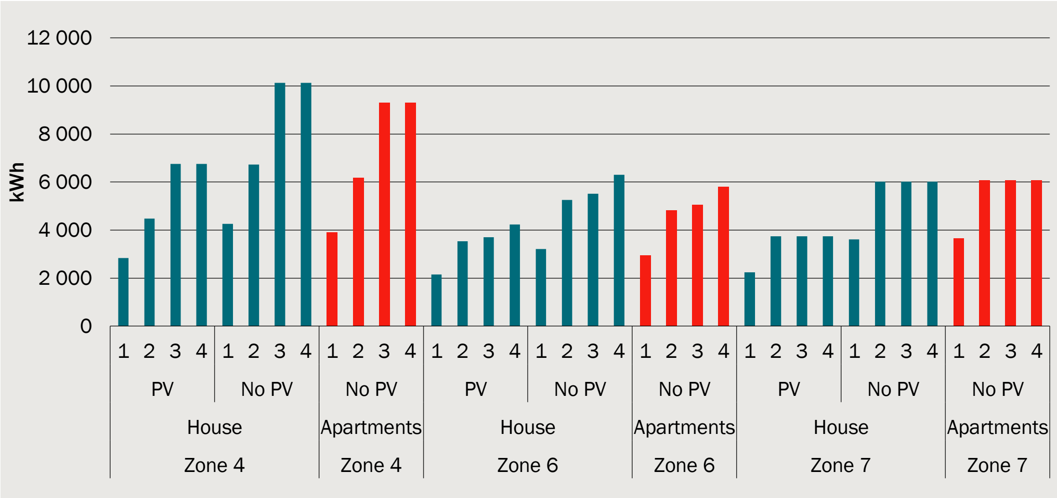
As an essential service, all dwellings constructed in Victoria are connected to the electricity network. Operational consumption is driven by a range of factors:

- Energy rating of a dwelling,
- Rooftop solar PV uptake,
- Electric Vehicle (EV) uptake,
- Type of dwelling,
- Occupancy rate, and
- Climate zone (chart E.5).

For example, while electricity consumption might increase with more electrification overall operational consumption could decrease due to a high uptake of rooftop solar PV.

Chart E.4 shows the average annual operational consumption in 2021 by climate zone, type of dwelling, with and without rooftop solar PV and occupancy rate (1 to 4 residents). Note that those figures exclude the consumption from EVs.

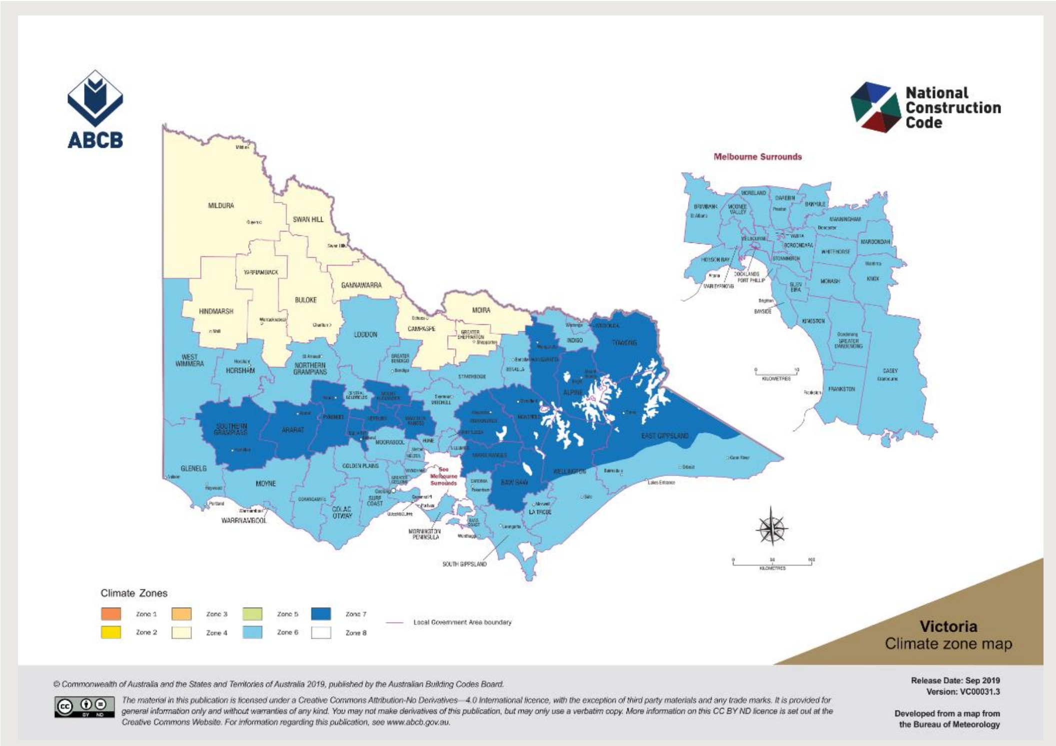
E.4 Annual residential operational consumption for different drivers (2021)



Note: Based on 6 star and 7 star rated dwellings. ACIL Allen note that, for the modelling it has been assumed that all Class 2 dwellings meet the Whole of House requirements using an 'all equipment pathway' and that effectively solar PV cannot be installed to offset the energy of other regulated buildings elements in SOUs. This assumption has been made due to the current practical difficulties with installing solar PV on Class 2 buildings.[120]

Data source: Frontier Economics (2020), Residential energy consumption benchmarks for Victoria; ACIL Allen (2021), *National Construction Code 2022 Consultation Regulation Impact Statement for a proposal to increase residential building energy efficiency requirements*, electricity consumption data provided by dwelling type (house/apartments, with/without rooftop solar pv, and energy efficiency rating), and climate zone. https://acilallen.com.au/uploads/projects/377/ACILAllen_RISProposedNCC2022_2021.pdf

E.5 Victoria Climate Zone Map



Data source: ABCB (2019) Victoria Climate zone map, available at: https://www.abcb.gov.au/sites/default/files/resources/2020//ClimateZoneMapVIC.pdf

Alternative growth paths will impact on the total operational consumption and peak demand for electricity through a number of channels:

- development in different climate zones
- lower density development will likely generate lower electricity consumption due to higher rooftop solar PV uptake, and
- the uptake of electric vehicles (EV) and battery energy storage systems.

Electricity consumption tends to be highest in the winter months for all climate zones, while consumption patterns vary between climate zones in summer and are higher in zones further from the coast such as Zone 4 and 7 (chart E.5). Zones 4 and 7 are hotter and likely to have a high uptake of air conditioning. A higher share of people living in those areas will lead to an increase in average operational consumption per dwelling across all scenarios.

120 ACIL Allen (2021), *National Construction Code 2022 Consultation Regulation Impact Statement for a proposal to increase residential building energy efficiency requirements*, Box 4.1, p.62, https://acilallen.com.au/uploads/projects/377/ACILAllen_RISProposedNCC2022_2021.pdf

PV uptake is forecast to increase substantially in the coming years as energy efficiency measures and the use of home rooftop solar PV systems is incentivised by the Victorian Government's Solar Homes Program.[121] A higher share of houses will lead to a decline in average operational consumption per dwelling across all scenarios.

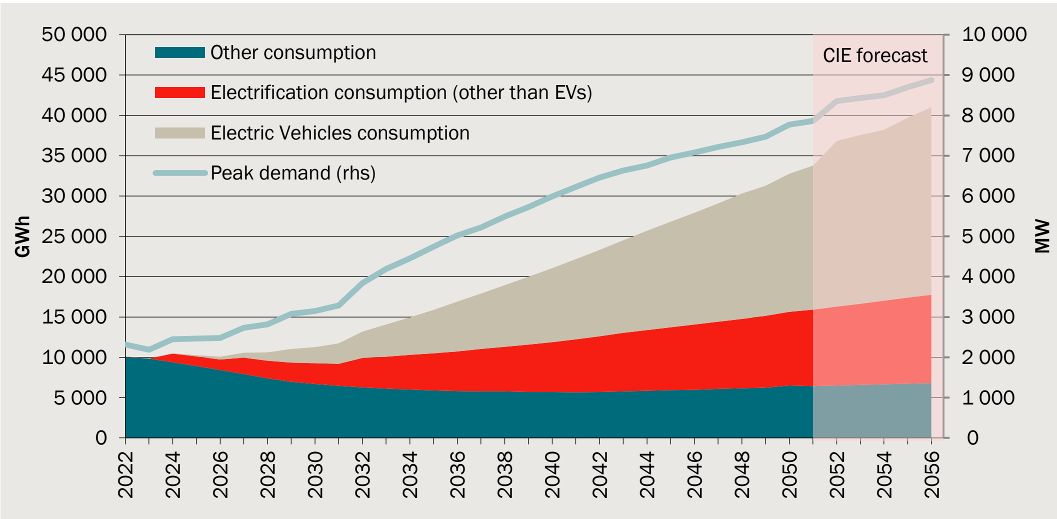
EV uptake is forecasted to increase substantially in the coming years. For scenarios that involve a higher utilization of EVs (i.e., more vehicle kilometres travelled), the average operational consumption will be higher.

All of these factors suggest that operational consumption and peak demand will be higher for a development scenario with more people in high density infill areas or scenarios which have a higher EV uptake.

Chart E.6 highlights the residential operational consumption and peak demand. Future consumption can be broken down in three main components:

- Electric vehicles consumption, whose share of total consumption increases from <0.1 per cent to 34 per cent by 2036 and 57 per cent by 2056,
- Electrification consumption other than from electric vehicles, whose share increases to 29 per cent by 2036 and 27 per cent by 2056, and
- Other consumption, which decreases in absolute and relative terms due to increased energy efficiency of buildings.

E.6 Residential operational consumption and peak demand forecast



Note: AEMO forecast is up to 2050. We have applied a linear trend until 2056. ISP 2022-Step Change scenario was adjusted for a higher EV uptake under the previously published Draft IASR 2023.

Data source: AEMO ISP (2022), Final ISP results workbook - Step change scenario, https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp

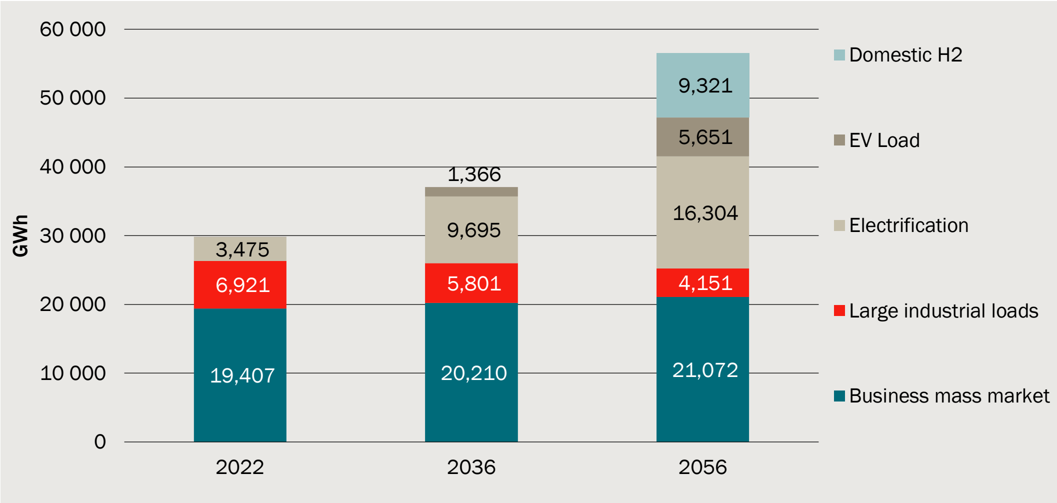
121 https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/transmission-connection-point-forecasting/victoria

Non-residential electricity use in Victoria

Non-residential electricity connections, such as businesses and industry are major electricity users, and accounted for approximately 75 per cent of the total operational electricity consumption in 2022. The future electricity demand and peak demand will be primarily driven by electric vehicle uptake, the moving away from fossil fuels (electrification) and domestic hydrogen production (chart E.7).

Rooftop solar PV plays only a subordinate role in covering consumption for businesses and industry. Currently it provides only ~2 per cent of the total consumption, while this share will increase to ~4 per cent by 2056, according to the AEMO ISP forecast.

E.7 Victorian electricity consumption profile for non-residential connections



Data source: AEMO ISP (2022), Final ISP results workbook – Step change scenario, https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp

Alternative growth paths will impact on the non-residential total operational consumption and peak demand through a number of channels:

- development in different climate zones, ie further from the coast, will have a greater impact on peak electricity load requirements as these areas are hotter and likely to have a high uptake of air conditioning,
- share of the energy intensive industry sector,, i.e., scenarios which see a more prevalent role of the traditional industrial sector (such as mining, manufacturing, or transport) will generally have a higher consumption,
- the uptake of electric vehicles and battery energy storage systems.

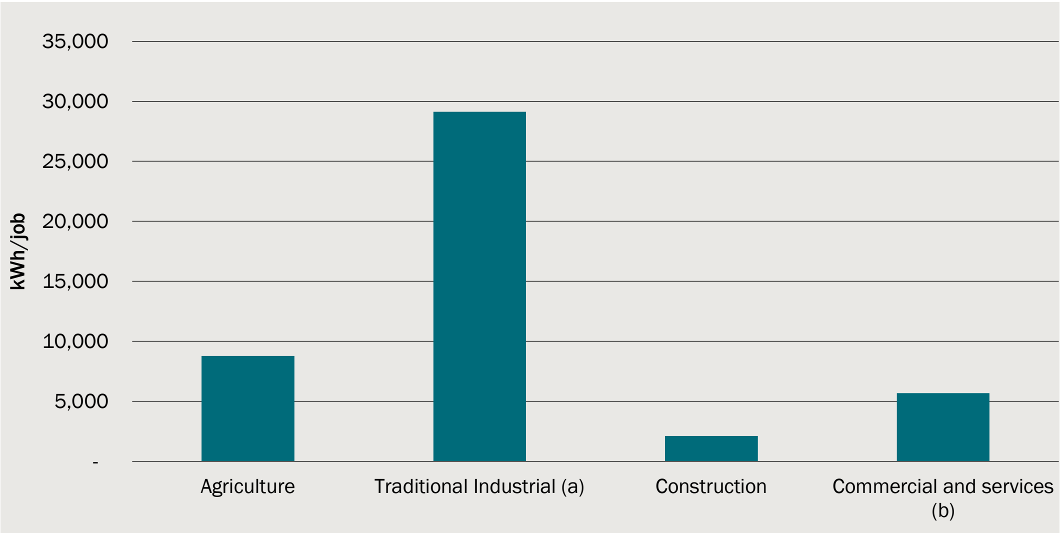
Data on electricity use by industry sector is available from the Australian Energy Statistics by state and territory.[122] This data summarises energy consumption by fuel

122 Department of Climate Change, Energy, the Environment and Water, Australian Energy Statistics, Table K, September 2022

type for each ANZSIC division[123]. We have used this data to estimate electricity consumption per employee based on the employment projections for each scenario provided by IV (chart E.8). We have not separately estimated different shares of rooftop solar PV uptake by industry due to its limited role for non-residential connections.[124]

Overall, operational non-residential consumption will be higher for a scenario with a higher share of traditional industry sectors in the economy.

E.8 Operational consumption per job, by industry sector



[a] Traditional industry (IV category) includes Mining, Manufacturing, Electricity generation, Transport, Gas supply, Water and waste from the Australian Energy Statistics.

[b] Commercial and services (Australian Energy Statistics category) includes Business & Government Services, Hospitals, Leisure Medical, Social & Community services, Retail Hospitality, School Education, and Tertiary Education from the IV jobs projections forecast.

Data source: CIE, IV job projections, Department of Climate Change, Energy, the Environment and Water, Australian Energy Statistics, Table K, September 2022

Approach to estimate additional electricity infrastructure

We have adopted the following approach for estimating additional infrastructure requirements (chart E.9):

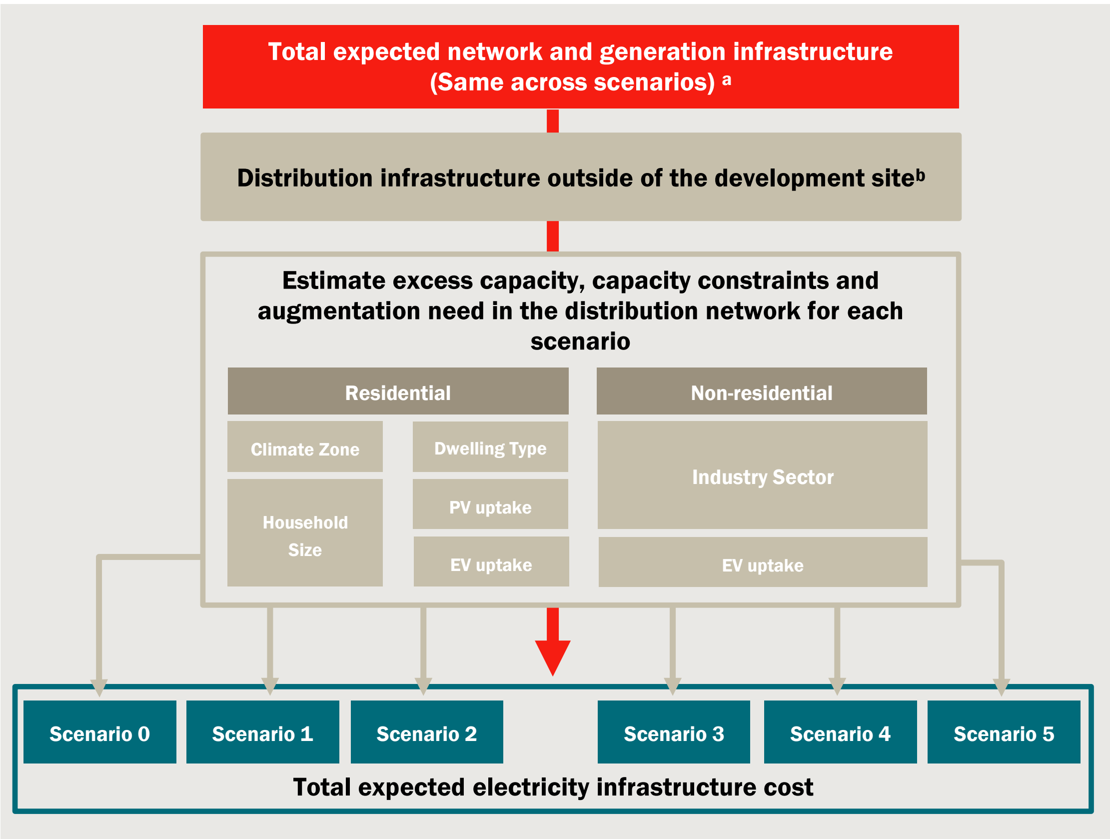
- Additional power generation and transmission network infrastructure requirements is based on the AEMO's Integrated System Plan (2022)
  - We assume that planned power generation capacity will not differ between scenarios, as generation infrastructure is typically designed to ensure a reliable and stable power supply. By building infrastructure with some excess capacity, it allows for flexibility to accommodate unexpected changes or growth in consumption, ensuring a margin of safety and system reliability. Cost will, therefore, not vary significantly between scenarios.

123 The Australian and New Zealand Standard Industrial Classification (ANZSIC) has been developed for use in the compilation and analysis of industry statistics in Australia and New Zealand.

124 Rooftop solar PV generation is forecasted to provide only a marginal share (<4 percent) of business and commercial energy consumption.

  - Future power generation will be more dispersed than today give the transition to renewable energy source. More additional transmission infrastructure could be needed the larger the spatial mismatch between renewable energy zones (REZ) (areas where utility-scale wind and solar farms are located) and the area where people live, and work is. Given the large uncertainty around the location of REZs we have assumed that the cost of additional transmission infrastructure will be the same across scenarios.
- Additional distribution network infrastructure requirements, which includes the zone substations, sub-transmission lines, transformers and feeders, is based on the excess capacity in the network and the need to augment the system if capacity constraints occur.
  - This will differ by scenario as population growth will happen in different areas. In addition, residential and non-residential consumption and peak demand will differ due to various factors as outlined in the previous sections.
- The additional costs of connection are estimated for each scenario as this cost is driven, amongst other factors, by Greenfield versus Infill development. This cost is part of the local infrastructure in development areas and not separately estimated in this chapter.

E.9 Conceptual methodology to estimate total electricity infrastructure need



[a] This includes the capital and fixed and variable operating cost of new power generator capacity, fuel cost, renewable energy zone (REZ) and flow-path augmentation.

[b] This includes substations, sub-transmission lines, transformers and feeders

Data source: CIE.

Approach to measure distribution network augmentation

The electricity distribution network in Victoria consists of a complex system of poles, wires, substations, and transformers that deliver electricity from power generators to homes, businesses, and other facilities throughout the state. The network is owned and operated by six different companies: AusNet Services, Citipower, Jemena, Powercor Australia, United Energy Distribution, and Essential Energy.[125]

The distribution network carries power from transmission network terminal stations to zone substations, where it is stepped down to lower voltages then carried along local power lines which are connected to individual homes and businesses. Each distribution company is responsible for maintaining its own portion of the network, and includes, amongst other, ongoing maintenance and upgrades to the network. We have aligned the catchment for each of the zone substations to the respective SA2s (table E.10).

E.10 Zone substations by distributor

Distributors	Zone substation		Population	Employment
	no.	Per cent	Per cent	Per cent
AusNet	53	21.6	25.2	17.1
Citipower	35	14.3	10.0	24.5
Essential Energy	20	8.2	0.1	0.1
Jemena	28	11.4	13.3	11.4
Powercor	63	25.7	28.3	24.8
United Energy	46	18.8	23.1	22.1
Total	**70**	**100.0**	**100.0**	**100.0**

Note: Historical population and population forecasts of SA2s are converted to a substation point basis by mapping substations to SA2s and based on the boundaries of each substation. Population and employment are allocated to each SA2 based on percentage overlaps calculated.

Source: CIE, Energy Networks Australia *Opportunities for demand management and renewables* https://www.energynetworks.com.au/projects/network-opportunity-maps/

The major driver of capacity expansion of electricity distribution infrastructure is peak or maximum electricity demand — that is, the maximum amount of electricity required at any time.

Box E.11 summarises in more detail the definition of distribution network capacity and when distributors are required to augment the network. Map E.12 presents the catchment and secure capacity of each zone substation by distributor.

125 https://www.aer.gov.au/consumers/who-is-my-distributor/victoria

E.11 Distribution Network Capacity

The distribution network is, if at all, usually constrained at the zone substation and/or sub-transmission line level. Zone substations and sub-transmission lines are considered to be constrained when the operational 10% PoE demand forecast exceeds the secure capacity:[126]

- **10% PoE demand forecast** is the peak or maximum demand forecast which has a 10% probability of being exceeded (PoE) in any year (i.e., an upper range forecast likely to be exceeded only once every 10 years), based on normal expected growth rates and one in ten-year extreme temperature condition.
- The **secure capacity** of a zone substation is the capacity of supply during single contingency emergency. Usually, the most severe or restrictive faults and outages are considered when assessed and is often referred to as its 'Firm' or N-1 rating.

Secure capacity is determined by a number of factors such as:[127]

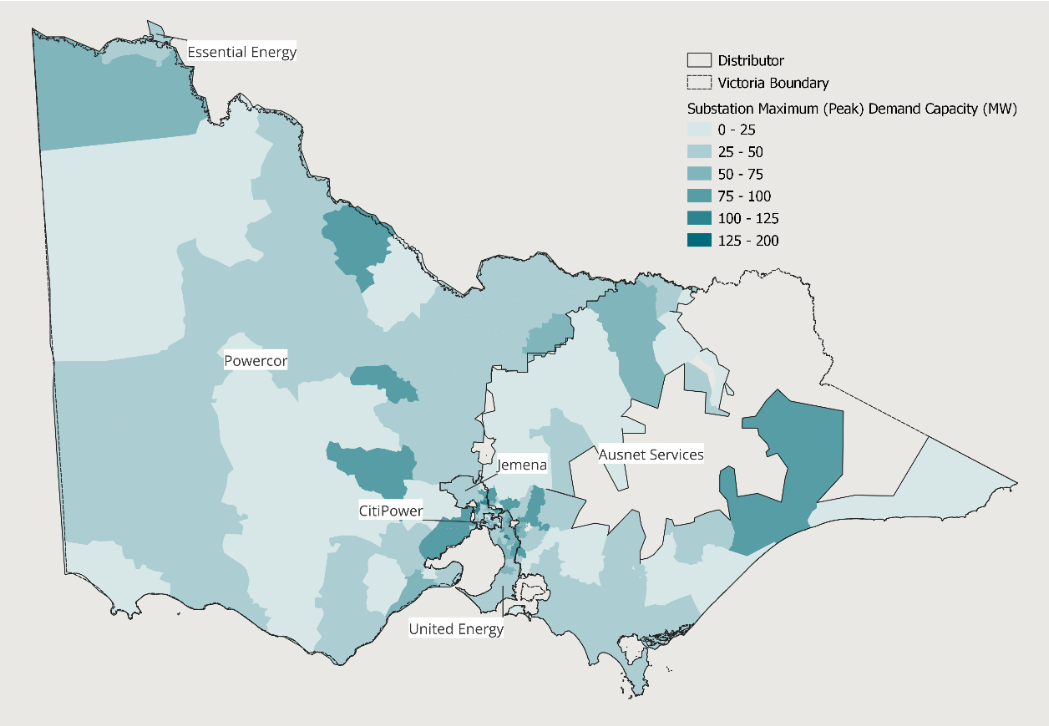
- Design working temperature and design of the particular network (which may impose loading or operational constraints)
- Thermal loading and voltage stability under outage conditions

Conductor size and type, and plant and equipment ratings.

126 https://www.aer.gov.au/system/files/ActewAGL%20-%20D5%20Distribution%20Network%20Augmentation%20Standard%20Rev%2001%20-%202014.pdf , p. 3,4 and 7

127 AusNet, 2022, *Distribution Annual Planning Report December 2022-2026,* https://dapr.ausnetservices.com.au/ausnet_data/AusNet%20Services_DAPR%202022-2026%20(Final)_v1.1.pdf , page 9.

E.12 Secure capacity of Victorian distribution substations



Data source: Energy Networks Australia *Opportunities for demand management and renewables* https://www.energynetworks.com.au/projects/network-opportunity-maps/

Chart E.13 outlines our approach to estimate the existing secure capacity and capacity constraints for each substation in Victoria:

1 Total annual operational consumption by zone substation is separately estimated for residential and non-residential customers for each scenario including the Victoria in Future (VIF) forecast[128]:
   a) SA2s are matched to the catchment of each zone substation.
   b) For residential connections the type of dwelling, climate zone, occupancy rates, rooftop solar PV uptake (linked to dwelling type), and total EV kilometres travelled are used to estimate total operational consumption. This is based on the average consumption per dwelling estimates described in the previous section (see chart E.4)
   c) For non-residential connection the total demand for each industry sector is estimated as described in the previous section (see chart E.7)

   We assume that the VIF forecast underpins the consumption forecasts developed by AEMO ISP (2022) – *Step change scenario.*[129] Based on the VIF estimates we calculate operational consumption and demand using the residential and non-residential unit estimates which is then adjusted to match the AEMO ISP (2022) – *Step change scenario*.[130] The parameter that is needed to adjust the VIF forecast to the AEMO

128 We assume that the Victoria in Future forecast matches the dwelling, population and employment projections which underpin the AEMO ISP forecast.

129 Note that we have adjusted this scenario by the more recently published EV uptake figures.

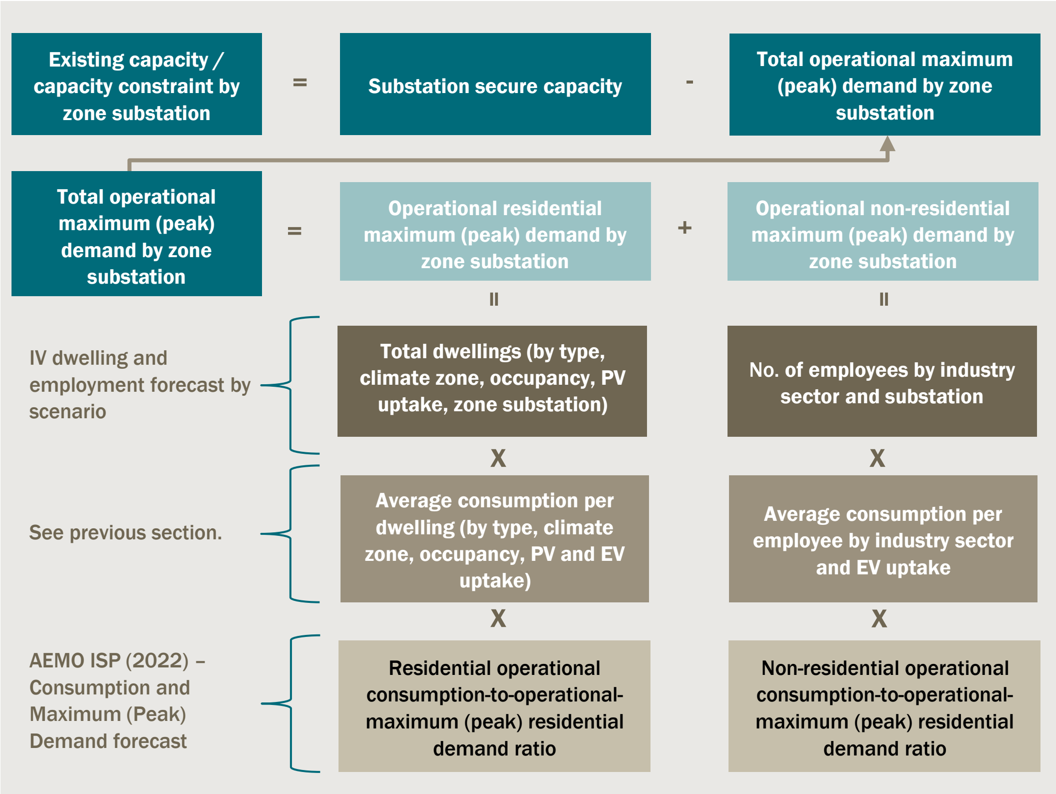
130 This means that the model consumption estimate is multiplied with a parameter to match the AEMO forecast. Our model matches the operational residential consumption within a

forecast is then used to adjust the operational consumption and demand forecast for each scenario.[131]

2 Total operational consumption is then multiplied with an operational consumption-to-maximum (peak) operational demand ratio based on the AEMO ISP (2022) – *Step change scenario* forecast. Note that this ratio is based on whole Victoria and might differ by regions and other factors. This provides us with a total maximum (peak) demand estimate for each zone substation per annum.

3 The remaining secure capacity or capacity constraint can then be calculated as the difference between the actual existing secure capacity[132] and the forecasted maximum (peak) operational demand for each zone substation.

E.13 Approach to estimate total operational maximum demand by zone substation



Data source: CIE.

margin of 2 percentage points with the AEMO forecast in 2021, however, operational non-residential consumption is 15 per cent higher in our model compared to AEMOs forecast in 2021.

131 Any difference between the AMEO forecast (assumed to be based on VIF) will then only be driven by the underlying difference of each scenario (such as dwelling typology, climate zones etc.)

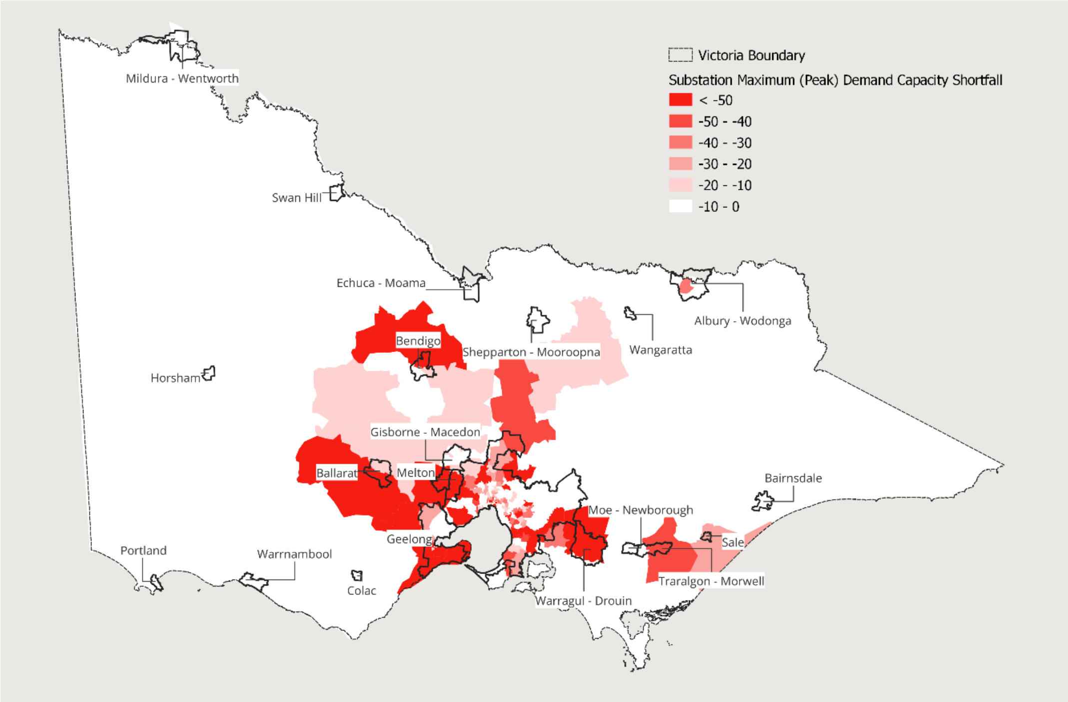
132 Data on each zone substation's secure capacity is publicly available here: https://network-opportunity-maps.s3.ap-southeast-2.amazonaws.com/constraints/published/available_capacity_timeseries.csv

Additional capacity required by population scenario

Under each population distribution scenario, the additional population across Victoria is the same, however, allocation to regions across Victoria varies considerably.

Map E.1510.5 shows the capacity shortfall at a zone substation level (i.e., existing secure capacity is not sufficient to service the operational maximum (peak) demand) by example for the Dispersed City scenario by 2036. While most regions have enough secure capacity to accommodate more people and jobs, some areas in inner and outer Melbourne, and the Melbourne new growth areas as well as some regional cities need additional capacity.

E.14 Zone substation secure capacity shortfall, Scenario 3 (2036)



Data source: CIE, Energy Networks Australia *Opportunities for demand management and renewables* https://www.energynetworks.com.au/projects/network-opportunity-maps/, AEMO ISP (2022), Final ISP results workbook - Step change scenario, https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp

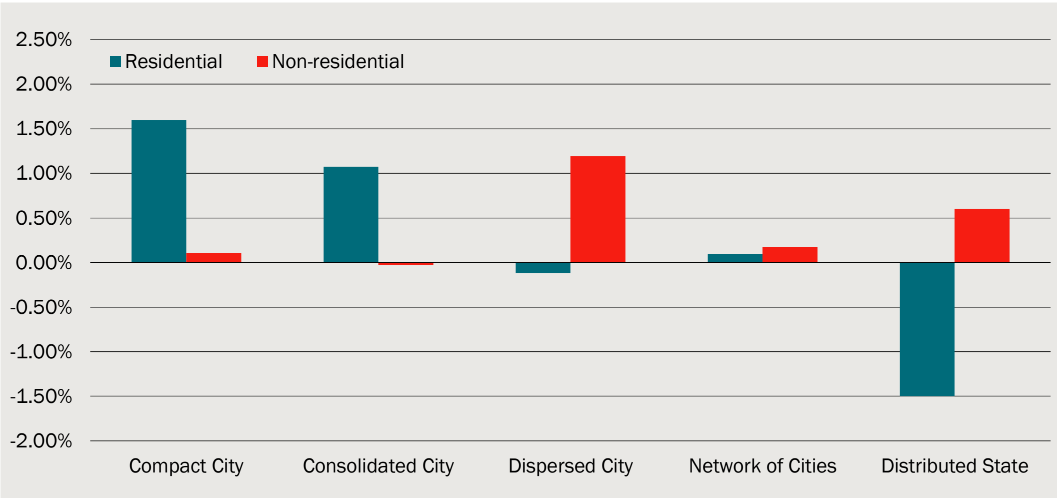
On average across the scenarios, operational maximum (peak) demand is set to increase by 42 to 43 per cent by 2036 and 92 to 98 per cent by 2056.

Chart E.15 and E.16 show total maximum demand in 2056 for each scenario relative to the AEMO ISP (2022) maximum demand forecast in 2056 with and without adjustment for EV utilisation across scenarios:

- Overall, scenarios do not differ significantly in terms of maximum demand, which is driven by the somewhat marginal differences in residential and non-residential consumption relative to the AEMO ISP (2022) consumption forecast in 2056.
- The highest increase in operational consumption from *dwellings* can be expected from the Compact City scenario which sees relatively more apartments compared to houses being developed. As apartments have on average a higher operational energy demand due to the lack of rooftop solar PV systems.

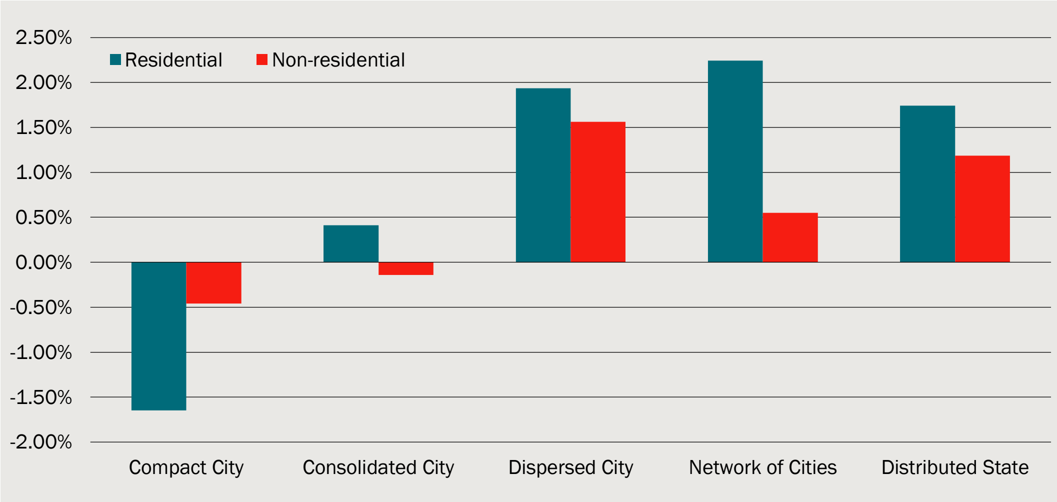
- The highest increase in operational consumption from *electric vehicles* can be expected from the Distributed State scenario which sees relatively more vehicle kilometres travelled compared to other scenarios.
- For non-residential consumption, the type of industry is the main driver. The Dispersed City scenario sees relatively more growth in the energy intensive traditional industries, leading to a higher overall operational consumption.
- In total, the Dispersed City scenario has the highest operational consumption across scenarios due to more EV kilometres travelled and more energy intensive traditional industries compared to the Compact and Consolidated City scenarios. The Distributed State and Network of Cities scenarios have a slightly lower operational consumption compared to the Dispersed City scenario. Both scenarios have higher EV kilometres travelled but less apartments and less energy intensive traditional industries compared to the Dispersed City scenario.

E.15 Estimated consumption by scenario relative to AEMO ISP (2022) consumption forecast in 2056 — WITHOUT EV's



Data source: CIE, AEMO ISP (2022).

E.16 Estimated consumption by scenario relative to AEMO ISP (2022) consumption forecast in 2056 — WITH EV's



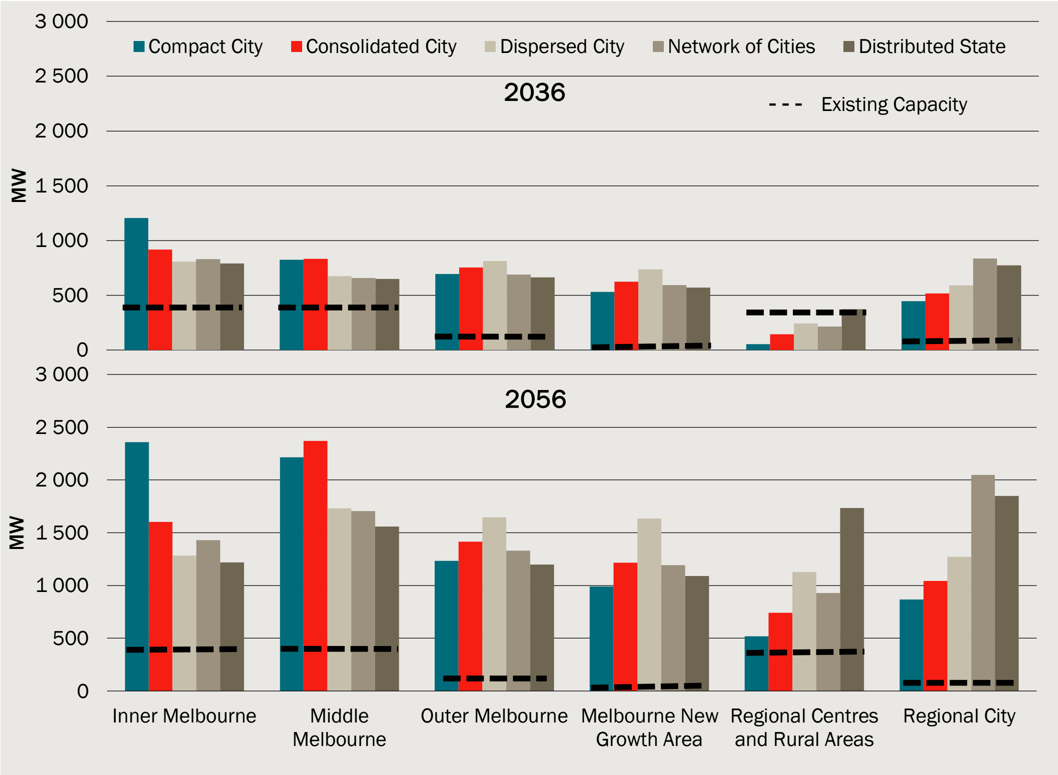
Data source: CIE, AEMO ISP (2022).

As overall operational consumption is the main driver of operational maximum (peak) demand, this pattern can also be observed in the additional secure capacity that is required in the future. By 2056, across all scenarios more than 8 000 MW of additional zone substation capacity must be created, which is almost double the currently available capacity. The main driver of this development is population and industry growth as well as the move away from fossil fuels to renewable energy and electric vehicle uptake in the coming years. Additional capacity is distributed across the State depending on where development is happening.

In summary (chart E.17):

- Metropolitan Melbourne (i.e., inner, middle, outer Melbourne and Melbourne new growth areas) sees the greatest share of additional capacity. Estimates range from as high as 86 per cent (Compact City scenarios) to as low as 61 per cent (Scenario 3) by 2056, and
- Regional Victoria (i.e., regional centres and rural areas, and regional cities) account for the remainder with shares ranging from 14 to 39 per cent, respectively.
- Of all functional urban areas, only regional areas have on average sufficient existing capacity until 2036. For the remainder, substations need to be augmented in the meantime.

E.17 Additional capacity and existing capacity, by scenario (2036 and 2056)



Note: Catchments of substations are very large in regional areas and cover often regional cities and regional areas. For the purpose of this chart most catchments were allocated to the regional cities rather than the regional area.

Data source: CIE.

Cost of additional electricity infrastructure

The following section provides details on how the cost estimates for the power generation and transmission infrastructure, and the distribution network infrastructure are derived.

Cost of power generation and high-voltage transmission

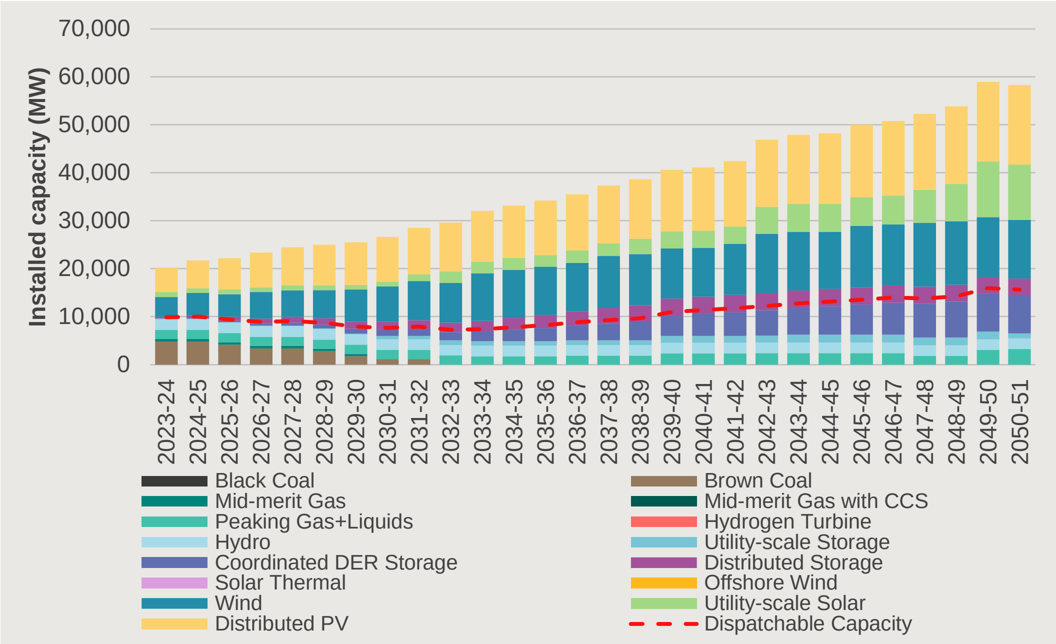
For the purpose of this analysis, we have used AEMOs ISP 'Step-Change' Scenario cost estimates.

A summary AEMOs relevant key assumptions, cost methodology, plans and recommendations for the development of renewable energy and transmission infrastructure in Victoria is provided at the end of this chapter on page 227.

Total installed capacity (TIC) will increase over the coming decades from 20 GW to almost 60 GW in Victoria. The main TIC will be created in the non-dispatchable power generation sector which includes distributed battery storage and PV, and wind and solar farms. The share of TIC consisting of dispatchable capacity (fossil fuels, hydro and utility scale storage) is expected to decrease from 50 per cent today to less than 25 per cent by 2050 in the AEMO step-change scenario (chart E.18).

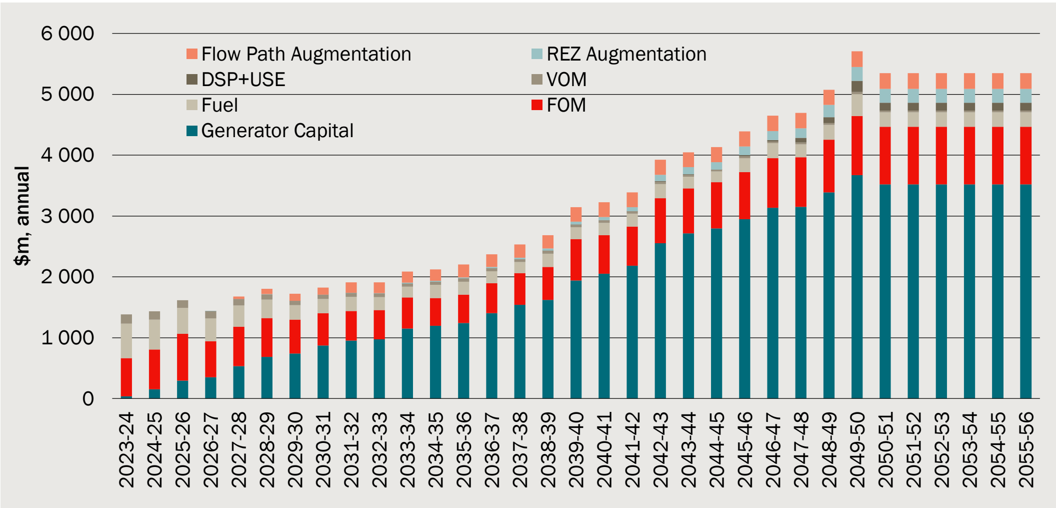
AEMO estimates the cost for the additional installed capacity at $1.6 billion per year for the next decade, and as more renewable capacity is installed at a maximum of $5.7 billion per annum by 2050.[133] Note that those cost do not include the cost for distributed rooftop solar PV on residential homes.

E.18 Total installed capacity



Data source: AEMO ISP (2022), 2022 Final ISP results workbook – Step Change, https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp

E.19 Annual additional power generation and transmission cost



Data source: AEMO ISP (2022), 2022 Final ISP results workbook – Step Change, https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp

133 AEMO 2022 ISP – Step change scenario https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/generation-outlook.zip?la=en,

Cost of distribution network

The Australian Energy Regulator is responsible for economic regulation of electricity transmission and distribution network providers and approves capital and operating expenditures for the distribution network. The *Distribution Annual Planning Reports* (DAPR) prepared by providers identifies, amongst other things, existing network capacity and infrastructure deficiencies including projections for capacity shortages and their asset renewal strategy. Electricity network providers develop the smallest viable network augmentation in response to demand.

The decision by AER for infrastructure investment is based on an assessment of:[134]

- recorded actual electricity demand,
- demand forecasts (including new customers),
- asset condition, and
- statutory and regulatory obligations.

For the purpose of this analysis, we have used long-run marginal cost (LRMC) to estimate the cost of capacity expansion and augmentation. Box E.20 provides a high-level overview of LRMC methodologies.

E.20 LRMC methodologies

LRMC are most commonly used by electricity distributor and the AER. Under the National Electricity Rules (NER) a distributor's tariff structure statement (TSS) must comply with a number of pricing principles. One of the required pricing principles is that each tariff must be based on LRMC.[135]

There are two methodologies which are commonly used to measure the financial cost of LRMC:

- the perturbation method, or Turvey approach, which specifies the increment as the demand from the expected profile to a different expected profile, and
- the average incremental cost approach (AIC), which specifies the increment as the future change in demand from current demand.

There are several variations to these approaches which can be used, such as in distributors tariff structure statement (TSS). These approaches follow similar steps diverging only in the definition of the hypothetical demand increment which is used to measure the cost increment. The demand increment chosen is important as it changes what we are conceptually measuring with LRMC. The interpretation of LRMC depends on how this increment is defined.

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134 AusNet, 2022, *Distribution Annual Planning Report 2022 – 2026,* https://dapr.ausnetservices.com.au/ausnet_data/AusNet%20Services_DAPR%202022-2026%20(Final)_v1.1.pdf , page 18,112.

135 https://www.aer.gov.au/system/files/AER%20-%20Explanatory%20note%20-%20Network%20tariffs%20and%20long%20run%20marginal%20cost_0.pdf

- Under the perturbation method, LRMC can be interpreted as the cost of bringing forward or delaying (in the case of a demand decrement) capital and operating costs. This approach assumes that future growth cannot be avoided but can be delayed or brought forward.[136] This conceives marginal cost as a time related dynamic concept.
- Under the AIC approach marginal cost can be interpreted as the cost of forecast growth, from current demand levels, occurring. This interpretation is appealing, where future demand can be defrayed or substituted. Here marginal cost is avoidable.

Distributors have been given flexibility to implement LRMC to best suit their network and consumer characteristics, while most use the AIC method.[137]

Cost for augmenting zone substations will differ depending on many factors, such as the type of technology used, the availability of materials and labour, and local market conditions, among others, but also the currently installed capacity. The per unit cost of augmenting a small zone substation from 10 to 20 MW will likely be higher than augmenting a larger zone substation from 50 to 60 MW. This can be observed in the LRMC estimates by zone substation developed for Powercor (chart E.21):[138]

- Each zone substation has a minimum cost of $45/kVA/year for maintenance, and
- the higher the relative capacity shortfall gap between existing capacity and forecasted operational maximum (peak) demand, the higher is the LRMC.
  – For example, the average unit cost per kVA of capacity for a 30 per cent increase is $67/kVA/year for five years while the average cost for a 50 per cent increase is $112/kVA/year for five years (exclusive of maintenance).

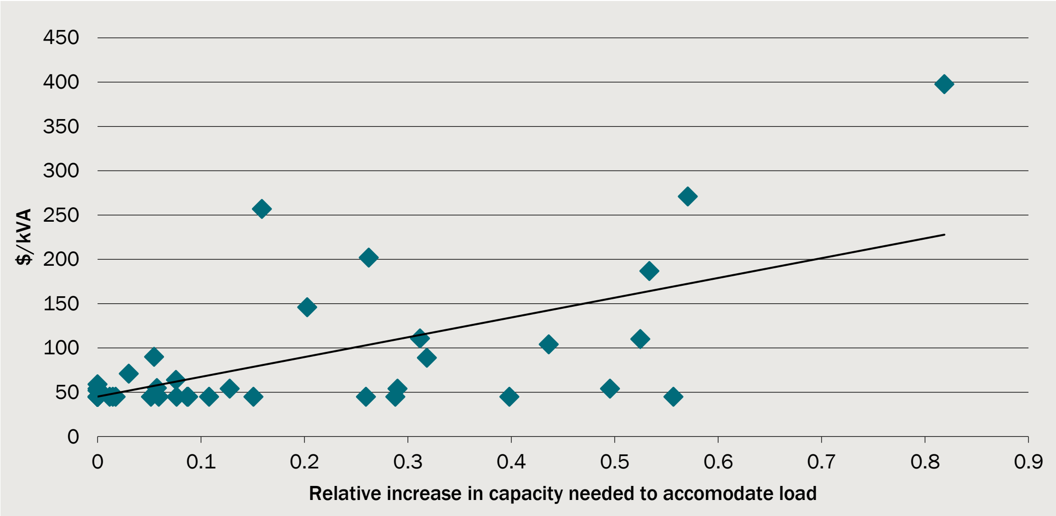
The LRMC estimates are based on the 5-year regulatory period of 2021/22 to 2025/26 and have been annualised.

136 Turvey discusses ‘central system costs’, which are not avoidable, hence in determining marginal cost, it is not a question of whether these costs are incurred or not, but rather their timing. For example, in the case of water infrastructure, Turvey argues that economy in water use may enable the next investment to be delayed, but would unlikely result in in it to be altogether dropped. Turvey, R. (1976), Analysing the Marginal Cost of Water Supply, Land Economics, 52(2), p. 158-168

137 https://www.aer.gov.au/system/files/AER%20-%20Explanatory%20note%20-%20Network%20tariffs%20and%20long%20run%20marginal%20cost_0.pdf

138 Powercor Tariff Structure Statement 1 July 2021 to 30 June 2026, https://media.powercor.com.au/wp-content/uploads/2021/06/24183829/Final-Decision-CitiPower-distribution-determination-2021%E2%80%9326-Revised-Tariff-Structure-Statement-April-2021-Clean.pdf, p.23

E.21 LRMC ($/kVA/year) by relative increase in capacity



Data source: CIE, Powercor Tariff Structure Statement 1 July 2021 to 30 June 2026, https://media.powercor.com.au/wp-content/uploads/2021/06/24183829/Final-Decision-CitiPower-distribution-determination-2021%E2%80%9326-Revised-Tariff-Structure-Statement-April-2021-Clean.pdf, Energy Networks Australia *Opportunities for demand management and renewables* https://www.energynetworks.com.au/projects/network-opportunity-maps/

Based on this we have made the following cost assumptions (table E.22). This covers the fixed cost of maintaining and augmenting all essential parts of a zone substation (i.e., low voltage feeder, low voltage transformer, high voltage feeder, zone substation, sub transmission feeder). As the cost of the augmentation is based on a 5-year regulatory period, we apply the annualised LRMC cost estimate for five years.

For example, a zone substation has a capacity of 40 MWA and a capacity gap of 20 MWA until 2036 (i.e., a 50 per cent capacity gap relative to the existing capacity):

- Total maintenance cost equals the new substation capacity multiplied by $45/kVA/year, amounting to $38 million, and
- total capacity augmentation cost is equal to $11.2 million.[139]

Note, we model that capacity constraints are met by augmenting existing zone substations which is a simplification to meet the objective of this analysis. In reality, distributors might construct new zone substations in particular dense areas.

E.22 Cost for distribution network augmentation and maintenance

Description	Applied over time period	Cost
		$/kVA/annum
Fixed maintenance rate	Every year	45
Capacity augmentation (50 per cent increase)	5 years	112

Source: CIE.

139 $Cost\ Augmentation = \$224 * 1000\ (conversion\ MWA\ to\ kWA) * 50\% * 20MWA * 5\ years = \$11.2\ million$

Cost summary

The cost of providing additional electricity infrastructure is high under all scenarios (~ $82 to $91 billion), while the cost of installing new (mostly renewable energy) power capacity accounts for over $42 billion until 2056 (tables E.23 and E.243.1):

- This would see the total installed power generation capacity to more than double by 2056 from 20 GW to over 59 GW, as well as
- a doubling of the current distribution network capacity from 9.6 GW to over 17 GW across all scenarios.

Overall, scenarios differ by ± $10 billion, while the Dispersed City and Network of Cities scenarios have the highest cost. Both scenarios need more widespread capacity augmentations across the whole of Victoria while the other scenarios see most of the augmentations either in Metropolitan Melbourne or Regional Victoria and not both. In particular, in Regional Victoria disproportional high growth leads to a higher augmentation need as the existing infrastructure is not sufficient.

E.23 Electricity infrastructure across scenarios by 2056

	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	MW	MW	MW	MW	MW
Total Installed Capacity by 2056	59 494	59 494	59 494	59 494	59 494
Total Dispatchable Capacity by 2056	15 589	15 589	15 589	15 589	15 589
Additional installed capacity (2056 vs. 2021)	39 050	39 050	39 050	39 050	39 050
	MW	MW	MW	MW	MW
Total Maximum demand by 2056	17 089	17 290	17 597	17 536	17 552
Additional Maximum (Peak) Demand (2056 vs. 2021)	8 185	8 386	8 693	8 632	8 648

Source: CIE Model, AEMO ISP (2022), 2022 Final ISP results workbook – Step Change, https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp

E.24 Cumulative electricity infrastructure costs across scenarios by 2056

Cumulative cost from 2021 to 2056	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$b	$b	$b	$b	$b
Additional Power Generation and Transmission Network infrastructure					
Capital Cost – Power Generation	25.8	25.8	25.8	25.8	25.8
Capital Cost – Transmission Network	3.5	3.5	3.5	3.5	3.5
Operating and maintenance cost – Power Generation & Transmission Network	13.0	13.0	13.0	13.0	13.0
Sub-total	**42.3**	**42.3**	**42.3**	**42.3**	**42.3**

Cumulative cost from 2021 to 2056	Sc1 Compact City	Sc2 Consolidated City	Sc3 Dispersed City	Sc4 Network of Cities	Sc5 Distributed State
	$b	$b	$b	$b	$b
Additional Distribution Network Infrastructure					
Capital Cost – Distribution Network	15.5	17.5	23.4	23.6	21.1
Operating Cost – Distribution Network	24.1	24.3	24.7	24.6	24.6
Sub-total	**39.6**	**41.9**	**48.1**	**48.1**	**45.7**
Total Additional Electricity Infrastructure					
Capital Cost	44.8	46.9	52.8	52.9	50.4
Operating and maintenance cost	37.1	37.3	37.6	37.5	37.6
Grand Total	**81.9**	**84.2**	**90.4**	**90.5**	**88.0**

Source: CIE Model, AEMO ISP (2022), 2022 Final ISP results workbook – Step Change, https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp

Distributional impact

For the purpose of this analysis, we have assumed that the cost of electricity infrastructure is predominantly recovered through user charges. However, we note that some proportion might be funded by the State Electricity Commission in the future, while the extent is still unclear.[140]

Additional information on AEMOs ISP — Step change scenario

This scenario involves a rapid transformation of the energy sector, with faster progress towards fulfilling Australia's net zero policy commitments and limiting global temperature rise to below 2°C compared to pre-industrial levels. The transition from fossil fuel to renewable energy is consistently fast paced, driven by a step change in global policy commitments and rapidly falling costs of energy production. Increased digitalisation helps with demand management and grid flexibility, and energy efficiency is as important as electrification. By 2050, most consumers rely on electricity for heating and transport, and internal-combustion vehicles have largely been phased out. There is also some domestic hydrogen production supporting the transport sector and blended pipeline gas, with some industrial applications after 2040.[141]

A summary of the key assumptions is shown below (chart E.25), however, we note that assumptions regarding the uptake of EV’s have been drawn from the more recently

140 https://www.vic.gov.au/state-electricity-commission-victoria

141 https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf?la=en#:~:text=In%20the%20Step%20Change%20scenario,of%20the%20Eraring%20Power%20Station., p.31

published AEMO Draft IASR (2023), which sees a 44 per cent uptake by 2036.[142] While we have adjusted the overall demand forecast, we have not adjusted the costs, since generation and transmission networks are not build at capacity but allow for excess capacity and cost would therefore unlikely be different.

E.25 AEMO ISP (2022) Scenario Input Assumptions

DEMAND	Slow Change		Progressive Change		Step Change		Hydrogen Superpower	
Electrification	2030	2050	2030	2050	2030	2050	2030	2050
- Road transport that is EV (%)	2	36	5	84	12	99	18	94
- Residential EVs still relying on convenience charging (%)	82	58	75	44	70	31	66	22
- Industrial Electrification (TWh)	-24	-21	4	92	27	54	37	64
- Residential Electrification (TWh)	0	0	0.2	15	4	13	2	4
- Energy efficiency savings (TWh)	8	19	14	40	22	55	22	56
Underlying Consumption								
- NEM Underlying Consumption (TWh)	163	213	201	394	222	336	243	330
- Hydrogen consumption - domestic (TWh)	0	0	0	32	0.1	58	2	132
- Hydrogen consumption - export, incl. green steel (TWh)	0	0	0	0	0	0	49	816
- Total underlying consumption (TWh)	**163**	**213**	**201**	**425**	**223**	**394**	**294**	**1,278**
SUPPLY								
Distributed PV Generation (TWh)	39	58	39	80	45	93	51	112
Household daily consumption potential stored in batteries (%)	3	5	5	22	12	38	13	39
Underlying consumption met by DER (%)	24	27	20	19	20	24	17	9
Coal generation (% of total electricity production)	32	5	38	2	21	0	6	0
NEM emissions (MT CO_2-e)	53.3	13.0	77.2	22.4	48.1	6.8	20.6	6.6
2020 NEM emissions (% of)	38	9	54	16	34	5	15	5

Data source: AEMO ISP (2022), https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-integrated-system-plan-isp.pdf?la=en#:~:text=In%20the%20Step%20Change%20scenario,of%20the%20Eraring%20Power%20Station., p.31

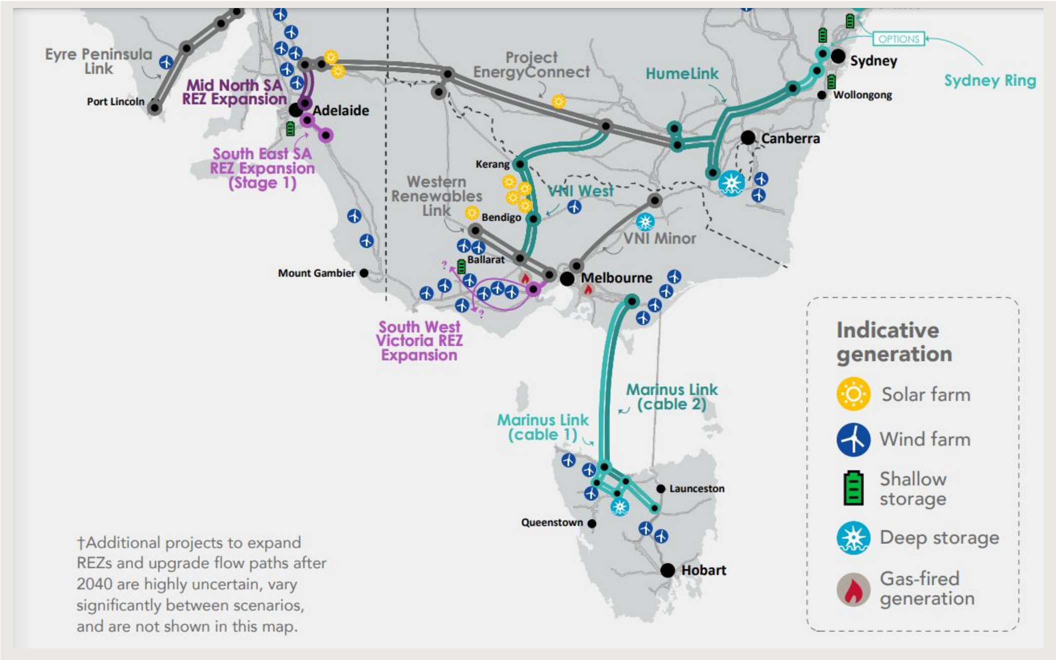
The AEMO ISP includes a number of plans and recommendations for the development of renewable energy and transmission infrastructure in Victoria. Some key points include (map E.26):

- Solar Farms: The ISP identifies a number of areas in Victoria that are well-suited for the development of large-scale solar farms. These include the northwest and northeast regions of the state.
- Wind Farms: The ISP identifies several areas in Victoria that are well-suited for the development of wind farms, including the southwest and southeast regions of the state.
- Transmission Infrastructure: The ISP recommends the development of several new transmission projects in Victoria to support the growth of renewable energy generation. These include the Western Victoria Transmission Network Project, which involves the construction of new transmission lines to support the connection of new wind and solar farms in the region, as well as the Renewable Energy Zone in the southwest region of the state.
- Energy Storage: The ISP identifies the need for increased energy storage capacity in Victoria to support the integration of renewable energy sources. This includes both shallow storage, such as batteries and pumped hydro, as well as deep storage technologies such as hydrogen, ammonia and other fuel-based systems.

142 AEMO Draft IASR (2023), Detailed Electric Vehicle Workbook - Draft 2023 IASR – Orchestrated Change, https://aemo.com.au/consultations/current-and-closed-consultations/2023-inputs-assumptions-and-scenarios-consultation

- Gas-Fired Generation: The ISP acknowledges that gas-fired generation will continue to play a role in Victoria's electricity system over the next few decades, but recommends that the use of gas be gradually phased out in favour of cleaner energy sources.

E.26 Network and indicative generation projects in the optimal development path



Data source: AEMO 2022 Integrated System Plan (ISP) https://aemo.com.au/-/media/files/major-publications/isp/2022/2022-documents/2022-isp-infographic.pdf?la=en

ISP Cost estimation methodology

The ISP approach to estimating the total cost of generation and transmission until 2050 involves several steps:

1 First, AEMO develops a set of scenarios that consider different assumptions about the future evolution of the electricity market, including changes in technology, policy, and consumer behaviour.

2 Second, AEMO models the electricity system under each scenario using a suite of energy and economic models to estimate the necessary investments in generation and transmission infrastructure to meet future demand.

3 Finally, AEMO estimates the total cost of these investments, including capital costs, operating costs, and financing costs, over the planning horizon.

F Gas networks

- **Please note that this analysis was undertake prior to Victoria Government announcement that all new home and subdivisions will only be connected to electric networks for energy.**[143]
- **The role of natural gas in Victoria will decline due to the de-carbonisation and electrification of the economy but will still play a role in the coming decades.**
- **While residential properties do not have to be connected to natural gas anymore it is unclear how high the adoption of gas will be in the future, however AEMO has prepared forecast, which determines how high the additional augmentation cost will be.**
  - **In general, total natural gas consumption and maximum demand are expected to decline over the decades making capacity constraints and additional large-scale infrastructure investments unlikely.**
- **Until 2056, the total cost under the central case is estimated to be around $12 billion. This includes capital for replacements and some services growth in Greenfield areas.**

F.1 Natural Gas infrastructure impacts

Additional			2036			2056
	low	central	high	low	central	high
	$b	$b	$b	$b	$b	$b
CAPEX	3.3	3.5	3.6	6.1	6.5	6.9
OPEX	2.7	2.8	2.9	4.9	5.3	5.7
Total	**6.0**	**6.2**	**6.5**	**11.0**	**11.8**	**12.6**

Source: CIE.

The future of gas in Victoria

The future of natural gas infrastructure in Victoria is a topic of great importance and interest, as the state seeks to transition towards a more sustainable and reliable energy system.

143 https://www.premier.vic.gov.au/new-victorian-homes-go-all-electric-2024

Infrastructure Victoria has undertaken a state-wide analysis of the implications of the energy transition for Victoria's extensive gas infrastructure assets.[144] The analysis provides advice and makes 11 recommendations to the Victorian Government, underpinned by extensive research, modelling and stakeholder input. The advice report informed the Victorian Government's Gas Substitution Roadmap, a policy framework that charts the strategic pathway for transitioning away from traditional natural gas usage:[145]

- A strategic plan for transitioning away from traditional natural gas towards low-carbon energy sources such as renewables, hydrogen and biogas.
- An emphasis of the importance of energy efficiency measures, promoting the use of energy-efficient appliances and systems to reduce overall energy consumption.
- A focus on strategic infrastructure planning and investment to support the transition, ensuring reliable supply and optimising existing infrastructure for new energy sources.

The Australian Energy Market Operator (AEMO) has recently published its Gas Statement of Opportunities (GSOO) report, which outlines the expected demand and supply of gas in the over the next 20 years.[146] The report indicates that natural gas demand in Victoria is expected to decline over time due to a range of factors, including increasing renewable energy generation and energy efficiency measures. Under the Orchestrated Step Change (1.8°C), current natural gas consumption will decrease from over 200 PJ today to less than 125 PJ by 2042.[147] This means natural gas will still play a role in the coming decades.

In response to this changing landscape, the Victorian government has developed a Gas Substitution Roadmap, which outlines a range of initiatives aimed at reducing natural gas consumption and increasing the use of alternative energy sources. The roadmap sets ambitious targets for the reduction of greenhouse gas emissions and the implementation of new technologies such as hydrogen and biogas.

The Victorian Gas Substitution Roadmap outlines steps to phase out natural gas over the coming decades. New homes requiring a planning permit will be required to be all-electric from 1 January 2024 and no longer connected to the gas network.[148] In addition,

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144 Infrastructure Victoria (2021), *Towards 2050: Gas infrastructure in a zero emissions economy* https://www.infrastructurevictoria.com.au/project/infrastructure-victoria-advice-on-gas-infrastructure/#about

145 Victorian Government (2023), *Victoria's Gas Substitution Roadmap*, https://www.energy.vic.gov.au/renewable-energy/victorias-gas-substitution-roadmap

146 AEMO (2023), *Gas Statement of Opportunities March 2023 For central and eastern Australia,* https://aemo.com.au/-/media/files/gas/national_planning_and_forecasting/gsoo/2023/2023-gas-statement-of-opportunities.pdf?la=en

147 http://forecasting.aemo.com.au/Gas/AnnualConsumption/Total

148 https://www.energy.vic.gov.au/renewable-energy/victorias-gas-substitution-roadmap#:~:text=From%201%20January%202024%2C%20planning,and%20infill%20sites%20across%20Victoria.

moving away from fossil fuels to renewable energy (electrification), all-electric developments and improved energy standards will be incentivised.[149]

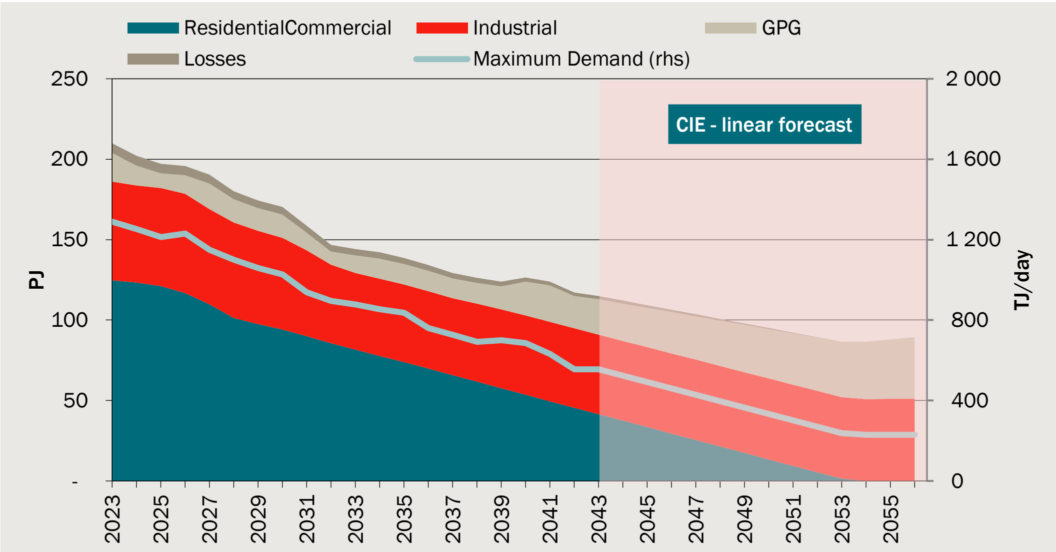
Natural gas will, therefore, no longer be servicing new greenfield or infill developments. Thus, natural gas supply networks and developments will be dealt with an as needs basis with Australian Gas Networks, Multinet Gas, and AusNet Services, the natural gas distribution network provider in Victoria.

Against this backdrop, the Victorian natural gas distributors have recently published their Revised Final Plan 2023-28, which outlines the revised and reduced proposed infrastructure investments and associated costs over the next five years.[150] [151] [152]

Approach to estimate additional gas infrastructure

In the coming decades natural gas consumptions is declining due to decarbonisation and electrification of the economy (chart F.2).

F.2 Natural gas consumption and maximum daily demand (2056)



Note: AEMO GSOO forecast available only until 2042. For the remainder period we have applied a linear trend based on the years 2032 to 2042.

Data source: CIE, AEMO GSOO (2023) – Orchestrated Step Change Scenario.

149 Victoria Government (2022), *Gas Substitution Roadmap,* https://www.energy.vic.gov.au/renewable-energy/victorias-gas-substitution-roadmap#heading-1, pp 24

150 https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/multinet-gas-access-arrangement-2023%E2%80%9328

151 https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/ausnet-services-access-arrangement-2023%E2%80%9328

152 https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/australian-gas-networks-victoria-and-albury-access-arrangement-2023%E2%80%9328

Since consumption and maximum demand are declining over the coming years, capacity constraints in the distribution network are unlikely. This means large augmentation investments are not to be expected. For example, according to AusNet Services, only 13 per cent of the total expected capital expenditure in the next 5 years will go towards asset augmentation, while the majority of capital is spent on replacements and services growth (while the total number of connections is declining, there are still new connections added in the coming years).[153]

We have, therefore, taken a pragmatical approach to estimate total cost. Total costs are estimated based on the most recent AER submissions from the three distributors and APA (who owns and maintains the Victorian Transmission System) (table F.3) and linearly reduced in accordance with the gas consumption demand in Victoria.

We assume:

- Overall natural gas consumption and in turn additional augmentation does not differ significantly by scenario as capacity constraints are not to be expected.
- New industrial and commercial users who require natural gas in their production will be located near existing natural gas infrastructure, which requires minimal additional assets.
  - While some growth scenarios expect a larger traditional industry (scenario 3), this additional demand can be met by the existing infrastructure or is already captured within the electrification cost.
- Growth scenarios will not differ in terms of residential natural gas demand and the overall trend follows the AEMO forecasts.
- Decommissioning of existing assets and in turn the cost of maintaining, replacing, and augmenting the system will follow the trend growth of AEMO's forecast and is the same across scenarios.
  - Note that there is also a potential alternative that would involve repurposing existing gas networks for low-emission gases, such as biogas or hydrogen. However, due to the uncertainty surrounding this pathway and its lack of clarity at present, we have not included this alternative in our costing analysis.

F.3 Natural gas infrastructure cost forecast

Measure	2023/24	2024/25	2025/26	2026/27	2027/28
	No.	No.	No.	No.	No.
Total Connections	2 251 354	2 248 449	2 228 881	2 196 205	2 151 307
	$m, 2023	$m, 2023	$m, 2023	$m, 2023	$m, 2023
CAPEX	485	407	340	321	312
OPEX	287	289	284	282	280
Total Cost	**772**	**696**	**624**	**604**	**592**

153 AER – AGN 2023-28 – Draft Decision – Capex Model - Attachment 9.3A - 25/10/22 version, Revisions to Capex Forecast Model, Response to Victorian Gas Substitution Roadmap, https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/ausnet-services-access-arrangement-2023%E2%80%9328

Note: Capex is 'Net Capital Expenditure (direct costs, real cost escalation and overheads, $2022/23)' and Opex refers to 'Total forecast opex, excluding category specific forecasts.'

Source: AER - AGN 2023-28 - Draft Decision - Capex & Opex model - December 2022, AER - MGN 2023-28 - Draft Decision - Capex & Opex model - December 2022, ASG - GAAR 202 4-28 Capex & Opex Model - 24 Jan 2023 – PUBLIC., AER - Final Decision - APA VTS 2023-27 Capex & Opex Model - December 2022 – Public.

Cost summary

We model the cost of providing additional natural gas distribution infrastructure through managing demand and existing capacity at a state level. We have estimated a low and high cost, while the central results reflect the average of both:

- The high-cost estimate assumes that the capital expenditure spending pattern remains the same and CAPEX is only declining in line with the consumption forecast, and
- The low-cost estimate assumes that there will be no additional capital expenditure in 'growth assets' after 2030.

Total cost across all scenarios ranges from $6.7 to $7.2 billion by 2036 and $12.4 to $14.0 billion by 2056 (table F.4). We note that this is a very high-level estimate based on the assumption that capital and operating expenditure are directly linked to natural gas consumption.

F.4 Natural gas infrastructure impacts across scenarios

Additional			2036			2056
	low	central	high	low	central	high
	$b	$b	$b	$b	$b	$b
CAPEX	3.7	3.8	3.9	6.7	7.1	7.5
OPEX	3.1	3.2	3.3	5.7	6.1	6.5
Total	**6.7**	**7.0**	**7.2**	**12.4**	**13.2**	**14.0**

Source: CIE.

Distributional impact

For the purpose of this analysis, we have assumed that the cost of natural gas infrastructure is predominantly recovered through user charges.

G Water and wastewater

- **There are 15 urban water corporations which provide water and wastewater services to residential and non-residential customers in cities and regional towns throughout Victoria.**
- **Across Victoria there is currently limited capacity in the water supply and wastewater treatment, as well as the distribution networks, to meet future growth beyond a 5 to 10 year horizon. Additional investments will, therefore, be required to support the future population and employment growth from 2023 onward. Climate change will also place further pressure on the water security which will also bring forward the need for new sources of supply to manage water security risks. Different solutions are required in the different locations, depending on the local circumstance.**
- **The level and cost of new investments will vary by water corporation. This, in part, reflects the higher water use per property in regional Victoria due to hotter and drier conditions. The costs differences will also reflect the different options available to manage water security and wastewater services. In coastal regions, for example, desalinated sea water is expected to be one viable option. New dams are unlikely to be viable due, in part, to future climate risk. Other solutions beyond these traditional approaches will be required, including recycled water will be required. Similarly, wastewater transport/treatment costs are expected to be higher in regional areas due to the higher levels of treatment required for discharge to inland waterways. Network upgrades to meet growth varies by corporation, although in aggregate the scenarios 4 and 5 have higher network costs.**
- **The precise solutions are expected to differ in different locations throughout Victoria depending on the unique options available. In some cases, for example, there may be scope to purchase water entitlements currently being used for low value agricultural use. Although these options are unlikely to be sufficient to meet the capacity required where the scenario results in a substantial increase in population/employment in that region.**
- **The analysis conducted for this report should, therefore, be interpreted as providing high level guidance on the costs of service provision under each option.**

Overview of water and wastewater services

As an essential service, all new dwellings constructed in urban areas are connected to the water and wastewater networks. The cost of connection and augmentation are typically divided between the developers and the service provider. Infrastructure costs for mains and treatment facilities (sewage and water) are predominantly met by the utilities in their area of operations with the costs recovered from customers. The costs of connection to the trunk infrastructure are typically funded by developers. The costs associated with managing stormwater are typically the responsibility of local councils, although there are some stormwater assets that are managed by the catchment management authorities. This chapter focuses on the water and wastewater costs.

The cost of utility infrastructure arising out of alternative growth paths will reflect the extent of capacity in existing areas, the economic viability of accessing this excess capacity and the costs of upgrades to meet the new demand. Upgrades will also need to meet existing standards imposed such as the Australian Drinking Water Guidelines and the EPA licences for discharges to the environment from wastewater treatment plants and overflow events from the network.

Over the past few years, there has also been an increased focus on supply resilience to manage future climate change risks (irrespective of any population increases), as well as, network resilience to manage events such as outages or water quality incidents in different parts of the network. There is also significant expenditure on meeting higher standards, particularly related to discharge to the environment.

Water and wastewater service providers

There are three types of water corporations in Victoria

- Urban (metropolitan): Melbourne is served by three water corporations[154] and a wholesaler, Melbourne Water which also manages the two main wastewater treatment facilities.
- Urban (regional): 12 water corporations provide water and sewerage services in regional cities and towns across the state.
- Rural water: 4 water corporations provide rural water services across Victoria for irrigation, stock and domestic, environmental and recreational purposes.

Chart G.3 presents a map of the urban water corporations throughout Victoria. These are the focus of our analysis, as well as Melbourne Water, which supports the three corporations servicing the wider Melbourne area.

154 The 3 retailers servicing the greater Melbourne area include Greater Western Water, South East Water, Yarra Valley Water. In July 2021 there was a restructure of retailers. Greater Western Water was previously two separate retailers Western Water and City West Water). https://www.melbournewater.com.au/services/water-retail-companies

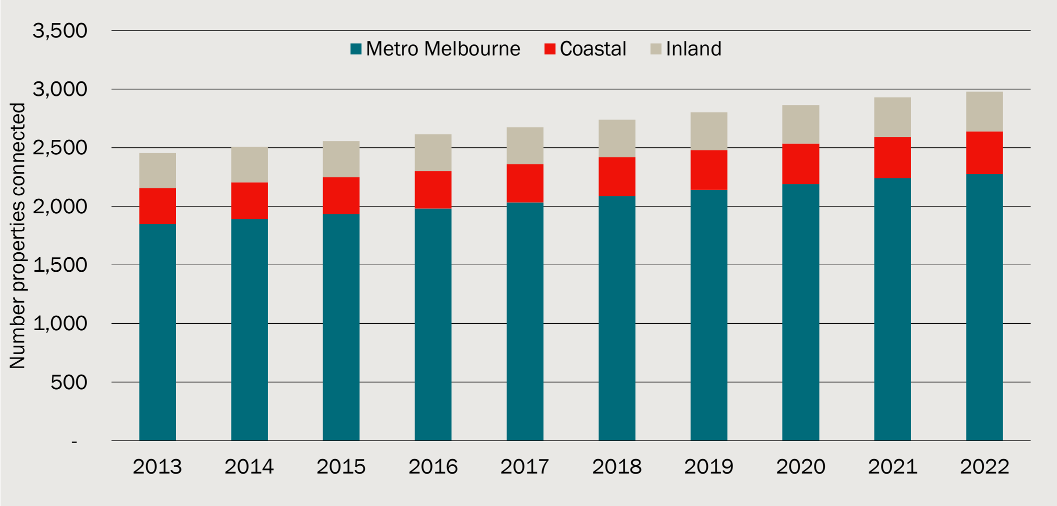
G.3 Victorian urban water corporations

Data source: https://datashare.maps.vic.gov.au/

Urban customers serviced

Over time there has been an increase in the number of customers serviced and volume of water provided. In 2021-22 there were 2.9m properties connected to water supply services in Victoria. Around 92% of properties connected to the water supply system are defined as 'residential' properties. 77% of the properties were located in the Melbourne metropolitan area, 12% in the coastal regions and 11% in the inland regions served by the corporations.

G.4 Number of residential and non-residential properties connected to water supply



Data source: BOM National Performance Report 2021-22, http://www.bom.gov.au/water/npr/

Chart G.5 presents the average volume of water supplied to residential and non-residential customers over the past 5 years. Around 70% of the water is supplied by the three Melbourne corporations, with around 14% supplied by the corporations on the coastal areas and 16% by the inland corporations.

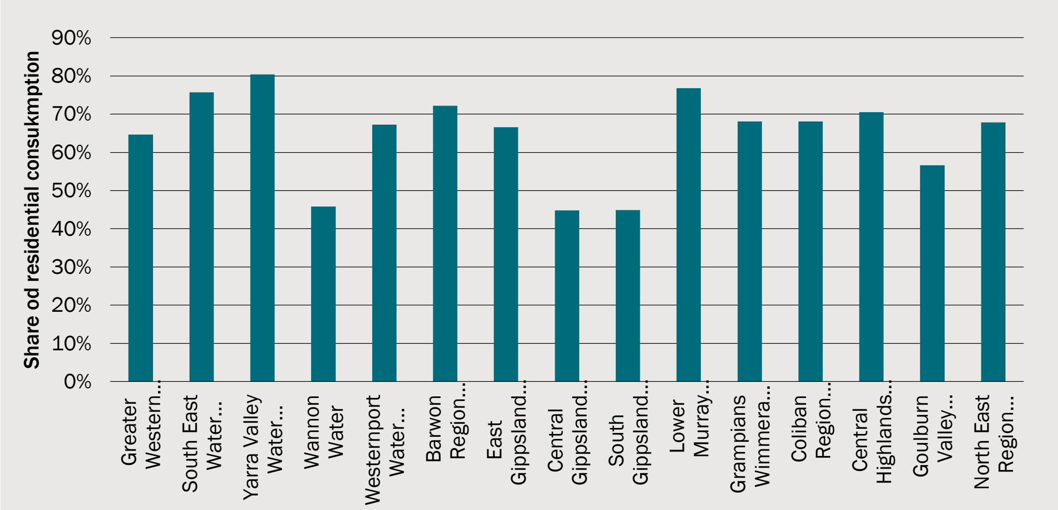
G.5 Total volume of water supplied, average 2017/18 to 2021/22

Corporation	Category	Total	Share
	ML/annum	ML/annum	%
Greater Western Water	Metropolitan	116,124	19.8
South East Water Corporation	Metropolitan	141,709	24.1
Yarra Valley Water Corporation	Metropolitan	144,050	24.5
Wannon Water	Regional coast	11,631	2.0
Westernport Water Corporation	Regional coast	2,147	0.4
Barwon Region Water Corporation	Regional coast	34,358	5.9
East Gippsland Region Water Corporation	Regional coast	4,790	0.8
Central Gippsland Region Water Corporation	Regional coast	24,343	4.1
South Gippsland Region Water Corporation	Regional coast	4,656	0.8
Lower Murray Urban and Rural Water Corporation	Regional Inland	19,616	3.3
Grampians Wimmera Mallee Water Corporation	Regional Inland	9,503	1.6
Coliban Region Water Corporation	Regional Inland	20,537	3.5
Central Highlands Water	Regional Inland	14,462	2.5
Goulburn Valley Region Water Corporation	Regional Inland	24,790	4.2
North East Region Water Corporation	Regional Inland	14,524	2.5
Total		**587,240**	**100.0**

Source: Data source: BOM National Performance Report 2021-22, http://www.bom.gov.au/water/npr/

In the metropolitan Melbourne utilities between 65 to 80% of the water is supplied to residential properties. The regional corporations supply a lower share of water to residential customers - between 45 to 72% for coastal corporations and 57 to 71% for the inland corporations.

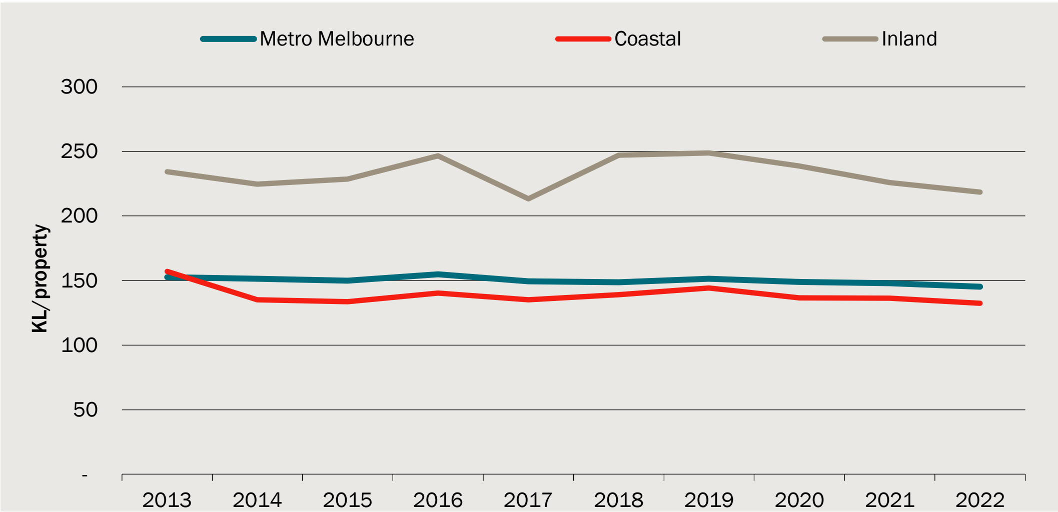
G.6 Share of water supplied to residential properties, average 2017/18 to 2021/22



Source: Data source: BOM National Performance Report 2021-22, http://www.bom.gov.au/water/npr/

Residential properties located in inland regional areas consume, on average, around 230kl/property over the past 10 years, although this does range between the corporations (the highest being around 500kl/property in Lower Murray Water and 150kl/property in Central Highlands Water). This compares to closer 150kl/property in metropolitan Melbourne and 140kl/property for coastal regions. This is likely to reflect the hotter drier conditions that prevail in inland areas, as well as different mix of dwelling types and size. Water demand by single dwellings is more seasonal and responsive to weather than demand by units and flats due to factors, such as the presence of garden areas and swimming pools.

G.7 Average volume of residential water supplied per property



Data source: BOM National Performance Report 2021-22, http://www.bom.gov.au/water/npr/

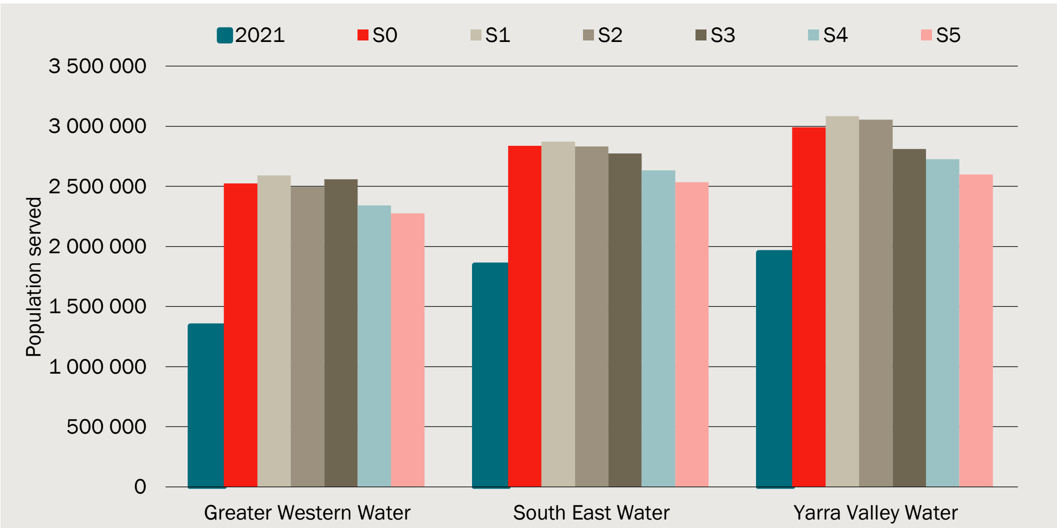
Future Scenarios

The spatial location of future growth can have a bearing on the water and wastewater infrastructure costs required to service the growth. IV's growth scenarios are prepared at an SA2 geographical level. We have allocated each SA2 in Victoria to the relevant corporation.[155] In some cases the corporations' service areas do not perfectly align with the SA2 boundaries. In these cases we have calculated the SA2 area within each corporation and allocated the population to the corporation based on the area (sqkm) of the SA2 within each corporations boundaries.

The charts below present the 2021 population in the relevant corporation and the 2056 population under each scenario. Scenario 0 aligns with the *Victoria In the Future* 2019 population forecasts.[156] The corporations are categorized as those servicing the Melbourne area, coastal regions outside Melbourne and inland regions.

- the Melbourne corporations serviced a population of around 5.1m in 2021, increasing by between 67% (in scenario 2) to 44% (in scenario 5) by 2056.
- the coastal corporations serviced a population of around 1.1m in 2021, increasing by between 125% (in scenario 5) to 48% (in scenario 2) by 2056.
- the inland corporations serviced a population of around 0.47m in 2021, increasing by between 78% (in scenario 5) to 12% (in scenario 2) by 2056.

G.8 2056 population serviced by corporations in the Melbourne area

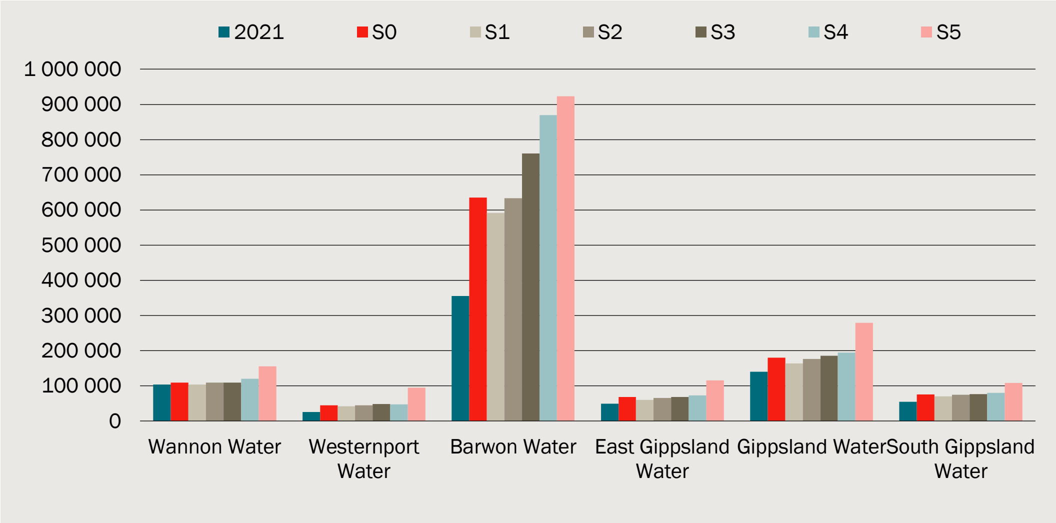


Data source: The CIE allocation based on IV scenario data.

155 Note that the SA2 boundaries may not perfectly align to each corporation's sewer sub-catchment and water distribution zone covering the area serviced.

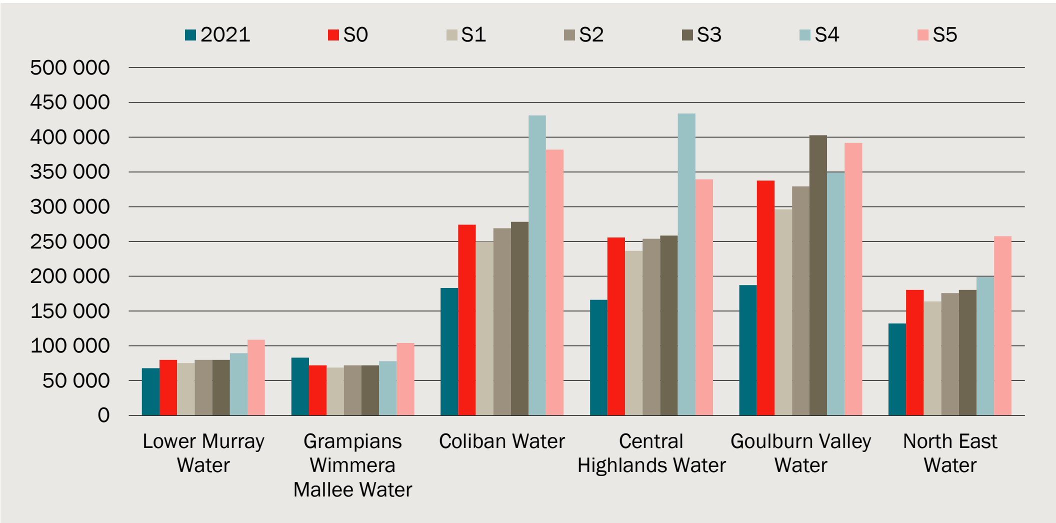
156 https://www.planning.vic.gov.au/__data/assets/pdf_file/0032/332996/Victoria_in_Future_2019.pdf

G.9 2056 population serviced by corporations in the coastal areas outside Melbourne



Data source: The CIE allocation based on IV scenario data.

G.10 2056 population serviced by corporations in the inland areas outside Melbourne



Data source: CIE allocation based on IV scenario data.

Employment growth

The scenarios also have different assumptions regarding growth in the number of jobs by the service area for the corporation. In aggregate across the whole of Victoria the scenario results in a 60% increase in the number of jobs, although the increase varies between the corporations, with the smallest growth in the metropolitan Melbourne area.

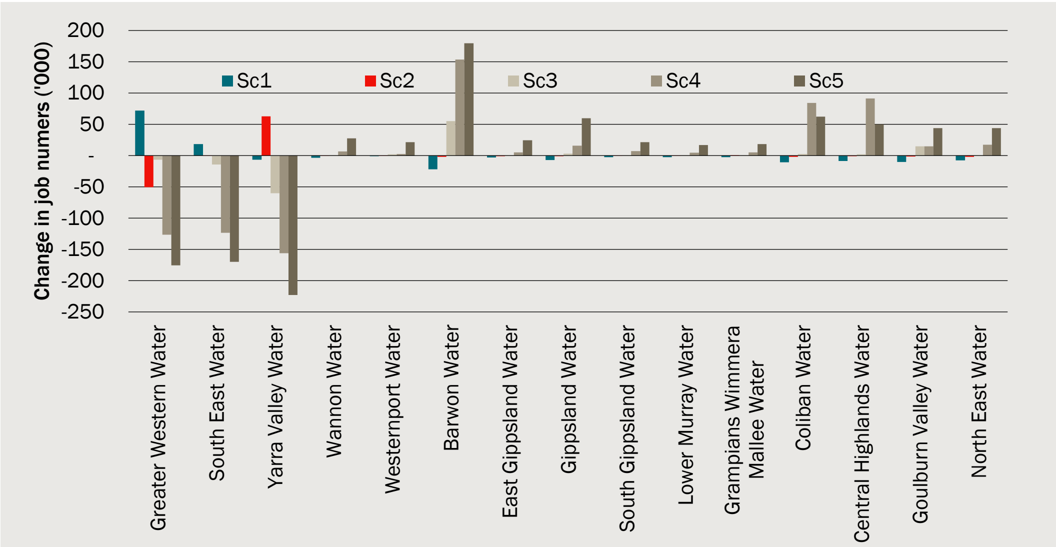
G.11 Jobs growth 2021 to 2056 (Scenario 0)

Corporation	2021	Sc_0_2056	Change
.	jobs ('000)	jobs ('000)	%
Greater Western Water	962	1,366	42%
South East Water	931	1,243	33%
Yarra Valley Water	844	1,320	56%
Wannon Water	43	77	77%
Westernport Water	8	34	309%
Barwon Water	161	455	182%
East Gippsland Water	19	50	166%
Gippsland Water	61	138	124%
South Gippsland Water	19	49	158%
Lower Murray Water	28	49	78%
Grampians Wimmera Mallee Water	32	51	59%
Coliban Water	78	170	117%
Central Highlands Water	71	150	111%
Goulburn Valley Water	72	141	97%
North East Water	58	118	104%
Total	**3 387**	**5 410**	**60%**

Source: CIE allocation based on IV scenario data.

Chart G.12 illustrates the change in the number of jobs in the different corporations' service area under the different scenarios. Under scenario 5, for example, there are around 0.6m less jobs in the metropolitan Melbourne corporations. Around 0.33m of these jobs are instead allocated to the coastal corporations and 0.27m to the inland regions.

G.12 Change in job numbers relative to Scenario 0, 2056



Source: CIE allocation based on IV scenario data.

Dwelling structure

Table G.13 illustrates the changing structure that is forecast in each corporation's region by 2056. The base case scenario demonstrates a substantial reduction in separate houses in the metropolitan Melbourne areas, compared to 2021. The share is more stable in the areas outside metropolitan Melbourne.

G.13 Separate houses as a share of all properties service by corporation

Corporation	2021	Sc0_2056	Change in share
	%	%	%
Greater Western Water	59%	51%	-9%
South East Water	65%	50%	-15%
Yarra Valley Water	70%	50%	-20%
Wannon Water	90%	89%	-1%
Westernport Water	90%	89%	-1%
Barwon Water	87%	81%	-6%
East Gippsland Water	89%	89%	-1%
Gippsland Water	89%	88%	-1%
South Gippsland Water	95%	94%	-1%
Lower Murray Water	84%	79%	-5%
Grampians Wimmera Mallee Water	91%	91%	-1%
Coliban Water	92%	85%	-6%
Central Highlands Water	88%	83%	-5%
Goulburn Valley Water	90%	90%	-1%
North East Water	89%	89%	0%

Source: CIE analysis based of IV scenario data.

Chart G.14 illustrates the change in separate houses in 2056 compared to Scenario 0. For example, in the metropolitan Melbourne area in Scenario 3 the share of separate houses is around 5% higher compared to Scenario 0. Barwon Water, Coliban Water and Central Highlands Water also experience is larger changes in the shares, compared to the Scenario 0.

G.14 Change in share of separate houses, compared to Scenario 0 in 2056

Source: CIE analysis based of IV scenario data.

Cost implications of scenarios – supply augmentation and wastewater treatment

In aggregate across the whole of Victoria, the population is forecast to increase by around 1.6 times the 2021 levels, reaching around 10.7m by 2056. The distribution of the future population throughout Victoria can have different cost implications:

- There may be 'excess capacity' in different parts of the system.
- Upgrades to manage future wastewater collected will vary by region:
  - For inland regions that are required to discharge to inland waterways, a higher level of treatment is typically required to meet EPA requirements for discharge to the inland rivers. In these regions investing in wastewater recycling plants is expected could be a viable option to manage both wastewater and providing additional water supply.
  - Discharge via ocean outfalls is likely to be cheaper (on a per ML basis) because it typically requires a lower level of treatment compared to discharging to inland waterways.
- In terms of upgrades to meet future water supply needs,
  - coastal locations have greater potential to rely on new desalination investments. Inland areas away from the coast have historically relied on dams, although these investments are considered unviable in many situations.[157] Other options, therefore, need to be considered including recycled water investments and purchasing water entitlements via the open trading market. The continued expansion of the Water Grid would also assist the ability to transfer water between different parts of the regions.

157 This reflects the lack of suitable sites and the community opposition to new dams.

- climatic variability in the short term can be a driver of investment. That is, while there may be sufficient water to meet growing demand, it is short term water shortages that trigger the need for early investments (irrespective of population growth rates).
- over the longer term, 'climate change' is expected to lead to longer periods of hotter/drier conditions, posing a greater risk to supply shortages. In this context, building new dams is unlikely to be a viable option because suitable dam sites have been exhausted and the lower expected future rainfall increase the average time to refill dams. Given this, there is an increased focus on manufactured water (i.e. desalination and recycled water facilities) to manage climate risks. This will also have a differential impact in inland and coastal areas.

Water Supply

The Victorian Government has developed three different Sustainable Water Supply strategies:

- **Central and Gippsland Region 2022**. The Central and Gippsland Region covers the waterways and catchments south of the Great Divide down to the coast – from the Otways to Mallacoota.
- **Northern Region 2009**. The Northern Region includes Victoria's share of the River Murray and the major Victorian tributaries that flow north into it. Major urban centres in the region include Wodonga, Wangaratta, Benalla, Shepparton, Bendigo, Swan Hill and Mildura.
- **Western Region 2011**. The Western region covers around one-third of Victoria from Colac and Lorne in the south-east to Ouyen in the north-west. Its agricultural and urban centres include Colac, Port Campbell, Horsham, Stawell, Ararat, Hamilton, Warrnambool and Portland.

The Sustainable Water Supply strategies provide a high level review of the water resources in the regions. More recently, each of the urban water corporations has developed an Urban Water Strategy (UWS) which are the

> … key planning tool to deliver water security for cities and towns. They identify the best mix of actions to provide secure water and sewerage services over the next 50 years.[158]

Overview of approach to estimate water supply costs

For the purpose of our analysis we have utilised the UWS for the corporations as the starting point for developing the cost estimates of the alternative scenarios. The following approach has been undertaken:[159]

- **Step 1.** Develop forecast water demand and volume of wastewater to be discharged to treatment plants. The UWS present demand forecasts based on the *Victoria In the*

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158 https://www.water.vic.gov.au/vic-water-supply

159 It is important to note that the approach adopted is intended to generate costings that provide a reasonable 'order of magnitude', rather than the precision that would be required undertaken by each corporation when developing their future cost estimates.

Future 2019 population forecasts which aligns to Scenario 0. In the UWS documents the demand forecasts are presented as a (wide) range which include an upper-bound (high demand, high climate change), as well as, a mid-demand (medium demand, medium climate change). Detailed spreadsheets of the forecasts were not available to us and the forecasts have also only been developed for a single scenario (based on the VIF). Therefore, we have developed an alternative approach which can be applied across scenarios for each corporation.[160]

– **Residential demand**.
  - As a starting point, we have adopted the average *residential* demand over the past 5 years.
  - For each corporation, we have 'scaled' this starting point demand in proportion to the population change for each scenario (in 2036 and 2056). A linear growth path between 2023 to 2036 and 2036 to 2056 has been adopted. No explicit adjustment has been made for 'climate change'.
  - For the 3 corporations in Melbourne we assume that the 150lcd target is achieved by 2036 and further declining to 140lcd by 2056. For the other corporations we adopt a 181 lcd target for scenarios 0, 1, 2 and 3. For scenarios 4 and 5 we assume that a 150lcd would be required to be able to meet the substantial additional demand in the regions.[161]
  - Adjustments have also been made for the change in dwelling structure. Some studies suggest that houses consume 1.38 times more than units/flats.[162] Melbourne Water has indicated that an existing house has an annual average day of 618Lday and 490L /day for new homes and 382L/day for new units. For Bendigo in 2021/22, the average house used 206.5kL and average flat used 108kL (around 2 times) but the flats are typically smaller. We, therefore, assume that new houses in Melbourne (and coastal areas) consume 1.28 times more than new units/flats. For inland areas, we assume new houses consume 1.9 times more than new units/flats.

– **Non-residential demand.**
  - As a starting point, we have adopted the average *non-residential* demand over the past 5 years.
  - For each corporation, we have 'scaled' this starting point demand in proportion to the change in the number of jobs for each scenario (in 2036 and 2056). A linear growth path between 2023 to 2036 and 2036 to 2056 has been adopted.

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160 We have sought to cross-check figures against the UWS for each corporation. For example, we estimate around 58GL of total water us by 2056 for Barwon Water which compares to 55GL on p.34 of their UWS (based on a visual check of the chart). However, the supply forecasts in the UWS documents for many corporations are reported at an individual 'system' level rather than an aggregate across the corporation.

161 We have not applied any water efficiency targets for the Lower Murray Water, given that its residential usage per capita is significantly higher than all other areas and it is not clear whether achieving the target is feasible.

162 This is based on an IPART study which estimated that a typical house uses 220kl/year compared to 160kl/year for a typical apartment.

- No adjustments have been made for changes in the composition of different types of businesses, given the limited data available to develop future forecasts based on changing sectoral composition in the different regions in the different parts of Victoria.

- **Step 2.** Based on discussions with Melbourne Water and Coliban Water we assume that the supply system is currently at full capacity. Therefore, any increase in demand will need to be serviced by additional investments.
- **Step 3**. Apply unit costs. We utilise the levelized cost data presented in a 2020 study by the Water Services Association of Australia (see chart G.15). The levelized cost reflects both the capital and ongoing operating costs.
  - for regional coastal and inland corporations we assume that recycled water investments are required to manage future wastewater supply. We assume that the recycled water is used to supply new non-residential demand.[163]
  - in order to meet the additional residential demand[164]
    - for the metropolitan Melbourne and coastal corporations we assume that the new supply is met via new desalination facilities.
    - for the inland corporations there are a range of options available. In the price submissions to the ESC a range of options including purchasing low reliability entitlements, accessing groundwater and stormwater recapture are considered.[165] These options vary between different parts of the corporations' networks. Given that the precise solutions are not well identified, we assume a purchasing entitlements, groundwater investments and stormwater capture are the options available and that corporations adopt these in equal share.[166]

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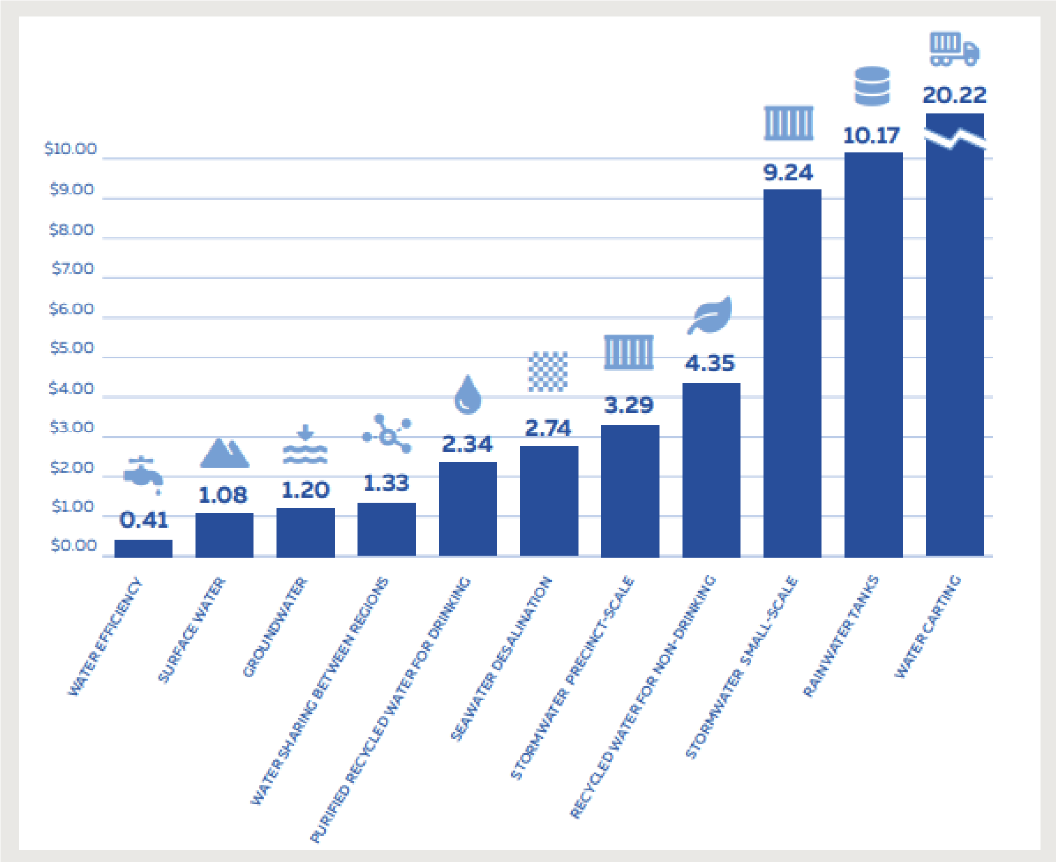
163 The volume of wastewater to be recycled exceeds the new non-residential demand. Any excess recycled water is assumed to be treated to the same recycled water standard and discharged to the environment.

164 This is the residential demand once the targets are (water efficiency investments costs are required to meet these targets).

165 https://www.esc.vic.gov.au/water/water-prices-tariffs-and-special-drainage/water-price-reviews/water-price-review-2023

166 A levelized cost from the WSAA study is available for 'groundwater' and 'stormwater small-scale'. We also assume a price of $3,000/ML to purchase low reliability entitlements (see http://www.bom.gov.au/water/market/documents/The_Australian_Water_Markets_Report_2020-21.pdf , p.50).

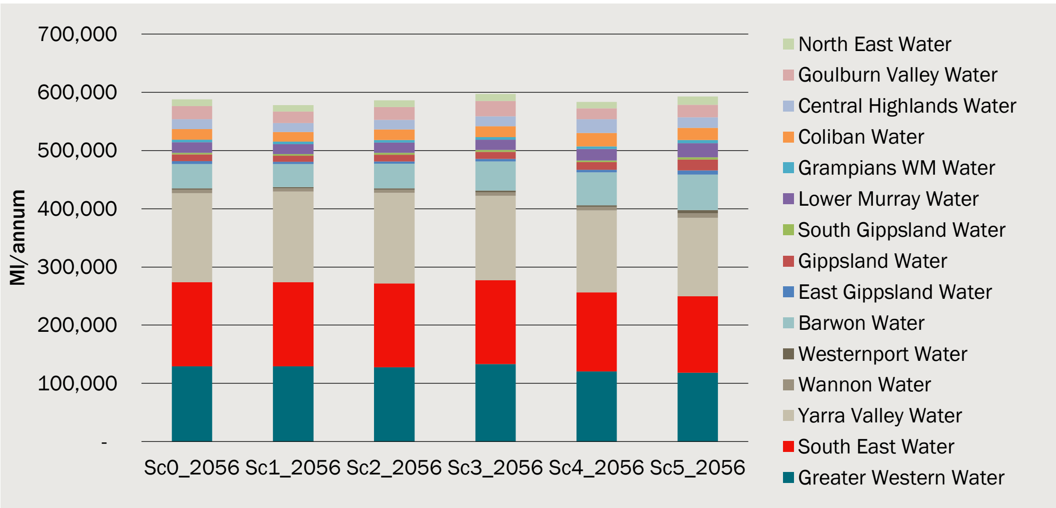
G.15 Costs of water supply option, levelized cost $/kL (2019-20)



Data source: WSAA (2020), Urban Water Supply Options for Australia, p.3.

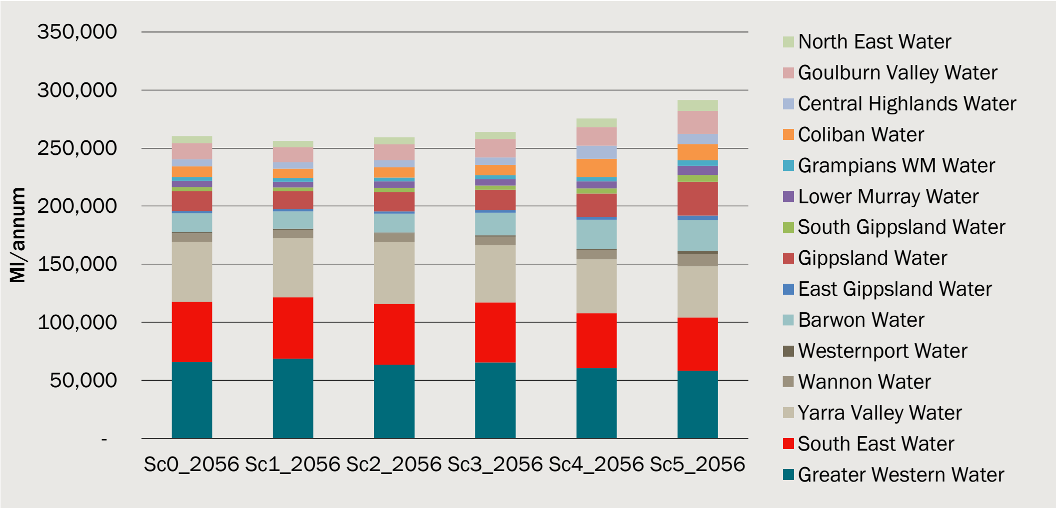
Based on these assumptions, tables G.16 and G.17 present the volume of water demanded for the different scenarios as at 2056.

G.16 Estimated volume for each Water Corporation of Residential Water in 2056 by Scenario



Data source: The CIE estimate based on IV scenario data.

G.17 Estimated volume of Non-Residential Water in 2056



Data source: The CIE estimate based on IV scenario data.

Table G.18 and G.19 presents the estimated additional water supply cost in 2036 and 2056 to meet the additional water demand under the different scenarios. Grampians Wimmera Mallee Water has limited population growth forecast, hence there is no cost increases. Similarly for Wannon Water and Central Gippsland Water future population growth in limited.

G.18 Additional water supply cost to 2036

Cost	S0	S1	S2	S3	S4	S5
	$m, real	$m, real	$m, real	$m, real	$m, real	$m, real
Greater Western Water	786	809	768	810	659	630
South East Water	515	524	515	510	392	367
Yarra Valley Water	423	444	442	350	290	268
Wannon Water	3	-	3	3	9	21
Westernport Water	10	9	10	12	12	25
Barwon Region Water	147	123	147	219	283	274
East Gippsland Region Water	11	7	11	11	14	28
Central Gippsland Region Water	-	-	-	-	-	32
South Gippsland Region Water	8	6	8	9	10	15
Lower Murray Urban Water	32	14	32	32	61	103
Grampians Wimmera Mallee Water	-	-	-	-	-	-
Coliban Region Water	25	3	24	30	131	96
Central Highlands Water	120	101	119	123	235	177
Goulburn Valley Region Water	50	17	48	71	65	89
North East Region Water	10	-	9	10	27	63
Total	**2 142**	**2 057**	**2 136**	**2 191**	**2 189**	**2 189**

Source: CIE estimate.

G.19 Additional water supply cost to 2056

Cost	S0	S1	S2	S3	S4	S5
	$m, real	$m, real	$m, real	$m, real	$m, real	$m, real
Greater Western Water	4 191	4 345	4 033	4 368	3 482	3 275
South East Water	2 871	2 903	2 849	2 803	2 164	1 925
Yarra Valley Water	2 813	2 940	2 993	2 361	1 974	1 677
Wannon Water	17	-	17	17	45	128
Westernport Water	56	48	56	68	64	177
Barwon Region Water	859	717	855	1 271	1 619	1 727
East Gippsland Region Water	65	38	58	65	79	195
Central Gippsland Region Water	8	-	-	29	60	302
South Gippsland Region Water	45	33	44	46	54	98
Lower Murray Urban Water	200	107	200	200	367	669
Grampians Wimmera Mallee Water	-	-	-	-	-	-
Coliban Region Water	261	131	243	286	770	563
Central Highlands Water	607	502	600	625	1 184	817
Goulburn Valley Region Water	523	312	491	785	401	573
North East Region Water	124	34	107	124	114	355
Total	**12 640**	**12 111**	**12 545**	**13 045**	**12 375**	**12 481**

Source: CIE estimate.

Wastewater

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.

Melbourne's sewerage system currently consists of:

- A network of over 3,000 km of large diameter pipes (300 mm or greater) (over 25,000 km including the reticulation system) and pumps that transfer sewage from homes and businesses to our treatment plants. It also has odour control facilities to prevent odour release from the sewerage network.
- Two large treatment plants, Eastern Treatment Plant (ETP) and Western Treatment Plant (WTP), and 26 smaller scale local treatment plants that process sewage, which can then be supplied as recycled water or safely released to a receiving environment.[167]

There are many system constraints that could impact on Melbourne's sewerage system. Some of these limits will only impact a localised area of the network, while others will impact the whole of the sewerage system. Some will occur in the near future, 10 to 20 years, while others are likely to be realised in the long term.

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167 https://www.melbournewater.com.au/water-and-environment/water-management/sewerage/importance-sewerage

The Melbourne Sewerage Strategy documents the process for considering investments and the potential drivers of investments but doesn't present the potential costs of alternative growth scenarios.

Wastewater infrastructure upgrades are typically driven by capacity constraints in either the network pipes or at the Wastewater Treatment Plants.

- The network pipes are typically sized to meet peak flows (which include stormwater infiltration). If volumes in dry days increases, there is limited capacity to manage volumes during peak periods, increasing the chance of 'overflow' events which could potentially breach licence conditions.
- The wastewater treatment plants upgrades could be impacted by the volume of wastewater and also type for chemicals entering the system (e.g. depending on non-residential activity). Ocean outfalls typically have a lower cost compared to increases in volumes to inland treatment plants which typically require wastewater to be treated to a higher level as part the environmental licence conditions for these plants. However, there are also environmental and social aspects that need to be considered not just the cost of treatment.

Different spatial growth patterns can have a bearing on the future wastewater costs, particularly if the growth is locating in parts of the network which are reaching capacity or where the wastewater is required to be discharged to inland systems (at a higher cost compared to the two large ocean outfalls).

IV's 2019[168] study on infrastructure costing indicates that Melbourne Water's centralised treatment plants have the capacity to support Melbourne's projected population growth for the next 30 years with incremental augmentation. The centralised plants treat around 90% of the sewage throughout Melbourne.

However, IV's 2019 (Appendix A, p.32) does highlight some differential cost implications of alternative growth scenarios

> 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.

IV's study also indicates that there are locations which may require a pressure sewer system (due to topography, poor soil or where there is high value vegetation). These systems are higher cost.

For the purpose of this analysis:

- for the three Melbourne corporations, we utilise Melbourne Water's estimate of the Long Run Marginal Cost (LRMC) of additional wastewater costs for its two major

168 IV (2019), Infrastructure Provision in Different Development Settings, Metropolitan Melbourne, Technical Appendix, August.

plants.[169] This includes the treatment, transfer and load costs.[170] The LRMC costs applied are $1,073/ML at Western Plant and $455/ML at the Eastern Plant.

  – Based on advice from Melbourne Water we assume that Greater Western Water discharges 100 per cent of sewage to the Western Treatment Plant (WTP). For South East Water and Yarra Valley Water 22 percent and 65 percent, respectively is assumed to be discharged to the WTP.

- for the regional coastal and inland corporations, we assume that the recycled water (for non-drinking purposes) option is adopted at a cost of $4,628/ML as identified in the WSAA report.[171]

Charts G.20 and G.21 presents the estimated additional wastewater transport and treatment costs in 2036 and 2056 for each scenario. This applies a discharge factor of 0.75 for houses and 0.85 for units. For businesses, we assume that 100% of water used is discharged to the sewer in Melbourne but 75% in other areas.

G.20 Additional wastewater treatment cost to 2036

Cost	S0	S1	S2	S3	S4	S5
	$m, real	$m, real	$m, real	$m, real	$m, real	$m, real
Greater Western Water	248	262	242	251	206	196
South East Water	87	90	87	84	65	61
Yarra Valley Water	100	107	105	81	67	61
Wannon Water	9	-	9	10	26	60
Westernport Water	18	15	18	22	22	47
Barwon Region Water	243	200	242	363	502	485
East Gippsland Region Water	21	12	20	21	29	55
Central Gippsland Region Water	-	-	-	-	20	122
South Gippsland Region Water	23	16	22	24	35	50
Lower Murray Urban Water	31	13	31	31	61	104
Grampians WM Water	-	-	-	-	-	-
Coliban Region Water	25	-	24	31	161	120
Central Highlands Water	122	102	122	126	251	191
Goulburn Valley Region Water	64	24	62	88	104	146
North East Region Water	10	-	8	11	38	78
Total	**1 000**	**843**	**992**	**1 144**	**1 587**	**1 775**

Source: CIE estimate

169 The LRMC does not include costs associated with servicing growth using existing assets which is effectively variable OPEX (e.g. electricity & chemicals) where existing assets are not at 100% utilisation.

170 Data on the BOD, TSS and TKN loads was estimated by Melbourne Water.

171 Costs has been inflated to current dollars using the Producer Price Index.

G.21 Additional wastewater treatment cost to 2056

Cost	S0	S1	S2	S3	S4	S5
	$m, real	$m, real	$m, real	$m, real	$m, real	$m, real
Greater Western Water	1 321	1 404	1 269	1 350	1 087	1 015
South East Water	490	507	488	470	364	321
Yarra Valley Water	697	737	747	577	484	408
Wannon Water	53	3	53	56	139	375
Westernport Water	94	78	94	117	114	325
Barwon Region Water	1 401	1 154	1 392	2 091	2 868	3 022
East Gippsland Region Water	113	65	101	114	154	370
Central Gippsland Region Water	-	-	-	60	263	1 020
South Gippsland Region Water	116	82	113	123	178	310
Lower Murray Urban Water	192	97	191	194	358	676
Grampians WM Water	-	-	-	-	-	-
Coliban Region Water	262	114	242	294	1 007	757
Central Highlands Water	601	491	593	621	1 319	918
Goulburn Valley Region Water	549	309	515	829	592	913
North East Region Water	124	20	104	128	198	477
Total	**6 013**	**5 062**	**5 902**	**7 026**	**9 127**	**10 907**

Source: CIE estimate

Note that the costs presented above are based on levelized cost estimates from WSAA and the LRMC estimates from Melbourne Water. These costs reflect a combination of both capital and operating expenditure, although they are not separately identified. We disaggregate the capital and operating components below.

Cost implications of scenarios – network augmentation

The costs discussed above do not include the networks costs required to meet the growth. This could include, for example, augmenting pipelines and upgrading pumping stations to deal with the additional loads, as well as, expanding the network to service new growth areas.

The corporations' price submissions to the ESC provide an indication of the potential network augmentation costs. The Excel spreadsheets to the ESC identify 'growth' investments associated with 'Pipelines/network' and customer numbers over the next 10 years.[172] We calculated a dollar per additional customer for each corporation, separately for water and sewerage. This provides an approximation although there are limitations to this approach. For example, it only covers a 10 year period and expenditure is not necessarily linearly related to growth in customer numbers. Further, within each

172 Costs for Melbourne Water and Greater Western Water were adopted for earlier submissions. Costs for North East Water was not available – we assumed an average of the inland corporations (excluding Goulburn Murray Water).

corporation there are likely to be different network augmentation costs. Therefore, it will depend on the location within each corporation where the future growth occurs.

The price submissions do not separately estimate the operating expenditure associated with growth network investments. However, the spreadsheets do report the capital and operating expenditure in each year over the forecast 10 year period. We apply these shares to estimate the additional operating expenditure associated with the network augmentation.

Table G.22 presents the estimated capital and operating cost per customer of the augmenting the network for growth, split by water and wastewater investments. For some regions such as Grampians Water and Westernport Water the network augmentation costs are low, reflecting the relatively lower growth in these regions.

G.22 Estimated network cost per customer, by water and wastewater

Cost	Capex Water	Capex Wastewater	Opex Water	Opex Wastewater
	$/customer	$/customer	$/customer	$/customer
Greater Western Water	4 805	6 338	4 842	3 913
South East Water	2 360	5 688	1 254	2 057
Yarra Valley Water	4 628	4 916	2 690	1 603
Wannon Water	5 454	2 624	10 359	4 398
Westernport Water	-	3 097	-	4 650
Barwon Region Water	7 414	4 558	5 578	5 092
East Gippsland Region Water	1 435	1 351	1 407	1 477
Central Gippsland Region Water	2 364	4 572	3 152	7 329
South Gippsland Region Water	5 142	13 447	5 113	7 447
Lower Murray Urban Water	5 264	4 276	5 147	6 846
Grampians WM Water	-	-	-	-
Coliban Region Water	2 582	3 004	2 531	1 625
Central Highlands Water	8 100	5 612	8 799	6 610
Goulburn Valley Region Water	5 900	2 758	5 882	5 077
North East Region Water [a]	5 462	3 913	5 590	5 039

[a] Costs for North East Water was not available – we assumed an average of the inland corporations (excluding Goulburn Murray Water).

Source: CIE estimate based on price submission spreadsheets to the ESC.

Tables G.23 to G.26 present the resulting cost by 2036 and 2056 for both water and wastewater expenditure.

G.21 Additional WATER NETWORK cost to 2036

Cost	S0	S1	S2	S3	S4	S5
	$m, real	$m, real	$m, real	$m, real	$m, real	$m, real
Greater Western Water	239	251	236	243	206	198
South East Water	639	674	638	617	520	493
Yarra Valley Water	1 248	1 345	1 277	1 047	972	925
Wannon Water	21	0	21	21	53	126
Westernport Water	0	0	0	0	0	0
Barwon Region Water	765	658	764	1 082	1 372	1 325
East Gippsland Region Water	12	7	11	12	15	29
Central Gippsland Region Water	53	31	51	60	71	136
South Gippsland Region Water	41	29	40	42	50	74
Lower Murray Urban Water	25	12	25	25	47	76
Grampians WM Water	0	0	0	0	0	0
Coliban Region Water	85	63	84	89	188	153
Central Highlands Water	299	238	298	310	688	492
Goulburn Valley Region Water	179	123	175	214	203	244
North East Region Water	95	63	93	95	129	198
Total	**3 699**	**3 493**	**3 714**	**3 858**	**4 515**	**4 469**

Source: CIE estimate

G.22 Additional WATER NETWORK cost to 2056

Cost	S0	S1	S2	S3	S4	S5
	$m, real	$m, real	$m, real	$m, real	$m, real	$m, real
Greater Western Water	556	587	543	573	471	439
South East Water	1 583	1 638	1 573	1 481	1 257	1,101
Yarra Valley Water	3 406	3 702	3 610	2 819	2 541	2,124
Wannon Water	40	1	40	40	109	352
Westernport Water	0	0	0	0	0	0
Barwon Region Water	1 786	1 511	1 777	2 588	3 286	3 625
East Gippsland Region Water	28	17	24	28	34	96
Central Gippsland Region Water	117	70	107	135	163	410
South Gippsland Region Water	90	67	88	94	109	228
Lower Murray Urban Water	68	41	68	68	119	225
Grampians WM Water	0	0	0	0	0	0
Coliban Region Water	203	149	192	213	555	444
Central Highlands Water	695	545	680	718	2 080	1 345
Goulburn Valley Region Water	588	426	555	843	632	800
North East Region Water	219	144	199	219	304	571
Total	**9 381**	**8 897**	**9 455**	**9 817**	**11 658**	**11 761**

Source: CIE estimate

G.23 Additional WASTEWATER NETWORK cost to 2036

Cost	S0	S1	S2	S3	S4	S5
	$m, real	$m, real	$m, real	$m, real	$m, real	$m, real
Greater Western Water	230	242	228	234	199	191
South East Water	1 328	1 400	1 325	1 282	1 081	1 023
Yarra Valley Water	1 039	1 119	1 063	872	809	770
Wannon Water	8	-0	8	8	20	48
Westernport Water	48	42	48	58	55	118
Barwon Region Water	517	445	516	731	928	896
East Gippsland Region Water	10	6	9	10	12	24
Central Gippsland Region Water	102	60	100	117	139	264
South Gippsland Region Water	74	53	73	76	90	134
Lower Murray Urban Water	24	12	24	24	43	71
Grampians WM Water	0	0	0	0	0	0
Coliban Region Water	70	52	69	74	155	126
Central Highlands Water	187	149	187	194	431	308
Goulburn Valley Region Water	105	72	103	126	120	143
North East Region Water	67	44	66	67	91	140
Total	**3 809**	**3 696**	**3 819**	**3 874**	**4 173**	**4 258**

Source: CIE estimate

G.24 Additional WASTEWATER NETWORK cost to 2056

Cost	S0	S1	S2	S3	S4	S5
	$m, real	$m, real	$m, real	$m, real	$m, real	$m, real
Greater Western Water	536	566	524	552	454	423
South East Water	3 288	3 402	3 266	3 076	2 611	2 286
Yarra Valley Water	2 836	3 082	3 005	2 347	2 116	1 769
Wannon Water	15	0	15	15	42	134
Westernport Water	109	92	109	132	123	394
Barwon Region Water	1 208	1 022	1 201	1 750	2 222	2 451
East Gippsland Region Water	23	14	20	23	28	79
Central Gippsland Region Water	228	136	207	261	316	796
South Gippsland Region Water	164	122	160	170	197	414
Lower Murray Urban Water	63	38	63	63	110	209
Grampians WM Water	0	0	0	0	0	0
Coliban Region Water	168	123	159	176	459	367
Central Highlands Water	436	342	426	450	1 304	843
Goulburn Valley Region Water	345	250	326	495	371	470
North East Region Water	155	102	141	155	215	403
Total	**9 574**	**9 291**	**9 623**	**9 665**	**10 567**	**11 040**

Source: CIE estimate

Summary

Table G.25 summarises the estimated expenditure, disaggregated by water supply augmentation and wastewater treatment costs, as well as, costs associated with upgrades to the network. Costs are highest for the scenarios 4 and 5.

G.25 Summary of estimated additional water and wastewater expenditure

Item	Sc0	Sc1	Sc2	Sc3	Sc4	Sc5
	$m	$m	$m	$m	$m	$m
Supply augmentation/treatment to 2036						
Water - capex	1 209	1 170	1 209	1 228	1 203	1 190
Water - opex	933	887	927	963	985	1 000
Wastewater - capex	554	487	550	614	823	880
Wastewater - opex	446	356	441	530	765	895
Sub total	**3 142**	**2 900**	**3 127**	**3 334**	**3 776**	**3 964**
Supply augmentation/treatment to 2056						
Water - capex	7 156	6 910	7 130	7 313	6 841	6 773
Water - opex	5 483	5 201	5 415	5 732	5 534	5 707
Wastewater - capex	3 321	2 912	3 274	3 729	4 743	5 351
Wastewater - opex	2 693	2 149	2 628	3 296	4 384	5 557
Sub total	**18 653**	**17 173**	**18 447**	**20 071**	**21 502**	**23 388**
Network to 2036						
Water - capex	2 154	2 067	2 165	2 225	2 536	2 488
Water - opex	1 546	1 426	1 549	1 633	1 979	1 982
Wastewater - capex	2 468	2 461	2 478	2 436	2 511	2 504
Wastewater - opex	1 342	1 235	1 341	1 438	1 662	1 754
Sub total	**7 509**	**7 189**	**7 533**	**7 731**	**8 688**	**8 728**
Network to 2056						
Water - capex	5 482	5 280	5 544	5 662	6 522	6 478
Water - opex	3 899	3 617	3 911	4 156	5 137	5 284
Wastewater - capex	6 235	6 216	6 300	6 067	6 338	6 307
Wastewater - opex	3 339	3 075	3 322	3 598	4 229	4 732
Sub total	**18 955**	**18 188**	**19 078**	**19 482**	**22 225**	**22 801**

Source: The CIE

In terms of the distributional analysis, for the purpose of this analysis, we have assumed that the cost of water infrastructure is predominantly recovered through user charges.

H Drainage/stormwater management

Stormwater drainage is required to protect property from flooding and to maintain water quality and biodiversity standards in receiving waters under fluctuating rainfall conditions, whether these are urban rivers and creeks or the bays. Inadequate stormwater drainage infrastructure exists in localised pockets across all of Melbourne's established areas constructed prior to the late 1970's, after which time improved stormwater drainage standards were introduced.

Stormwater drainage within a development site is the responsibility of the developer via the construction of drainage pathways that lead directly to receiving waterways. Outside the development site, local councils are responsible for managing stormwater.[173]

There could potentially be differences in drainage costs between scenarios. IV's 2019[174] study indicates that 'civil works' was the second largest cost category aside from transport, amounting to around $35,000/dwelling in capital and $34,000/dwelling in operating costs over a 30 year period. However, these costs included a wide range of other costs, both inside and outside the development area.[175]

Stormwater cost within the development site have been estimated as part of the local infrastructure cost. Stormwater cost outside the development site have not been estimated due to the lack of robust data that can be applied to our analysis.

173 Melbourne Water is responsible for some major drainage works. In it's area of operation it manages 1,400 kilometres of regional drains with the local councils responsible for 25,000 kilometres of local drains and street gutters. https://www.melbournewater.com.au/water-and-environment/flooding-advice/drainage-system

174 IV (2019), Infrastructure Provision in Different Development Settings, Metropolitan Melbourne, Technical Appendix, August.

175 It includes all earthworks, lot benching and retaining walls, transport and circulation infrastructure (including roads, pathways and nature strips) and landscaping within the development estate. Stormwater drainage both within and external to the development estate is included in the civil works cost. Stormwater drainage has not been reported separately as a cost as development as it cannot be accurately separated from other civil costs.

I Telecommunications

Telecommunications infrastructure is another key utility service that is required in new developments. Telecommunications services cover broadband and mobile services. Mobile services are provided in a competitive market and can adapt to provide a level of quality consistent with nationally harmonised pricing that is used by most mobile telecommunication companies. Mobile coverage is available across Victoria in urbanised areas and beyond.[176]

Broadband infrastructure is provided as a last resort by NBN Co as a government owned monopoly, providing wholesale broadband, which can be accessed by all retail service providers. However, infrastructure can also be provided by others.[177] Broadband is provided by fibre, wireless and satellite technology. For fibre developments a developer will be responsible for installing pits and pipes ready for broadband. Where there is no fixed line, connection is provided fixed wireless and satellite services by NBNCo or private operators such as Starlink.[178]

Costs drivers

Developers are responsible for meeting the costs of connecting their estate to the telecommunications network (the point of interconnection). NBN Co will leverage transmission capacity from their NBN Fibre Access Nodes to the relevant point of interconnection.

There are a range of factors that drive costs for the provision of telecommunications services:

- The distance between the boundary of the property and connection point to the wider area network
- The density of the development (economies of scale can be achieved through higher levels of density)
- The terrain on which the assets will be installed.

The telecommunications cost that we included is the cost of pit and pipes for developers and cost of running fibre to new developments. We assume all new developments are serviced with fibre to the home.

The cost of telecommunications has been included as part of the local infrastructure (see chapter A.

176 https://www.telstra.com.au/coverage-networks/our-coverage

177 https://www.infrastructure.gov.au/department/media/publications/telecommunications-new-developments

178 https://www.starlink.com/map

J Health

- **We have not estimated the cost of providing additional health infrastructure related to hospitals. There are many factors that determine how health infrastructure is provided in addition to population growth and so, for each scenario, many different approaches could be undertaken. As major hospitals service large catchments we have assumed that hospital infrastructure provision will not vary significantly across the scenarios.**
- **We have costed local community health facilities as part of the community facilities cost. Those capture the local community needs and cover, for example, specialist medical treatment, nursing care, allied health, dental services, antenatal and postnatal clinics, district nursing, primary injury, services for children (immunisation, speech therapy, etc) and community mental health.**

While future population distribution is a possible factor influencing health infrastructure costs, it is only one aspect of the complexity of health services demand and delivery. Ageing of the population and changes in population health and treatment pathways will drive continuous growth in demand for health infrastructure and services in Melbourne over the next several decades. This is driving innovation in service delivery models as suppliers of health services find new ways of meeting demand growth in cost effective ways.

The population distribution scenarios examined in this review impose different magnitudes of population change in each local area, which may trigger new health infrastructure costs depending on local capacity constraints and demand management options.

A variety of interrelated demand and supply factors influence health infrastructure expenditure and delivery decisions:

- While the magnitude of future population changes will place pressure on necessary health infrastructure costs, other relevant demand-side factors affected by population distribution include the demographic and socioeconomic profile of the resident population and the degree of existing unmet or underserviced demand across the broad and interconnected spectrum of health services.
  - For instance, different population cohorts require different types of health services. Younger communities are more likely to require a higher proportion of child and family services and primary health care, compared to more aged communities that may require more sub-acute, residential aged care and community-based services.
- Demand for types of health services can also reflect differing levels of access to appropriate preventative and early intervention health services.

- For instance, demand for acute health services can often reflect local population access to effective primary and allied health services.

This complexity means that different local populations are likely to require access to different combinations of general practice services, primary and community health care, aged care, private health services, dental care, medical imaging and pathology services, day procedure services, allied health and other services.

Although not impacted by the dispersion of population, the increasing prevalence of chronic and non-communicable diseases, consumer preferences for new care delivery models and the availability of new forms of health intervention technologies will also exert demand pressure and may ultimately prompt new health infrastructure costs.

Several supply side responses have the potential to offset this demand pressure, including new models of care to manage demand more efficiently, the rollout of specialist health services, and the opportunity to co-locate complementary providers of health services. Advances in technological innovations can contribute to an overall reduction in costs of delivering healthcare through newer delivery models. For example, the hospital in the home model of care allows for care to be delivered outside of hospital without compromising on standard and quality of care.

However, there are limits to the flexibility and adaptability of supply to additional demand, which varies from one geographic area to the next. For instance, large inner-city hospitals that already have large catchment areas and older hospitals that may be ill-suited to capacity enhancing measures may not be able to flex enough to meet new demand without changes to the servicing of existing demand. The (lack of) land availability, planning and zoning restrictions, and price of land for expanded health infrastructure stocks, can also present a challenge to geographic areas trying to cater for higher than forecast population (and health services) demand.[179]

Chart J.2 shows the various demand and supply side factors resulting from or associated with each of the population distribution scenarios, which will influence future health infrastructure costs for the wide spectrum of health services including hospitals, primary and allied health care facilities, medical imaging and pathology practices and infrastructure for other health services.

Clearly there are many forces in play, which results in an important degree of regional variation. For instance, Melbourne's metro area contains several well-established hospitals (see chart J.1) which offer high complexity services and have a large drawing area as a result. This service model may in some cases limit the extent to which the distribution of growth at the local level will impact on the need for additional capacity at existing health sites and/or the need for new facilities. In other cases it will exacerbate existing pressure depending on the options available to the hospital and other health services in the area to otherwise manage demand.

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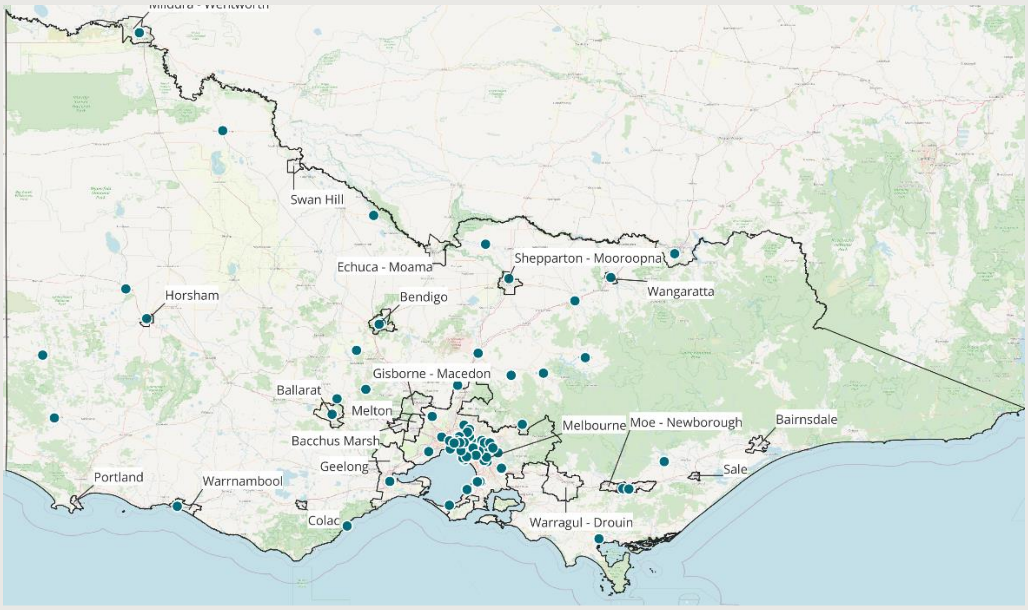
179 While it is acknowledged that land costs can impact on health infrastructure costs in different geographic areas, land costs comprise a very small proportion of total construction costs for new health services, which in the case of hospitals is around 3 per cent of construction costs.

J.1 Victorian private and public hospitals



Data source: CIE.

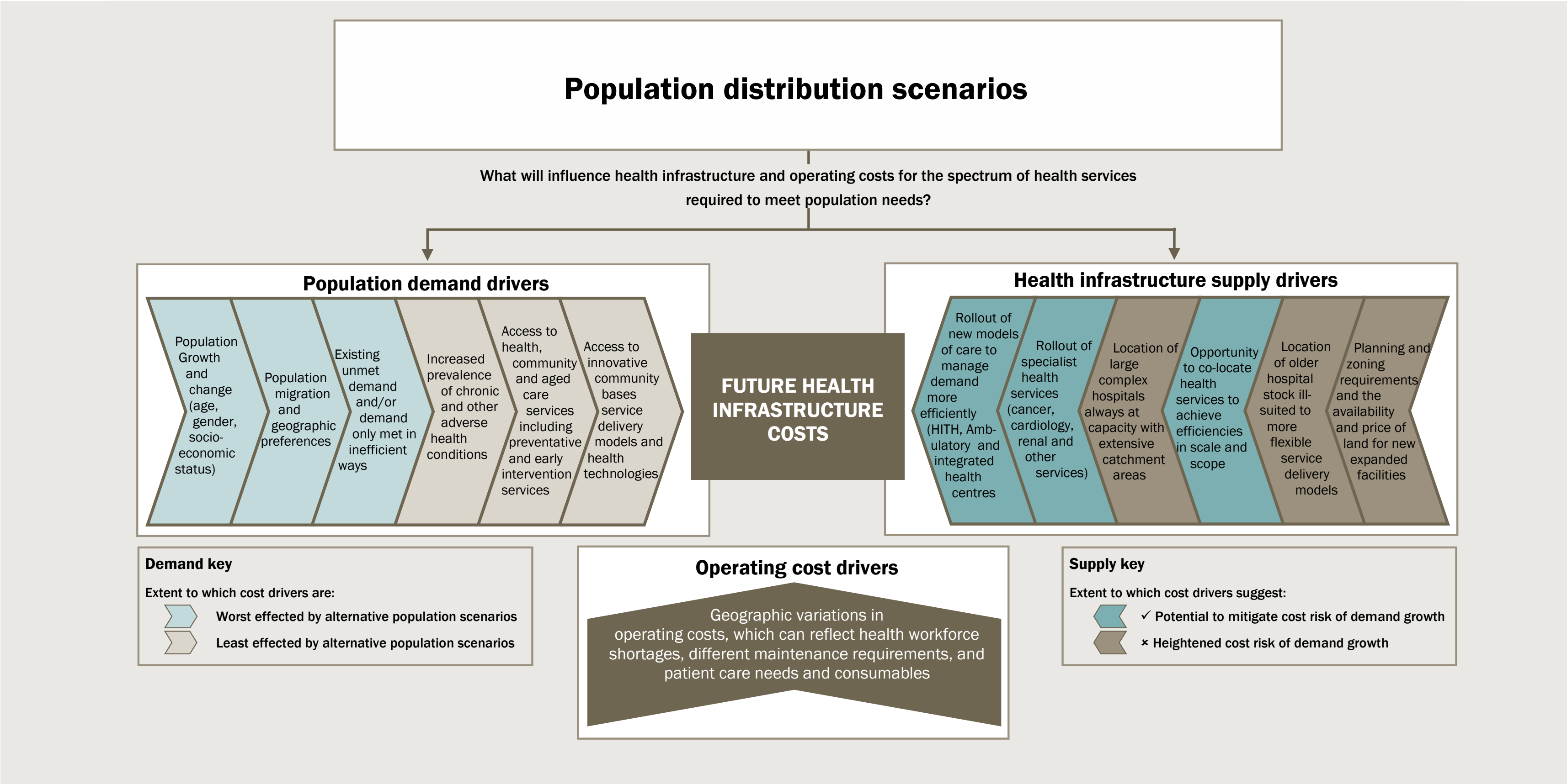
Given that the scenarios impose differing magnitudes of population changes across Victoria to 2056, they can potentially impact on future infrastructure costs depending on the:

- total number of additional residents in each LGA over the years to 2056;
- proportional change in residents compared to existing 2021 population in an LGA;
- existing unmet or underserviced demand for health services in each LGA — shown by measures such as available public beds per 100 000 of population, available private beds per 100 000 of population, and emergency department waiting times for triage relative to the Victorian average, and
- access to effective hospital demand management programs in each LGA, shown by measures such as the rate of hospitalisations for ambulatory sensitive conditions per 100 000 population for a particular LGA relative to the Victoria average.

To meet the objectives of this analysis, we have costed local community health facilities as part of the community facilities cost. Those capture the local community needs and cover, for example, specialist medical treatment, nursing care, allied health, dental services, antenatal and postnatal clinics, district nursing, primary injury, services for children (immunisation, speech therapy, etc) and community mental health.

We have not estimated the cost of providing additional health infrastructure in terms of hospitals given That there are many factors that determine how health infrastructure is provided in addition to population growth and so, for each scenario, many different approaches could be undertaken. Further, as major hospitals service large areas, we have assumed that the cost of hospital infrastructure provision will not vary significantly across the scenarios.

J.2 Demand and supply factors affect future demand and infrastructure costs



Note: CIE.

K Other infrastructure sectors

This chapter includes high-level descriptions of infrastructure sectors which have not been quantified as part of this analysis.

Ports

Ports include sea and airports. Victoria has one international airport (Melbourne Tullamarine), 19 regional airports and airfields,[180] and five commercial seaports.[181] The infrastructure cost of building new or augmenting existing ports and operating those can be significant. However, as sea and airports serve large catchments and in some cases the whole of the state, we do not expect that cost would vary by scenario.

Police, emergency services, and Justice

Government is the primary provider of police, emergency services and justice as part of the basic community services. The estimation of those cost is outside of the scope of this analysis, however, in general, it is expected that scenarios with more greenfield development would have higher infrastructure requirements for police, emergency services, and justice.[182]

180 https://airport-authority.com/browse-AU-VIC

181 https://transportsafety.vic.gov.au/maritime-safety/ports-and-shipping/victorian-ports

182 SGS (2016), *Comparative costs of urban development: a literature review*, https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/SGS-Economics-and-Planning-Comparative-costs-of-infrastructure-across-different-development-settings.pdf, p. 38

L Detailed assumptions for assessment of housing impacts

Value assumptions

Price of dwellings by characteristic

To estimate the value of housing at current attributes of each place (i.e. each SA2), there are two broad approaches:

1 estimating the mean sale price and rent for each combination of SA2 and dwelling type, or

2 estimating a model to predict mean sale price based on SA2, dwelling type and other characteristics such as dwelling size.

The first approach implicitly assumes that floor area and lot size of new dwellings are the same as existing dwellings for each combination of dwelling type and SA2.

Hence, we use the second approach. We estimate six linear regression models, namely three sale price models and three rental models, with one for each dwelling type in the PropTrack data (houses, townhouses and apartments). Each of these models consists of the following variables:

- Sale prices or rents as the dependent variable,
- The number of bedrooms, bathrooms and car spaces,
- Land area of each property,
- Floor area (for houses only),
- The quarter in which the property is sold or leased, and
- SA2.

We then use the coefficients estimated by this model to predict the sale price and rent for each property type in each SA2. This requires assumptions about the land area of new dwellings, floor area of new houses, and the number of bedrooms, bathrooms and car spaces. For consistency, we assume that each new dwelling has three bedrooms, two bathrooms and one car space.

In practice, the size of dwellings will depend on the occupancy rate for each dwelling type, with apartments likely to have fewer people and therefore have less bedrooms on average. However, since the total number of dwellings in each scenario is the same, and therefore, occupancy rates are the same in aggregate, it is reasonable to assume that dwellings have the same number of bedrooms, bathrooms and car spaces.

The assumed floor area of new dwellings is shown in table L.1. The average lot size of new dwellings is shown and explained in Appendix O.

L.1 Assumed floor size of new dwellings

Measure	Houses	Townhouses	Apartments
	sqm	sqm	sqm
Average floor area of a new dwelling - Victoria – 2021/22	240.8	170.6	114.9

Source: ABS, 2023, *Building Activity, Australia, April 2023*.

Rent and sale price growth

Data about historical median prices of dwellings in Victoria is available from the ABS publication *Total Value of Dwellings*.[183] Real growth in dwelling prices has been lower in Melbourne that in the Rest of Victoria over the period since September 2003 to December 2022 (table L.2). We calculate a weighted average growth in prices for all of Victoria based on the share of dwellings in Melbourne vs the Rest of Victoria, which is based on the Victoria in Future population projections (VIF) for 2021. This is applied to derive housing values for 2036 and 2056.

L.2Comparing historical price growth between Melbourne and Rest of Victoria (2003 to 2022)

Measure	Melbourne	Rest of VIC	Average
	Per cent	Per cent	Per cent
Median Price of Established House Transfers (Unstratified)	2.9	3.6	3.1
Median Price of Attached Dwelling Transfers (Unstratified)	1.5	2.5	1.8
Share of dwellings (2021)	71	29	

Source: Median prices are sourced from ABS *Total value of dwellings*, while the share of dwellings is based on the Victoria in Future population projections data for 2021, CIE.

Data about dwelling rents in Victoria is available from the ABS Consumer Price Index.

L.3Dwelling value growth assumptions

Dwelling type	Renter share	Real rental growth rate			Implied dwelling services price index		
		Rents	Sales	Weighted average	2021	2036	2056
	%	%/annum	%/annum	%/annum	2021 = 1	2021 = 1	2021 = 1
Separate house	21%	0.9%	3.1%	2.6%	1.000	1.479	2.491
Attached	45%	0.9%	3.1%	2.1%	1.000	1.368	2.077

183 ABS, 2023, *Total Value of Dwellings*, March Quarter 2023, Table 2, available at: https://www.abs.gov.au/statistics/economy/price-indexes-and-inflation/total-value-dwellings/latest-release

Dwelling type	Renter share	Real rental growth rate			Implied dwelling services price index		
		Rents	Sales	Weighted average	2021	2036	2056
	%	%/annum	%/annum	%/annum	2021 = 1	2021 = 1	2021 = 1
Low rise apartments	64%	0.9%	3.1%	1.7%	1.000	1.287	1.803
Medium rise apartments	64%	0.9%	3.1%	1.7%	1.000	1.287	1.803
High rise apartments	64%	0.9%	3.1%	1.7%	1.000	1.287	1.803
Other	40%	0.9%	3.1%	2.2%	1.000	1.390	2.157

Source: ABS Consumer Price Index.

Construction costs

We have used the ABS estimates of the cost of construction. These are published in the *Building Activity, Australia, April 2023*,[184] and are Victoria-specific estimates of the average cost of new dwelling construction.

These estimates align reasonably well to two other sources available for construction costs:

- Construction cost estimates based on data provided by JLL as part of The CIE (2020).[185] These estimates were in the form of $/m2 of floor area, and have been converted to estimates for Victoria based on average floor area of new dwellings. These are very close to the ABS estimates, except are around $130 000 higher per dwelling for attached dwellings compared to the ABS data.
- Estimates of construction costs published by SMEC in the *Infrastructure Provision in Different Development Settings: Metropolitan Melbourne Costing and Analysis Report*.[186] These have been escalated based on the ABS Producer Price Index for house and other residential building construction. These estimates are lower for houses, and what SMEC refers to as 'medium density' (which we align to low rise apartments and attached houses). However, the estimated cost of 'high density' construction (which we align to mid- and high-rise apartments) is far higher than both ABS and JLL.

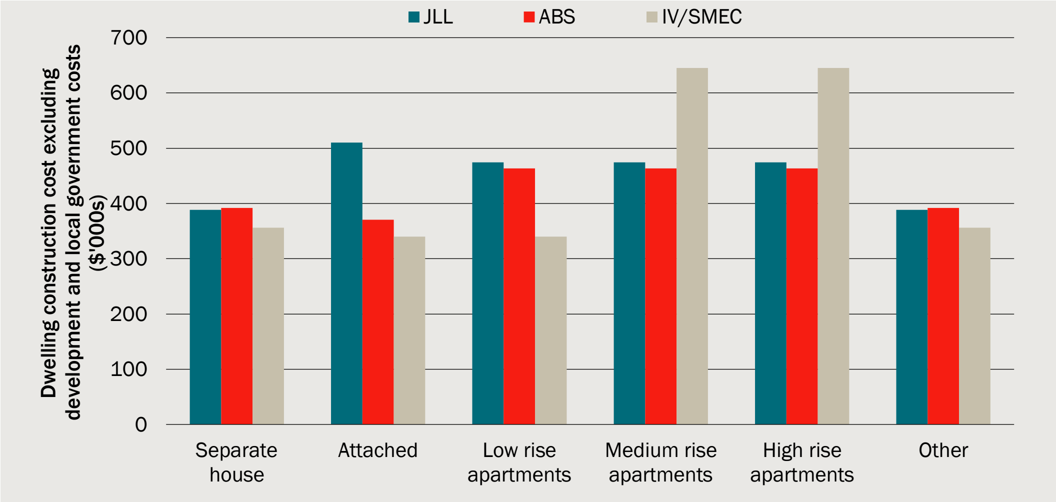
We have preferred the ABS estimates since they are the most recent and are part of a widely cited publication.

184 Available at: https://www.abs.gov.au/statistics/industry/building-and-construction/building-activity-australia/dec-2022/Building%20Activity%20Average%20Cost.xlsx

185 The CIE, 2020, *Western Sydney Place Based Infrastructure Compact*, Final Report, prepared for the Greater Sydney Commission, available at: https://gsc-public-1.s3-ap-southeast-2.amazonaws.com/s3fs-public/appendix_6_-_economic_evaluation_pic_2.pdf?YI2OKoda1ZmXFIXYZH3cXVDJurKoxcM.

186 SMEC, 2019, *Infrastructure Provision in Different Development Settings: Metropolitan Melbourne Costing and Analysis Report*, prepared for Infrastructure Victoria, available at: https://www.infrastructurevictoria.com.au/wp-content/uploads/2019/04/SMEC-Infrastructure-Provision-in-Different-development-Settings-Metroplitan-Melbourne-Costing-and-Analysis-Report-January-2019.pdf

L.4 Construction cost estimates per dwelling, by dwelling type and organisation source



Data source: As noted in chart.

Construction cost escalation

Construction cost escalation is based on historical growth in ABS Producer Price Indices for house and other residential building construction in Victoria.[187] The price of house construction in Victoria has increased by 1.03 per cent on average in real terms since the beginning of the data series (September 1998). On the other hand, other residential building construction has fallen on average 0.07 per cent annually in real terms over this period (1998 to 2023). We assume that real cost escalation is zero for apartments rather than assuming that real costs fall, on the basis that the rate of real cost escalation is small and subject to some uncertainty. The same construction cost escalation is applied to all areas.

L.5 Assumed rate of real escalation for dwelling construction costs

Dwelling type	Assumed real cost escalation rate per annum
	Per cent
Separate house	1.03
Attached	1.03
Low rise apartments	0.00
Medium rise apartments	0.00
High rise apartments	0.00
Other	1.03

Source: CIE, based on analysis of ABS Producer Price Indices.

187 ABS, Producer Price Indices, https://www.abs.gov.au/statistics/economy/price-indexes-and-inflation/producer-price-indexes-australia/latest-release#construction.

Opportunity cost of land used for dwellings

The housing model estimates the value of housing net of construction costs and the opportunity cost of land (including an allowance for land taken by local infrastructure to support residential development, discussed in Appendix O).

The share of dwellings that are greenfield developments, by region, is shown in table L.6, and the one-off value of this land is shown in table L.7. Note that Inner and Middle Melbourne are excluded from this table of values since no development in this region is assumed to be greenfield. Agricultural land is used as the opportunity cost, as this is the most likely source of additional urban land.

L.6 Share of dwellings in each region that are greenfield developments

Share Greenfield	Share	Source
	Per cent	
Inner Melbourne	0%	UDP Melbourne Growth Area Landuse
Middle Melbourne	0%	UDP Melbourne Growth Area Landuse
Outer Melbourne	2%	UDP Melbourne Growth Area Landuse
Melbourne New Growth Area	100%	UDP Melbourne Growth Area Landuse
Regional City	95%	UDP Regional 2022
Regional Centres and Rural Areas	100%	UDP Regional 2022

Source: As noted, CIE.

L.7 Value of agricultural land

Region	Value of agricultural land
	$/m2
Outer Melbourne	54.2
Melbourne New Growth Area	7.8
Regional City	7.8
Regional Centres and Rural Areas	2.4

Source: Valuer General data, CIE.

Churn rate

Construction of new dwellings typically requires demolition of existing dwellings. We refer to the 'churn rate' as the ratio of gross new dwellings to the number of net new dwellings. A ratio of 2 implies that 2 separate houses have to be constructed to achieve 1 net new house, since for each new house constructed an existing house has to be demolished. For high rise apartments the churn rate will be lower — i.e. construction of 11 new dwellings would require demolition of one dwelling, giving a net of 10 dwellings. The implied churn rate is then 1.1.

For the Melbourne new growth areas and regional areas, we assume that there are no demolitions required and, therefore, the churn rate is one. The churn rate assumptions are shown in table L.8.

Note that there is limited data to support developing these estimates of churn rates, but they are consistent with the rates assumed in our past work.[188]

L.8 Churn rate assumptions for dwellings

Region	Separate house and other dwellings	Attached	Low- and medium-rise apartments	High-rise apartments
	Gross number of homes per net new home	Gross number of homes per net new home	Gross number of homes per net new home	Gross number of homes per net new home
Inner Melbourne	2	1.5	1.3	1.1
Middle Melbourne	2	1.5	1.3	1.1
Outer Melbourne	2	1.5	1.3	1.1
Melbourne New Growth Area	1	1	1	1
Regional City	1	1	1	1
Regional Centres and Rural Areas	1	1	1	1

Source: CIE assumptions.

Hedonic modelling for the value of accessibility

We have estimated hedonic models of sale prices for each type of dwelling in the PropTrack data. These models are aimed at estimating the relationship between job access density by car and public transport and sale prices, in order to value changes in accessibility.

These estimates imply that a 1 per cent increase in job density by car for a travel zone leads to a 0.09 per cent increase in house and townhouse values, and a 0.20 per cent increase in apartment values.

A key limitation of this modelling is that we cannot use a log specification for job access density via public transport, because many travel zones have a value of zero for public transport accessibility.[189] Hence, for public transport, a 50 000 unit increase in the job access density via public transport metric is associated with a 4.16 per cent increase in house values, a 3.08 per cent increase in townhouse values, and a 1.21 per cent increase in apartment values.

188 The CIE, 2020, *Western Sydney Place Based Infrastructure Compact*, Final Report, prepared for the Greater Sydney Commission, available at: https://gsc-public-1.s3-ap-southeast-2.amazonaws.com/s3fs-public/appendix_6_-_economic_evaluation_pic_2.pdf?YI2OKoda1ZmXFIXYZH3cXVDJurKoxcM.

189 This would reflect that the modelled public transport time from these travel zones to each destination exceeds 180 minutes, suggesting that these are travel zones without any public transport service.

L.9 Hedonic modelling accessibility

Variable	Houses	Townhouses	Apartments
Number of bedrooms			
0 or 1	Base level	Base level	Base level
2	.26397932***	.38653963***	.39269221***
3	.29836307***	.54539239***	.62759047***
4 (and for townhouses and apartments, also 5 or more)	.42854755***	.72141704***	.55564556***
5 or more	.55371325***	N/A	N/A
Number of bathrooms			
0 or 1	Base level	Base level	Base level
2	.13372364***	.08699614***	.1470114***
3 (and for townhouses and apartments, also 4 or more)	.34615436***	.15741307***	.20428016***
4 or more (houses only)	.27040289***	N/A	N/A
Number of car spaces			
0	Base level	Base level	Base level
1	-0.00348227	-0.01742629	.19860657***
2	.02565614***	.08813087***	.36124463***
3 (and for townhouses and apartments, also 4 or more)	.05512902***	-0.01715609	.2007254***
4 or more (houses only)	-.01591689***		
Other characteristics			
Ln(land area)	.19138001***	.05371182***	(omitted)
Ln(floor area) (houses only)	.07067912***	(omitted)	(omitted)
Ln(job access density by private vehicle)	.08865734***	.09004347***	.19879653***
Job access density by public transport	8.315e-07***	6.159e-07***	2.412e-07***
Within 800m of a metropolitan centre	-.14064525***	-.22847642***	-.15251359***
Within 800m of a major activity centre	.08299871***	-.01191568***	-0.00413337
Within 800m of the Central City (i.e. CBD)	-.68467402***	0.1818724	-.07711755***
Within 250m of an arterial road	.06864507***	.04186997***	0.00385961
Within 100m of an arterial road	.00999342***	-.01198159***	-.0205262***
Ln(distance to the coast)	-.11300399***	-.09007169***	-.07444449***

Note: Asterisks indicate that the variable is significant at a particular level of significance threshold, as follows: * = 10 per cent, ** = 5 per cent, *** = 1 per cent.

Source: CIE.

Based on these outputs, in the housing model we apply the relationships between accessibility and values shown in table L.10. Note that the impact of private vehicle accessibility to jobs is applied in a multiplicative fashion. For example, a 1 per cent increase in job access density by private vehicle is associated with an approximately 0.089 per cent increase in separate house values. A 10 000 unit increase in public transport accessibility is associated with a 0.83 per cent increase in separate house values.

L.10 Coefficient on job access density by mode and dwelling type

Mode	Link function	Separate house	Attached	Low rise apartments	Medium rise apartments	High rise apartments	Other
Private vehicle	log	0.089	0.090	0.199	0.199	0.199	0.089
Public transport	linear	8.315E-07	6.159E-07	2.412E-07	2.412E-07	2.412E-07	8.315E-07

Source: CIE.

M Detailed assumptions for assessment of economic impacts

Industry groupings

Industries are grouped into knowledge (which uses office space), population serving (which uses retail space), industrial (which uses industrial space) and health and education. Health and education space is not estimated, as a large part of this is government provided and is considered in cost estimates. The alignment of industries in the scenarios and the broader groupings for the purposes of considering non-residential space is shown in table M.1.

M.1 Industries in scenarios to broad categories of non-residential space

Scenario industry	Included in space estimates	Broad category	Broad category used
Agriculture	No	NA	NA
Business & Government Services	Yes	Knowledge	Knowledge
Construction	No	NA	NA
Hospitals	No	Health and education	NA
Leisure	Yes	Population serving	Population serving
Medical, Social & Community services	No	Health and education	NA
Retail Hospitality	Yes	Population serving	Population serving
School Education	No	Health and education	NA
Tertiary Education	No	Health and education	NA
Traditional Industrial	Yes	Industrial	Industrial

Source: CIE.

Floor space per job

Floor space per job is used to convert the job estimates to floor space requirements. The estimates used are shown in table M.2. The study adopts similar estimates to previous work for NSW Department of Environment and Planning in Sydney. The exception is that a lower estimate is used for population serving jobs to broadly calibrate with Victorian Valuer General data on the total value of commercial (including retail) property.

Note that in reality space per person will vary across areas depending on cost. For example, it would be expected that there would be higher floor space per job in outer suburbs and regional areas as compared to the inner city. The same benchmarks are used so that the value of new space is on a comparable basis wherever it is provided.

M.2 Floor space per job

	City of Sydney study	NSW DPE	This project
	m2/job	m2/job	m2/job
Health and education	44.4	40	40
Industrial	93.9	100	100
Knowledge	22.7	30	30
Population serving	51.7	55	25

Source: The CIE 2020, Western Sydney Place Based Infrastructure Compact, https://gsc-public-1.s3-ap-southeast-2.amazonaws.com/s3fs-public/appendix_6_-_economic_evaluation_pic_2.pdf?YI2OKoda1ZmXFIXYZH3cXVDJurKoxcM.; The CIE;

Cost of constructing floor space

Costs of construction used are shown in table M.3. These are based on previous estimates provided for a similar project in Sydney, escalated from 2020 to 2022 dollars using the ABS Producer Price Index for Non-residential building construction Victoria.

Yields are also shown in table M.3. These are based on the implied yields from the Victorian Valuer General's outcomes report for 2022, which has an annual value and a capital improved value, and yield data collected from commercial property providers.

A high density premium is applied to development in Inner Melbourne. This estimate is based on previous benchmarking work.

M.3 Costs of construction

Costs used	Cost	Cost premium for higher density	Yield (nominal)	Yield (real)
	$/m2 of gross floor area	Per cent	Per cent	Per cent
Health and education	4,849	0%	6%	3.4%
Industrial	1,287	0%	6%	3.4%
Knowledge	4,937	42%	6%	3.4%
Population serving	3,634	0%	6%	3.4%

Source: CIE.

Additional land is only assumed for greenfield development. The shares of assumed greenfield are shown in table M.4.

M.4 Greenfield shares for new non-residential space

Area	Share Greenfield	High density premium	Cost of additional greenfield land
	Per cent		$/m2
Inner Melbourne	0%	Yes	NA
Middle Melbourne	0%	No	NA
Regional Centres and Rural Areas	100%	No	20
Regional City	95%	No	161
Outer Melbourne	2%	No	692
Melbourne New Growth Area	100%	No	530

Source: CIE.

We have sought to cross check costs with data collated by the Victorian Building Authority on construction costs. However, the ranges across the building permits were so wide (see table M.5) we did not use this data. For example, the cost of public buildings is highly skewed, with the average cost being above the 75th percentile.

M.5 Cost estimates from the Victorian Building Authority 2022

	Median	Average	25th percentile	75th percentile
	$/m2	$/m2	$/m2	$/m2
Commercial	772	8 837	280	2 312
Public Buildings	794	17 818	255	3 836
Hospital/Healthcare	4 462	7 822	1 472	9 675
Retail	1 598	10 349	648	3 552
Industrial	504	4 384	239	1 275

Note: Any development with a cost of less than $100 000 was excluded.
Source: CIE based on building permits data from the Victorian Building Authority for 2022, https://www.vba.vic.gov.au/about/data.

For development that is not greenfield, there is an assumed churn rate — that is some amount of space has to be lost in order to redevelop more space. For example, if the churn rate is 25 per cent, then for each additional 100m2 of floor space, 25m2 of floor space is demolished and has to be rebuilt. The costs apply to the demolished space as well as the additional space, while the benefits apply only to the additional space.

We have assumed a 25 per cent churn rate across all types and all non-greenfield areas. Note that any churn rate is possible within the scenarios, depending on how focused the development is.

Lease rates used

The lease rates used are shown in table M.6. These are drawn from commercial property reports, but adjusted to be on the basis of m2 of pure lease (after costs) per m2 of gross floor area. Note that health and education is excluded from the analysis as costs enter the cost side of the model for these areas. Note that the lease rates are applied to much broader regions than in the residential model, given the much lower quality of data and lack of sales data to construct spatial metrics.

M.6 Lease rates used for analysis

	Health and education	Industrial	Knowledge	Population serving
	$/m2 gross floor area	$/m2 gross floor area	$/m2 gross floor area	$/m2 gross floor area
Inner Melbourne	NA	120	450	450
Middle Melbourne	NA	100	300	350
Regional Centres and Rural Areas	NA	90	200	200
regional City	NA	90	250	250
Outer Melbourne	NA	100	250	300
Melbourne New Growth Area	NA	100	250	300

Source: CIE.

Lease rates for industrial, office and retail space from various commercial property providers are shown in tables M.7 to M.9. The rates shown vary according to what they are measuring and type of space. The estimates for the model are net effective rents per m2 of gloss floor area. Metrics provided in property reports vary as follows:

- Gross face rents — this is the amount a lease agreement states for rent plus outgoings (such as energy and cleaning)
- Net face rents — this is the amount a lease agreement states for rent but does not include outgoings
- Gross effective rents — this is the amount a lease agreement states for rent plus outgoings (such as energy and cleaning) less the amount of incentives that reduce the actual amount paid
- Net effective rents — this is the amount a lease agreement states for rent not including outgoings (such as energy and cleaning) less the amount of incentives that reduce the actual amount paid

Note that the rates stated are per m2 of space that a tenant is actually leasing so excludes common areas. For places like shopping centres, the common areas will be a substantial part of overall gross floor area.

M.7 Industrial lease rates

Region	JLL	Cushman and Wakefield	Cushman and Wakefield	Charter Keck Cramer	Charter Keck Cramer	Knight Frank	Knight Frank	CBRE
	Dec-22	Sep-22	Sep-22	NA	NA	Dec-22	Dec-22	Sep-22
	Net face rent	Net face rent	Net face rent	Net face rent	Net face rent	Net face rent	Net face rent	Net face rent
	Prime	Prime, <5000 SQM	Prime, >5000 SQM	Prime	Secondary	Prime	Secondary	Super prime
	$/m2	$/m2	$/m2	$/m2	$/m2	$/m2	$/m2	$/m2
Melbourne – North	112	110	95					95
Melbourne – South East	120	130	117.5	90	60			120
Melbourne – West	108	110	100					95
Melbourne – East		120	115	100	70			130
Melbourne – City fringe				135	77.5			
Melbourne – North and West				80	57.5			
Melbourne						126	109	
Melbourne – Inner (prime)								130

Source: JLL Australian Industrial Market Overview, 4q22, https://www.jll.com.au/en/trends-and-insights/research/australian-industrial-market-overview-4q22; Cushman and Wakefield, Market beat, https://www.cushmanwakefield.com/en/australia/insights/melbourne-marketbeat; Charter Keck Kramer, The current state of play for commercial property markets Melbourne, https://charterkc.com.au/valuations/the-current-state-of-play-commercial-property-markets-melbourne/; Knight Frank; CBRE.

M.8 Office lease rates

Region	JLL	Cushman and Wakefield	Charter Keck Cramer	Knight Frank	CBRE
	Dec-22	Dec-22	Not clear	Dec-22	Sep-22
	Gross effective rent	Net effective rent	Net face rent	Net effective rent	Net effective rent
	Prime	Prime	Prime	Prime	Prime
	$/m2	$/m2	$/m2	$/m2	$/m2
Melbourne CBD	500	410	700	409	399
Melbourne City Fringe	450		450	315	
Melbourne South East Suburbs	360				
Suburban			390		
St Kilda Rd				342	
Metro Inner East				360	
Metro Outer East				296	
Metro South East				195	
Metro North and West				214	

Source: JLL ; Cushman and Wakefield, Market beat, https://www.cushmanwakefield.com/en/australia/insights/melbourne-marketbeat; Charter Keck Kramer, The current state of play for commercial property markets Melbourne, https://charterkc.com.au/valuations/the-current-state-of-play-commercial-property-markets-melbourne/; Knight Frank; CBRE.

M.9 Retail lease rates

Region	Type	Charter Keck Cramer Not clear Net face rent	CBRE Sep-22 Net face rent
		$/m2	$/m2
Melbourne CBD	CBD	3500	7250
Melbourne	Regional centres	1325	1445
Melbourne	Sub-regional centres	975	
Melbourne	Neighbourhood centres	625	
Melbourne	Prime strips	1075	
Melbourne	Large format	240	300

Source: Charter Keck Kramer, The current state of play for commercial property markets Melbourne, https://charterkc.com.au/valuations/the-current-state-of-play-commercial-property-markets-melbourne/; CBRE.

The lease rates and m2 per job used have been broadly adjusted to give alignment between overall Victorian Valuer General estimates of capital improved value for industrial and commercial property. A comparison across region types is shown in table M.10. Chart M.11 shows a comparison for industrial value for each LGA and chart M.12 shows a comparison for commercial (including retail) for each LGA.

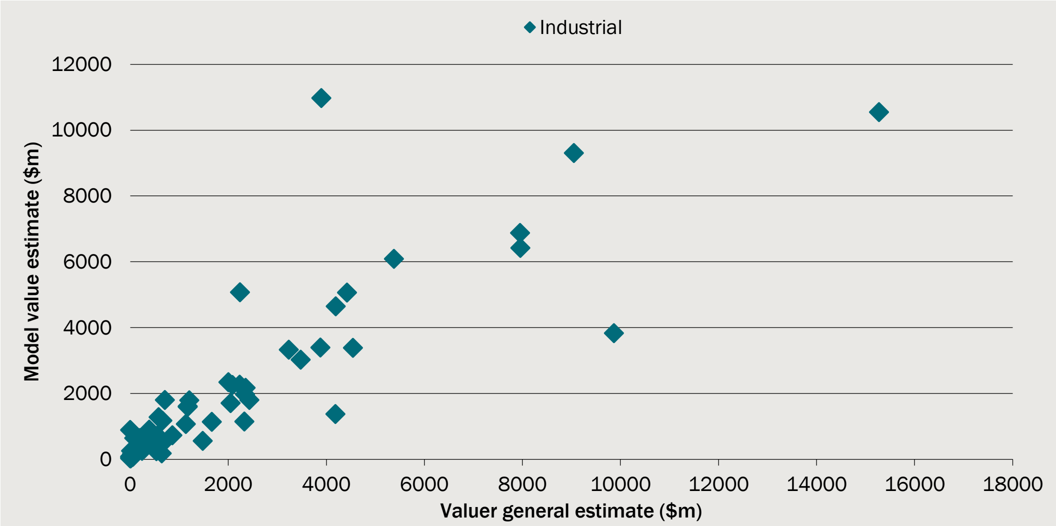
- The benchmarks perform relatively well, given the number of assumptions made to get to them.
- Industrial somewhat overstates value in Melbourne City, likely because of much lower metres per job in Melbourne City industrial areas.

M.10 Comparison of Valuer General and model capital improved value estimates by region type

	Inner Melbourne	Middle Melbourne	Regional Centres and Rural Areas	Regional City	Outer Melbourne	Melbourne New Growth Area	Total
	$B	$B	$B	$B	$B	$B	$B
Commercial							
Model	125 870	72 245	17 450	15 070	41 053	4 067	275 755
Valuer General	115 301	61 940	21 624	16 007	38 456	3 305	256 632
Industrial							
Model	22 497	40 596	13 104	8 008	39 445	2 284	125 934
Valuer General	12 381	43 363	13 388	5 977	47 320	4 000	126 429

Note: The model uses a constant assumptions of m2 per job so would be expected to deviate in inner areas in particular.
Data source: The CIE and Valuer General 2022 Outcome Summary, https://www.land.vic.gov.au/valuations/resources-and-reports/revaluation-2020-outcomes.

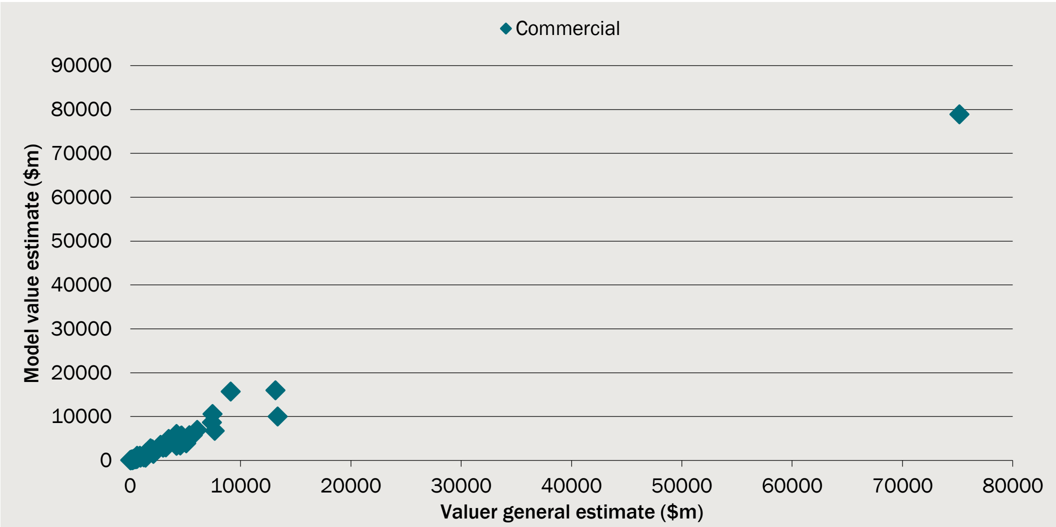
M.11 Capital improved value for Industrial property — model versus Valuer General estimates



Note: The outlier to the top left is Melbourne City and the top right is Dandenong.

Data source: The CIE and Valuer General 2022 Outcome Summary, https://www.land.vic.gov.au/valuations/resources-and-reports/revaluation-2020-outcomes.

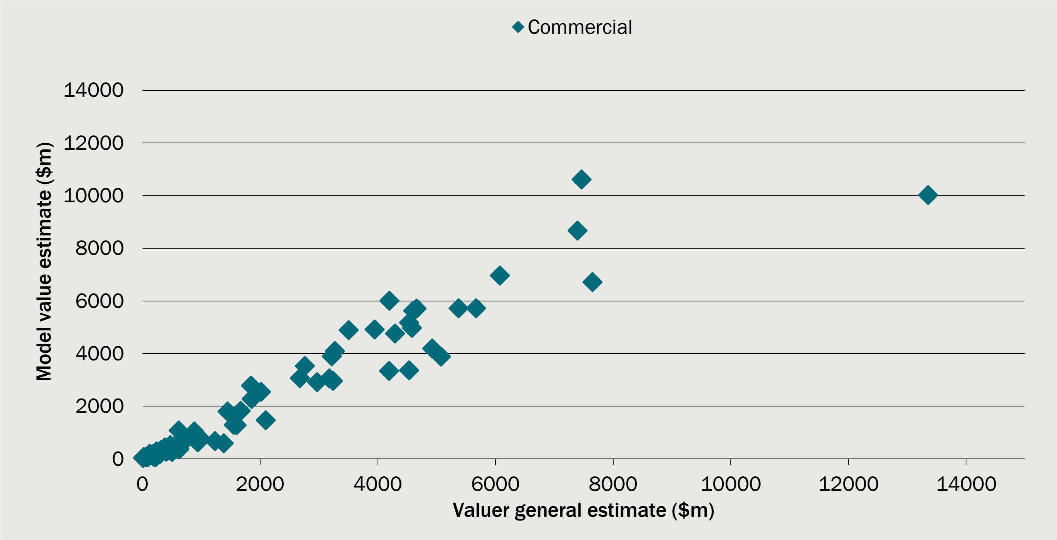
M.12 Capital improved value for Commercial property — model versus Valuer General estimates



Note: The outlier to the right is Melbourne City.

Data source: The CIE and Valuer General 2022 Outcome Summary, https://www.land.vic.gov.au/valuations/resources-and-reports/revaluation-2020-outcomes.

M.13 Capital improved value for Commercial property — model versus Valuer General estimates excluding Melbourne City



Note: The outlier to the right is Stonnington..

Data source: The CIE and Valuer General 2022 Outcome Summary, https://www.land.vic.gov.au/valuations/resources-and-reports/revaluation-2020-outcomes.

Impacts of accessibility on willingness to pay

CIE has previously found that accessibility to jobs and population can be a driver of commercial and industrial land values. In Sydney, a 1 per cent increase in accessibility to jobs (i.e. job density) was found to increase commercial land values by 0.992 per cent and to increase industrial land values by 0.583 per cent.[190] Access to the labour force — i.e. accessibility to people[191] — was not statistically significant for commercial property but was for industrial. The statistical significance of population accessibility was more sensitive than job accessibility, with prior econometrics having found a statistically significant relationship.

For this project, data from the Valuer General on sales transactions and land values was not available to estimate Melbourne specific impacts.

Given the paucity of data, we apply the factors estimated for Sydney to property values for Melbourne. The Sydney values were based on land, so the impacts are reduced by the share of land value in property value, based on Victorian Valuer General averages.

190 The CIE 2020, Western Sydney Place Based Infrastructure Compact, https://gsc-public-1.s3-ap-southeast-2.amazonaws.com/s3fs-public/appendix_6_-_economic_evaluation_pic_2.pdf?YI2OKoda1ZmXFIXYZH3cXVDJurKoxcM.

191 Accessibility from public transport was statistically significant rather than by car.

M.14 Impact of accessibility on willingness to pay

	Commercial	Industrial
	Impact of 1 per cent improvement	Impact of 1 per cent improvement
Accessibility to other jobs (by car)	0.992	0.583
Accessibility to labour market (by public transport)	0.000	0.217

Source: The CIE 2020, Western Sydney Place Based Infrastructure Compact, https://gsc-public-1.s3-ap-southeast-2.amazonaws.com/s3fs-public/appendix_6_-_economic_evaluation_pic_2.pdf?YI2OKoda1ZmXFIXYZH3cXVDJurKoxcM

N Measuring GHG emissions

Operational emissions

Measuring operational emissions for each scenario requires the following pieces of information:

- Total energy demand in the scenario. This will be determined by
  - the dwelling types being constructed
  - the number of new dwellings in each climate zone, and
  - the number of people living in those dwellings (occupancy rates)
- Emissions intensity of energy use. That is, how many kilograms of CO2 or CO2 equivalent gas is released for each unit of energy consumed

Once these elements have been established, they are multiplied together (adjusting for unit changes) to get estimates for total tonnes of CO2-equivalent GHG released.

Energy emissions intensity

Emissions associated with one unit of energy consumption need to be calculated separately for electricity, gas and firewood.

Emissions from electricity change dramatically over time as the grid decarbonises.

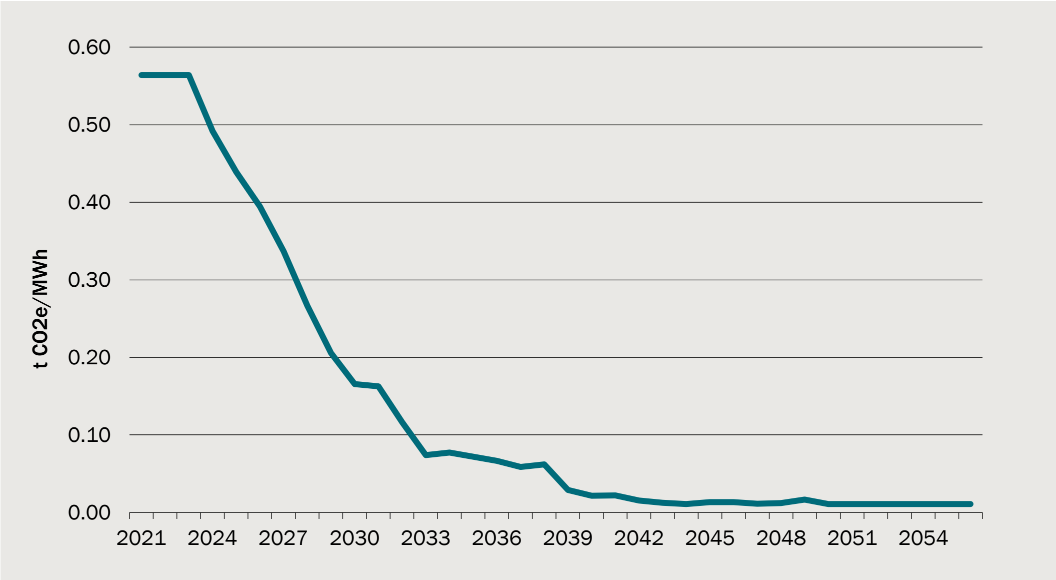
Forecasts of electrical emissions intensity to 2050 were taken from the 2022 Integrated Systems Plan from AEMO.[192] These emissions intensity forecasts align closely to Victorian government targets for renewable energy by 2035. Chart N.1 shows this change over time.

By 2036 electricity drawn from the grid is almost entirely decarbonised. This means that differences in electricity use across scenarios, either from buildings or from vehicles, will not have much of an impact on total emissions.

Further, differences between 2021 and 2036 are much more impactful than differences between 2036 and 2056.

192 AEMO 2022 Integrated Systems Plan, Generation outlook, https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2022-integrated-system-plan-isp, accessed 14 July 2023

N.1 Electrical emissions intensity over time



Data source: AEMO 2022 ISP.

Estimates for electricity intensity for gas and firewood were drawn from the DCCEEW report on GHG accounts factors.[193] It was assumed that the emissions intensity of both gas and firewood stays constant over time (table N.2).

N.2 Emissions intensity for gas and firewood

	CO2	CH4	N2O
	kg CO2-e/GJ	kg CO2-e/GJ	kg CO2-e/GJ
Natural gas distributed in a pipeline	51.4	0.1	0.03
Dry wood	0	0.1	1.1

Source: DCCEEW 2023.

Energy demand

The amount of **energy used per person** depends partly on the climate in which the building is located, and partly on the energy efficiency of the building itself. Climates with more extreme temperatures are associated with higher energy used per person, and the better insulated a building is, the less energy used.

In each scenario, we know the number of new dwellings in each climate zone, grouped into:

- Detached dwellings
- Attached dwellings
- Low rise apartments

193 DCCEEW 2023, National Greenhouse Accounts Factors, https://www.dcceew.gov.au/climate-change/publications/national-greenhouse-accounts-factors-2022, accessed 14 July 2023

- Medium rise apartments
- High rise apartments
- Other

Due to data availability, it was necessary to group some of these categories together. We used two final categories, using NCC building classifications.[194]

- Detached dwellings, attached dwellings and other were classified as class 1
- Low rise apartments, medium rise apartments and high rise apartments were classified as class 2

Table N.3 shows the energy demand over a year in each climate zone for the two building classes.[195] These numbers are based on data provided by ABCB and ACIL Allen, drawn from analysis underpinning the NCC 2022 residential building energy efficiency decision regulatory impact statement.[196]

Class 1 and class 2 dwellings have very similar energy use per household. However, table N.4 shows that class 2 dwellings have substantially higher energy demand per person, as occupancy rates in class 2 dwellings are lower on average (see table N.11).

In these tables, we report electricity drawn from the grid, as opposed to total energy, which may include energy drawn from private solar panels. Solar energy is excluded as it does not produce emissions.

N.3 Total yearly energy use per dwelling

	Climate zone 4	Climate zone 6	Climate zone 7
	MJ per year	MJ per year	MJ per year
Class 1			
Electricity from the grid	10 720	11 843	12 029
Gas	7 492	9 177	9 543
Firewood	538	986	9 543
Total	**18 750**	**22 006**	**22 818**
Class 2			
Electricity from the grid	11 134	11 904	13 526
Gas	7 599	9 309	9 628
Firewood	0	0	0
Total	**18 733**	**21 212**	**23 153**

Note: Data was not provided on energy demand for class 2 buildings in climate zone 4. Instead, this was calculated assuming the ratio of energy use between climate zones 4 and 6 is the same for class 1 and class 2 dwellings.

Source: CIE, based on data provided by ABCB and ACIL Allen.

194 See https://www.abcb.gov.au/sites/default/files/resources/2022/UTNCC-Building-classifications.PDF, accessed June 14, 2023

195 Climate zone 8 which represent the top of mountains in Victoria, was excluded from our analysis, as the housing model has no new dwellings being added to climate zone 8 in Victoria

196 https://abcb.gov.au/ncc-2022-residential-energy-efficiency-final-decision-ris, accessed June 14,2023

N.4 Total yearly energy use per person

	Climate zone 4	Climate zone 6	Climate zone 7
	MJ/year/person	MJ/year/person	MJ/year/person
Class 1			
Electricity	4 870	4 801	4 880
Gas	3 403	3 720	3 871
Firewood	244	400	506
Total	**8 517**	**8 920**	**9 257**
Class 2			
Electricity	6499	6230	7884
Gas	4436	4872	5612
Firewood	0	0	0
Total	**10935**	**11102**	**13495**

Note: Data was not provided on energy demand for class 2 buildings in climate zone 4. Instead, this was calculated assuming the ratio of energy use between climate zones 4 and 6 is the same for class 1 and class 2 dwellings.

Source: CIE, based on data provided by ABCB and ACIL Allen.

The result that class 2 dwellings use more energy per person than a class 1 dwelling is perhaps surprising, considering that often houses are cited as having higher energy use per person than an apartment (see for instance Rickwood 2009[197]).

The driver of this result is the new energy efficiency standards for Victoria, in which apartments are given a higher allowance for energy than a house of the same size. Using the NCC Whole of Home Calculator tool[198], we can see that a 150 square meter house in climate zone 6 has a net energy usage allowance of 2.4, while a 150 square meter apartment has net energy usage allowance of 3.4.

Using average house and apartment sizes (see the end of this appendix), we find that an average house has 25 per cent higher energy usage allowance. However, a house in climate zone 6 has on average about 30 per cent more people than an apartment (see occupancy rates section of this appendix), meaning that **under new energy efficiency standards, energy usage allowance per person is higher for apartments**.

To model the electrification process, we assumed gas use decreases over time, being replaced by additional electricity use (chart N.5).

Total gas consumption was multiplied by an index calibrated to match AEMO's forecasted residential and commercial annual gas consumption in the 'orchestrated step change' scenario from their GSOO 2023 publication[199]. The forecast ends in 2042, so to

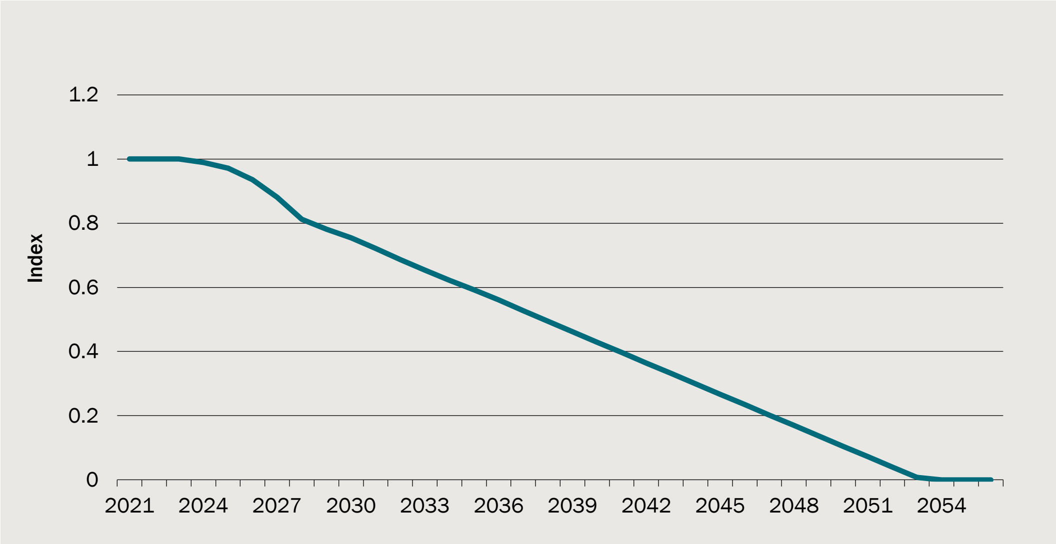
197 Rickwood, Peter. (2009). Residential Operational Energy Use. Urban Policy and Research. 27. 10.1080/08111140902950495

198 NCC 2023, https://www.abcb.gov.au/resource/calculator/ncc-whole-home-calculator, Accessed 1 August 2023

199 AEMO 2023, http://forecasting.aemo.com.au/Gas/AnnualConsumption/Total, Accessed 14 July 2023

extend the index to 2056, a linear forecast was used, with no gas use being achieved in 2054. Chart O.5 shows the index applied to gas.

N.5 Decrease in gas consumption over time



Data source: CIE based on AEMO.

Treatment of solar PV

One difference between class 1 and class 2 dwellings under the most recent energy efficiency standards is that more class 1 dwellings have solar panels. Under the 2022 residential energy efficiency regulations, each class 1 dwelling in Victoria is assumed to have at least some PV use. On the other hand, no class 2 dwelling is assumed to use any solar power (see table N.6).

N.6 New dwelling type distribution

	High PV use	Moderate PV use	Moderate PV use and a pool	No PV use
Class 1	27.3%	70.4%	2.3%	0%
Class 2	0%	0%	0%	100%

Note: Dwellings with a pool were included because they have a substantially higher energy use than other dwelling types.
Source: ABCB and ACIL Allen.

In our analysis, we assume that these ratios stay constant for new dwellings built over time, though we add a sensitivity to test the impact of all class 2 dwellings having moderate PV use.

The difference between total electricity and electricity drawn from the grid across each climate zone is shown in table N.7. We show a sensitivity in which total electricity is used for calculating emissions rather than electricity from the grid. This scenario would be consistent with an assumption that overall grid decarbonisation is independent of the rate of residential solar PV uptake.

Instead, for our central estimates, **we assume that a higher uptake of residential PV will result in faster overall decarbonisation across the state**. This allows us to make meaningful comparisons across scenarios.

N.7 Impact of PV on electricity drawn from the grid

		Class 1		Class 2
	Total electricity	From the grid	Total electricity	From the grid
	MJ/year	MJ/year	MJ/year	MJ/year
Climate zone 4	14550	10720	10775	10775
Climate zone 6	15556	11843	11904	11904
Climate zone 7	16421	12029	13526	13526

Source: CIE, based on data provided by ABCB and ACIL Allen.

Number of new dwellings

The number of new dwellings constructed in each climate zone across each of the five scenarios was drawn from the housing model. To make comparisons across scenarios clearer, and to maintain consistent with our measurement approach for embodied emissions (see below), we exclude operational emissions from the existing housing stock.

To avoid all new dwellings being built at the same time in 2036 and 2056, the total new buildings at 2036 were spread evenly between 2022 and 2036, and the total new buildings at 2056 were spread evenly between 2037 and 2056.

N.8 Number of new dwellings by class and scenario

	2021 to 2036	2036 to 2056	Total
	No. dwellings	No. dwellings	No. dwellings
Class 1			
Scenario 1	407,907	482,599	890,506
Scenario 2	522,458	581,340	1,103,798
Scenario 3	608,447	791,378	1,399,825
Scenario 4	570,803	737,319	1,308,123
Scenario 5	589,114	870,107	1,459,221
Class 2			
Scenario 1	313,345	602,852	916,197
Scenario 2	198,793	494,084	692,878
Scenario 3	112,805	296,090	408,895
Scenario 4	150,448	350,149	500,598
Scenario 5	132,138	217,361	349,500

Source: CIE.

Because emissions intensity is so low beyond 2036, results for operational (and embodied) energy are primarily driven by new dwellings added from 2021 to 2036. In this time, scenario 3 has the highest number of class 1 dwellings, even above scenario 5, which has the highest total number of class 1 dwellings. Scenario 1 has the fewest class 1 dwellings in every time period.

Once constructed, each new dwelling will contribute towards total operational energy every year until it is demolished. We assume that no new buildings are demolished before 2056. This means that every year, the total emissions are determined by the total number of new buildings constructed between 2021 and that year, and the emissions factor for that year.

Occupancy rates

To get to an estimate of total energy use for each scenario, we also need to know how the occupancy rates (on average, the number people living in a dwelling) for each dwelling changes over time. Estimates for average occupancy rates were obtained using data on new dwellings and population in 2036 and 2056 drawn from the housing model[200].

These occupancy rates were used to find forecasted occupancy rates for scenario 1, climate zone 6. Next, the occupancy rates from the housing model were used to find relativities across climate zones and across scenarios for class 1 and class 2 dwellings. These are shown in tables N.9 and N.10 respectively. All other occupancy rates were then calculated by multiplying scenario 1, climate zone 6 occupancy rates (shown in table N.11) by the relevant relativities[201].

Between scenarios, scenario 1 generally has the highest average occupancy rates, with high rates across both class 1 and class 2 dwellings. Scenario 5 has the lowest occupancy rate for class 1 and the highest for class 2. This is due in part to so few new class 2 dwellings being built in scenario 5. Scenario 1 has relatively high occupancy rates in both dwelling classes, which ultimately contributes towards its high emissions from buildings relative to other classes.

N.9 Change in occupancy rates relative to climate zone 6

Climate zone	2021	2036	2056
Class 1			
Climate zone 4	0.89	0.83	0.82
Climate zone 6	1.00	1.00	1.00
Climate zone 7	1.00	0.96	0.95

200 A regression was run for 2036 and 2056 where the dependent variable was the population and the independent variable was the number of dwellings, controlling for building class and climate zone.

201 On top of this, we assumed that all change in average occupancy rates is achieved through changes in the occupancy of new dwellings. This means that an increase in overall occupancy rates can only be achieved by a larger increase in occupancy rates for new dwellings, with no change for existing stock. Finally, an adjustment was made to ensure that the implied added population remained the same across all scenarios.

Climate zone	2021	2036	2056
Class 2			
Climate zone 4	0.90	0.96	1.00
Climate zone 6	1.00	1.00	1.00
Climate zone 7	0.90	1.05	0.96

Source: CIE.

N.10 Change in occupancy rates relative to scenario 1

Scenario	2021	2036	2056
Class 1			
Scenario 1	1.00	1.00	1.00
Scenario 2	1.00	1.00	0.99
Scenario 3	1.00	1.00	1.01
Scenario 4	1.00	0.99	0.98
Scenario 5	1.00	0.97	0.93
Class 2			
Scenario 1	1.00	1.00	1.00
Scenario 2	1.00	0.97	0.99
Scenario 3	1.00	0.92	0.91
Scenario 4	1.00	0.99	0.98
Scenario 5	1.00	1.05	1.19

Source: CIE.

N.11 Forecasted occupancy rates for scenario 1 climate zone 6

	2021	2036	2056
	No. people per dwelling	No. people per dwelling	No. people per dwelling
Class 1	2.47	2.63	2.54
Class 2	1.91	1.82	1.96

Source: CIE.

Embodied emissions

Calculating embodied emissions requires two components:

- The total volume of dwellings constructed in each scenario, determined by:
  - the number of new dwellings, and
  - the average floor area of each new dwelling
- GHG emissions factors for each square metre of construction, by dwelling type

As with operational emissions, these numbers are multiplied to get estimates for total tonnes of CO2-equivalent gasses.

Different materials used in construction will result in different emissions being produced. A dwelling that is made from predominantly timber and brick will result in far less GHG emission than a dwelling made from concrete and steel. This is because the production processes associated with concrete and steel are much more emissions intensive than other materials[202].

With operational emissions, we sorted new buildings into either class 1 or class 2. However, for embodied emissions, it is important to be able to distinguish between different types of dwelling structure within these classes, and so the original building types were kept separate.

Emissions factors for each building type were sourced from Thinkstep-ANZ and GBCA (2021)[203]. They report embodied emissions rates per square metre of building construction separately for class 1 and class 2 dwellings. They also have forward estimates for the rate at which embodied emissions decline over time[204].

However, while their class 1 dwelling embodied emissions estimates are based on a representative sample of Victorian class 1 dwellings, class 2 estimates are based off a single type of apartment building. Embodied emission rates increase as the height of the building increases, as more material is needed in the foundation and other stabilising components[205].

To account for this, we drew on a separate study of Australian embodied emissions by Prasad et al. which has separate estimates for medium and high rise apartments[206]. To get our embodied emission rate for high rise apartments, we applied the ratio of high to medium rise apartments found in Prasad et al. to the thinkstep-anz class 2 estimate[207].

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202 DCCEEW 2022. More timber in construction to lower emissions. https://www.energy.gov.au/news-media/news/more-timber-construction-lower-emissions, accessed 14 July 2023

203 GBCA and thinkstep-anz (2021). Embodied Carbon and Embodied Energy in Australia's Buildings, https://www.thinkstep-anz.com/resrc/reports/embodied-carbon-and-embodied-energy-in-australias-buildings-gbca/

204 Forward estimates are given for an average of class 1 and class 2 emissions. We assumed that emissions factors decrease for each dwelling class at the same rate. This is a fairly uncertain assumption, and so should be treated with caution.

205 Du, Peng & Wood, Antony & Stephens, Brent & Song, Xiaoyu. (2015). Life-Cycle Energy Implications of Downtown High-Rise vs. Suburban Low-Rise Living: An Overview and Quantitative Case Study for Chicago. Buildings. 5. 1003-1024. 10.3390/buildings5031003.

206 Prasad, Deo & Dave, Malay & Kuru, Aysu & Oldfield, Philip & Ding, Lan & Noller, Caroline & He, Bao-Jie. (2021). Race to Net Zero Carbon: A climate emergency guide for new and existing buildings in Australia, https://www.researchgate.net/publication/356717453_Race_to_Net_Zero_Carbon_A_climate_emergency_guide_for_new_and_existing_buildings_in_Australia

207 We chose to use thinkstep-anz over Prasad et al. for our point estimate because Prasad used an input-output (IO) method rather than the process-based method used by thinkstep-anz. IO methods sometimes yield estimates which are much larger than is supported by the emissions factors of the actual building materials, and so are generally less favoured in Australia.

N.12 Embodied emissions intensity for different dwelling types

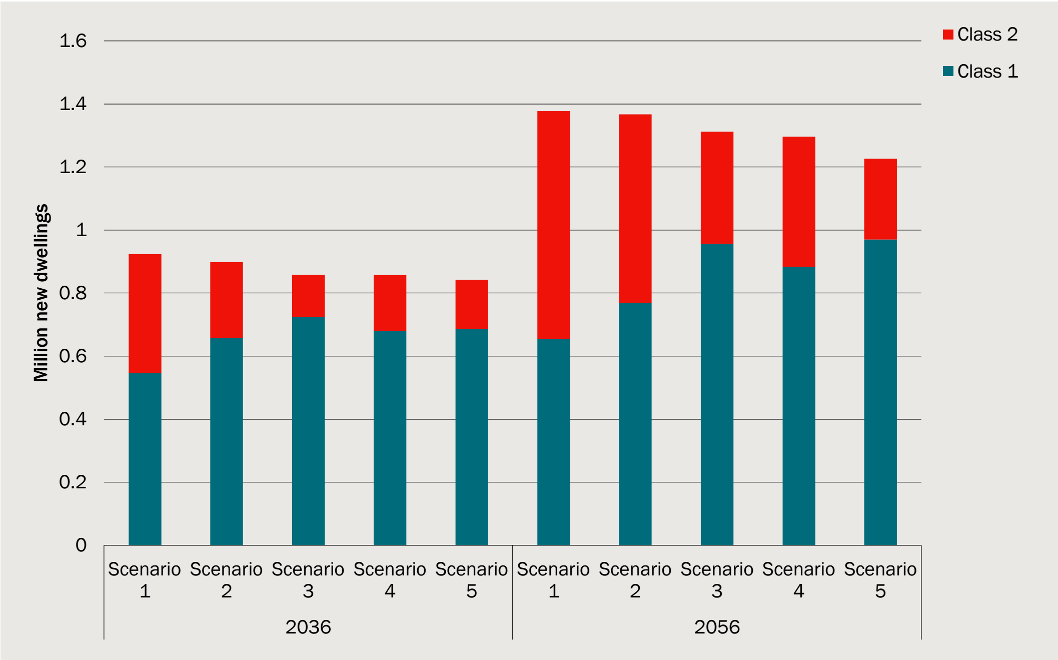
	2021	2025	2030	2040	2056
	kg CO2e/m2	kg CO2e/m2	kg CO2e/m2	kg CO2e/m2	kg CO2e/m2
Class 1	192	177	162	147	131
Class 2 low/mid rise	330	308	288	267	246
Class 2 high rise	560	539	518	497	418

Source: CIE analysis based on GBCA and Thinkstep-anz (2021) and Prasad et al. (2021).

Like operational emissions, calculating embodied emissions requires knowing the total **number of new dwellings** constructed each year. However, unlike operational emissions, rather than needing the net new dwellings (the final number of new dwellings), operational emissions requires knowing gross new dwellings (the total number of buildings added, including buildings added to replace demolished buildings).

In each scenario, the number of buildings demolished changes depending on how much infill development is occurring. Higher density housing requires demolishing more units, and thus more buildings added in total to reach the same net new dwellings. Gross new dwellings by scenario are shown in chart N.13. It is highest for the compact city scenario, and lowest for the distributed state scenario.

N.13 Gross new dwelling construction by scenario



Data source: CIE.

The **average floor area** for each dwelling is calculated based on the occupancy rate. We assume that floor space per person will stay constant over time. For instance, if the number of people living in a house increases from 2 to 3 on average, we increased the embodied emissions generated by that house by 50 per cent.

Table N.14 shows the initial average floor areas. These were taken from ABS building activity data from 2023[208].

N.14 Average floor size by dwelling type

	Average floor size
	m2
Houses	240.8
Townhouses	170.6
Apartments	114.9

Source: ABS Building activity 2023.

208 ABS April 2023, Average Floor Area of New Residential Dwellings, https://www.abs.gov.au/articles/average-floor-area-new-residential-dwellings

O Estimating changes in land take

Urban Area definition

O.1 Meshblock included as Urban Area by Functional Urban Area

MB_CAT21	Regional City	Regional Centres and Rural Areas	Inner Melbourne	Middle Melbourne	Outer Melbourne	Melbourne New Growth Area
Education	✓	✓	✓	✓	✓	✓
Commercial	✓	✓	✓	✓	✓	✓
Residential	✓	✓	✓	✓	✓	✓
Parkland	✓[a]	✓[a]	✓	✓	✓	✓
Water	×	×	×	×	×	×
Primary Production	×	×	×	×	×	×
Other	✓	✓	✓	✓	✓	✓
Industrial	✓	✓	✓	✓	✓	✓
Hospital/Medical	✓	✓	✓	✓	✓	✓
Transport	✓	✓	✓	✓	✓	✓
SHIPPING	×	×	×	×	×	×
MIGRATORY	×	×	×	×	×	×
OFFSHORE	×	×	×	×	×	×
NOUSUALRESIDENCE	×	×	×	×	×	×

[a] Includes only parkland which is not defined as conservation or reserves.

Source: ABS Meshblock 2021

Objective of the analysis

We have estimated the amount of land take associated with development in greenfield areas. Land take refers to the amount of land newly used for dwellings, infrastructure and employment purposes.

In greenfield areas, land take for dwellings, infrastructure and employment purposes comes at the expense of land used for agriculture or sometimes natural/semi-natural open space.

We do not estimate any changes to land take in established (i.e. non-greenfield) areas. Land in established areas is already being used for some purpose, and development will come at the expense of land already used for dwellings, infrastructure and employment purposes. While there is some natural/semi-natural open space, it is more limited in established areas and unlikely to be developable. Hence, it's reasonable to assume that there is no change to land take for dwelling, infrastructure or employment purposes in established areas.

Land take by dwellings

Data sources

State of the Land greenfield single dwelling lot size

The Urban Development Institute of Australia (UDIA) *State of the Land 2023* publication[209] states that the median lot size of greenfield single dwellings in 2022 is 352 square metres.[210] This includes both detached and attached single dwellings, but excludes multi-unit dwellings such as apartments.

Distribution of site area per dwelling from ABS data

Data about site area per dwelling by type of dwelling is available from the Australian Bureau of Statistics *Land and Housing Supply Indicators*, publication.[211] Dwellings are classified based on the Functional Classification of Buildings (FCB). This data relies on counting the number of building approvals, the number of dwellings approved, and size of each lot for which there is an approval. The publication reports the number of dwellings that are in lots of different size bands and by SA2. We have classified SA2s into regions such as Inner Melbourne and Melbourne new growth areas. We convert the number of dwellings in each size band to an average lot size per dwelling (table O.2).[212]

The site area per dwelling for all areas looks reasonable, except for Regional Centres and Rural Areas, for which an average site area per dwelling of 1217m^2 seems unrepresentative of typical greenfield development. This may be due to a high

209 UDIA, 2023, *State of the Land 2023: National Residential Greenfield and Apartment Market Study*, released March 2023, available at: https://udia.com.au/wp-content/uploads/2023/03/State-of-the-Land-2023_Digital-Version-FINAL.pdf

210 UDIA (2023), p.62.

211 Australian Bureau of Statistics, 2022, *Land and Housing Supply Indicators*,

212 Since site area per dwelling in this publication is reported in bands, we assume the average site area within each band, and then calculate a weighted average site area per dwelling based on the number of dwellings of each size. For example, lots between 200-400m2 are assumed to be 250m2 on average. To illustrate the calculation, there are 151 apartments in regional cities that are in lots under 200m2 per dwelling (assume 150m2 on average) and 22 on lots between 200-400m2 per dwelling. This implies a weighted average site area per dwelling of 163m2 per dwelling for apartments in regional cities.

representation of knock-down-rebuilds in these areas, which would be existing lots with large site areas per dwelling. In contrast, we are seeking to apply these parameters to estimate the size of new dwellings, which would be on rezoned lots and likely to have smaller site area per dwelling.

O.2 Average site area per new dwelling in *Land and Housing Supply 2022* publication

Region category	Detached	Attached	Apartment	All types
	Sqm	Sqm	Sqm	Sqm
Inner Melbourne	472	195	150	180
Middle Melbourne	558	237	152	289
Outer Melbourne	743	294	152	530
Melbourne New Growth Area	372	230	150	364
Regional City	678	309	163	627
Regional Centres and Rural Areas	1217	302	N/A	1084

Source: ABS *Land and Housing Supply Indicators 2022*, CIE.

UDP Regional Greenfield 2022 rezoned lot size

As a cross-check on the site area per dwelling for Regional Centres and Rural Areas, we have estimated the average size of rezoned regional lots from data provided together with the UDP Regional Greenfield 2022 report. Only some of these regions are regional centres or rural areas rather than regional cities, namely:

- Baw Baw,
- Macedon Ranges
- Latrobe
- Surf Coast

The average size of rezoned lots in regional centres or rural areas, excluding Surf Coast which has very little development (95 lots), is 645 square metres. If all regional areas are considered, including regional cities and Surf Coast, the average rezoned lot size is 645 square metres (table O.3).

O.3 Average size of rezoned regional lots

Region	Less than 300m2 (=250m2)	300-499m2 (=400m2)	500-649m2 (=575m2)	650-799m2 (=725m2)	800m2 or more (=900m2)	Average across all bands
	Number	Number	Number	Number	Number	sqm
Greater Geelong	1 513	6 986	2 630	516	412	450
Ballarat	219	2 627	3 253	628	281	526
Greater Bendigo	44	289	908	848	319	644
Macedon Ranges	48	95	239	219	254	672
Baw Baw	94	248	1 363	768	454	640

Region	Less than 300m2 (=250m2)	300-499m2 (=400m2)	500-649m2 (=575m2)	650-799m2 (=725m2)	800m2 or more (=900m2)	Average across all bands
	Number	Number	Number	Number	Number	sqm
Latrobe	181	111	492	556	325	642
Mildura	66	181	464	423	167	625
Horsham	20	50	36	136	139	707
Surf Coast	0	0	0	0	95	900
All councils	**2 185**	**10 587**	**9 385**	**4 094**	**2 446**	**535**
Regional Centres (Baw Baw, Macedon Ranges and Latrobe)	**323**	**454**	**2 094**	**1 543**	**1 033**	**645**

Source: UDP Regional Greenfield 2022, available at: https://www.planning.vic.gov.au/land-use-and-population-research/urban-development-program/regional-greenfield-2022

Assumed site area per dwelling in our modelling

Table O.4 shows the land take we assume per dwelling in greenfield areas.

For all areas except detached houses in Regional Centres and Rural Areas, we assume that site area per dwelling is as per the average size from ABS's *Land and Housing Supply Indicators* publication. For detached lots in Regional Centres and Rural Areas, we assume they have the same site area per dwelling as detached dwellings in Regional Cities per table 1, which is 678 square metres. This is based on the data from UDP Regional Greenfield 2022, from which we conclude that the site area per dwelling from *Land and Housing Supply Indicators* for detached dwellings in Regional Centres and Rural areas is unlikely to be reflective of the pattern of typical greenfield development.

For apartments in Regional Centres and Rural Areas, we assume that site area per dwelling is the same as in Regional Cities.

O.4 Average site area per new dwelling assumed in our modelling

Region category	Detached	Attached	Apartment
	Sqm	Sqm	Sqm
Melbourne New Growth Area	372	230	150
Regional City	678	309	163
Regional Centres and Rural Areas	678	302	163

Source: CIE.

Land take associated with employment and infrastructure uses

Land take in greenfield areas associated with employment and infrastructure uses is based on data about land use in greenfield areas from Precinct Structure Plans (PSPs).

This data is obtained from the Victorian Planning Authority Open Data portal.[213] The number of hectares by land use class and type as categorised by VPA is summarised in table 4, excluding "existing" land area, such as existing roads and dwellings. Note that the PSPs specify planned future land use, but actual future land use will not necessarily reflect the PSPs exactly.

Data from the PSPs suggests that there are:

- 0.42 hectares of new infrastructure land per hectare of new residential land, or 0.31 hectares if credited local and municipal open space is excluded, and
- 0.34 hectares of new employment land per hectare of new residential land.

This allows us to estimate the amount of land take in greenfield and regional areas by applying these rates to the amount of residential land take. For example, if there are 10 hectares of new residential land required in an area, we estimate there are 4.2 hectares of new infrastructure land and 3.4 hectares of new employment land required to service these dwellings.

Note that while there are PSPs for regional areas, spatial data for regional PSPs is not published by VPA.[214] For the purpose of the modelling, we assume that the ratio of new infrastructure and employment land per hectare of new employment land is the same in regional areas as implied by the metropolitan Melbourne PSP used in table O.5.

O.5 Future planned land take in completed PSPs

Land use class	Land use type	Classification	Area
			Hectares
Other	Investigation Area	N/A	270
Credited Open Space	Local Open Space	Infrastructure	2 103
Developable Area - Employment	Commercial	Employment	2 297
	Industrial	Employment	2 579
	Town Centre	Employment	0
Developable Area - Residential	Mixed Use	Employment	355
	Non-Arterial Road	Infrastructure	326
	Residential	Residential	20 952
	Town Centre	Employment	731
Education/Community/Government	Community Facilities	Employment	156
	Education	Employment	935
	Government Services	Employment	10
Other Non-Developable Land	Existing Developed Land	Residential	81
	Utility Facility	Employment	133

213 Data is available for download through the open data portal (https://data-planvic.opendata.arcgis.com/datasets/d0e72fe577bf4a4abf4782a57c8fd386_0/explore?location=-37.762374%2C144.678768%2C14.73), and full metadata is available for these files at: https://vpa.vic.gov.au/wp-content/uploads/2022/02/VPA-Greenfields-PSP-Spatial-Data-Metadata_v5.pdf

214 See https://vpa.vic.gov.au/regional/

Land use class	Land use type	Classification	Area
			Hectares
Regional Open Space	Municipal	Infrastructure	207
Transport	Arterial Road	Infrastructure	1 364
	Non-Arterial Road	Infrastructure	48
	Other Transport	Infrastructure	0
	Rail	Infrastructure	91
Uncredited Open Space	Other	Infrastructure	247
	Cemetery	Infrastructure	2
	Conservation	Infrastructure	1 439
	Drainage	Infrastructure	2 713
	Existing Open Space	Infrastructure	4
	Heritage	Infrastructure	36
	Non-Arterial Road	Infrastructure	0
	Utility Easement/Corridor	Infrastructure	350
Totals			
Infrastructure			8 931
Infrastructure excluding open space			6 621
Employment			7 195
Residential			21 033
Grand Total (infrastructure + employment + residential)			**37 429**

Source: VPA open data portal ‘Land Use Future Urban Structure’ dataset from completed PSPs.

P *Measuring changes in accessibility*

There are a number of possible measures of job accessibility:

- absolute measures of job accessibility — such as the number of jobs that you have access to within a particular time limit, or the number of high paying jobs within a particular time limit, or a more continuous measure of weighted average job accessibility such as job access density, discussed below.
- jobs accessibility per competing worker — these measures account for the number of other people seeking jobs. For example, an area in West Melbourne might have access to a large number of jobs nearby. However, there are twice as many people wanting access to these jobs as there are jobs. This type of measure would reflect that these people will have to travel further afield to find jobs because there is a local deficit in the number or type of jobs.
- job deficits — this represents the difference between expected number of job seekers and jobs available in a defined spatial area.

Access to population, which from the perspective of a business represents access to labour supply, can similarly be measured using absolute measures of population accessibility such as the number of people accessible within a time limit, or continuous measures.

We measure using continuous measures, because they do not impose time constraints on which jobs people care about accessing. Commute times exceed 30 or 45 minutes for many people, so an accessibility metric should factor in access levels for these longer journeys as well as access within these thresholds.

Box P.1 shows the specification we use for job access density and population access density.

P.1 Calculating access density metrics

Job access density can be represented using the following equation:

$$JA^j = \sum_i J^i . f(t^{ji})$$

where

- JA is job access,
- j is the travel zone we are looking at,
- i is the destination travel zone,
- J^i is the number of jobs at destination i and

- t^{ji} is the time to go from *j* to *i*.
- The function $f(t^{ji})$ is an exponential $e^{b.(t^{ji}-a)}$ where time is between *a* and *c*. Where time is below *a* it is 1 and where time is above *c* it is zero. We use the following parameters: *a* = 15 minutes, *b* = -0.016 and *c* = 180 minutes.[215]

Population access density can be represented using the following equation:

$$PA^i = \sum_j P^j . f(t^{ji})$$

where

- *PA* is population access,
- *i* is the travel zone we are looking at,
- *j* is the origin travel zone,
- P^j is the number of people at origin *j* and
- t^{ji} is the time to go from *j* to *i*.
- The function $f(t^{ji})$ is an exponential $e^{b.(t^{ji}-a)}$ where time is between *a* and *c*. We use the same parameters as those used in the job access density function.

These access metrics are not denoted in units that are easy to interpret. Therefore, we calculate them according to the functions above, and then compared them between scenarios using indexes that take value 100 in 2016.

For all accessibility metrics using catchment time thresholds (such as 30 minutes or 45 minutes), we use generalised total time from origin to destination. This weights the components of travel time according to preferences of travellers about the relative disbenefit of increases to each component. Generalised car time is calculated as the sum of in-vehicle time, vehicle operating cost and a travel time penalty dependent on the amount of tolls paid on the journey between travel zones. Generalised public transport time is the minimum generalised time across public transport modes. For public transport (including buses, rail, light rail and ferry) trips, this includes:

- **Access time** for the main mode of transport, whether by walking, car or bus,
- **Waiting time** for the transport vehicle (such as waiting at a station)
- **In-vehicle time**
- 2 minutes of **interchange time** between modes or different vehicles of the same mode
- **Egress time**, which refers to time spent walking between the end of the main mode journey and the final destination.

215 See the parameters used for the decay curve for commuting trips: KPMG, 2017, *Effective Density*, Appendix A p.7, available at: https://atap.gov.au/public-consultations/files/_KPMG_Wider_Economic_Benefits_of_Transport_2017.pdf

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