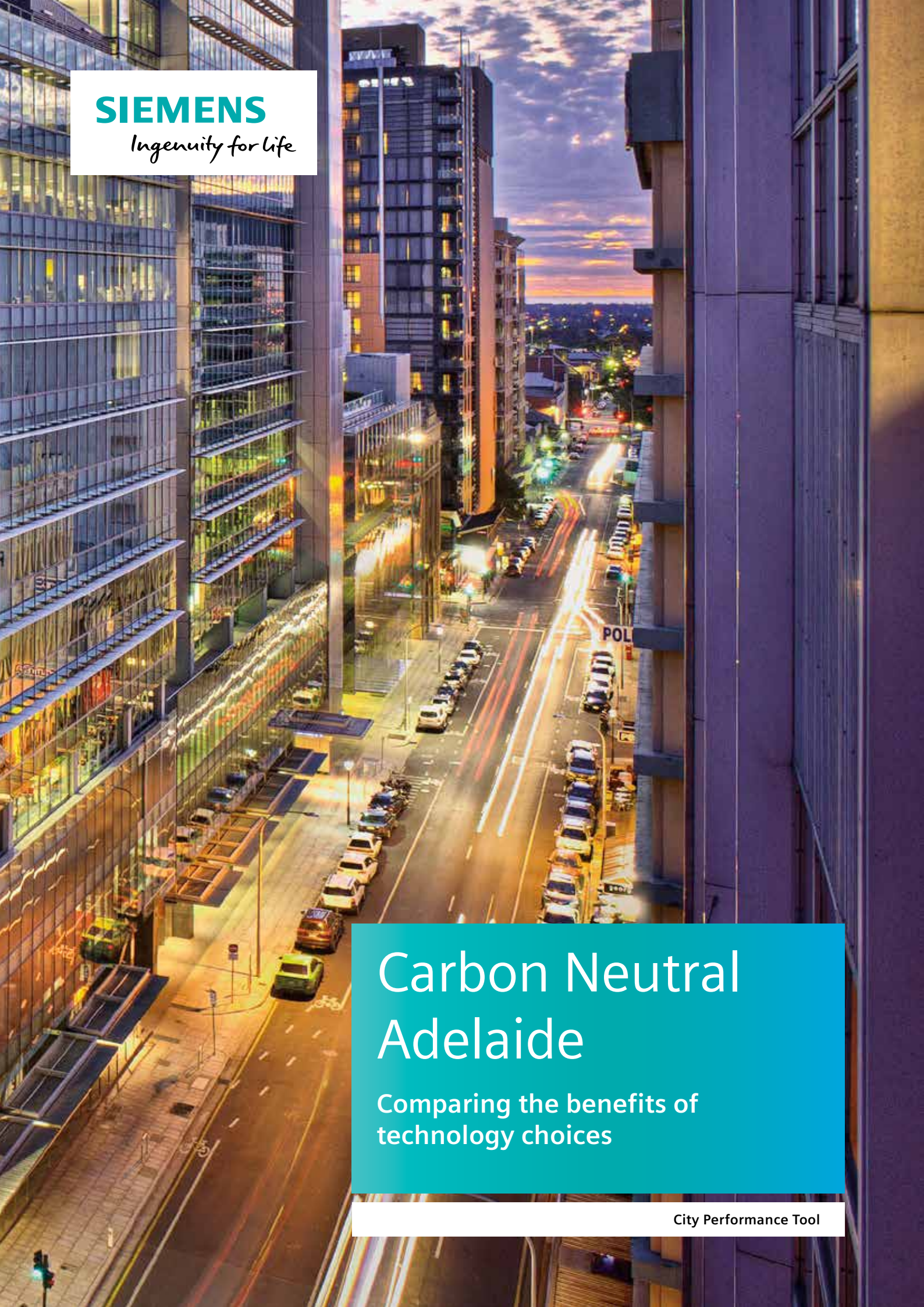

SIEMENS

Ingenuity for life

Carbon Neutral Adelaide

Comparing the benefits of technology choices

City Performance Tool

The Government of South Australia and the Adelaide City Council want the City of Adelaide to become the world's first carbon neutral city.

Executive Summary

Through strong uptake of wind and solar power, the state of South Australia with its key private sector partners has become the country's standout-out renewable energy leader, with 41% of the electricity generated in the state coming from these sources in 2015.[1]

Both the carbon emissions of greater metropolitan Adelaide, with a population of 1.3 million inhabitants, and the commercial and administrative centre of the City of Adelaide, with a daily population of approximately 230,000[2] people, have reduced significantly as a result of this rapid decarbonisation of the state's electricity supply.

The Government of South Australia and the Adelaide City Council want the City of Adelaide to become the world's first carbon neutral city.

To achieve this ambitious shared vision, further mitigation programmes in the buildings, transport and energy sectors are required. To test the mitigation impact of technologies in each of these sectors, they recently teamed up with Siemens to look at the most cost effective technologies that the city needs to implement, in order to reach its carbon neutral goal.

Using Siemens' proprietary model, the City Performance Tool (CyPT) that looks at the environmental and economic benefits of technology investments, this study has found five key strengths and opportunities behind Adelaide's technology choices:

1. **Coordinated action by the city and state can yield deep cuts in emissions:** Aggressive investments in the building, transport and energy sectors can help the City of Adelaide reduce CO_2e emissions by a further 56% by 2025 compared to a business as usual scenario. Local and State level governments both influence these sectors and must therefore continue to coordinate their efforts in investing or incentivising technology implementation in order to benefit from these potential savings.

2. **Decarbonisation efforts need to span energy, buildings and transport:** Although investments in renewable energy in the State have been unprecedented, building floor area growth and hence energy demand in the City of Adelaide have offset some of the emissions reductions arising from decarbonisation of the city's electricity supply. Whilst the recent closure of the state's last coal-fired power station and future large scale renewable investments will further drive down electricity intensity, city and state governments must influence the energy performance and solar installations of buildings and drive a mobility future based on heavy investment in low emission vehicles and increasing shifts to public transit.

3. **Start with commercial buildings:** The commercial sector remains the largest source of emissions in the City of Adelaide and this is also the sector that the city and state governments can most directly influence and regulate. With new programmes such as the introduction of Building Upgrade Finance being rolled out in 2017, the city can benefit from over 15% savings in buildings related emissions through just five building technologies modelled in this study. These same building technologies can deliver over 60% savings of buildings related emissions based on a scenario with heavier investments to further clean the electricity mix.

4. **Decide whether to focus on public transport or low emission vehicles or both:** For decades, South Australia has been one of the country's main auto-manufacturing regions. Although this provided considerable labour returns, a 'car-biased' economic policy made it difficult for the city to counter the carbon impacts of a very high car dependency in the city. With the imminent closure of car manufacturing in Australia in 2017, Adelaide is entering a new phase of economic development based on growing innovation and export capacity in minerals, energy, both traditional sources and renewables, food and wine, healthcare, higher education, tourism and advanced manufacturing. This study modelled potential savings in the transport sector based on two scenarios. The first, a mobility future based on low emission vehicles with medium public transport investment delivering 47% savings in transport related emissions. The second, a future with higher public transport / lower uptake of low emission vehicles, delivering over 38% savings in transport related emissions.

5. **Significant jobs can be created through strong action:** By cutting emissions by as much as 56% over the next decade, the City of Adelaide can also contribute to the state's transition to a low carbon economy. Our report has calculated a large gross employment benefit of nearly 23,000 full time equivalent jobs[3] in installation, operation and maintenance jobs in low carbon energy, public transport mobility and buildings systems spread over the next decade in the Greater Adelaide area.

[1] The 2014/15 stats breaks down to 34% wind and 7% solar in terms of proportion of electricity generated within the state. Solar uptake equates to approximately 28% of households.

[2] Breakdown of population - 23,169 residents, 141,275 workers and 64,229 visitors – http://economy.id.com.au/adelaide and http://www.adelaidecitycouncil.com/assets/documents/INFOGRAPHIC_-_Adelaide_on_a_page_-_leadership_group_version.PDF

[3] One full time equivalent job (FTE) equates to 1800 hours of labour. 10,000 FTEs relates to the total employment output over the next decade.

Introducing the City Performance Tool

Siemens has developed the City Performance Tool (CyPT) in order to help cities make more informed infrastructure investment decisions. The tool identifies which technologies from the transport, building and energy sectors best fit a city's buildings, mobility and energy characteristics in order to mitigate CO_2e levels, improve air quality and add new jobs in the local economy. The CyPT compares the performance of over 70 technologies and creates a shortlist of the most cost effective solutions that will help a specific city meet its environmental targets.

The model takes over 350 inputs from the City of Adelaide's transport, energy and buildings sectors, which include the energy mix of electricity generation, transport modalities and typical energy, travel and building space demand. We refer to this as a city's energy DNA, which we split into transport and buildings energy demand. How high this is and how it is split between the transport and buildings sector depends on how people use transport and building space and how the city generates its electricity and heating.

As soon as the DNA is calculated we estimate the CO_2e emissions and PM_{10} and NOx levels. The model measures the impact of technologies on the CO_2e, PM_{10} and NOx baselines of the city with CO_2e accounting performed at scopes 1 and 2 levels for the building and transport sectors. This means that we have taken into consideration both the emissions that are occurring within the city boundaries but also those to generate the relevant energy powering the technologies. Scope 3 emissions that look at the energy required to feed the electricity and heating generation in the city have also been included.

The model also tests the performance of each technology on two economic indicators. Firstly, the total capital investment needed to deliver the technologies. Second, the total number of new jobs that could be created in the local economy. These include installation, operation and maintenance jobs, which are calculated as full time equivalent jobs of 1800 hours per annum. Manufacturing jobs are not accounted because some of these technologies may be produced outside the city's functional area, with no local benefits to the economy.

The effects of the technologies represent proprietary data on the performance of actual Siemens products implemented by cities around the world. Importantly, they also represent non-Siemens products, allowing both Siemens and cities to compare a full spectrum of solutions from diverse technology sectors.

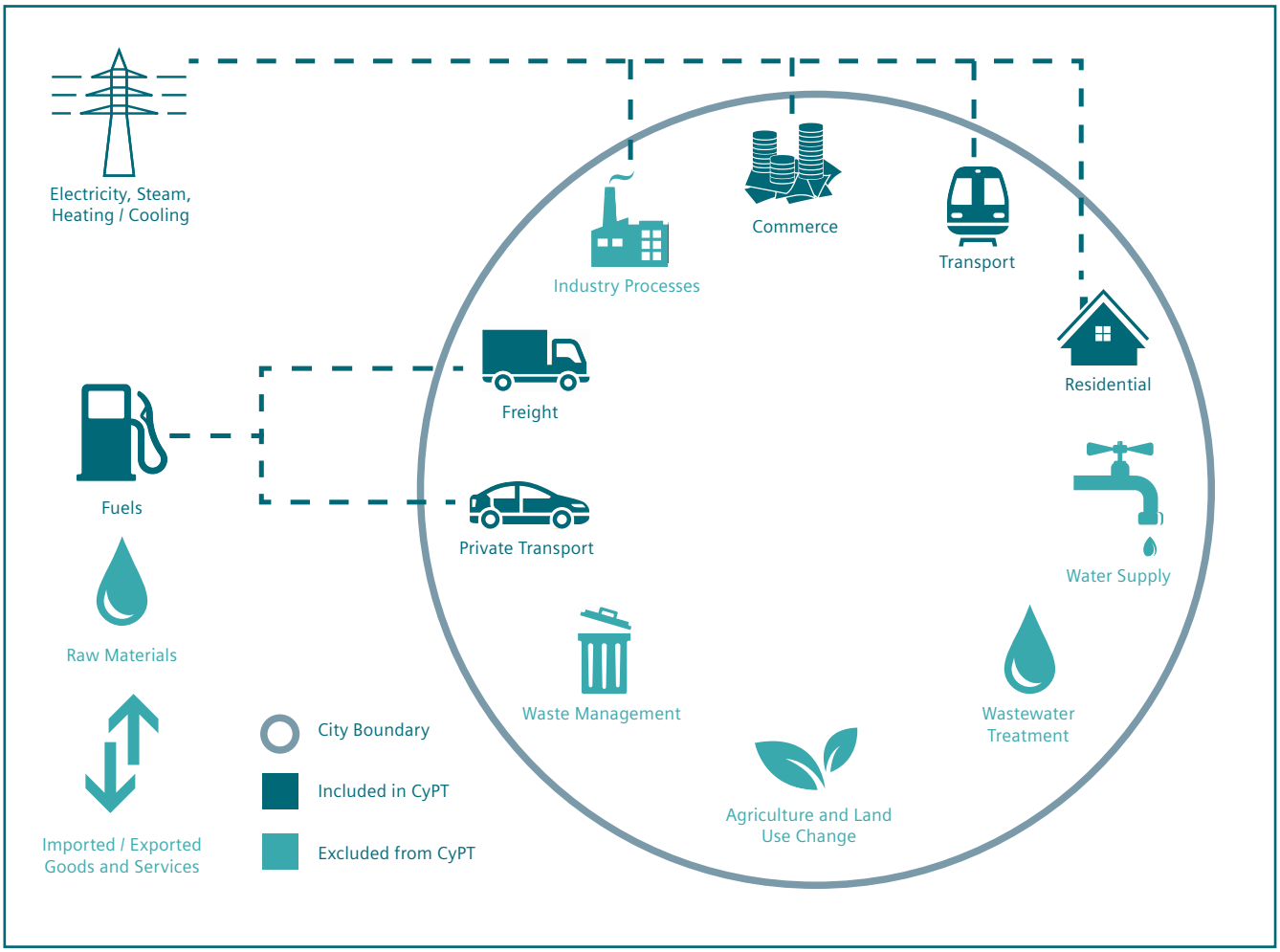

Figure 1: Emissions captured in this study. Icons are for indicative purposes only

Starting with the city's population, energy performance, and environmental baseline, the model estimates the future impacts of technologies along the following three drivers:

1. **Cleaner underlying energy mix:** Shifting the energy generation mix from non-renewable to renewable energies (e.g., photovoltaic) and/or improving the efficiency of the current, fossil fuel, sources (e.g., Combined Cycle Gas Turbines)
2. **Improved energy efficiency:** Replacing existing technologies with more energy efficient technologies. For example replacing traditional street lighting with LED and/or demand oriented street lighting
3. **Modal shift in transportation:** Modeling changes in the modal split of the city. For example by expanding its light rail network, a city potentially moves passengers away from high-emitting cars and into railcars.

The model has so far been used in cities such as London, Mexico City, Copenhagen, San Francisco and Nanjing with each city identifying infrastructure solutions that best fit the city's energy demand and production characteristics.

Figure 2: Cities that have conducted CyPT studies

Adelaide's Climate Policy Context

In February 2015, the Government of South Australia and Adelaide City Council announced their shared ambition for the City of Adelaide to be the world's first carbon neutral city. This target was not based just on aspiration, but supported by existing policy initiatives and sound legislation.

As the City achieved a 20% reduction in carbon emissions between 2007 and 2013, Carbon Neutral Adelaide was conceived as a mechanism to further drive down carbon emissions. The target was set to act as a catalyst to increase demand for renewable energy; help build up the state's green industries; enable the transition to cleaner transport modes and secure wider resource efficiency.

The environmental policy landscape in Adelaide has evolved in recent decades, beginning with a focus on ecological systems within the environment, moving to the recognition of climate change and its impact on people and security, and reaching its focus today on economic opportunities from the transition to a low carbon economy.

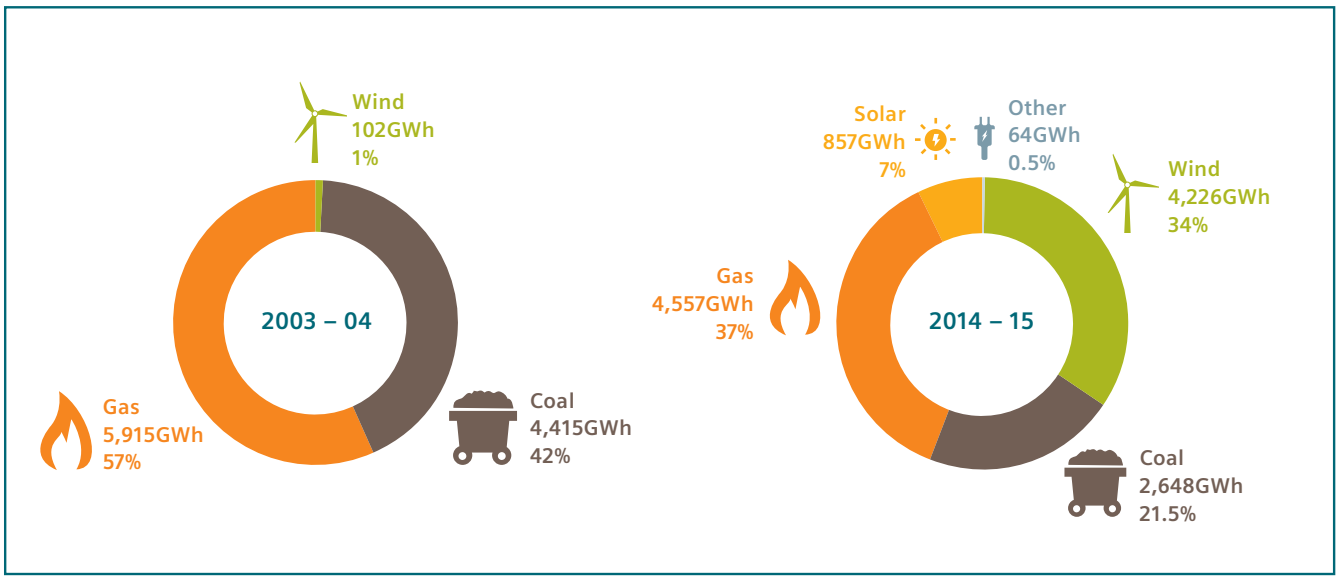

Figure 3: Changes in Electricity Output in South Australia in the last decade (Source: South Australia Low Carbon Investment Plan, 2015) Note: 'Other' includes generation from small diesel, landfill methane and hydro generating systems. Source: Various AEMO reports.

South Australia's climate change legislation

South Australia led the way as the first Australian state to legislate targets for the reduction of carbon emissions, through the Climate Change and Greenhouse Emissions Reduction Act 2007.

This legislation also commits the State Government to work with businesses and communities to develop and implement practical strategies. Such initiatives include climate change sector agreements and the Premier's Climate Change Council, and an independent regular review of progress by the Commonwealth Scientific and Industrial Research Organisation (CSIRO).

The legislation set out three targets:

1. Reduce carbon emissions within the state by at least 60% to an amount that is equal to or less than 40% of 1990 levels by 31 December 2050 as part of a national and international response to climate change
2. Increase the proportion of renewable electricity generated so it comprises at least 20% of electricity generated in the state by 31 December 2014
3. Increase the proportion of renewable electricity consumed so that it comprises at least 20% of electricity consumed in the state by 31 December 2014.

In 2009, the Government further committed to a target of 33% of South Australia's electricity generation to come from renewable energy by 2020. By late 2014, South Australia exceeded this target and in the 2014/15 financial year around 41% of electricity generated in the state was from renewable sources, with wind generation accounting for 34%, and solar providing 7%. This comes from an investment of $3.7 billion for wind and $2.7 billion for solar across the state.

This significant success has been achieved through a combination of federal policies and the state establishing itself as an investment friendly destination for renewables. For example by producing maps of South Australia's wind and solar resources, establishing stable planning laws for large scale wind farm developments and establishing a solar feed in scheme.

South Australia's Climate Change Strategy 2015-2050

Current priorities and targets in South Australia, one of which is Carbon Neutral Adelaide, are informed by the Government of South Australia's Climate Change Strategy 2015-2050. As well as the aspiration to establish Adelaide as the world's first Carbon Neutral City, the strategy advances plans for the future and places importance on economics and investment. South Australia's targets now include:

- Achieving state wide net zero emissions by 2050
- Attracting $10 billion in low carbon investment by 2025
- Generating 50 per cent of its electricity from renewable sources by 2025
- Improving the energy efficiency of government buildings by 30 per cent of 2001 levels by 2020

These targets reflect the state's economic priorities in unlocking the full potential of the state's resources, energy and renewable assets. Through this there is the opportunity to transform the economy through fostering an environment of innovation and ensuring that small businesses have access to capital and global markets.

The importance of addressing economic issues is paramount in South Australia, as the change from traditional to low carbon industries is already being felt by those who work in the industrial and manufacturing sectors. Adelaide has suffered what is a familiar post-industrial decline for Australian cities, seeing many of its traditional manufacturing jobs being lost to overseas competitors. The target to generate 50 per cent of electricity from renewable sources by 2025 will likely be achieved early, in part due to the closure of South Australia's last coal fired power station in 2016, which also requires the transition of power station workers into new skills and new jobs.

Responding to this, the Climate Change Strategy outlines a number of initiatives. The $7 million grant assistance package for the Upper Spencer Gulf and Outback region provides grants to local communities and businesses to undertake regional projects that will create jobs and drive economic growth in the region. South Australia's strengths in education and the potential for these to be applied to a transitioning workforce offer a significant market opportunity, in both an international and domestic context. The Tonsley development in the southern suburbs of Adelaide, is Australia's first innovation district. Here, on the site of an old auto factory, Siemens, Flinders University and other investors have partnered with the State, City and businesses to develop start-ups and accelerators in high-value industry, research and education. With $253 million of investment from the State government, which is expected to leverage $1 billion of investment from private sources, the stated ambition to develop significant full time jobs and educational opportunities in sustainable high-tech

roles holds significant potential.

The strength of these initiatives and support for the Climate Change Strategy come in part from the public engagement process. Embedded into the climate change legislation is regular community consultation. In the last round, general community feedback welcomed the Government's climate change leadership and called for information and behaviour change programmes to help support household decision-making. The community responded strongly in support of the increased uptake of renewable energy, including solar thermal; the uptake of electric vehicles; effective use of regulation; increased investment in waste and recycling; and increased support for low income households to improve energy efficiency.

The Government and Council are active global citizens and have signed parallel international agreements on climate change – the Compact of Mayors and the Compact of States and Regions. Both have formalized their joint commitment to establishing the City of Adelaide as the world's first carbon neutral city via the Carbon Neutral Adelaide Sector Agreement under the *Climate Change and Greenhouse Emissions Reduction Act 2007*.

This bold ambition builds on work undertaken previously by the Government and the Council through the Adelaide Green City Sector Agreement that ran between 2010 and 2012.

What is clear from recent policy is that the City of Adelaide will continue to go forward as a significant testing platform for the roll out of successful carbon mitigation initiatives across South Australia. The challenge for the Adelaide City Council, in collaboration with the Government of South Australia and other stakeholders, is to develop a framework and toolbox of practical solutions to achieve carbon neutrality that are relevant, realistic, coordinated, transparent and achievable. This report will go forward to identify the greatest opportunities to reach towards carbon neutrality for the City of Adelaide.

Carbon Neutral Strategy 2015-2025

Council's Carbon Neutral Strategy 2015-2025 identifies three outcomes and the following targets for the Adelaide City Council area.

Outcomes

1. A carbon neutral city where economic growth and carbon emissions are decoupled.
2. A carbon neutral Council that is effecting change in the community.
3. Leadership that embraces and shares great ideas and opportunities.

Targets

1. The City of Adelaide has zero net carbon emissions by 2025.
2. The City of Adelaide has reduced its carbon emissions by 35% by 2020 (from the 2006–07 baseline year).
3. Adelaide City Council has zero net carbon emissions from its operations by 2020.
4. Establishment of a Carbon Neutral Adelaide partnership framework by 2016.
5. One million square metres of city floor space is committed to the Carbon Neutral Adelaide partnership framework by 2020.

A Carbon Neutral Adelaide Action Plan will be finalised during 2016.


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Adelaide's emissions baseline

We modelled over 900kt of annual CO_2e emissions in the City of Adelaide, which we took as the 2015 emissions baseline for this study[1]. As highlighted earlier in the report, heavy investments to green the electricity mix will drive large mitigation savings in the building sector. We modelled over 32% city wide savings over the next decade when the city follows through on its current climate action plan. Nearly all of these savings will accrue in the building sectors with limited savings being realised in the transport sector in this timeframe. This will radically shift the emissions split landscape in the city between transport and buildings. From a near 50-50 split in 2015, emissions in the buildings sector will drop to 33% with 67% of emissions accruing from transportation. The city will increasingly need to tackle its transport emissions to meet its targets.

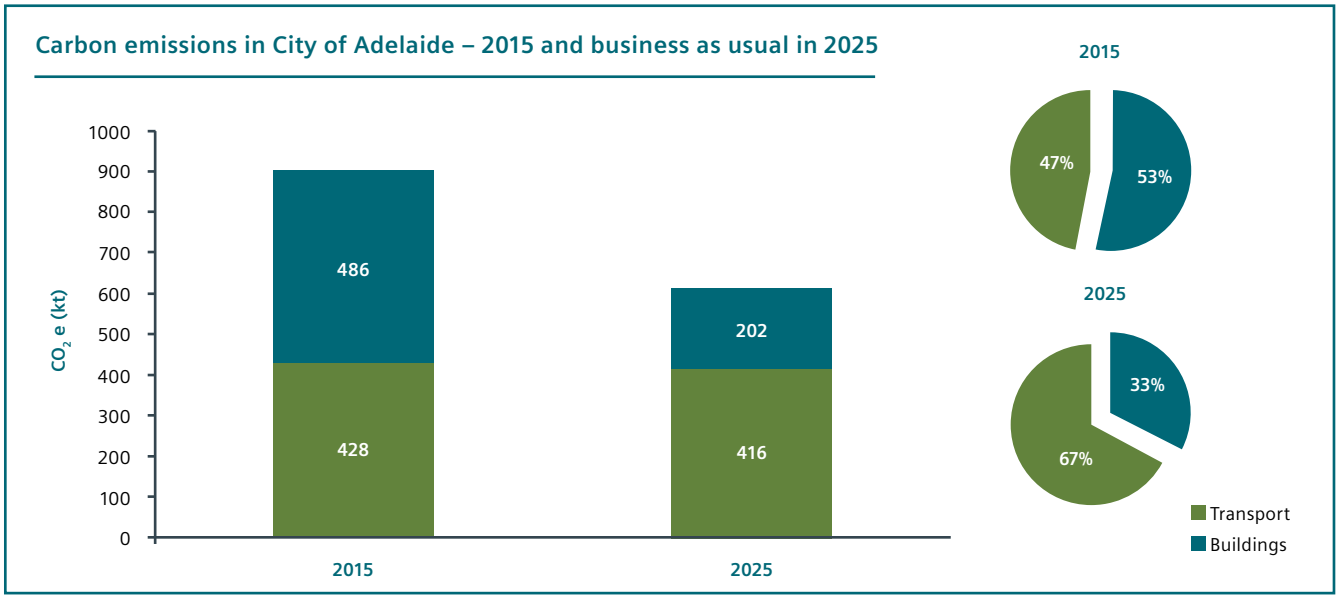


Figure 4: Carbon Emissions breakdown in the baseline year of 2015 and in 2025 for the City of Adelaide

[1]The City of Adelaide emissions baseline as calculated by CyPT yields a slightly different result to the city's 2015 carbon account as calculated in accordance with the GHG protocol for Cities, i.e. due to slight differences in scope and calculation methodologies. The difference in total emissions between the two estimations is below 5%.

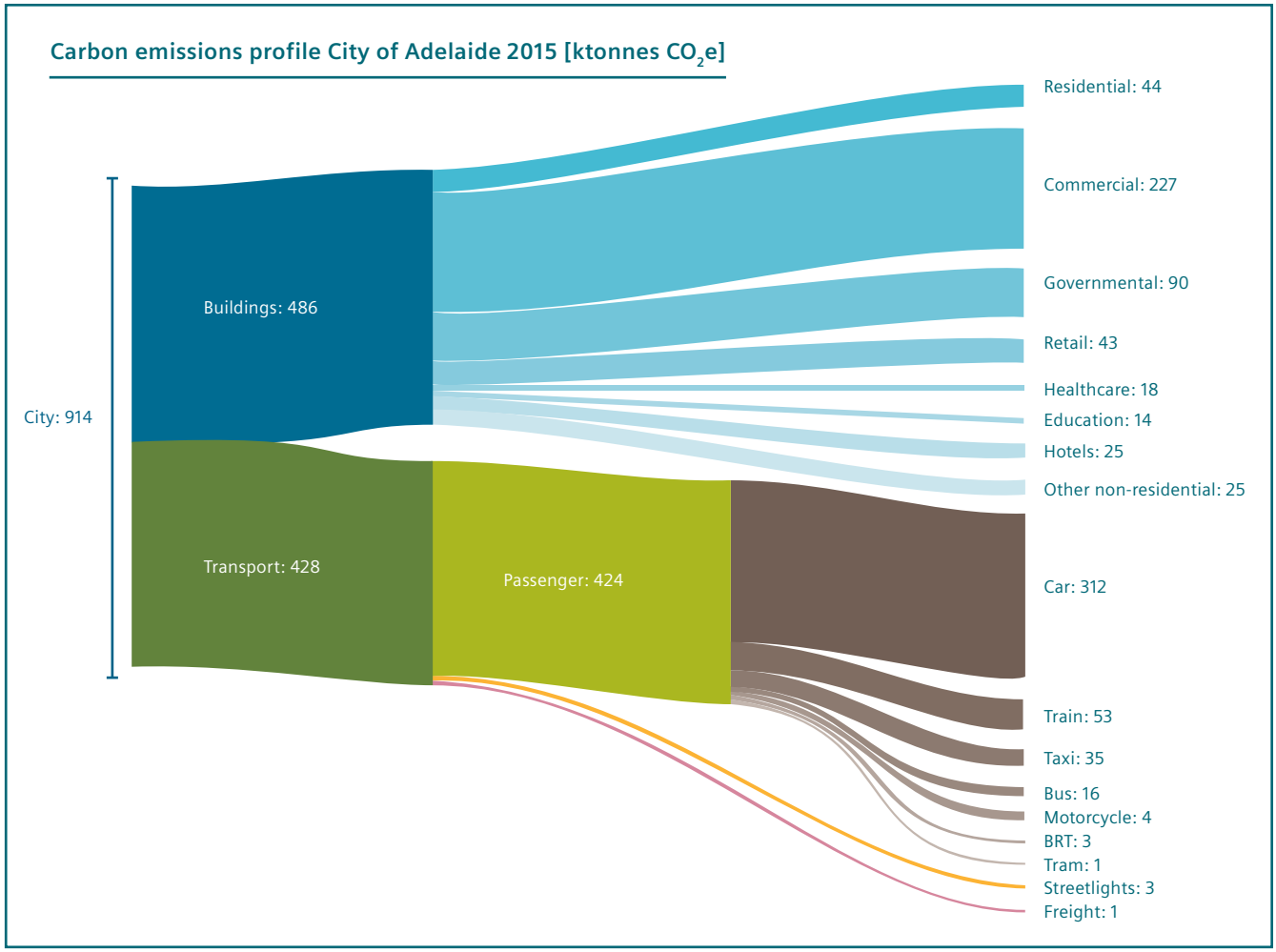


Figure 5: 2015 Emissions profile – all values are in kt of CO_2e

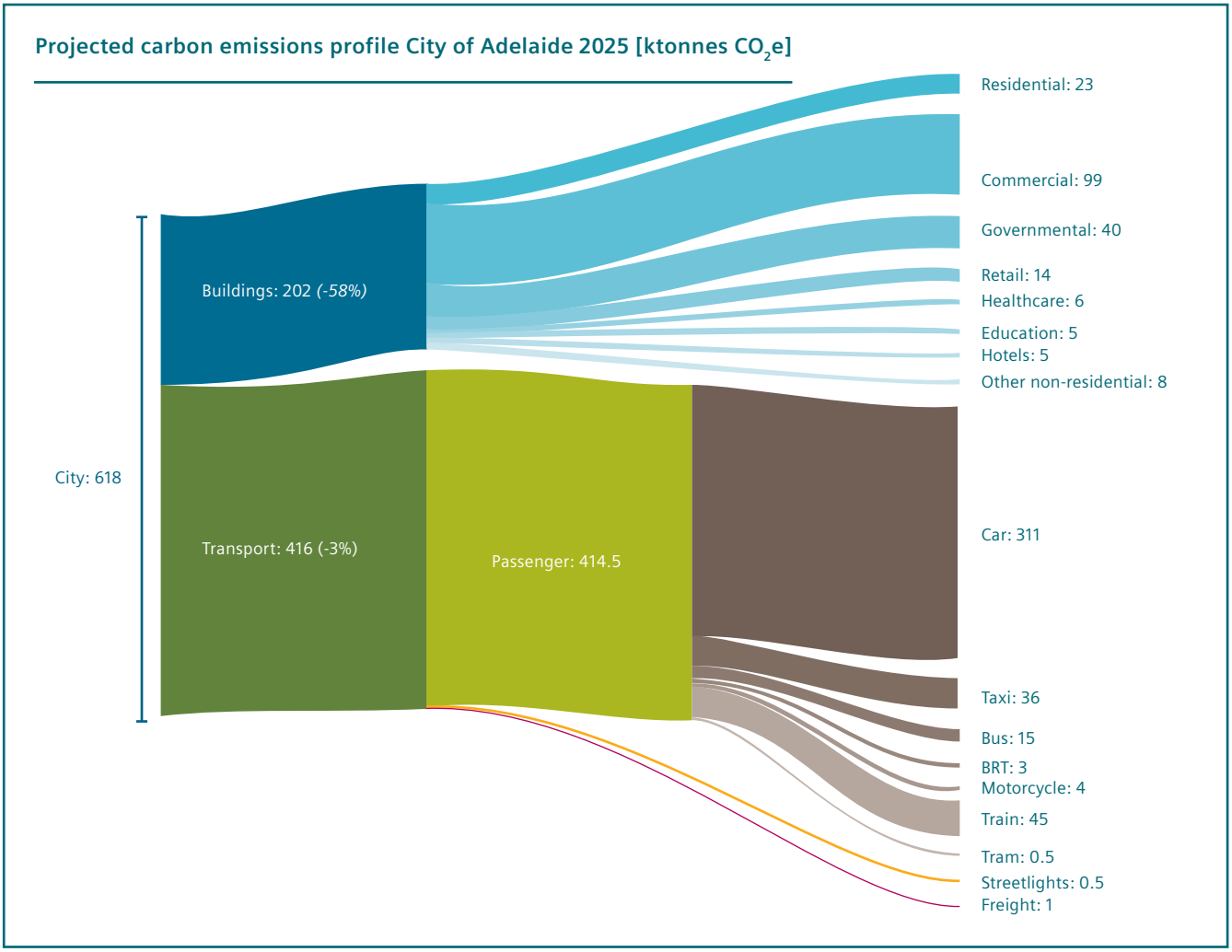


Figure 6: 2025 Emissions profile – all values are in kt of CO_2e (relative change to 2015 baseline)

This poses important questions to City and State authorities. Should the City of Adelaide continue concentrating on buildings emissions whilst mobilising other Councils in the Greater Adelaide area to finally tackle car related emissions? How aggressively should technologies be implemented in each of the sectors?

In the next section, we will model emissions savings based on three technology implementation scenarios. The first scenario looks at changing the State energy mix with further investments in wind, solar and combined cycle gas generation and further automation in the distribution system. The second scenario will look at the savings potential of five commercial building technologies. Savings will be based on annual emissions reductions in the year 2025 with and without these technologies. A variation of this scenario will look at the same building technologies plugged to a cleaner State level electricity mix. The final scenario looks at two transport futures. The first looking at heavy investments in public transportation shifting passenger trips away from private cars. The second looking at the take up of alternative cars shifting passenger trips from petrol and diesel to low emission technology automobiles.

Overall electricity demand is supposed to increase mainly because of the increasing city footprint, and because electricity production is capped by heat demand, more electricity will need to be imported (61 GWh, +3.5%) from higher emission generators interstate, thus nudging up carbon emissions. There will also be a gap of 110 GWh, between the energy produced locally via co-generation or city owned renewable generation and overall demand.

Scenarios & Results

Energy Scenario

There has been significant private sector investment in wind and solar power generation in South Australia, bringing the projected electricity share by 2025 to 53% and 17% for each source respectively. This study looks at the potential savings of further investments in renewable energy and network optimisation as highlighted in the 2050 long term objectives of the State of South Australia.

We selected three energy generation technologies and two distribution technologies and modelled their impacts on carbon emissions based on higher implementation as shown in Table 1. To take the example of wind generation, the electricity share of wind power generation will rises from 53% to 63% by 2025 – an effective increase from the projected 2025 business-as-usual of 10 percentage points.

Our results show that the City of Adelaide can reduce carbon emissions by as much as 20% on a high implementation of wind and solar power generation with a total capital investment of AUD300 million over the next 10 years and job returns of around 2,000 full time equivalents in installation, operations and maintenance related employment.

Overall, it is wind power that provides the greatest individual carbon savings at over 60,000 tonnes of CO_2e. It is also by far the most cost efficient technology saving over 800kg of CO_2e for every AUD1,000 spent.

		Implementation level		
Energy lever[1]	Unit	Current 2015	Projected for 2025	Energy scenario 2025 modelled in CyPT
Wind	% of el. consumption	30.5%	53%	63%
PV	% of el. consumption	7.5%	17%	27%
Combined Heat and Power	% of heat consumption	0%	0%	4%
Network Optimisation	% of grid targeted	0%	0%	40%
Power System Automation	% of grid targeted	0%	0%	40%

Table 1: Implementation rates of energy related technologies

[1]See full technology lever description in appendix

Energy scenario	19% citywide	2,110	300 mn
	Carbon savings	Jobs [FTE]	CAPEX [AUD]

Table 2: Environmental and economic benefits of investments in energy related technologies

Technology performance by emission savings and cost efficiency
Energy scenario

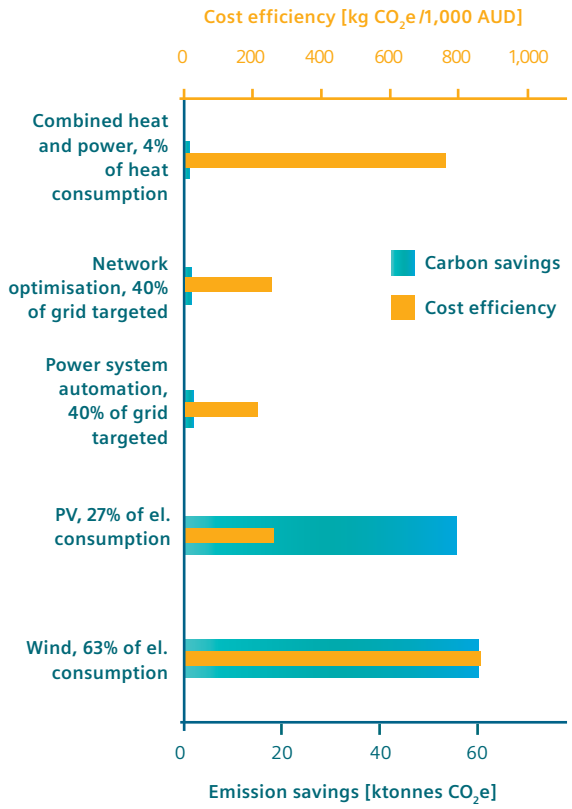
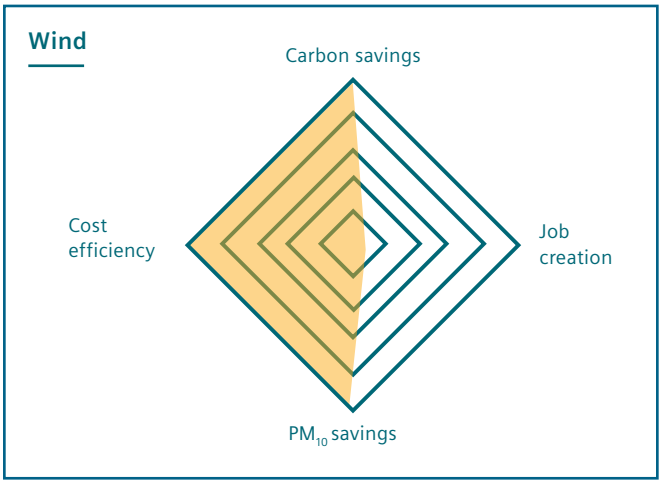
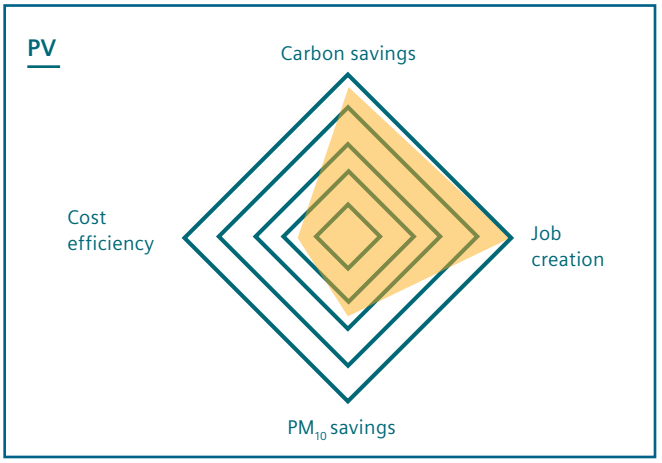


Figure 7: Comparing performance of energy related technologies in terms of GHG emission savings and cost efficiency given the implementation rate listed in Table 1.

Multiple performance indicators for top performing technologies.





Buildings Scenarios

a. Commercial Buildings

We modelled the impacts of five commercial building technologies on the projected annual emissions in the City of Adelaide in the year 2025. We assumed that a percentage of the total commercial stock to have the technology fitted by 2025 (indicated by BAU 2025) in Table 3. To take the example of double glazing, which we assumed to cover 35% of the commercial stock, we modelled the carbon savings of a medium implementation rate. Medium implementation rates will see 3% of the total building stock being retrofitted annually, an addition of 30%, so that by 2025, 65% of the total stock will be fitted with more efficient double glazing in the model.

Based on the medium implementation rate modelled in the study, buildings specific emissions can be reduced by as much as 15% and create more than 1,700 full time equivalent jobs as is shown in Table 4. To mobilise such an effort, the commercial buildings sector will need to invest around AUD 37 million per annum in these building technologies. The next chapter will look at some international examples of how such technologies can be implemented and incentivised.

		Implementation level		
Building lever[1]	Unit	Current 2015	Projected for 2025	Building scenario 2025 modelled in CyPT
Glazing	Stock / year	5%	35%	65%
Efficient lighting technology	Stock / year	5%	20%	70%
Building performance optimisation (BPO)	Stock / year	5%	20%	40%
Room automation, BACS A	Stock / year	10%	25%	45%
Building remote monitoring (BRM)	Stock / year	5%	20%	60%

Table 3: Annual implementation rates for five commercial building technologies

[1]See full technology lever description in appendix

Building scenario	5% citywide	15% Building sector	1,770	370 mn
		Carbon savings	Jobs [FTE]	CAPEX [AUD]

Table 4: Environmental and economic benefits of investments in five commercial building technologies

b. Commercial Buildings with cleaner electricity

When the same commercial building technologies are connected to a cleaner energy mix, the savings are considerably higher. Using the medium implementation rates of energy technologies, our model shows that the five commercial building technologies can deliver up to 63% carbon savings on a electricity mix based on 63% wind and 27% photovoltaic power generation.

Overall, it is room automation technologies, which automatically control the electricity, heating and cooling of a building based on occupancy levels that save the most CO_2e. However, in terms of cost-efficiency it is the building performance optimisation services that are the most cost effective saving 4,500kg of CO_2e per AUD1,000 of investment.

When the three top performing building technologies were compared simultaneously on four KPIs (overall CO_2e savings; cost efficiency in terms of CO_2e savings per investment spent; total jobs created and PM_{10} savings), Building Remote Monitoring is on average more effective on all measures. The spider diagrams opposite show the comparative performance of each of the technologies compared to the average performance of all buildings related technologies used in table 3.

Building + Energy scenario	21% citywide	63% Building sector	3,420	613 mn
	Carbon savings		Jobs [FTE]	CAPEX [AUD]

Table 5: Environmental and economic benefits of investments in five commercial building technologies linked to a cleaner electricity mix

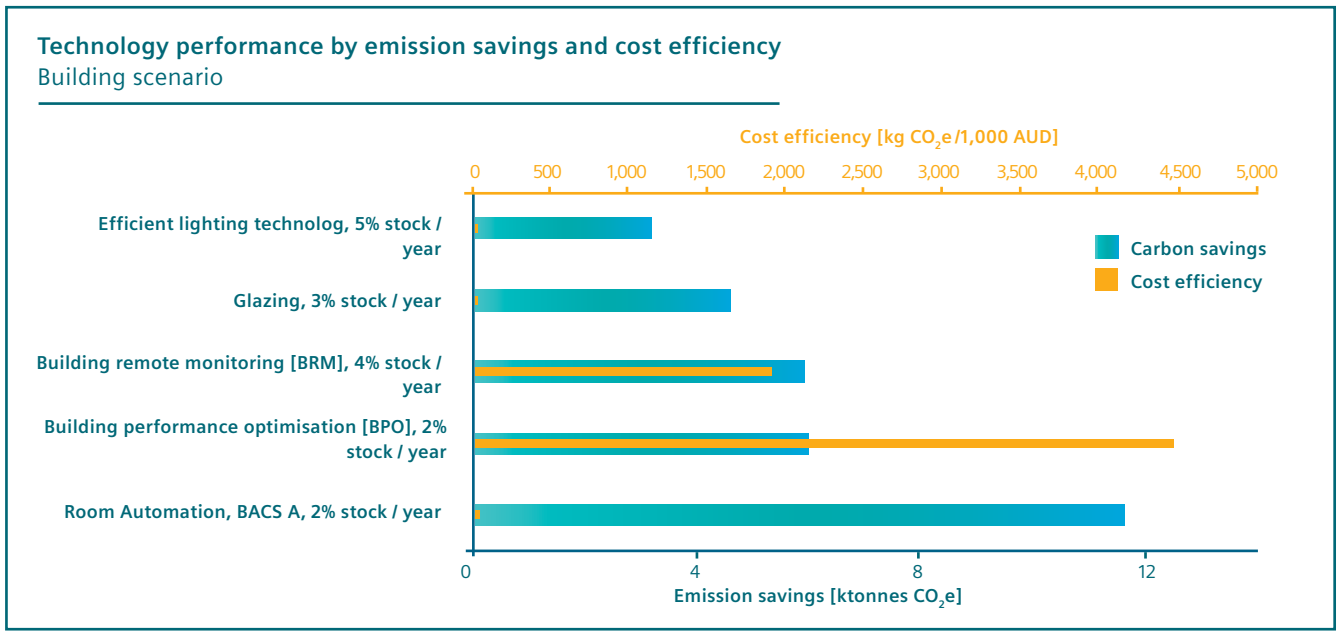
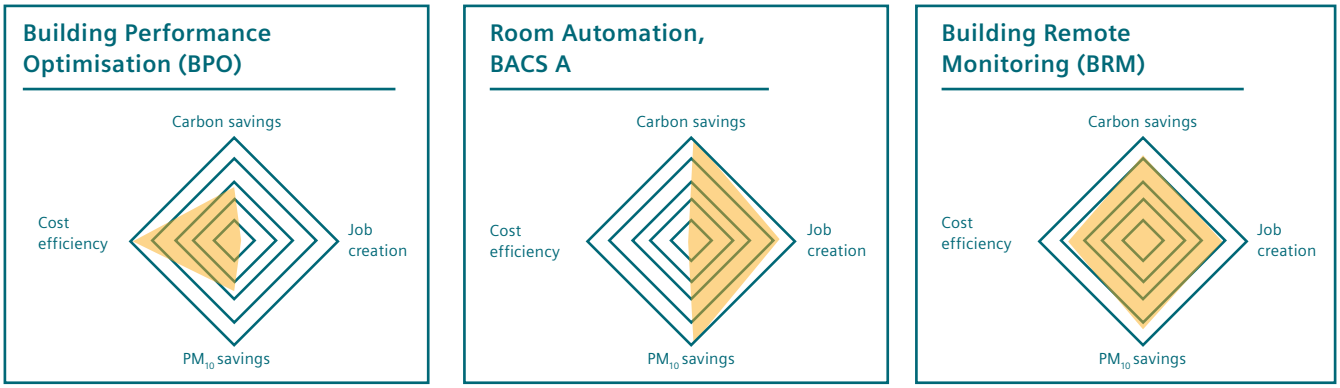


Figure 8: Comparing performance of commercial building technologies in terms of emission savings and cost efficiency given the implementation rate listed in Table 3.

Multiple performance indicators for top performing technologies.



Transport Scenarios

Although the potential 63% carbon emissions savings from building technologies linked to a cleaner energy mix is high, building related emissions only account 33% of city wide emissions in 2025. To reach the goal of carbon neutrality, the city will need to tackle the 67% transport related emissions that are modelled in this study. We looked at two potential transport futures. The first, based on low public sector investment, will see households and businesses upgrade Adelaide's current car fleet to low emission technologies. The second scenario sees the large public sector investments in public transit. Based on current car replacement rates every 20 years in Adelaide, public authorities will need to incentivise and accelerate the change through a number of initiatives that will also be explored in this section.

Our point of departure for both scenarios was a baseline transport modal share for 2025 that was split between 70% private modes and 30% on public transit.

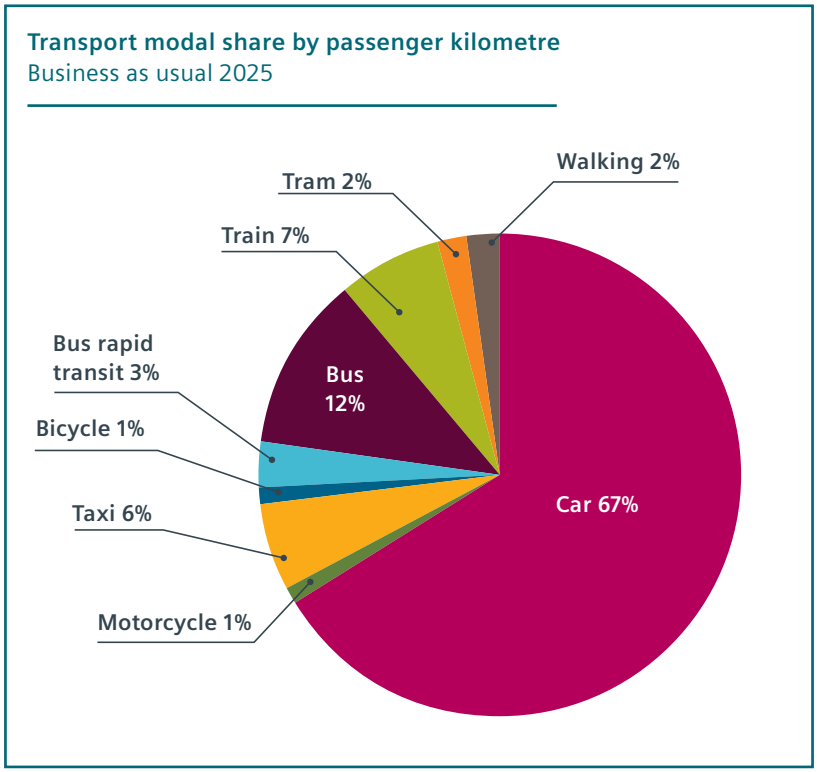
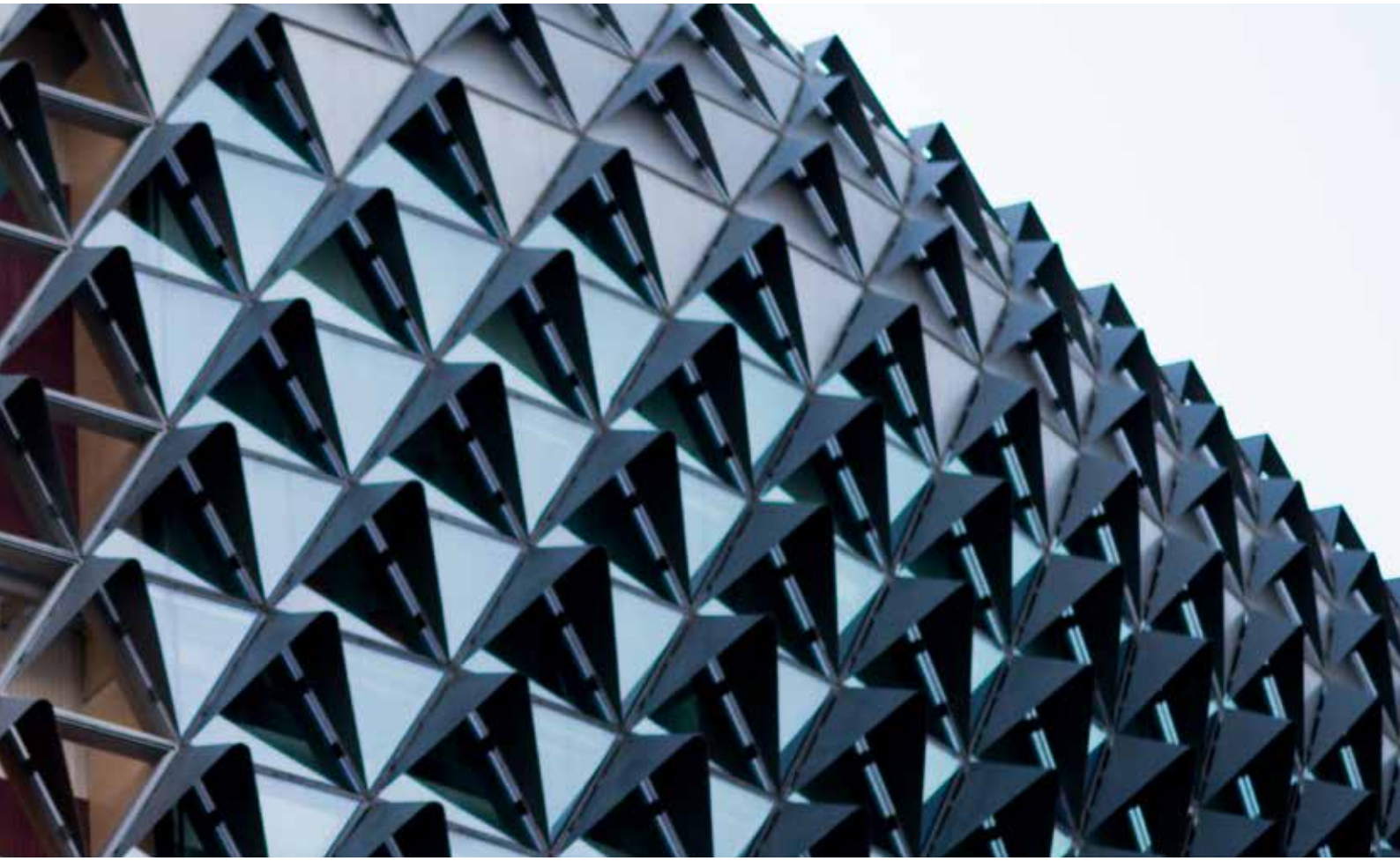


Figure 9: Modal share based on annual passenger kilometres. To account for commuting trips, we have taken into consideration 50% of the trip length in the greater metropolitan area



		Implementation level			
Transport lever[1]	Unit	Current in 2015	Projected for 2025	Low public transport, high alternative car scenario 2025 modelled in CyPT	High public transport, low alternative car scenario 2025 modelled in CyPT
Electric buses	Fleet	0%	0%	10%	50%
Electric cars	Car fleet	0%	1%	20%	5%
Hydrogen cars	Car fleet	0%	0%	3%	1%
Hybrid electric cars	Car fleet	1%	2%	20%	5%
Plug-in hybrid electric cars	Car fleet	0%	2%	20%	5%
Electric taxis	Car fleet	0% (54% hybrid)	0% (54% hybrid)	60%	20%
Electric car sharing	Cars / 1,000 inhabitants	0 cars	0 cars	10	1
Train – Electrification	Lines electrified	28%	28%	56%	100%
Tram – new line	Lines	2	2	3	6
e-BRT (Bus Rapid Transit) – new line	Lines	1	1	3	5
Train – reduced headway	Seconds	540	540	420	180
Cycle highway	km	102	102	152	252

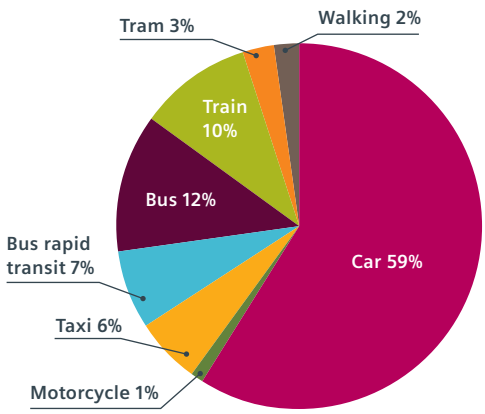
Table 6: Implementation rates and modal shares of technologies in the two transport scenarios

[1]See full technology lever description in appendix

For each of the scenarios, we shifted the modal share and the types of vehicles in the Greater Adelaide area. In the low public transport – high alternative car uptake, private car annual passenger kilometres were reduced to 59% with some annual passenger kilometres shifted to light rail. More importantly, alternative car implementation was set high so that more than 60% of cars would be electric, hybrid electric or plug-in hybrid electric as shown in Table 6.

Our results show that the low public transport – high alternative car scenario can reduce annual emissions by as much as 47% of transport related emissions with a capital investment by the Greater Adelaide area of AUD1.4 billion in public transit and charging infrastructure for alternative vehicles. The high public transport – low alternative car scenario returns less carbon emission savings at a higher capital investment by the Governments. The job returns of the high public transit scenario, which includes 6 tram lines are over 21,000 spread over the decade when the systems will be implemented and delivered.

Transport modal share by passenger kilometre
Alternative car scenario 2025



Transport modal share by passenger kilometre
High public transport scenario 2025

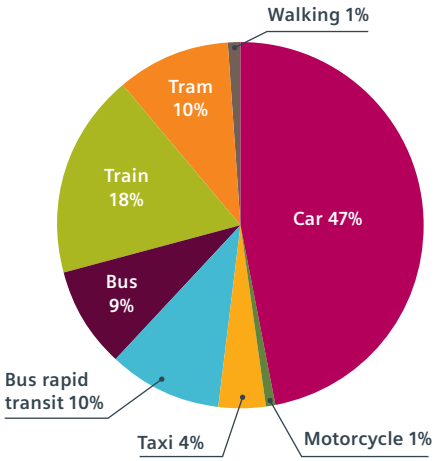


Figure 10: Modal share changes for the two transport scenarios

Transport scenario: low public transport, high alternative car	**31%** citywide	**47%** Transport sector	**5,600**	**1.4 bn**
	Carbon savings		Jobs [FTE]	CAPEX [AUD]
Transport scenario: high public transport, low alternative car	**26%** citywide	**38%** Transport sector	**21,000**	**4.9 bn**
	Carbon savings		Jobs [FTE]	CAPEX [AUD]

Table 7: Carbon emission savings based on a high public transit vs high alternative fuel car

Looking at the results of the more impactful alternative car scenario in more detail, although the majority of the jobs are created in the capital intensive projects such as the new tram line (2,500 FTE jobs), these same technologies do not deliver as much savings as the alternative car technologies (because only 1 new line is modelled) nor do they return the best return on investment for the public authorities. This is by far dominated by the plug-in hybrid technology, which delivers over 30,000kg of CO_2e per AUD1,000 of capital investment as shown in figure 12.

New jobs created locally, accumulated until 2025 [FTE]
Alternative car scenario

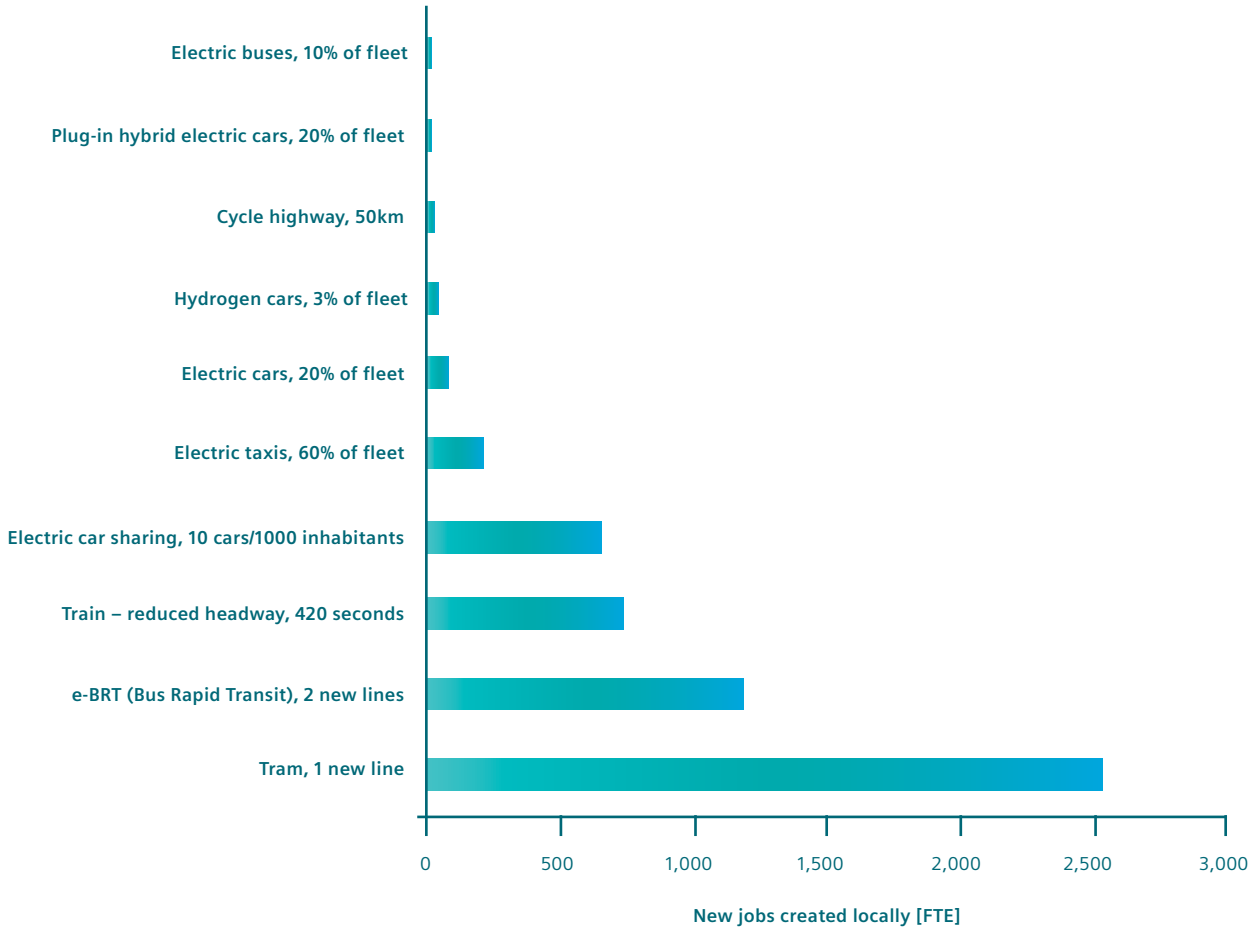
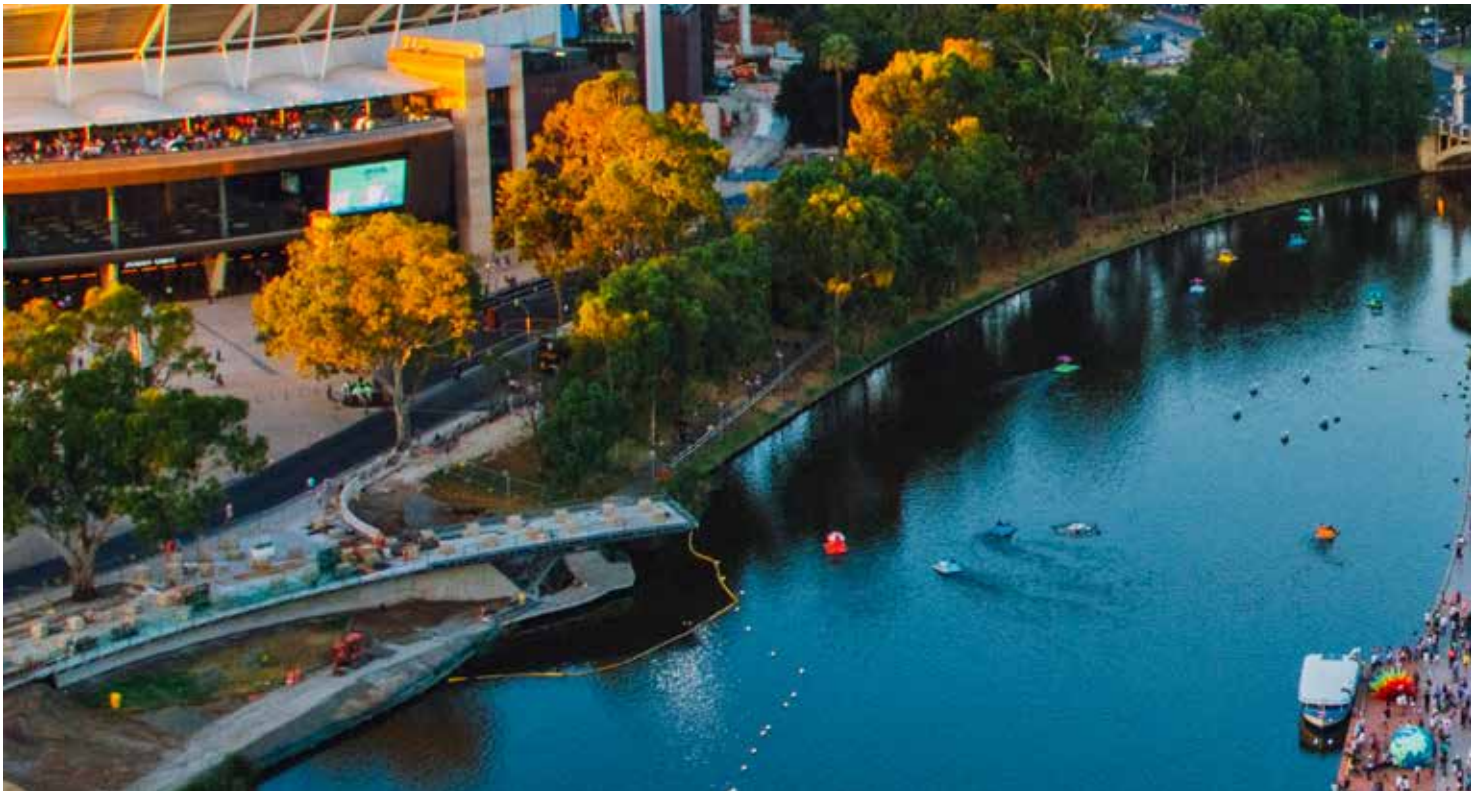


Figure 11: Job returns of transport technologies in alternative car scenario



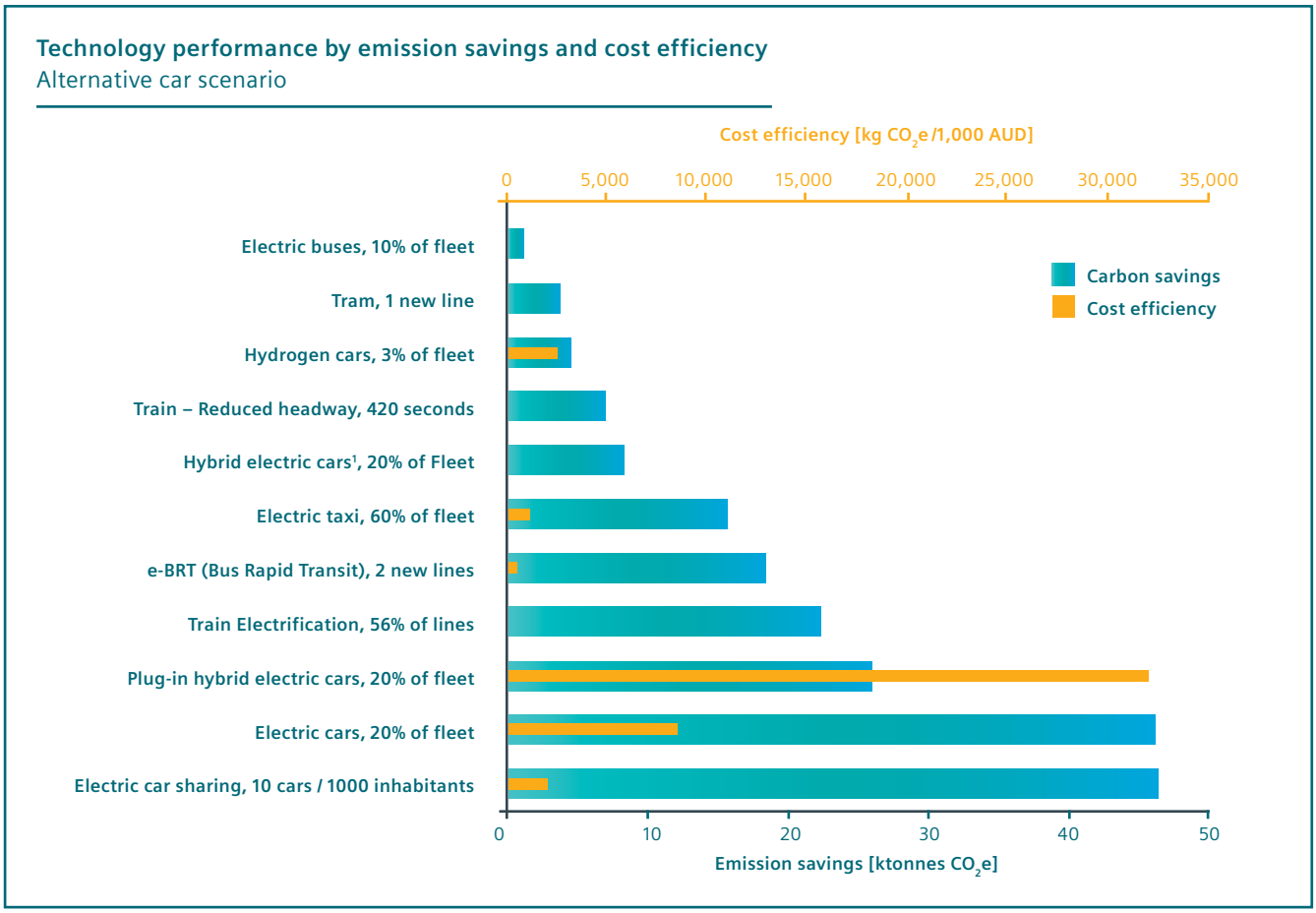
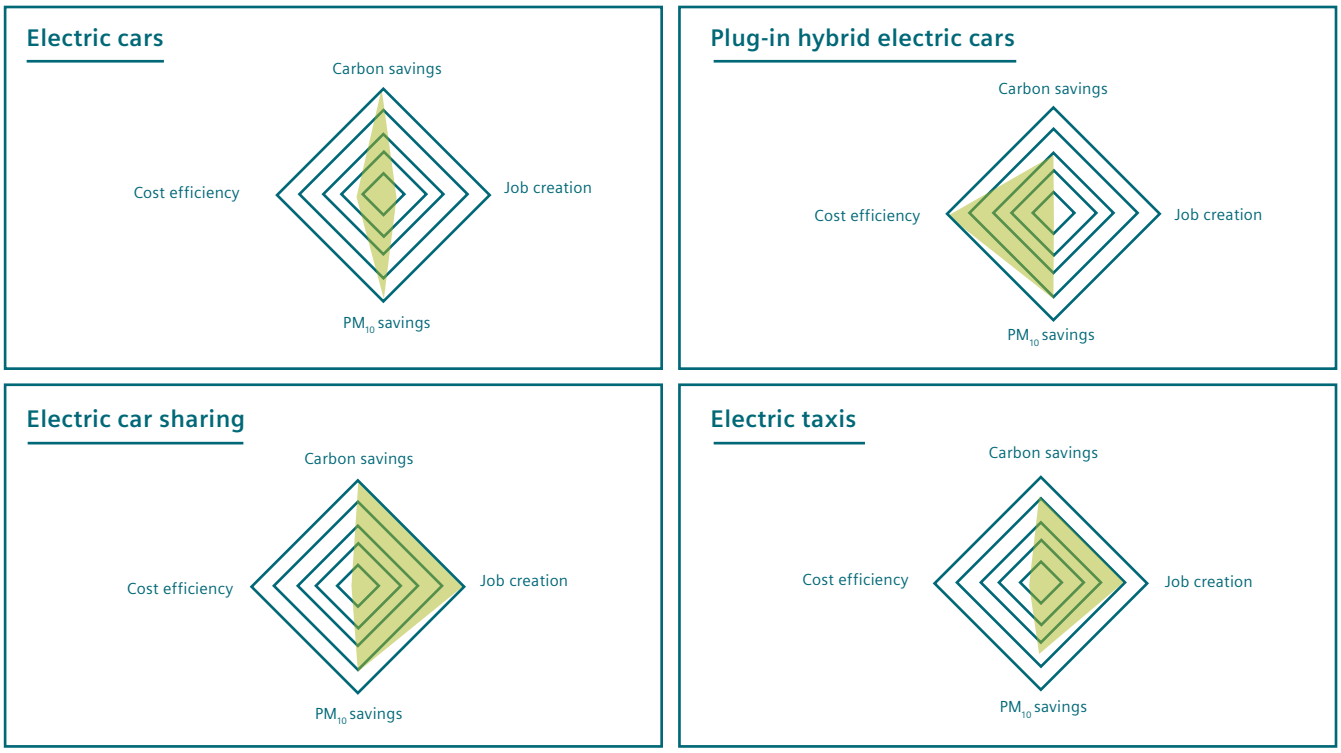


Figure 12: Comparing the cost effectiveness of technologies in the alternative car scenario

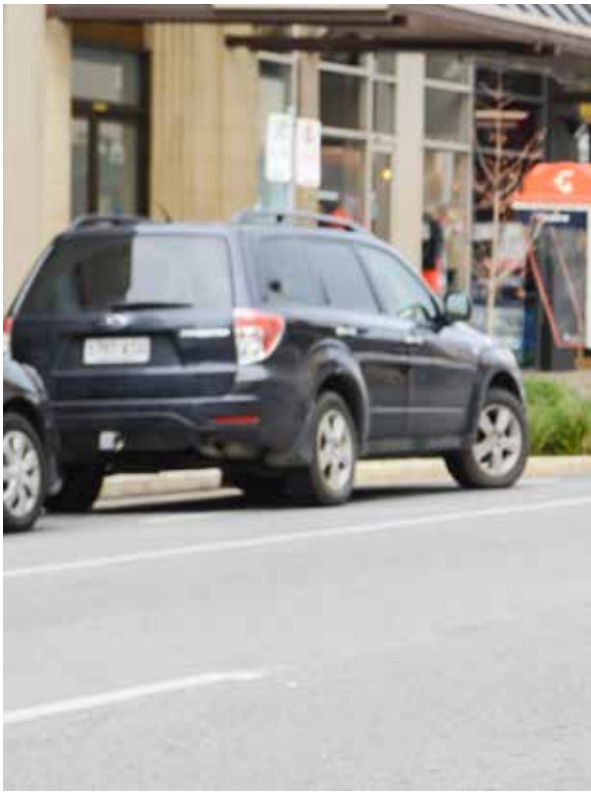
[1]In our model the Hybrid electric cars lever has zero investment cost for the city and the cost efficiency measure is not applicable.

When the top performing car technologies and services were compared simultaneously on four KPIs (overall CO_2 savings; cost efficiency in terms of CO_2e savings per investment spent; total jobs created and PM_{10} savings), electric car sharing and electric taxis are on average more effective on the jobs returns. Plug-in hybrid cars are less environmentally impactful than electric cars but more cost effective because of a less intensive charging infrastructure investment. The spider diagrams below show the comparative performance of each of the technologies compared to the average performance of all car related technologies used in table 6.

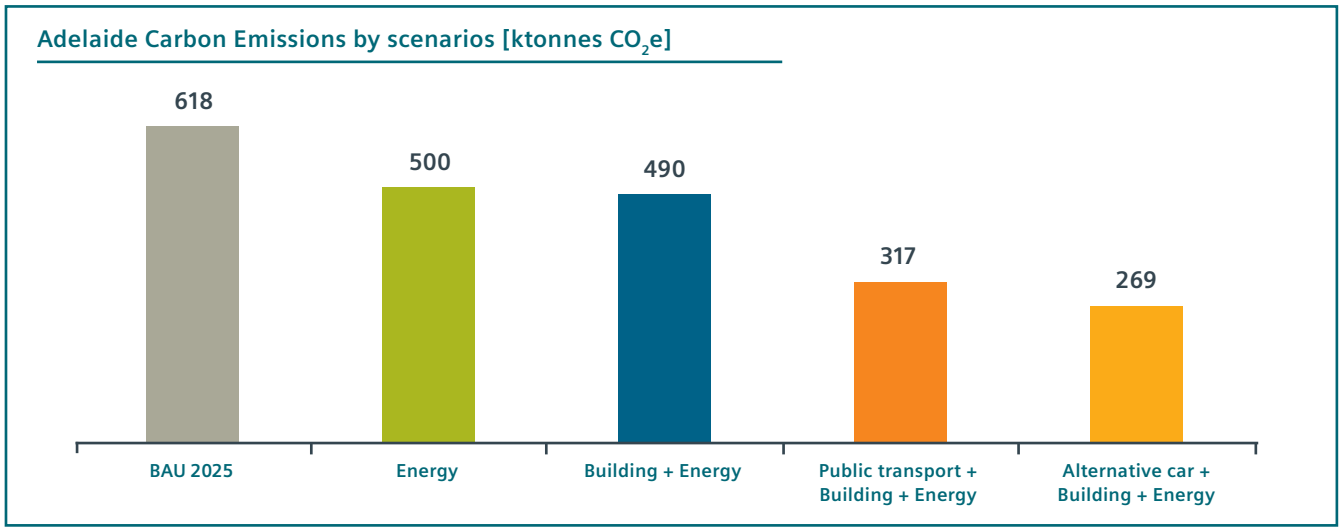
Multiple performance indicators for top performing technologies.



Implementing the change



Results from this study, show that the City of Adelaide can achieve significant further reductions in its carbon emissions by as much as 56% compared to 2025 BAU based on a future of alternative car technologies and building technologies all plugged to a cleaner electricity mix. This section looks at some of the ways that the city can achieve this change looking at some of the key strengths and opportunities in each of the sectors.



	BAU 2025	Energy	Building + Energy	Public Transport + Building + Energy	Alternative Car + Building + Energy
CO_2e emissions [ktonnes]	618	500	490	317	269
% reduction compared to BAU 2025		19%	21%	49%	56%
Jobs (FTE)		2,110	3,420	23,000	7,700

Figure 13: Emission savings for each scenario. (Energy= Energy investment scenario; Buidling + Energy=Building technologies based on cleaner energy mix; Public + Building + Energy = Public transport heavy investments and building technologies plugged to a cleaner energy mix; Car + Building + Energy = Alternative car heavy investments and building technologies plugged to a cleaner energy mix)

To achieve this level of reductions would mean reliance upon private sector investment attraction in wind power and national level policies and incentives. To counterbalance this reliance, consideration could be given to influence in the commercial buildings sector through regulatory reform or softer incentive based approaches including rebates and community bulk purchase schemes. Although the overall city wide emission reductions are small for this building scenario – because the electricity mix is already so much cleaner in 2025 (as shown in Figure 13), the city can build the necessary momentum and max out the mitigation potential within its remit. Box 1 showcases some of the instruments that the city can deploy based on some international examples.

Figure 14: SWOT analysis for the City of Adelaide's climate reduction plans

Box 1: Regulatory and incentive based instruments to accelerate building technology implementation in commercial buildings

Retrofit Chicago – The Commercial Buildings Initiative

The City of Chicago has some of the most iconic buildings which showcase the city's strength in global business and innovative architecture. The Commercial Buildings Initiative is one of three components of Retrofit Chicago, a coordinated, cross-sector plan to bring energy efficiency improvements to municipal, commercial, and residential buildings throughout the city. Structured as a voluntary leadership effort, Chicago's Commercial Buildings Initiative aims to increase energy efficiency in commercial buildings larger than 200,000 square feet. By reducing energy use by at least 20% within 5 years, participants support the City of Chicago's private sector's commitment to increasing asset value, reducing operating costs, creating jobs, and lowering carbon emissions. In joining the programme, participating buildings also commit to begin energy efficiency work within 6 months, track progress and share efficiency successes with the public, as well as serve as ambassadors to other buildings interested in increasing energy efficiency.

When the programme was launched in 2012, 14 buildings covering 14 million square feet of office and hospitality space joined the Commercial Buildings Initiative. This number has increased to 32 buildings and 28 million square feet since then. Programme partners develop a participant value proposition that focuses on increased building asset value through reduced operating expenses and improved tenant attraction and retention. By providing technical support, access to financial incentives, public recognition, expedited permits and fee waivers, and peer-to-peer engagement and best practice sharing, the Commercial Buildings Initiative is achieving great economic and environmental benefits for the City of Chicago.

Tokyo – Cap-and-Trade Programme

In 2006 Tokyo announced its aim to cut emissions by 25% from 2000 levels by 2020. As part of the strategy to achieve this goal, the Tokyo Metropolitan Government (TMG) focuses to reduce emissions from the city's new and existing building stock, implementing a cap-and-trade programme for existing large commercial, government, and industrial buildings. Launched in 2010, the Tokyo cap-and-trade programme is the world's first urban cap-and-trade programme.

The cap-and-trade system sets out that buildings over a certain size to take action in reducing its emissions. The cap is fixed for reducing carbon emissions at 6% for the first compliance period (FY2010-FY2014) and 15% for the second compliance period (FY2015-FY2019). If a building reduces emissions beyond the cap, then it is eligible to sell "credits" to buildings unable to match those targets. Thus, a market for carbon emissions is established, which produces the market-allocated distribution of a government-set level of emissions. In its first year of the programme, 1,159 participating buildings in Tokyo exceeded expectations and reduced emissions by a total of 13%. Of the participating commercial buildings, 93% have now met the first compliance factor, and more than 70% have already surpassed the target for 2019. Because of the market mechanism the cap-and-trade programme provides greater emissions reductions at a reduced cost to all participants. Moreover, energy efficiency efforts are now addressed jointly by tenants and building owners, which has led to greater public awareness of climate change issues.

Driving down the costs of capital for energy efficiency retrofits in the United States

Energy efficiency is often cited as one of the least expensive measures for GHG emission reductions. However barriers including sufficient scale, geographic diversity and performance data have limited it from accessing capital.

WHEEL (Warehouse for Energy Efficiency Loans) is a facility in the US, that commits a financial institution to purchase and "store" (warehouse) loans that meet certain agreed upon criteria until the aggregated value of the loans is sufficient to be securitised (meets the size and other criteria of larger institutional investors). It builds on the success of a large number of state and locally-sponsored energy efficiency programmes that have been running for a number of years; building-up volume and performance data. By aggregating state and local energy efficiency programmes, WHEEL drives down the cost of capital and thereby incentivises additional activity; and provides an appropriate vehicle for institutional investors with a desire to invest in energy efficiency.

A "socialised" credit enhancement facility is built from state contributions of public, utility benefits charge, or other monies to help support from a credit perspective the specific policy objectives of a participating state (e.g. interest rates offered to households, or inclusion of certain income levels).

WHEEL is supported by several policy framework-related provisions including state and local programmes that develop a sufficient pipeline that can be aggregated, the Federal government's allowance for American Recovery and Reinvestment Act (ARRA) funds which are used in the socialised credit enhancement facility.

Box 1 continued:

The consortium closed the first asset-backed securitisation of energy efficiency loans to market in 2015. Subsequent securitisations will continue as the facility fills, and depending on programme growth the facility could be resized, and the frequency of securitisations increased, accordingly.

WHEEL involves a range of stakeholders, from philanthropic organisations that provided seed funding (e.g. Rockefeller Foundation and Ford Foundation), NGOs that were instrumental in its development (e.g. Energy Programmes Consortium, National Association of State Energy Offices – NASEO), state and local programmes (e.g. Pennsylvania's Keystone Help), Federal agencies such as the Department of Energy that facilitates use of Federal funds and financial institutions such as AFC First, Citi and Renewable Funding).

A number of lessons were learned in the development of WHEEL. These include the multiple components and stakeholders required to deliver the scale of aggregation needed. Whilst capital markets are not a panacea they do offer a path to larger quantities and more efficient capital, a key ingredient for programme growth. As such it was critical to ensure that state and local programmes, and their aggregation, meet the needs of the capital markets in terms of size, diversity (across several dimensions of risk), and required data/information. The time required to establish and launch WHEEL was considerable. Establishing new asset classes in the capital markets takes time, but now that it is established, a platform exists to rapidly grow energy efficiency programmes and provide larger amounts and more efficient sources of capital.

If commercial building technologies are implemented at maximum levels in the city, the majority of city wide emissions in 2025 would be in the transport sector. Figure 13 shows that citywide $C0_2e$ emissions can be reduced from 600,000 tonnes to 270,000 tonnes if the alternative fuel car mobility future is coupled with the buildings and energy investments. This provides greater savings than the public transit option, which would also require heavier public investments by the transit authorities. To achieve this scenario, the challenge will be how to get Adelaide households and businesses to upgrade their cars when average fleet upgrade in the city takes over 20 years. Box 2 lists a number of options that other cities have taken to accelerate the implementation of alternative fuel cars to replace diesel and petrol stock.

Box 2: Increasing alternative car implementation in cities

Oslo

Norway has emerged as the world's largest electric cars market with over 22% of market share in 2015[1]. With just 5.1 million people, Norway accounts for a third of all European electric car sales, with Oslo having the highest concentration across the country. There are several national level incentives that promote electric cars in Norway. All-electric cars are exempt from all non-recurring vehicle fees, including purchase taxes, which are extremely high for ordinary cars, and consumers benefit from 25% VAT on purchase. This incentive makes the price for electric vehicles very competitive with petrol- and diesel-fueled cars, which can be relatively expensive in Norway due to high tax regime. Electric vehicles are also exempt from the annual road tax, all public parking fees, as well as road and ferry toll payments. Moreover, electric car drivers are allowed to use dedicated bus lanes, which speeds up journey times; cost less to insure and local governments subsidize the installation of charging points in private homes. These incentives are in effect until 2018 or until the 50,000 EV target is achieved. More recently, the new Green coalition government in Oslo has pledged to turn the city centre car free by the year 2025.

Rotterdam

The Rotterdam Electric programme, launched by the City of Rotterdam in 2012, intends to support and accelerate the development of the electric mobility market. Several incentives have been put in place such as the provision of sufficient network of charging stations in across Rotterdam. Owners of an electric vehicle parked on private property (such as a driveway or garage) can apply for a grant towards the purchase of the equipment for an electric charging station, up to a maximum of € 1000 per station. If green energy is used to charge the vehicle, the municipality will reimburse the energy costs for the first year that the charging station is in use, up to a total of € 450. Owners of an electric vehicle who cannot park on their own property, can apply to the City of Rotterdam to have a public charging station provided. The municipality will install this charging station in a car park or on the street in the applicant's vicinity. If this charging station is placed in a paid parking zone, the applicant will receive the cost of the parking permit for the first year, up to a maximum of € 678. The city of Rotterdam is also offering business buyers €2,500 scrappage incentives which, together with other state-funded subsidies, can bring the price of a e-NV200 Visia Flex down to just €4,950. The same discount opportunities can bring the price of a new Nissan LEAF down from €24,110 to just €7,450, which make electric vehicles substantially cheaper than conventional cars.

San Francisco

The City of San Francisco boasts more electric vehicles per capita of chargers-per-electric than any other city in the U.S. To address the predicament of finding available charging stations across the city, which is still one of the main reasons globally many car drivers shy away from

[1]Norwegian Electric Vehicle Association - http://elbil.no/english/norwegian-ev-market/

Box 2 continued:

purchasing an electric vehicle, the City of San Francisco incentivizes people by facilitating chargers for the private sector, so that whoever wants to install one can do so without bureaucratic hurdles, while also benefiting from state-level grants and a streamlined permitting process. In addition, the state of California recently passed a building code mandating that a certain portion of new construction come pre-wired for electric vehicle chargers. San Francisco is also working on its own code, which will be see even stricter building rules that favor electric mobility. Moreover, the city installed three off-the-grid solar-powered charging station, which allow electric vehicle owners to pull up and charge their cars for free.

At over AUD1.5 billion of capital investment spread over 10 years, the transport investments in the alternative fuel car future are high so the state and city governments making up the Greater Adelaide area will need to look at innovative funding mechanisms. Box 3 gives an example of such a mechanism, a Green City Bond, that was recently issued by the city of Gothenburg. Green City bonds may be particularly relevant to Adelaide as they can be used to spread investments across the building and transport sectors.

Box 3: The Gothenburg Green City Bond Programme

Green City Bonds are traditional municipal bonds issued by cities in order to generate upfront capital for investment. Their key difference is that they are labelled as green with a commitment to deliver environmental benefits within the maturity period of the bond.

In 2013, the city of Gothenburg raised its first green city bond at a value of €200m. Within only a couple of days the bond was oversubscribed due to the high credit rating of the municipality. Rather than the city telling capital markets where the money would be spent, it launched an innovative competition model for organisations to submit green projects that they wanted to fund in diverse sectors such as renewable energy, waste management and mobility. This was also open to departments within the municipality itself. Each submission had to be accompanied with an estimate of CO_2e savings that the project would deliver. As soon as all submissions were received a selection committee composed of the Environment and Energy departments as well as the City Council selected the most impactful projects on a cost to CO_2e savings ratio. The winners were a water purification plant, a biogas heat & electricity plant and the replacement of municipal cars with e-cars.

Gothenburg 2013 Green City Bond

Issuance

Markets → €200m City Bond →

Lending

- Renewable energy (solar, wind, wave and hydro)
- Energy efficiency
- Waste management
- Water management (efficiency)
- BioFuel (from forestry waste)
- Smart grids
- Sustainable housing (ex. infrastructure and construction)
- K2020 public transport development programme
- Environmental (max 20%)
- Development of new nature conservation areas
- Water cleaning facilities

Selection committee: Environmental Department, Treasury department, City Council

Reporting

Annual investor letter with a list of projects financed. However, no standardised monitoring and verification process.

Water purification filter

Total cost: AUD 300m

Benefits: Capacity increase by 40%

Socioeconomic gains in terms of lower disease outbreaks which saves up to 290 days in productivity loss between 2014-2038

Biogas heat & electricity plant

Output: 800 – 1,000 GWh

Electric car city fleet

100 electric vehicles

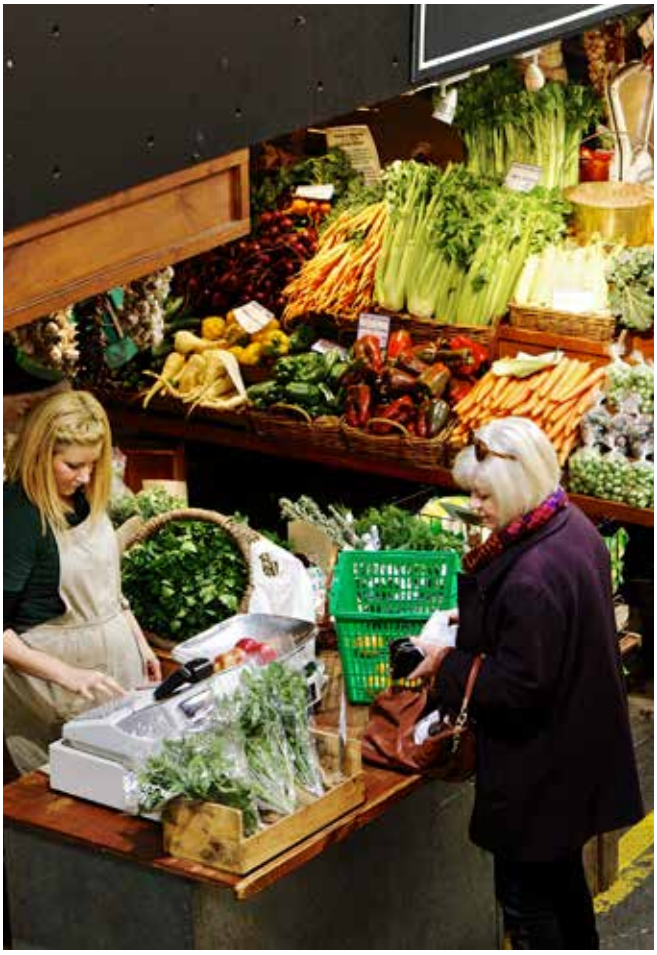
Conclusion

This report has looked at the potential carbon emission reductions when a coordinated mitigation effort at Local and State level is implemented in Adelaide.

If the City of Adelaide were to accelerate commercial building retrofit programmes over the next decade, the city could reduce citywide emissions by 5%. If it continues to encourage private investments to further decarbonise the States' electricity mix, these commercial building based carbon reductions will rise to over 20%.

In the transport sector, coordinated action in the Greater Adelaide area that will see households switch 60% of their cars to low emission technologies will see citywide emission reductions of 31%. To deliver this change, over AUD1.5bn of capital investment will need to be spent on public transit and charging infrastructure but return over 5,600 full time equivalent green infrastructure jobs in the Greater Adelaide area over the next decade.

Using examples from various international cities, this report has also looked at policy and funding instruments that the City of Adelaide can deploy to incentivise and accelerate change in both the commercial buildings and alternative fuel car sectors. Through an enduring commitment to investment attraction, clean technologies and strong community partnerships, the City of Adelaide's can achieve its aspiration to be the world's first carbon neutral city.



Appendix

Building technologies

Glazing

Applying double glazed window made of two panes of glass and a space between them filled with air or insulating gases and reduces heat and noise transmission as well as solar gain from solar radiation through the window. Due to better window insulation less heating and cooling energy is needed inside the building.

Efficient lighting technology

Significant electrical energy can be saved by replacing conventional luminaires by more efficient lighting fixtures and/or changing magnetic ballasts to electronic ballasts. Further reductions in power consumption can be achieved with the use of light-emitting diodes (LEDs), which also have a far higher lifespan than conventional lighting. LED solutions combined with intelligent light management systems can lower lighting costs in a building by as much as 80%.

Building Performance Optimisation (BPO)

Building Performance Optimisation (BPO) is a range of services designed to increase the energy efficiency of an existing building by implementing proven building control strategies otherwise known as Facility Improvement Measures. BPO can improve thermal and electrical energy efficiency in a building in many ways; typically via improved HVAC technology, by adapting the building to suit usage profiles or providing information and analytics for operational personnel. Building Performance Optimisation can be applied to building with an existing energy monitoring system.

Building Automation and Control System (BACS) Class A

Energy-efficient building automation and control functions save building operating costs. The thermal and electrical energy usage is kept to a minimum. It is possible to estimate the efficiency of a building based on the type of operation and the efficiency class of the building automation and control systems (BACS). High energy performance Class A provides integrated control of all zones throughout the building, including HVAC, lighting and shading, as well as sophisticated diagnostics and adaptive controls.

Building Remote Monitoring (BRM)

Remote Monitoring allows individual building performance to be measured and compared against benchmark values for similar building types or sizes. Energy experts are able to remotely analyse building energy usage, to detect problems and make proposals for improvements. Monitoring and performance reports creates awareness and transparency and enable continuous improvement and reduction of overall energy consumption.

Energy technologies

Wind power

Share of electricity provided by wind power at target year changing the energy mix and its related emissions provides cleaner electricity for buildings and electric powered transport modes.

Photovoltaic

Share of electricity provided by Photovoltaic at target year changing the energy mix and its related emissions provides cleaner electricity for buildings and electric powered transport modes.

Combined Heat and Power

Share of heat supplied at target year changing the energy mix for heating and its related emissions – provides cleaner heat for buildings.

Network Optimisation

Design, layout, optimisation of energy transmission & distribution networks ensures economic, reliable and simplified network operation. A well-structured, secure and highly available electricity supply infrastructure is one of the most important elements of a sustainable energy business. Reduces emissions from energy generation by reducing losses on high and medium voltage level transmission and distribution.

Power System Automation

Design, layout, optimisation of energy transmission & distribution networks. Economic, reliable and simplified network operation and energy management system for monitoring, planning, and optimisation of distributed energy resources. Includes full control of switches, very high level of automation, Feeder Condition Monitoring (FCM) devices installed at every transformer station, digital power meters installed at Low Voltage side of the Medium Voltage/ Low Voltage transformers. Provides faster system analytics and faster decision making on network reconfiguration. Reduces emissions from transmission and distribution caused due to energy losses including non-technical losses which requires more energy generation at the end.

Transport technologies

Electric Buses

Share of the vehicle fleet operated by battery electric vehicles. Battery electric vehicles are zero exhaust gas emission vehicles. They provide significant reduction of local emissions like PM_{10} and NOx. A charging infrastructure is set up and the electricity used for charging is generated according to the general local electricity mix.

e-Bus Rapid Transit (eBRT) – New Line

Number of new eBRT lines at target year. eBRT is a high performance public transport combining bus lanes with high-quality bus stations and electrical vehicles. It provides a faster and more efficient service than ordinary bus lines. Results in modal shift from private transport to public transport, shift from combustion engines and reduced energy demand per person km together with related emissions.

Electric cars

Share of conventional combustion vehicles replaced by battery electric vehicles. Battery electric cars are zero exhaust gas emission vehicles. It provides significant reduction of local emissions like PM_{10} and NOx. A charging infrastructure is set up and the electricity used for charging is generated according to the general local electricity mix.

Hydrogen cars

Share of conventional combustion vehicles replaced by hydrogen vehicles at target year. Hydrogen vehicles with fuel cell technology are zero exhaust gas emission vehicles. It provides significant reduction of local emissions like PM_{10} and NOx. The hydrogen is generated with fuel cell technology, using the local electricity mix. A refuelling infrastructure is set up.

Plug-in hybrid electric cars

Share of conventional combustion vehicles replaced by plug-in hybrid electric vehicles at target year. Small combustion engine for base energy demand combined with an electric drive for acceleration and for brake energy recuperation. Energy demand is reduced due to a higher efficiency of the combustion engine, operating at optimum and brake energy recuperation together with related emissions.

Electric taxis

Share of conventional combustion vehicles replaced by battery electric vehicles. Battery electric cars are zero exhaust gas emission vehicles. It provides significant reduction of local emissions like PM_{10} and NOx. A fast charging infrastructure is set up and the electricity used for charging is generated according to the general local electricity mix.

Electric car sharing

Number of sharing cars/1,000 inhabitants at target year: model of car rental where people rent e-cars for short periods of time, on a self-service basis. It is a complement to existing public transport systems by providing the first or last leg of a journey. Result in fewer driving emissions due to electric powered cars and shift to non-vehicle travel, such as walking, cycling and public transport.

Train – Electrification

Share of electrified train network with new electric train vehicles at target year. Provides a shift from diesel to electric powered trains, increased energy efficiency and greater passenger comfort based on lightweight chassis and use of energy efficient innovative technologies (e.g. for lighting and air-conditioning). Overall the lever reduces energy demand per passenger kilometre and related emissions.

Tram – new line

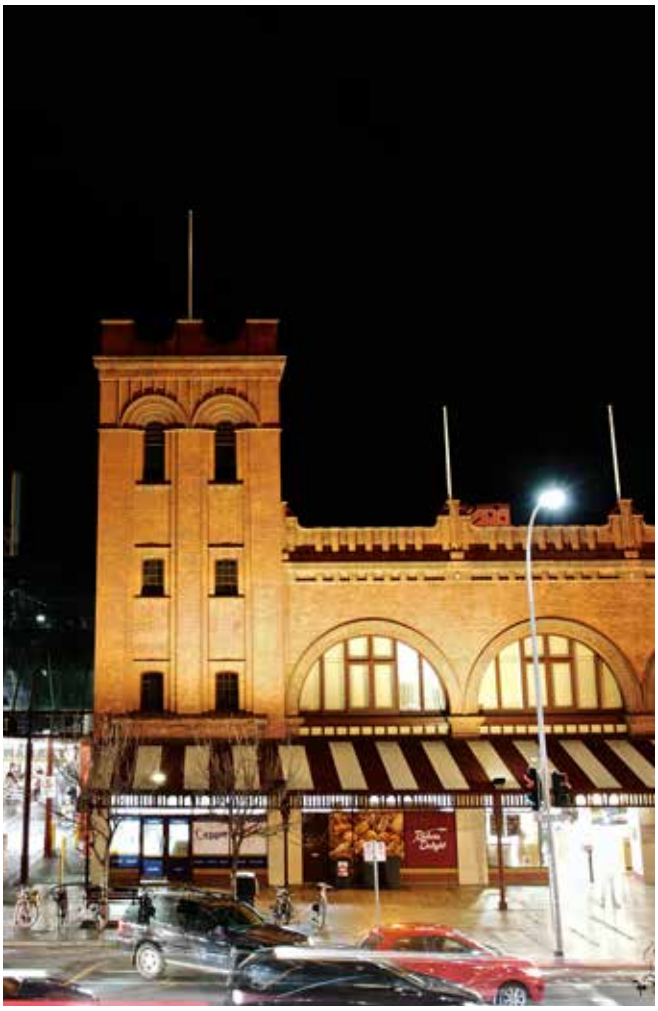
Number of new tram lines at target year of average tram length, shifting passengers from all other mode according to the transportation performance of existing lines in the city. Public transport attractiveness is increased and energy demand per passenger kilometre is reduced together with related emissions.

Train – Reduced headway

This lever increases the capacity of over-utilised train lines by modelling the introduction of additional trains and a signalling automation system, inducing a modal shift from motorized modes of transport to trains.

Cycle highway

Additional cycle highway at the target year. The lever increases the modal share of bicycles, reducing the modal share from motorised vehicles.



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