ZEB Forum
Zero Emissions Bus Forum

2020 Zero Emissions Bus Forum

Report and Key Findings

FEBRUARY | 2021

UITP INTERNATIONAL ASSOCIATION OF PUBLIC TRANSPORT
AUSTRALIA / NEW ZEALAND

L.E.K. ARUP

Foreword

It has been an incredible opportunity to work with our members Transport for NSW, Arup and L.E.K. Consulting to bring together local and global expertise in a virtual forum format in which we shared examples, case studies, best practice and lessons learned to inform Zero Emission Bus (ZEB) transition pathways for Australia and New Zealand. Through the ZEB Forum we considered the key questions that government and industry need to solve for in order to integrate ZEB fleets into transport networks in our region. This report captures and analyses what was shared at the UITPANZ ZEB Forum in late 2020 and offers key insights to power the way forward in our region.

We have an opportunity to emerge as global leaders in the zero emissions technology and sustainable transport space. While in some ways we're playing catch up to Europe and Asia, we also have an opportunity to leap ahead by investing in the latest technology and learning from the lessons of our peers from countries around the world including China, Singapore, the United Kingdom, France, Netherlands, Norway, the United States and Canada. This is the benefit of the global UITP network, where we can harness the expertise, lessons and case studies of members from 100 countries around the world, to inform the ZEB transition in our region and support the sustainable mobility agenda more broadly.

I'm delighted by the proactive response of many state and territory governments in Australia, as well as the regional and national governments in New Zealand, to move towards an accelerated ZEB transition in our region. This report includes statements about the zero emissions bus transition plans of each government (refer to the Addendum) and offers strategic insights to help them achieve those goals. Their statements provide the roadmap for our industry moving forward and empower all stakeholders, from energy suppliers, bus manufacturers and operators, to get on board.

No matter which part of the public transport industry you're from, I trust this report will help you in your mission and transition to a zero emissions future.

If you would like to be part of the ongoing ZEB discussion in our region and globally, please contact us to find out how you can join the UITP network.

I look forward to continuing the ZEB conversation with our members.

Michelle Batsas
Executive Director
UITP Australia New Zealand

Contents

1: Pathways to consider in your transition 4

2: The state of play in Australia and New Zealand 6

3: The importance of transitioning of ZEBs 10

4: The technology behind ZEBs 11

5: Potential pace of transition 13

6: Key challenges and considerations for transitioning to ZEBs 15

7: Overcoming the barriers and maximising opportunity 18

8: Conclusion 20

About the authors 21

Addendum 23

1: Pathways to consider in your transition

1.1 Make clear long-term commitment(s) to ZEBs, and set in motion short term actions to give industry confidence to make the transition

Short-term actions need to be founded on evidence, have clear communication and deliver upon the long-term commitment of transitioning to a widescale ZEB fleet. Multiple electric bus trials have been conducted across Australia and New Zealand, with several jurisdictions now implementing wider fleet deployments and putting bans in place on the procurement of diesel buses. Though jurisdictions are moving towards wider deployments, ongoing data collection and information sharing will be vitally important to inform both industry and government in their strategic and operational planning. A long-term agreed strategy for the rollout of ZEBs will help industry develop their own long-term plans to ensure that they adapt and are not left behind in the evolving bus market. A clear long-term commitment to ZEBs also means bus operators can make informed decisions when decommissioning buses and investing in ZEBs.

1.2 Think through regulatory frameworks for technical and safety standards

As with many other public transit modes, regulatory frameworks will need to be developed to ensure ZEBs meet technical and safety standards to remain compliant throughout their life. Technical standards need to be jointly defined by both private and public stakeholders in order to be effective and realistic while also in line with the overarching goal of environmental sustainability. While different trials have been occurring in different state or city-level jurisdictions, national regulations of ZEBs could produce significant economic benefits for local ZEB producers and operators by delivering consistency. The harmonisation of standards across both nations will allow bus manufacturers to benefit from economies of scale and allow government to purchase ZEB fleets at a lower cost.

1.3 Realise the benefits of coordination and cohesion across all stakeholders and jurisdictions

Whilst sharing experiences and knowledge across stakeholders and jurisdictions helps advance the transition to ZEBs, collaboration is also required to overcome some of the larger transition hurdles. Organisations have different roles to play in this collaboration. Next to government's role of helping to bridge the high initial costs of ZEBs, the role of government has been described as one of multi-factored leadership and facilitation. This might include setting targets for industry partners to mobilise around and collaborate with influencers, deliverers and manufacturers to realise the vision. Suppliers are required to collaborate with transport agencies and operators to develop vehicles and infrastructure that fits market requirements. Whereas operators and agencies are required to outline business requirements and feedback, share information and create guidance to transition to ZEBs.

A key goal of the coordination is to identify the limiting factors and solutions in technology, finance, operations and institutions to enable operational and transition readiness of ZEBs. A lack of coordination and misalignment of pathways and approaches leads to siloed studies and trials across jurisdictions resulting in unnecessary delay. Coordinated efforts in trials could result in a larger body of knowledge in a shorter timeframe. Within Australia it remains unclear who the central coordinating body would be – options include the National Transport Commission (NTC), Austroads or the Federal Government.

1.4 Better educate stakeholders about the benefits and transition towards ZEBs

Although the scope of benefits are well understood, local experiences with ZEBs will further detail the benefits and provide opportunities for stakeholders to better understand the technology. Private operators are capable of learning without much support, and government typically does not see the need to step into that space. However, there is a role for government to facilitate the educational process of internal and external stakeholders and the wider community. Firstly, more direct communications between local transport agencies, operators and international jurisdictions would help share lessons learned. Secondly, national transport organisations could play an important role in developing knowledge and guidance for practitioners to support the transition. Third, frameworks are required to monitor and share progress and lessons learned of ZEB introductions in New Zealand and Australia, and the benefits being realised.

Though one of the key drivers for transitioning towards ZEBs centres around climate change and cleaner air, the transition to ZEBs has significant ramifications for the regional economy. Given our long history of manufacturing in the region, there is the capacity and capability to build ZEBs locally generating new advanced manufacturing jobs. Furthermore, developing the technology and capability locally can be applied to other vehicles and sectors, including waste collection trucks and intelligent energy storage systems.

1.5 Reduce uncertainty around technology, financing, infrastructure and operations

The ZEB Forum highlighted there are still many uncertainties and knowledge gaps around technology, infrastructure, and operations. Some uncertainties include how diesel buses will be phased out or transitioned to a second-hand market, depot energy capacity, constraints to charging and impacts on service schedules. Potential solutions that have been raised include: the coordinated and transparent purchasing of vehicles and infrastructure across governments and jurisdictions, sharing of data and lessons learned, stronger policy guidance from government and coordination of larger trials for agencies that are looking to grow existing ZEB fleets. Finally, it has been noted that innovative financing structures need to be developed, and committed to, in order for agencies and operators to plan their acquisition strategies.

2: The state of play in Australia and New Zealand

2.1 The scale of the transition and opportunity

The transition to ZEBs is no longer a question of "if" for our region, but of "when and how". With the evolution of zero emission technology and the impacts of diesel fleets on public health, liveability, and climate change, the status quo of diesel buses can no longer be justified into the future.

Governments and operators are now presented with the opportunity to feasibly transition their fossil-fuelled bus fleets to cleaner zero emissions technology. The ZEB transition is not just a fundamental change for the way we operate our on-road public transport services, but has the potential to stimulate the economy and further develop our advanced manufacturing capabilities, especially as we turn our attention to recovering from the impacts of COVID-19.

The funding of the transition is a key question many planners are asking, not only for the bus fleet but also the associated infrastructure both inside the depot gate and outside it, such as depot charging facilities and energy network capacity. With many funding options available, it is expected funding models will differ depending on the local context and fleet ownership.

Jurisdictions are finding that ZEBs can have lower whole-of-life costs when both operational expenditure (OPEX) and capital expenditures (CAPEX) are considered. This will continue to improve in the coming years. Spreading and operationalising the cost of the ZEB transition is a challenge but can yield positive results especially if the full package of wider economic and environmental benefits are accounted for, including job creation and seeding the region's advanced manufacturing capabilities.

It is acknowledged that the carbon reduction impact of ZEBs depends on the availability and usage of 100% renewable energy sources such as solar energy or green hydrogen. As such, cooperating with the energy sector is essential to ensure energy supply readiness and that emissions are reduced from day one.

2.2 Commitments in Australia and New Zealand

Several state and local governments have expressed their desire to transition from mainly diesel fleets to zero emissions buses, acknowledging the need to provide leadership and financial support to help the industry make this transition. ZEB trials have already been conducted in various cities, with many using locally produced ZEBs. The trials to date have received overwhelmingly positive feedback from operators and the community, such as noise reduction, improved reliability and ride comfort. The increased government commitment to ZEBs is providing confidence for industry to transition towards ZEBs. Recent announcements and/or commitments include:

Australia

- The New South Wales Government has set a goal of transitioning the State's fleet of 8,000 buses to ZEBs by 2030, with more than 50 new electric buses expected to hit the road in 2021 on top of the existing electric bus fleet.[1] This follows a successful round of trials in recent years.
- Subject to the findings of the market soundings, the ACT Government will undertake a process for the procurement of ZEBs which will progress through either the release of a Request for Expression of Interest or direct progression to Request for Proposal depending on which is deemed the most efficient and appropriate for this procurement activity. The first of the 90 buses are expected to commence operation in 2021-22 financial year with the remainder delivered no later than 2024.[2]
- The Department of Transport and Main Roads in Queensland has announced all buses purchased by 2030 will be zero emissions. Several electric bus trials have been announced including 10 new electric buses to be operated in South-East Queensland in 2021.
- The Victorian Government recently announced it has committed $20 million in the 2020/21 budget for a three-year trial of electric buses.[3]
- The South Australian Government has released their new Climate Change Action Plan (2021-25) which has promised the transition of its entire public transport fleet to low and zero emissions vehicles powered by hydrogen and battery-electric technologies.[4]
- The Western Australian Government has announced from early 2022, battery-electric buses will operate on the Joondalup CAT service, which includes a new high-voltage EV charging system for the bus depot.

New Zealand

In New Zealand strong efforts are being made to support the transition from diesel buses to ZEBs. Bus trials have been conducted in Auckland, Wellington and Christchurch. The New Zealand Transport Agency, Waka Kotahi, is working closely with public transport operators to support their transition to electric fleets through co-investment. The agency is also exploring public transport bus ownership options with councils to encourage a faster uptake of zero emission vehicles and provide better value for money.

Approximately 80% of the nation's bus fleet is operated in the three main cities of Auckland, Wellington and Christchurch (around 2,000 buses). Wellington will increase its current fleet of 10 battery-electric buses to 108 by early 2023, accounting for 22% of its total fleet.[5] They have also declared they will not consider bids from any bus company running diesel vehicles when regional bus contracts expire in 2027.[6] Auckland Transport plans to have 34 electric buses in operation by the end of 2021, while in Christchurch 25 electric buses will be added to the public transport fleet in the coming year. Auckland Transport has announced no new diesel bus will be purchased from 2025, with a transformational goal making the entire fleet zero emissions by 2030.[7]

Statements about the zero emission bus transition plans for Australian and New Zealand jurisdictions from the relevant public transport authority can be found in the Addendum to this report.

---

1 https://nsw.liberal.org.au/Shared-Content/News/2020/GOVERNMENT-CHARGES-AHEAD-WITH-ELECTRIC-BUSES, accessed 14 Dec 2020

2 https://www.cmtedd.act.gov.au/open_government/inform/act_government_media_releases/chris-steel-mla-media-releases/2020/act-government-leads-the-way-with-ambitious-roadmap-for-zero-emission-buses, accessed 9 Sep 2020

3 www.premier.vic.gov.au/investing-buses-future, accessed 15 November 2020

4 https://www.premier.sa.gov.au/news/media-releases/news/south-australias-climate-change-action-plan-launched#:~:text=%E2%80%9CToday%20the%20Marshall%20Liberal%20Government,climate%2C%E2%80%9D%20Minster%20Speirs%20said , accessed 17 Dec 2020

5 https://www.metlink.org.nz/news/metlink-to-boost-electric-buses-from-2-to-22-per-cent-of-its-fleet-to-meet-climate-change-goals-and-passenger-growth/, accessed 14 Dec 2020

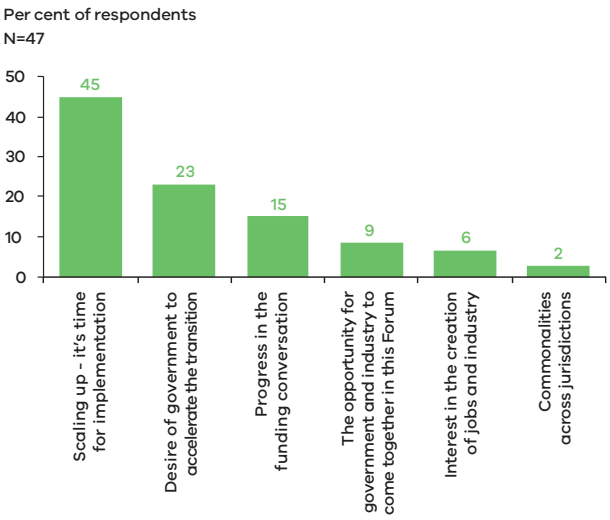
6 https://www.stuff.co.nz/dominion-post/news/wellington/123593561/wellington-will-have-fully-electric-bus-fleet-by-2027#:~:text=Wellington%E2%80%99s%20%20public%20transport%20is%20going,current%20contracts%20expire%20in%202027, accessed 14 Dec

7 https://www.newsroom.co.nz/bus-plans-an-electric-shock-to-council-climate-ambitions , accessed 21 Jan 2021

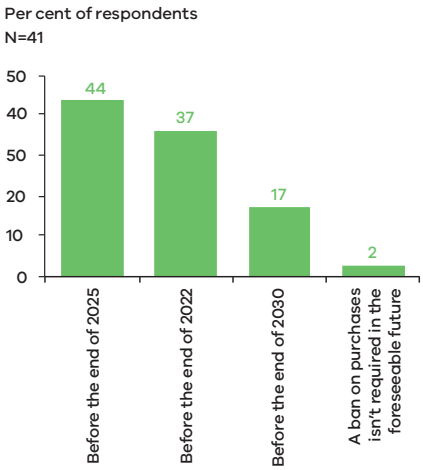
2.3 Level of interest in the transition

Industry has shown a high level of interest in the transition to ZEBs, as demonstrated during the recent Transport for NSW EOI process, over 300 people joined the Industry Briefing livestream and 72 company profiles were posted via the Online Collaboration Portal.[8] For the inaugural UITPANZ ZEB Forum,[9] over 265 people attended. During the ZEB Forum, attendees were asked to respond to a number of questions via polling software. When asked 'What are you most excited about?', the top response was 'the scaling up and implementation of ZEBs'. This reinforces the point that attendees were keen to see the transition move from small trials to scaled up deployments.

ZEB Forum attendees are most excited for...



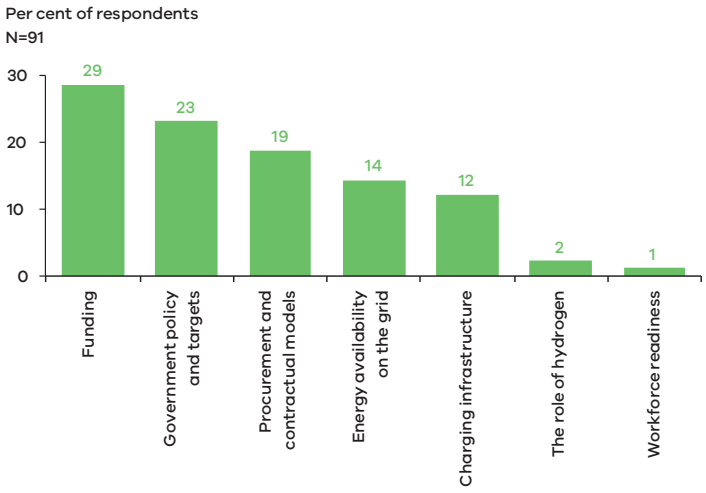
ZEB Forum attendees views on when authorities should commit to stopping the purchase of fossil-fuelled buses



2.4 Industry readiness

ZEBs bring the opportunity for manufacturers and assemblers to establish themselves as leaders in advanced manufacturing. It has been noted that Australia has resources of multiple battery components such as lithium, nickel and cobalt, but has immature expertise in the actual manufacturing of these components into batteries. Increased demand for ZEBs and accompanying technology brings with it an exciting opportunity for domestic producers to innovate and meet this new demand.

ZEB Forum attendees top issues on mind for transition



8 Transport for NSW

9 2020 UITPANZ ZEB Forum Attendee List

There are a number of bus manufacturers and assemblers based in our region who have developed capability in producing ZEBs. For example, Bustech Group[10] is currently building 10 electric buses for the Gold Coast. Volgren began production of battery-electric buses (BEBs) in 2019 with one of its vehicles currently being used for the Melbourne electric bus trial.[11] Custom Denning announced in late 2020 that it had begun production of locally designed and built BEBs and Fuel Cell Electric Buses (FCEBs)[12] with on-road testing beginning in December 2020. New Zealand's first fleet of electric double-decker buses (Wellington) – believed to be the first full electric double deckers in the world were constructed by Kiwi Bus Builders Ltd. It is acknowledged that while BEBs have been extensively used in trials, the production of hydrogen fuel-cell buses in Australia and New Zealand has been less common, largely due to the lack of hydrogen infrastructure, affordable hydrogen production and the purchase price of the vehicle.

The production of high quality ZEBs by bus builders in Australia and New Zealand shows that there is the technical capability and a willingness to invest in new advanced technology. It has been suggested, that proactively facilitating this advancement in manufacturing capability has ramifications more broadly for employment and economic development, as someone mentioned during the ZEB Forum – **'if we can build an electric bus, we can build an electric rubbish truck – same motor, same batteries, different payload'.**

2.5 Commercial competitiveness

While ZEBs will continue to evolve, BEBs are already reaching cost parity with traditional diesel buses. NSW believes that current BEB technology could serve around 80% of its current metropolitan bus routes. Battery pack prices have fallen almost 90% since 2010, becoming increasingly cheaper as technological advancements are made. Alongside the improvement in affordability, battery cell density has also increased, making them a more effective and reliable investment. It is acknowledged that hydrogen FCEBs are being actively considered by transport authorities and operators, however given the technology is still in its infancy, it still needs to go through initial trials. FCEBs are being considered for use cases in areas that experience high temperatures/humidity, longer range journeys (e.g., 400kms+ per day), and where there is a need for quicker re-fuelling.

The question is no longer whether ZEBs are commercially viable, but rather when do governments want to realise the opportunities and benefits presented by the transition to ZEBs. Environmental consciousness is higher than ever, and society expects both government and industry to make commercial choices that reflect community expectations surrounding environmental sustainability. According to UNSW, air pollution cost the Australian economy an estimated $11.1bn to $24.3bn in 2017,[13] up from $5.8bn in 2010. Thus, the health and economic benefits can be significant and supports the argument for a timely transition to ZEBs.

10 https://thedriven.io/2020/10/16/bustech-secures-electric-deal-with-queensland-and-with-us-bus-giant-cummins/ , accessed 21 Jan 2021

11 https://www.transdev.com.au/press-release/victorias-first-electric-bus-saves-61-6-tonnes-of-co2-emissions/, accessed 14 Dec 2020

12 https://www.custombus.com.au/custom/custom-denning-a-new-beginning/, accessed 14 Dec 2020

13 Dean, Annika & Green, Donna. (2017). Climate Change, Air Pollution and Health in Australia: A Blueprint for Action

3: The importance of transitioning to ZEBs

3.1 Environmental goals

Environmental sustainability is a topic that has become increasingly important as global warming continues to cause widespread climate instability. Customers and government are becoming more convinced that the prioritisation of public transport over private vehicles is key to reaching overarching goals of sustainability. It is likely that in order to reach state and territory 2050 zero net emissions targets, a move to ZEBs faster than an organic fleet replacement program will be required. Currently, transport emissions account for c.20% of all CO2 emissions in Australia and New Zealand. With rates of car ownership decreasing among the younger population, mass transit will see an increase in patronage, adding further strain on an already mass polluting transport mode. In order to achieve domestic and international emission goals, it is necessary for a decrease in public transport emissions to be realised. ZEBs can contribute to advancement of environmental goals as they have the potential to be net zero carbon emissions and also contribute to the adjacent goal of smart and liveable cities. A fast transition will allow the environmental and health benefits associated with zero emission bus fleets to be realised as quickly as possible.

3.2 The opportunity for industry

The transition to electric buses allows industry players the opportunity to advance environmental sustainability while developing technical capability. Though the bus industries in Europe and Asia have been quicker to introduce large scale ZEB fleets, there is still an opportunity for Australia to emerge as a lead exporter of ZEB components including batteries, bus bodies, chassis and fuel cell packs due to its unique natural resource advantage. The newfound technical knowledge can also be transferred to vehicle types such as freight and refuse trucks. In addition, the importance of sovereign capability has been further emphasised during the COVID-19 pandemic and is aligned with the push towards fostering the domestic manufacturing capability of ZEBs in Australia and New Zealand respectively. A long-term commitment by government to transition also means more local jobs can be created and sustained over time. As the transition is still in its early stages, further collaboration between government and industry is required to best navigate contractual constraints, significant investment costs and infrastructure challenges to deliver the optimal pathway for rollout.

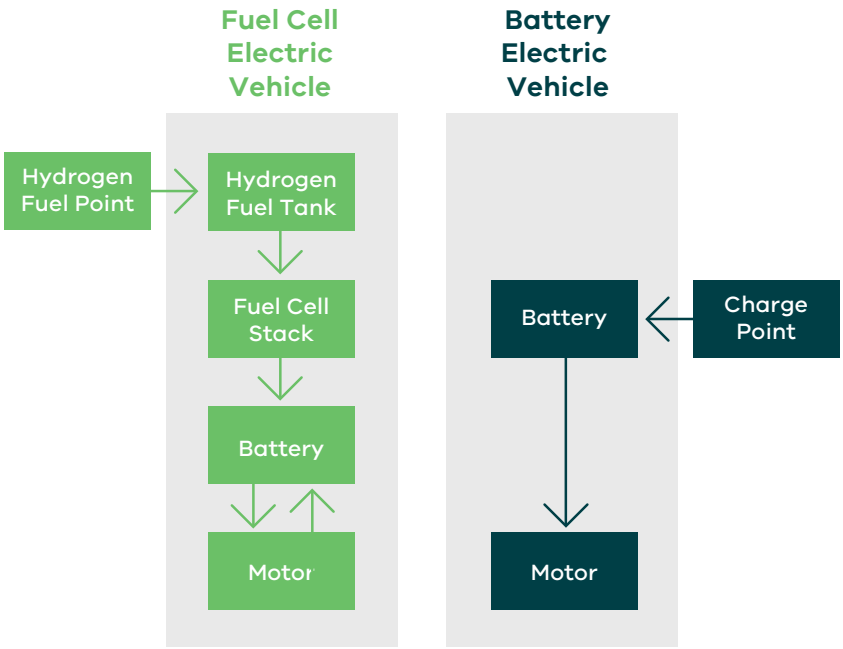
3.3 Zero emission policies in public transport

Increased pressure from society has translated into the introduction of environmental policies at the state and federal government level. In the bus industry, this has meant a strong push for ZEBs which are able to meet service demands and provide quality user experience, whilst also upholding environmental standards. A poll conducted during the ZEB Forum shows nearly 44% of forum participants believe that government should commit to stopping the purchase of fossil fuelled buses for public transport services by 2025, while 37% believe this should happen before the end of 2022. In Australia, both Victoria and NSW aim to achieve zero net emissions by 2050, with NSW aiming to transition all 8,000 buses by 2030. This type of commitment to the transition signals the government's expectations to industry to start adapting and preparing for change.

4: The technology behind ZEBs

4.1 ZEB overview

The term ZEBs includes both Battery Electric Buses (BEBs) and Fuel Cell Electric Buses (FCEBs). BEBs encompass an onboard battery pack that is charged using electricity, while FCEBs utilise an onboard fuel cell stack to create an electrical current from the conversion of hydrogen to water vapour. Both BEBs and FCEBs have zero tailpipe emissions, however the use of green electricity and hydrogen is a key factor in the overall environmental performance.



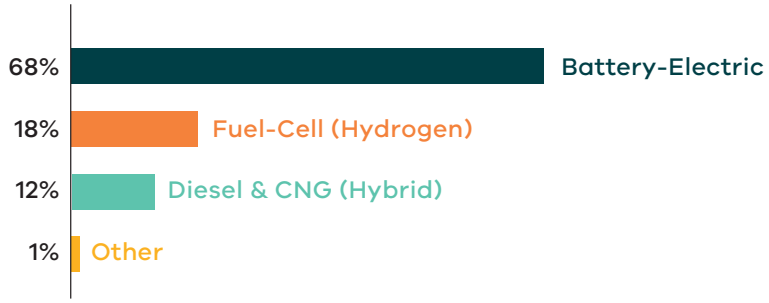
Current uses of BEBs, both here in our region and globally has suggested that there are potential reductions in maintenance costs, improved reliability, and cheaper fuel costs. While operating BEBs can be cost competitive, it is acknowledged they can carry additional upfront capital costs, such as the purchase price, need for depot charging infrastructure, and may require investment in the local energy network to ensure capacity is available. It is recognised current bus batteries are still relatively large and heavy; and have a much lower energy to weight density compared to diesel. These drawbacks can have implications on range, especially in hilly areas and when running in very cold or hot places. It is currently estimated around 17% of the world's buses are now electric (mostly battery-electric), with 99% of them in China.[14]

FCEBs in this region are not at the same level of maturity of BEBs. To date, only limited trials have been undertaken, with no widescale deployments. Hydrogen's key benefit is its exceptional energy density by weight, meaning that a small mass of fuel can transport a vehicle a long way when compared to a battery. However, hydrogen has its drawbacks, including its low energy density by volume which necessitates high pressure storage; and the additional energy needed to compress the gas and inefficiency of electrochemical reactions to produce and use the hydrogen. Some FCEBs can travel further than BEBs without refuelling, and can refuel in the same time as diesel buses. One particular use case for FCEBs is in colder climates, such as the UK where it is used for high kilometre double-decker routes, where the bus is capable of operating consistently throughout the day (18 hours).

14 https://www.sustainable-bus.com/electric-bus/electric-bus-public-transport-main-fleets-projects-around-world/ , accessed 25 January 2021

During the ZEB Forum, participants were asked what they thought the percentage split of buses being purchased in 2030 could be. Though BEBs overwhelmingly were the most likely, participants thought c. 1 in 5 buses purchased could be a FCEB.

What do you think will be the % split of buses being purchased in 2030?



In addition to commercial and environmental benefits, operations have also highlighted the noticeable amenity benefits of ZEBs. As ZEBs are powered by electricity, they are much quieter than traditional diesel buses which can produce large levels of noise and noticeable diesel fumes. A quieter bus greatly benefits passengers, bus drivers and the community that interfaces with the bus network.

4.2 Battery technology

Charging technology is an important consideration for BEBs and there are a number of different charging options that can be pursued, each holding unique infrastructure implications.

Charging can be approached in three main ways: slower charging at the depot overnight, fast charging at the depot, and flash or opportunity charging en-route. There is a balancing act between just having depot charging and complementing it with opportunity charging. Having additional infrastructure en-route can add substantial costs and complexity, while on the another hand it may negate the need for additional fleet. Charging infrastructure represents a significant cost factor in the transition to BEBs but is expected to be less of a factor as costs drop and the charging eco-system is developed.

It has been suggested that charging large BEB fleets can put significant strain on the energy grid, especially a large number of buses fast-charging at once, creating high intermittent power demands. To ensure grid stability and reduce peak strains on the local distribution network, flexibility around charging time may need to be encouraged. To support this, the future of charging will see the integration of digital technology and smart charging components.

Battery cell technology has significantly improved in recent years. New materials, increased battery cell density and reduced weight, faster charging and longer battery lifetimes, in combination with improved manufacturing of batteries, all strengthen the use case for BEBs. Current energy densities for bus batteries can range between 100-to-150-watt hours per kilogram (wh/kg), therefore a 350 kilowatt hour (kWh) battery could weigh up to 3.5 tonnes. It is worth keeping in mind that Tesla CEO Elon Musk has predicted a 400 wh/kg battery within the next 5 years. If this is achieved for bus batteries in the future, the weight of a 350 kWh battery could drop to 875 kgs.

In terms of price, the cost of battery packs* has fallen from near $1,200 per kW in 2010 to just under $200 per kW in 2019. As battery technology continues to develop and more suppliers emerge to increase competition and scale, it is expected that prices will decrease even further.

**This is a generic figure for battery packs - bus battery packs can still carry a premium due to the size and heavy-duty requirements.*

5: Potential pace of transition

5.1 Factors influencing the pace of transition

The level of enthusiasm demonstrated by the ZEB Forum delegates has shown that the question is not whether the transition to ZEBs should be made but rather, what is the right pace of transition. Top-down, the enthusiasm is driven by governments that are expressing their desire to transition to ZEBs, demonstrating leadership and providing confidence to operators and suppliers. Several state governments and leaders across Australia and New Zealand have passed the trial phase of electric buses, and are currently focused on scaling operations. Bottom-up it is driven by the positive experiences operators are having with ZEBs and growing capabilities by suppliers. As the feasibility, adequacy and desire of the pace of transition is different for suppliers, governments, operators and customers, the actual pace of transition will be determined by the level of collaboration between the parties involved.

The ZEB Forum has highlighted factors that either accelerate or decelerate the transition to ZEBs, creating a tension on the pace of transition. Current key accelerating factors include:

- More ambitious and prevalent emission targets by federal and state governments;
- Willingness of operators, driven by quality of service, simplified maintenance and reduced operational costs;
- Environmental and air quality benefits; and
- Innovations in bus technology including range, charging speed and vehicle design.

Furthermore, the ZEB Forum has identified various opportunities to accelerate the transition. They include:

- Development of local standards that facilitate innovation in public transport, as well as integration with other industries; and
- Encouragement of the local suppliers of bus bodies, batteries and required minerals.

Current key factors that could slow down the transition include:

- Reliability of bus technology;
- Uncertainty about reliability and timeliness of energy distribution;
- High upfront cost of infrastructure;
- Issues related to depot conversion and development including land use considerations;
- Bus contract lengths and complexity; and
- Government provision of financial support, leadership and collaboration.

The ZEB Forum has brought to light other factors that are not deemed as major concerns for transitioning to ZEBs. They include the availability of energy (as opposed to the distribution), future financial feasibility (battery costs have been dropping and operational costs are already lower) and driver and crew training.

5.2 Technology and path dependency

The level of commitment to ZEBs and institutional frameworks established by organisations and governments can have a large influence on future decision-making around ZEBs. The concurrent development of battery-powered and hydrogen-powered buses is a key example of this. As discussed, BEB technology is currently more advanced than fuel-cells, with significantly more investment around the world. The less mature supply chain, the price of production and ability to store and distribute hydrogen has slowed down investment into hydrogen vehicles, even in more mature ZEB markets like Europe. However, elements including longer range, energy resilience and potentially limited environmental footprint makes FCEBs promising in the medium to longer term.

Operators and suppliers are grappling with the question of which technologies to invest in, driven by investments already made, available financial arrangements, fleet size, contract lengths, route lengths and more. The rate of change of technology development will determine if both technologies will be used concurrently in the long run, or if one clear winner will emerge.

6: Key challenges and considerations for transitioning to ZEBs

Participants in the 2020 UITPANZ ZEB Forum cited a number of key challenges for the transition, with the top being technology capability and uncertainty.

6.1 Technology

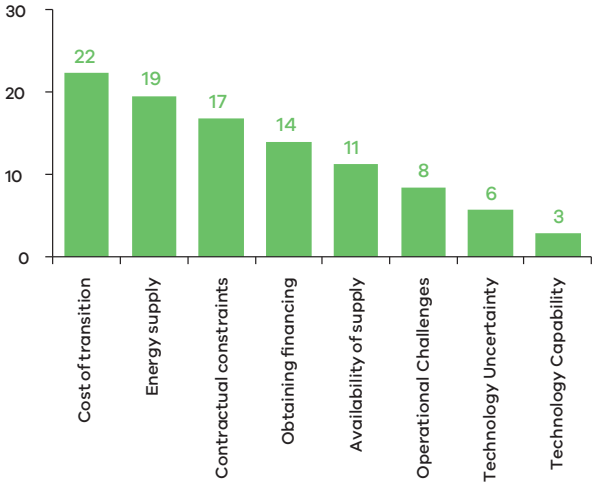
High upfront costs of ZEBs (BEBs and FCEBs)

High upfront capital costs represent the key challenge faced by operators in transitioning from diesel buses to ZEBs (both BEBs and FCEBs). While ZEBs currently cost more than traditional diesel buses, it has been suggested that price parity for BEBs could be achieved by 2030. Additionally, the transition to BEBs requires significant infrastructure investments, such as upgrading and establishing new depots and charging stations, and decommissioning current diesel fleets. Participants believe that without government support, funding these initial capital costs is a challenge for bus operators.

ZEB Forum attendees top challenges for transition

Per cent of respondents

N=45



FCEBs face similar cost challenges. They are more costly to acquire and require refuelling and storage infrastructure. FCEBs require hydrogen supply operating at scale in order to be cost efficient and this supply chain is not yet established in Australia or New Zealand. Moreover, the hydrogen supply chain typically requires demand from multiple industries to reach scale and attractive cost levels. Thus, it is necessary that there is collaboration between multiple industries such as the transport, medical and mining industry on cost sharing to achieve mutually beneficial cost outcomes.

The funding challenge experienced by bus operators is further complicated by the fact that many operators currently own relatively young diesel buses (lifespan up to 25 years) or have invested recently in new diesel fleets, and still need to earn a return on their significant investment. Hence it is not financially viable for some operators to transition well before the natural retirement date of their diesel fleets. Additionally, participants cited typical bus contract lengths as being too short to recover upfront investment in new charging infrastructure and fleet. In addition to the financial considerations, the environmental impact of decommissioning diesel fleets before the end of their useful life also plays a role.

Over time, it is likely that advances in technology will lower upfront capital prices to allow ZEBs to be more competitive against diesel buses. Increased financial support from the government through initiatives, such as subsidies or investment grants, can fast-track the transition to ZEBs by alleviating the high upfront CAPEX costs associated with acquisition of the buses themselves, as well as infrastructure development to support the lifecycle of ZEBs.

6.2 Operational

Depot infrastructure

The addition of ZEBs to bus fleets will accelerate the capacity of already near-full depots, requiring upgrades or the establishment of new depots to house ZEBs. The ease at which a depot can be upgraded or established varies significantly by location. The ability to execute upgrades to or establish new depots within the new contract time frames is also a difficulty experienced by operators.

Electricity grid

One key challenge in the transition to BEBs involves ensuring sufficient grid capacity to produce the necessary levels of power to support BEBs. The transition is likely to require upgrades to the electricity grid across Australia and New Zealand, which will involve varying levels of ease and cost depending on location. Augmenting the network capacity is also a complex task, and should be conducted alongside network planning for recharging infrastructure. Hence, it is essential that players collaborate with energy providers early in order to ensure a successful transition.

The distribution of recharging demand over the course of the day is the most important factor for grid stability, and it is likely that incentives for off-peak charging will need to be introduced. Smart and AI-based storage options will play an important role in future-proofing the grid and will help to balance micro-surpluses (locally) and generic surpluses (on the whole grid). Globally, some depots now have on-site energy storage to store energy when its cheap (wind and solar), providing a back-up system should the grid have issues.

Charge cycles and scheduling

The duration of charge cycles for BEBs requires effective charging stations at convenient locations. Bus depots appear to be the most natural location for these stations with the possibility for further charging stations to be positioned en route or end of route, for fast charging. Depots will therefore require infrastructure upgrades and the installation of charging infrastructure. However, it remains unclear as to how this infrastructure will be paid for. Operators are hesitant to pay for this new infrastructure and private ownership is likely to cause an inefficient monopoly, as owners can refuse to offer charging services to other bus operators. This would cause further complications in situations where the transport authority does not own or have control over the depots. However, there is potential for governments to provide a 'charging as a service' option whereby the government owns the depots / charging stations, and spreads the capital cost over a longer period of time through alternative payment mechanisms. This would greatly reduce the upfront capital burden currently faced by operators.

6.3 Financing

Technical uncertainty has made it difficult for operators to commit to the significant upfront capital costs required to make the transition to ZEBs. The consistent decrease in price indicates that further technical developments will continue to drive costs down, encouraging operators to wait until costs fall even more before making the transition. With current bus contract lengths, it is difficult for bus operators to justify acquiring finance for the initiative.

However, there are a number of finance options involving government support that could significantly reduce the costs of transitioning to ZEBs borne by operators. For BEBs, one such method involves the government buying electric bus fleets while operators bid to deliver the service. This method removes the initial cost barrier discouraging operators from transitioning to electric fleets, and is currently being utilised in South Australia and Western Australia. A ZEB Forum poll revealed that over 60% of respondents believe that government ownership of fleets and depots is the primary asset ownership factor that would drive the fastest transition to ZEBs in Australia and New Zealand. Further, if the government secured access to the depots, they could ensure a more level playing field at the time of re-tendering.

Furthermore, while preliminary emission targets are useful for operators, the provision of tangible information relating to technical standards and increased financial support to offset the initial high CAPEX by the government, will greatly support operators in their transition journey. During the UITP ZEB forum, government policy and targets ranked as the second most important issue on mind for the transition to ZEBs. With clearer direction from the government along with further financial support, bus operators will have the direction and confidence to prepare a more realistic and well-informed timeline of their transition to ZEBs.

6.4 Industry

Currently, manufacturing capability and supply chains for battery production are less mature in Australia and New Zealand than Europe and Asia. While Australia currently exports a significant number of materials that are required to manufacture batteries, it imports ZEB batteries from overseas. Increased investment in strengthening local supply chains as well as industry training can empower local industries, thereby increasing domestic production of batteries and decrease costs for the local bus industry. Furthermore, if manufacturing capability is developed locally, Australia could very well become an exporter in batteries given it is rich in the raw materials required for production.

7: Overcoming the barriers and maximising opportunity

7.1 The role for government

Clear targets and policies

Participants indicated that the government should play a key role in setting clear and committed emissions targets, public transport policies and programs to allow industry to prepare for the transition to ZEBs. The bus industry requires clear targets in order to invest in production to deliver the necessary volume of supply, while operators are reliant upon the government commitment to the transition, to justify the upfront capex costs associated with switching to ZEBs. This sentiment is confirmed by poll results during the ZEB Forum, with strategy being voted the top area governments should lead during the ZEB transition. In addition to the provision of strategic direction with regards to acquiring ZEB fleets, the government can also play a pivotal role in advancing climate stability by establishing environmentally friendly programs for the decommissioning of redundant diesel fleets.

While state and territory net emission targets exist, more specific guidance on the implications for the bus industry such as internal combustion engine (ICE) bus end dates, required electric bus fleet volumes, rate of transition and strategic support offered by the government will provide greater clarity to manufacturers, assemblers and bus operators. Alongside targets, government investment will also have the effect of signalling to industry that it is committed to the transition to ZEBs and provide confidence to industry who need to justify large amounts of capital spend on new buses and the accompanying infrastructure needs.

Determining objectives and standards

The government should also play a role in determining its objectives for ZEB fleets and outlining standards and requirements. In order to preserve flexibility and achieve efficiencies of scale, government should also encourage uniform fleet and infrastructure standards.

7.2 The role for industry

Industry plays an integral role in technical innovation, with a ZEB Forum poll revealing that over 50% of respondents believe that industry should lead innovation in the transition to ZEBs. Key industry players such as manufacturers, assemblers and operators need to be prepared to innovate and meet demand when it materialises, while also reaching a cost curve that makes them competitive against imports from overseas. The industry must embark on the journey and invest accordingly in order to remain relevant and competitive with existing international players. Upon the commitment to ZEBs from government, if the industry does not invest and innovate, it will lose to international competition.

It is also important for adjacent industries such as energy grid managers and the bus industry to collaborate when developing their long-term transition strategies to support an effective long-term fleet electrification. Collaboration across different industry sectors will ensure that the most cost-efficient methods of production are pursued, and that technical and cost risks are shared across industries and do not act as an impediment to transition.

7.3 The importance of working together

The increased exchange of information between government and industry can bring to light the challenges faced by either side in the transition to ZEBs, as well as highlight key opportunities to be pursued. Governments which provide some certainty on the level of demand in the near future through to the long term will assist industry in making the appropriate investments in machinery. Further, through greater collaboration with government, industry can provide greater visibility on the readiness of current technology as well as capacity, so that governments can plan appropriately. Valuable insights can also be generated through shared data from ZEB trials to inform both sides of the successes and complications with current ZEB technology. The greater exchange of information will allow for a smoother procurement process as government can set out more detailed requirements and are in a better position to make informed decisions on operator capability.

Further, cost sharing may be another form of cooperation between multiple stakeholders, allowing the capital burden associated with developing new infrastructure to support ZEBs to be split between multiple parties or industry groups who benefit from the transition. Shared investment can diminish risk on both the demand and supply side and encourage faster transitions to ZEBs. Additionally, alternative ownership models such as the situation where government owns ZEB fleets and depots while operators bid to operate the bus service can significantly fast-track the transition to ZEBs, as bus operators are not delaying transition due to concerns about technical uncertainty or high capital costs.

8: Conclusion

We hope that in reading this paper you have reached the conclusion that the transition towards ZEBs is no longer about understanding the technological and commercial feasibility but rather how soon do jurisdictions want to realise the opportunities and benefits presented by ZEBs. The transition is gaining traction and as we move beyond Covid-19, ZEBs present the perfect opportunity to spur economic development of next generation manufacturing jobs, make a significant impact on our regions' carbon emissions, and improve the liveability of our towns and cities.

It is acknowledged that the carbon reduction impact of ZEBs will depend on the usage of renewable energy sources such as solar energy or green hydrogen. As such, bringing the energy sector inside the tent early in the transition will be essential to ensuring energy supply readiness and that emissions are reduced from day one. Importantly, working hand in hand with the energy sector will build resilience into the energy system and prevent fleet operational issues from interruptions in the energy supply.

The funding of the transition remains a key question for operators and transport authorities. In funding the transition, it will be important to consider the purchase of new buses alongside the associated infrastructure both inside the depot and outside it, so that depot charging facilities and energy network capacity are ready. Importantly, there are a range funding options available to jurisdictions. Funding models will likely differ across the region depending on the local context and fleet ownership.

Key pathways to consider in accelerating your transition include:

- Make clear long-term commitment(s) to the wide scale implementation of ZEBs, alongside setting in motion committed short term actions to give industry confidence to invest and make the change.
- Work through regulatory frameworks for technical and safety standards, ideally in partnership with other jurisdictions, to prevent incompatibilities between networks and reduce costs of compliance.
- Given the significant benefits involved in the transition it will be important to coordinate and gain cohesion across all stakeholders and jurisdictions.
- Though the ZEB Forum was a good opportunity to share the benefits and educate people on ZEBs, this is just the start and it will be important to continue to better educate stakeholders and the community about the benefits of transitioning towards ZEBs.
- Continue building and sharing our knowledge around the uncertainties of technology, financing, infrastructure and operations.

About the authors

International Association of Public Transport Australia/New Zealand (UITPANZ)

The International Association of Public Transport (UITP) is a passionate champion of sustainable urban mobility and is the only worldwide network to bring together all public transport stakeholders and all sustainable transport modes. We have 1,800 member companies from 100 countries. Our members are public transport authorities and operators, policy decision-makers, research institutes and the public transport supply and service industry.

L.E.K. Consulting

L.E.K. Consulting is a global management consulting firm that uses deep industry expertise and rigorous analysis to help governments, organisations and businesses to achieve practical results with real impact. We are uncompromising in our approach to helping clients consistently make better decisions, deliver improved business performance and create improved market outcomes. L.E.K. advises and supports global companies that are leaders in their industries — including the largest private- and public-sector organizations, private equity firms, and emerging entrepreneurial businesses. Founded in 1983, L.E.K. employs more than 1,600 professionals across the Americas, Asia-Pacific and Europe. For more information, go to www.lek.com.

ARUP

Arup is an independent firm of designers, planners, engineers, architects, consultants and technical specialists, working across every aspect of today's built environment. Together we help our clients solve their most complex challenges – turning exciting ideas into tangible reality as we strive to find a better way and shape a better world. Arup came to Australasia in 1963 to undertake the structural design of the Sydney Opera House and we now work from multiple cities across four key areas of influence: cities, connectivity, health, resources. Our desire to shape a better world ensures our clients receive smart design ideas with a social purpose, which will have a positive influence for current and future generations.

For more information please contact:

Michelle Batsas
Executive Director
International Association of Public Transport Australia/New Zealand (UITPANZ)
P: +61 438 076 036
michelle.batsas@uitp.org

Natasha Santha
Partner
L.E.K. Consulting
P: +61 2 9323 0700
N.Santha@lek.com

Mark Rowland
Transport & Highways Advisory Leader (Australia & NZ)
Arup
P: +61 4 01798435
Mark.Rowland@arup.com

Methodology

This research paper was developed using:

- Content from the 2020 UITPANZ ZEB Forum
- L.E.K. Consulting and ARUP research and analysis

The paper integrates the views and consultation with UITPANZ members and industry advisory groups. We would like to acknowledge and thank the following:

Organisations

- Transport for NSW
- Auckland Transport
- The Queensland Department of Transport and Main Roads
- The Victorian Department of Transport

Contributors

- Angé Anczewska, International Association of Public Transport Australia/New Zealand (UITPANZ)
- Will Griffiths, L.E.K. Consulting
- Andrew Hooley, Transport for NSW
- Franziska Korte, ARUP
- Joey Schaasberg, ARUP
- Andre Tibyrica, L.E.K. Consulting
- Evan Walker, Transport for NSW

Addendum

ANZ Jurisdictional Statements February 2021

Auckland *(Auckland Transport)*

Auckland Transport has adopted a Low Emission Bus Roadmap, which committed to purchasing only zero emission buses from 2025 and full fleet transition by 2040. Funding to accelerate this is in discussion with politicians and is likely to be included in a 2021 onwards Mayoral funding proposal for no diesel bus purchases from July 2021. An aspiration to further improve on this and bring forward the transition to a full fleet ZEB by 2030 has been approved in principle, subject to funding, by the AT Board as part of an update to the Roadmap.

Following successful trials of standard two axle e-buses with a number of contracted bus operators and with greater confidence in new technology fleet by operators, Auckland Transport is implementing eight e-buses on Waiheke Island services, a new Airport Link service in January 2021 with nine e-buses and replacing the 12 buses on the City Link service with an all new electric bus fleet from February 2021. A total of 32 electric buses will be in service by February 2021.

Australian Capital Territory *(Transport Canberra)*

In September 2020, the ACT Government released its ambitious Zero Emission Transition Plan for Transport Canberra to transition its bus fleet to zero-emissions by 2040, in accordance with its climate change commitments. The Plan identifies a series of actions across 5 strategic priority areas to deliver a successful transition: 1. Building the infrastructure we need, 2. Procuring a zero-emission fleet, 3. Partnering with the energy sector, 4. New skills, protecting jobs and growing the economy, and 5. Increasing public transport use through better buses and a better service.

Key actions committed under the Plan include procurement of at least 90 battery electric buses in the current term of Government, design and construction of a new zero emissions bus depot in Canberra's North and building electric bus infrastructure as part of the new Woden Depot.

Greater Wellington *(Greater Wellington Regional Council)*

Greater Wellington Regional Council is working out options for a pathway to decarbonisation to make the biggest impact on the reduction of CO2 for the available funds (options will be the subject of public consultation).

Our current fleet includes 10 electric 2-axle double deckers with another 98 new EV buses due for delivery from April 2021 to January 2023. Additionally, Council has approved in principle (subject to funding) the purchase of 4 additional electric buses to meet projected growth.

There is a trial underway by one of our Public Transport Operators to convert diesel buses to electric buses and Council has approved introducing an electric ferry into the fleet, a first in the Southern Hemisphere.

We have collaborated with Victoria University of Wellington and Emissions Impossible to develop new tools to help understand bus emissions. We will continue to evolve our emissions modelling to enable us to make informed decisions.

New South Wales *(Transport for NSW)*

The NSW Government is committed to delivering more sustainable outcomes for our community with the transition to zero emission buses. We believe that this transition will both reduce emissions, providing environmental and health benefits, and make our bus operations more financially sustainable over the long term.

Transport for NSW is undertaking a number of initiatives to understand the most effective way to transition our bus fleet, including partnering with leaders in the energy, transport, manufacturing and financing sectors to participate in trials of zero emission buses. The results of these initiatives will help to shape the direction of zero emission buses in this state, including the most appropriate technology for the range of environments that the bus fleet operates in.

Queensland *(Department of Transport and Main Roads)*

It's an exciting time for zero emission bus technology in Queensland, with the introduction of battery electric vehicles into passenger service on regional, suburban and city centre routes commencing in 2020. Working with multiple delivery partners and vehicle manufacturers, the Department of Transport and Main Roads will evaluate ZEB technology across a range of service types to understand performance in local conditions, whole of life operating costs and customer feedback. To achieve the Queensland Government net zero emission targets by 2050, zero emission fleet will be progressively implemented across South East Queensland from 2025 and regional centres by 2030.

South Australia *(DIT - South Australian Public Transport Authority)*

Two of at least seven state-of-the-art hybrid buses rolled off the production line in recent weeks as part of the South Australian Government's commitment to lower-emissions and a better, cleaner and more environmentally friendly public transport network. The two Scania Hybrids, constructed locally by Precision Buses, are currently undergoing extensive acceptance testing with a further five vehicles in pre-production. The supply contract with Scania includes provisions to order additional hybrid buses and adapt to new technologies as they emerge over time. In addition, the South Australian Public Transport Authority is undertaking evaluation of two electric buses that have been built locally in Adelaide by Bustech which will look to optimise the battery pack size and type that suits Adelaide's operational needs. The first of these electric buses entered service in late January. South Australia is committed to delivering a cleaner environment and is working to have Electric Vehicles mainstream in the metropolitan areas with the South Australian Government's fleet, including taxi and rideshare vehicles, envisioned to be fully electric by 2030..

Victoria *(Department of Transport)*

The Victorian Government has committed $20 million for a trial of zero emissions bus technology. The trial will run over three years and create a pipeline of local job opportunities. An expression of interest process will begin soon. In the meantime, we are supporting the trial of our first locally built, fully electric bus on the network.

Western Australia *(PTA WA)*

The Public Transport Authority of WA (PTA) will take delivery of 4 Volvo/Volgren battery-electric buses in 2021, with trials of this technology commencing in the Perth northern suburbs including the Joondalup Central Area Transit (CAT) service in early 2022. The E-bus trial also includes the construction of an electric vehicle charging station at the Joondalup Bus Depot that will service the charging requirements of these electric buses during the trial. Participating in such trials will allow the PTA to assess the operating capabilities of these vehicles and determine the necessary capital and infrastructure requirements specific to the Transperth operating environment and climatic conditions.

A project plan has been developed for the Joondalup electric bus trial which includes elements of vehicle design, personnel training, procurement and logistics, high voltage electric charging infrastructure and electric bus operating simulations for the Joondalup CAT service. Modification of the Joondalup bus depot to accommodate electric buses has commenced. These works include significant alterations to the depot parking layout to accommodate the new vehicles and a high voltage EV charging system with capacity to expand beyond four buses if required. This work is expected to be completed in the first half of 2021.

UITP Australia New Zealand
www.uitp.org/regions/australia-new-zealand/
UITP Australia New Zealand
@UITPANZ

L.E.K. Consulting
www.lek.com
L.E.K Consulting
@LEK_Consulting

Arup
www.arup.com
Arup
@ArupGroup

UITP
INTERNATIONAL ASSOCIATION OF PUBLIC TRANSPORT
AUSTRALIA / NEW ZEALAND

L.E.K.
ARUP