Submission No 11

ELECTRIC BUSES IN REGIONAL AND METROPOLITAN PUBLIC TRANSPORT NETWORKS IN NSW

Organisation: Transit Systems Pty Ltd

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RESPONSE TO THE INQUIRY INTO ELECTRIC BUSES IN REGIONAL AND METROPOLITAN PUBLIC TRANSPORT NETWORKS IN NSW

1. Overview

Transit Systems welcomes the opportunity to submit our response to the Inquiry into Electric Buses in Regional and Metropolitan Public Transport Networks in NSW.

Transit Systems is recognised as an industry leader in the development of practical strategies to introduce zero emission buses into Australia.

We have met several times with NSW Government Agencies to further the deployment of Electric Battery Buses (EBBs), as well as Hydrogen Fuel Cell Buses (HFCBs).

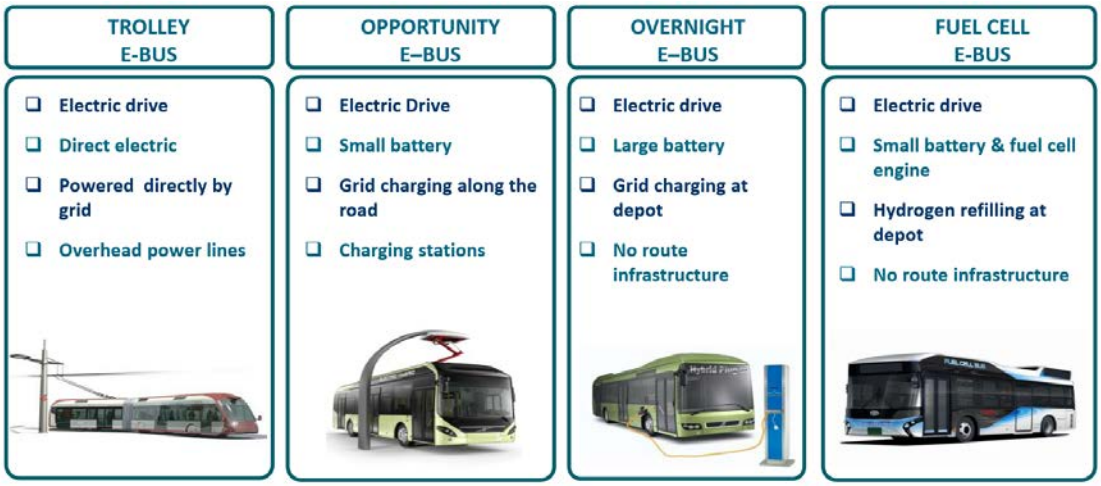
Transit Systems operates over 830 diesel and CNG buses in Sydney from six strategically located Depots. To transition just 10% of this fleet would transform the bus industry in NSW and provide attractive commercial opportunities for bus manufacturers and equipment suppliers, which will in turn provide downward pressures on capital expenditure.

Transit Systems is at the forefront of zero emission technology and has the experience necessary to effectively operate and maintain almost all variations of powered vehicles and are well placed to mobilise and maintain a fleet of new buses; whatever the energy source.

The NSW Government can leverage off our capability to establish a flourishing EBBs and HFCBs in New South Wales. This is predicated on the assumption that we are selected to partner with the NSW Government to deploy zero emission buses in NSW.

Hydrogen Fuel Cell Bus - London

2. Benefits of Electric Buses and factors that limit their wider uptake



Trolley Buses

Trolley buses are suitable for high patronage City services where road-space and infrastructure allow for their deployment.

Significant infrastructure capital cost generally restricts deployment to large Cities.

Characterised by

- high capital costs;
- extensive electrical infrastructure;
- visual impacts of overhead wiring and electrical poles; and
- loss of road-space for other road uses.

Opportunity Charging – On Route Charging

Similar to a Trolley Bus but does not require electrification of the entire route. Challenges associated with accessing the Charging Pad enroute, or at the terminus if services are running late, or services are disrupted.

Given the significant technology advances with battery buses, Opportunity Charging may not be as cost effective as Overnight Charging at the Bus Depot.

Overnight Depot Charging – Electric Battery Buses (EBBs)

Electrical infrastructure is concentrated at the Bus Depot which removes the need for on-street Opportunity Charging, or electrification of the entire route as is the case with Trolley Buses. Electricity supply and Grid capacity can limit deployment in some jurisdictions.

Pure battery electric buses pose operational challenges (high weight, limited range and relatively long recharging times; together with high capital cost for electricity distribution network upgrade.

Hydrogen Fuel Cell Bus (HFCBs)

HFCBs have similar operating characteristics to diesel and CNG buses. No additional fleet requirements as the HFCB can be fuelled in approximately 10 minutes.

3. Minimum energy and infrastructure requirements to power electric bus fleets

Depot Charging Buses - Electrical Infrastructure

The cost of electrical infrastructure upgrades to accommodate Electric Battery Charging vehicles needs to be considered carefully as initial cost estimates may be under-estimated.

In early 2019, Leichhardt Bus Depot underwent a significant electrical upgrade in preparation for the commencement of the Region 6 Electric Bus Pilot which included a new distribution board, extensive cable runs to the charging bays and sub-station improvements.

Transit Systems regularly charges the four BYD Buses and the Yutong Electric Bus at the same time with data suggesting that each bus takes around 2-3 hours to obtain full charge.

Based on this real-life experience, there is a potential to charge multiple banks of buses overnight and on broken shifts in the middle of the day.

The next logical step is to install a Solar Array on the roof space of a Bus Depot to directly charge the buses with energy derived from sunshine or to store that energy in an On-Site Battery System.

The costs were in excess of $2.3M which could not be justified for the relatively small fleet of four Electric Buses.

For large scale deployment of EBBS, it is recommended that NSW Government provides funding assistance or grants to property owners to upgrade the electric systems to accommodate the EBBs as the cost would be prohibitive for most Bus Operators.

Transit Systems has actively explored options to install a large 500kW Solar Systems and On-Site Battery Storage System at Leichhardt Bus Depot as detailed below.

Other renewable, emissions neutral energy sources

The natural energy available through Solar Farms and Wind Turbines provides the ideal environment to tap into “green electrons”, with the potential not only to charge EBBs, but also the supply of hydrogen locally to support the deployment of HFCBs.

At the present time, the only viable zero emission buses are EBBs and HFCBs.

4. Ways to support manufacture and assembly of electric buses in NSW

Transit Systems has been working closely with the following Zero Emission Bus Manufacturers:

Electric Battery Buses - Depot Charging (EBBs)

- BYD – Gemilang
- Yutong
- Optare
- ARCC

Hydrogen Fuel Cell Buses (HFCBs)

- Wrightbus
- Van Hool
- Optare
- Yutong
- ARCC
- Global Bus Ventures (NZ)

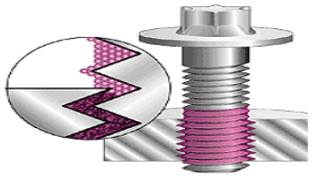
Although several Bus Manufacturers have signalled that they would consider building zero emission buses in Australia, only one has committed to building EBBs and HFCBs in NSW.

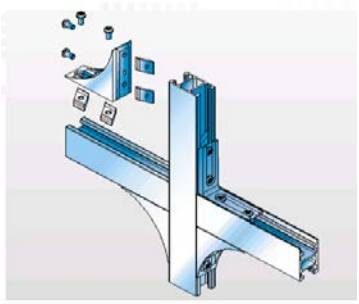
Transit systems has been working closely with ARCC as they come to market with their revolutionary aluminium chassis with two propulsion options – Electric Battery with Depot Charging (EBBs) and HFC.

ARCC is the only Bus Manufacturer in Australia that is building a super lightweight bus that meets all Australian Design Rules (ADR's) but uses clever technology to create fast building solutions.

Features of which are

- Quick and easy assembly and repair
- Clean production process
- Cold assembly
  (no welding distortion)
- Consistent quality
- Bolts are coated with self-locking
  micro-encapsulated liquid adhesive

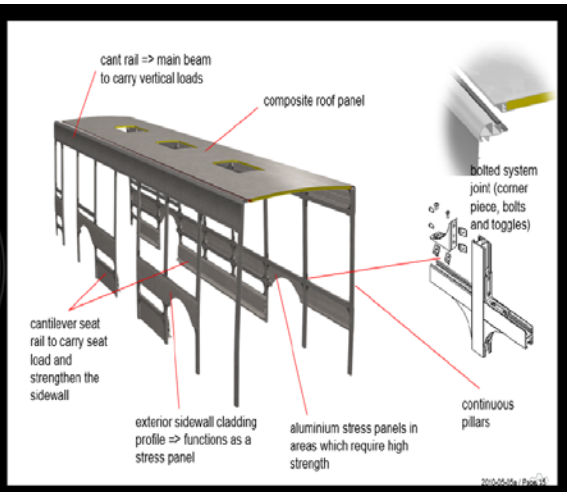




Manufacturing
1, Infrastructure
: Simple jigs and fixtures
: Minimal heavy machinery

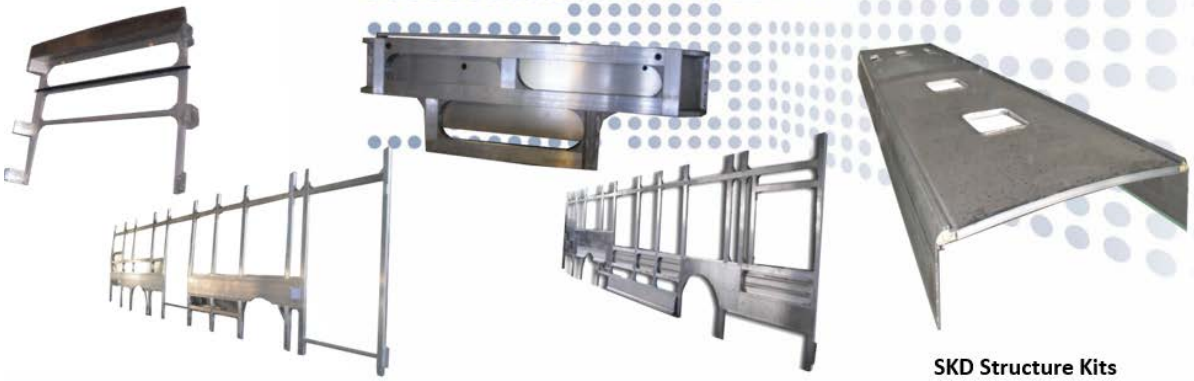
2, Production
: Lower assembly hours
: Full Cold assembly
: In house mould manufacture

Fourth Generation of the Eco Range System



EcoRange extrusions & corner joints from Switzerland
Made by Constellium

Machining



SKD Structure Kits

The system is made even easier to set up and deploy due to the availability of composite structure panels

EcoRange™ Composite Panels

- High stiffness
- Flat and smooth surface
- Integration of functions (insulation, fixing points, ducts for cables etc.)
- Cut-outs for roof hatch, air con etc. included

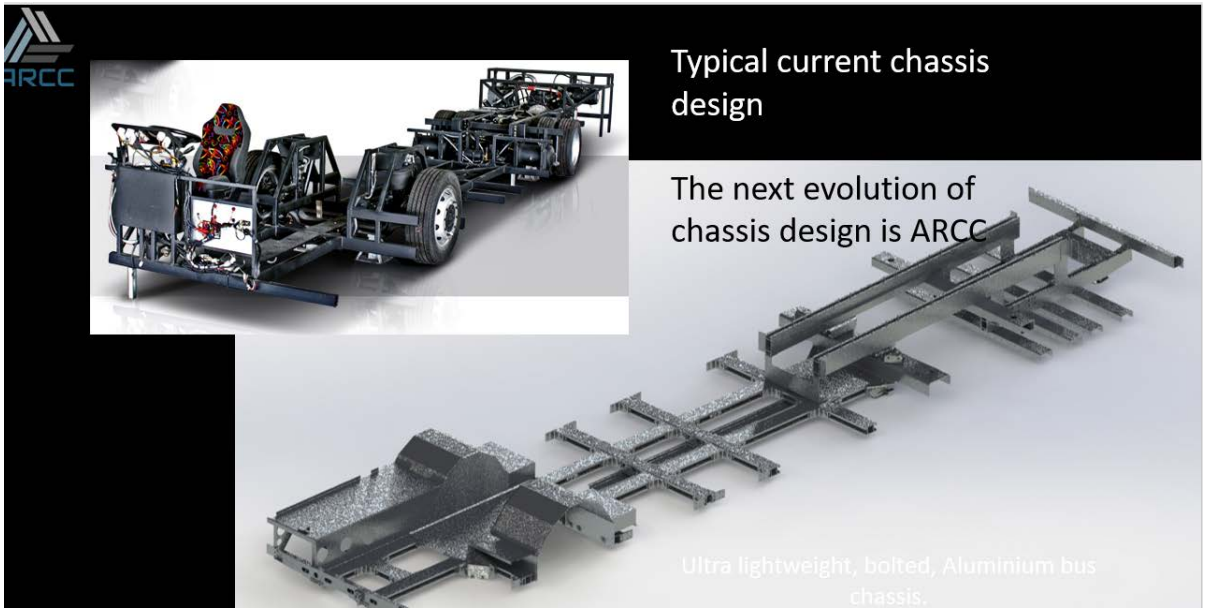
Large size 2D composite panels

ARCC has a chassis that can be adapter to a range of renewable energy technologies and can also be adapted to use a number of different OEM power trains. The ability to provide a chassis that is 2 tonnes lighter and able to utilise a variety of power train options makes it very flexible in adopting new technology as it evolves in the renewable mobility space.

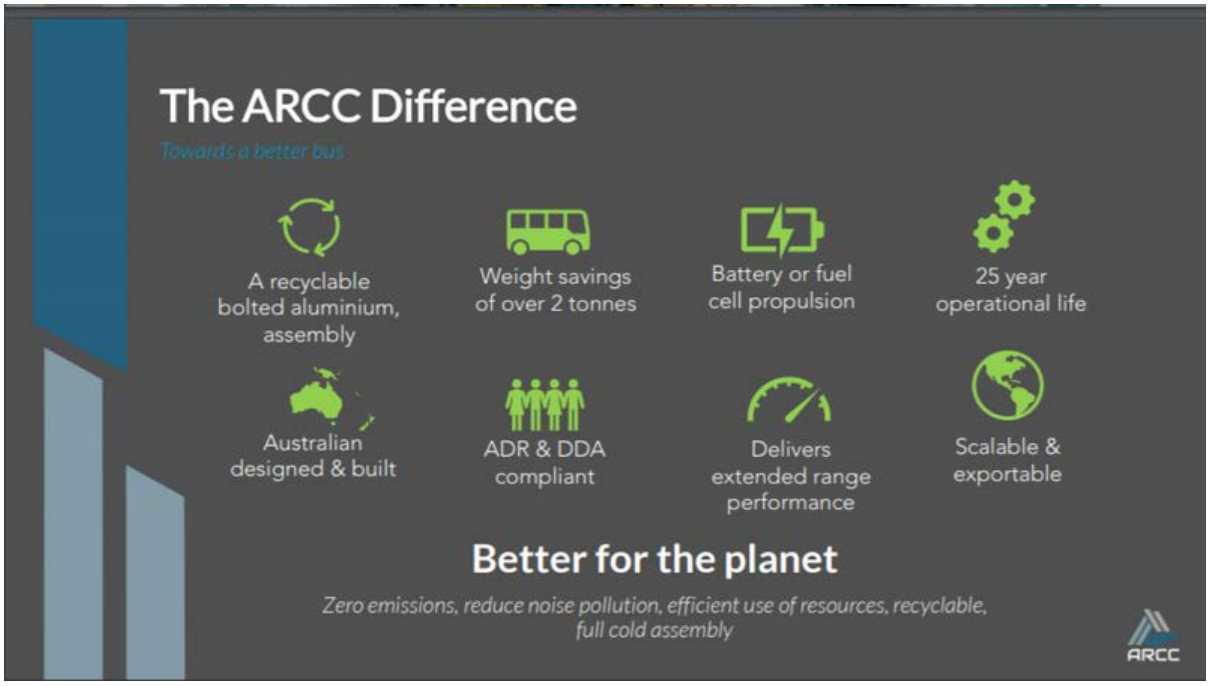
Where are we now?

ARCC is currently producing **four complete prototypes**:

- **Retrofit** – as an to option convert existing diesel/CNG buses
- **Hydrogen Fuel Cell Electric**
- **Fast Charge Electric**
- **Park & Charge Electric**



ARCC Chassis under construction - Smithfield


The ARCC Difference
Towards a better bus
A recyclable bolted aluminium, assembly
Weight savings of over 2 tonnes
Battery or fuel cell propulsion
25 year operational life
Australian designed & built
ADR & DDA compliant
Delivers extended range performance
Scalable & exportable
Better for the planet
Zero emissions, reduce noise pollution, efficient use of resources, recyclable, full cold assembly
ARCC

5. Experience with introducing electric bus fleets in other jurisdictions

ELECTRIC BATTERY BUSES

Transit Systems recently commenced an Electric Bus Pilot comprising four state-of-the-art full electric buses under contract to TfNSW.

Under the Contract with TfNSW, Transit Systems is required to implement an Electric Bus Pilot involving four buses over a two-year period. Valuable data is now being captured in real-time from the on-board data loggers, which allows maintenance and operational personnel to monitor the vehicles in real-time.

This is the first time in Australian Bus History that full electric buses have been deployed on normal route services to this scale. The Contract with TfNSW requires each bus to travel 50,000 klms annually. Extensive performance reports provide rich data on the CO2 and NOX savings, as well as the operational range and overall performance of each Electric Bus.

The EBBS are capable of travelling over 300 km and 16 hours between charging.

The purchase of the four buses by Transit Systems provided a degree of security around the financing aspects given the two-year term of the Bus Pilot.

Electric Buses – Leichhardt Bus Depot

The BYD-Gemilang option was chosen, as it is a proven product having similar buses operating at Sydney and Brisbane Airports. Mechanics were trained to maintain the new fleet with the support of the component manufacturers during the warranty period.

Drivers were specially selected based on their safe driving record and customer service history. The vehicles are fitted with diagnostic telematics, which can be viewed in real-time to ascertain on-road performance.

BYD-Gemilang Driver's Area – Sydney

Transit Systems NSW –Electric Bus.

We are very confident that we can deploy EBBs and HFCBs in the demanding operational environment experienced in Sydney and to meet the NSW Government goals to achieve zero emission outcomes from the passenger transport fleet of buses in Sydney.

BYD Depot Based Charger – Leichhardt Bus Depot

Transit Systems the only Australian Bus Company that has successfully integrated full electric buses into the wider bus network as demonstrated recently the commissioning of the Electric Bus Pilot in Sydney.

HYDROGEN FUEL CELL BUSES

In October 2018, Transit Systems led the first ever Hydrogen Fuel Cell Bus Roadshow, where Government Representatives and key decision makers were able to attend presentations provided by leading International Companies including:

- Engie - Energy Provider
- Ballard – Hydrogen Fuel Cell Manufacturer
- Wrightbus – Bus Manufacturer
- ITM Power – Electrolyser Manufacturer
- Transit Systems and Tower Transit – Bus Operator

Presentations were conducted in the following locations:

- Singapore
- Perth
- Adelaide
- Melbourne
- Canberra
- Sydney
- Brisbane

Transit Systems international affiliate, Tower Transit, has been operating HFCBs since 2013 and currently operates a fleet of 10 HFCBs in London. The fleet has been providing good performance results in the challenging and heavily congested streets of London with one fuel cell stack reaching an impressive 36,000 hours before being replaced.

Van Hool Single Deck HFCB -Tower transit - London

Transit Systems has also established relationships with the following key organisations in the Hydrogen Supply Chain for deployment of HFSBs in Australia:

- ITM Power –Hydrogen Electrolysers
- BOC – Linde Group – Hydrogen Refuelling and Storage
- Ballard Fuel Cells –Hydrogen Fuel Cells
- Wrightbus – Bus Manufacturer
- ARCC – Aluminium Bus Chassis
- Van Hool – European HFCB Manufacturer
- Palisade Investment Partners

HFCBs require a reliable supply of high quality hydrogen, which is either produced by an electrolyser at the Bus Depot or delivered by tube trailer to the Depot - similar to the current diesel supply arrangement. Refuelling and compression equipment is required at the Depot to provide hydrogen to the buses. Fuelling a HFCB takes around 7-10 minutes, which compares favourably to the time taken to fuel a diesel, or CNG Bus.

Australia has significant solar and wind energy resources which can be used to make 100% renewable energy sourced hydrogen. This hydrogen can be used domestically to decarbonise transport, but also exported to markets such as Japan, Republic of Korea, Singapore and China which are projected to have a very large and long-term demand for this clean fuel.

For these bulk scale hydrogen opportunities to be realised, there is a need to first begin the build-up of the use of hydrogen for motive energy applications in Australia. Creating hydrogen infrastructure deployment will allow the skills and supply chain to develop which will in turn stimulate the establishment of large-scale transport related applications throughout Australia.

Of the available options for deploying hydrogen today, its use in the transport sector offers the highest value end use as detailed in the recent CSIRO roadmap. Within the transport sector, the most commercially viable option is to use renewably generated hydrogen to fuel large fleets of heavy-duty vehicles, with back-to-base transit buses being the leading near-term option.

The field of hydrogen fuel cell bus deployment is on the cusp of a commercial breakthrough. A series of demonstration projects worldwide have proven that these vehicles can undertake the day-to-day task of a conventional diesel or CNG bus without requiring any significant operational compromise from bus operators. Furthermore, several bus manufacturers have now recognised the potential to reduce the price of fuel cell electric buses on the basis of sufficient order volume which will enable them to set up a dedicated production line.

First Starter advantage for HFCB applications are significant; ranging from establishing a local bus manufacturing capability, through to support industries and skills training.

Several States are lobbying to establish a HFCB capability along with the opportunity to attract bus building and associated industries to their respective State.

Transit Systems is a member of the Australian Hydrogen Council (AHC) where we are an active member on three of AHC’s Committees.

We are also working closely with AHC to establish a Code of Conduct and a Standards Based Framework to ensure that the appropriate safety systems are established for all hydrogen related componentry, as well as driver and mechanic skills recognition.

Transit Systems recently attended the two-day workshop (A-Lab) which was conducted by the Australian Renewable Energy Agency (ARENA), which focused on the zero emission solutions, including the use of HFCBs in Australia.

Hydrogen Fuel Cell Bus Deployment

The overall objective is to deploy a fleet of 100 HFCBs in up to 10 central hub locations across Australia where interest and demand for fuel cell buses has already been identified.

The vehicles will be maintained and operated by Transit Systems as part of their daily urban transit operations or within a strategically located demonstration project managed by Transit Systems.

It is proposed to establish the fleets initially in projects identified in:

- Perth;
- Adelaide;
- Melbourne; and
- Sydney

The buses will be refuelled at hydrogen stations located at the bus depots or other suitable locations using on-site electrolysis of water (the splitting of water into hydrogen and oxygen using an electric current), or tube trailer delivery - similar to the delivery of diesel. The stations will be supplied by renewable energy purchased via direct Power Purchase Agreement (PPA) or similar arrangement, thereby guaranteeing a 100% renewable fuel.

Where possible, the hydrogen refuelling stations will be designed so that they can also provide hydrogen to other nearby users such as local council refuse trucks and fuel cell passenger cars used in local fleets (taxis, police etc.).

Bus Operations

- Demonstrate that HFCBs can provide a like-for-like replacement for diesel and CNG buses in day-to-day bus operations even on the most challenging sub-urban routes (i.e. service cycles >350km and 20+ hour operation);
- Demonstrate a pathway to completely emission free public transport for Sydney by deploying fleets of at least 10 fuel cell buses in each of the nominated locations. At this volume, the economies of scale mean that the cost of the hydrogen fuel cell bus becomes a viable option;
- Prove that HFCBs can offer a long term affordable and sustainable option in Sydney, with lifecycle costs below the battery electric and diesel options;
- Demonstrate the ability to train local maintenance technicians to service HFCBs and to build a critical mass of expertise in Australia;
- Equip bus depots to enable safe maintenance of HFCBs: and
- Develop a standard for a hydrogen fuel cell vehicle maintenance workshop.

Bus Manufacture

- Work with global supplier of buses and local manufacturers to develop a HFCB specified for Australian operations and climatic conditions;
- Make use of concerted procurement across the sites to ensure the purchase price of the buses is competitive with other zero emission options even for these low volumes and with clearly demonstrated plans for further reduction in per unit costs; and
- Link to, and coordinate with, fuel cell vehicle procurement activities in Europe, where new large volume procurements are driving down the costs of HFCB drivetrains and hence enabling a low-cost bus offer for Australia.

Hydrogen Production and Fuelling

- Demonstrate highly reliable hydrogen bus refuelling, with an average fill time of less than 10 minutes per fill, capable of expanding to refuel entire bus fleets and a refuelling station with >99% up-time;
- Demonstrate the ability to generate 100% renewable fuel for bus operations and the way in which these stations can be used for other hydrogen uses to catalyse further uptake of 100% renewable transport for other uses such as council refuse trucks and cars;
- Demonstrate the ability to procure a Power Purchase Agreement (PPA) for the 100% renewable electricity for the electrolyser at a competitive price, which enables affordable electrolytic hydrogen generation at below the price of taxed diesel on an OPEX basis. This will be achieved through direct contracting with renewable energy producers and operating the electrolysers flexibly to match the profile of output of the renewable generator;
- Where the depot layout allows, we will explore the use of locally sourced solar power connected directly to the electrolyser “behind the meter”; and
- Operate the electrolyser flexibly to offer balancing and demand response services to the local electricity network operators and hence further reduce the price of electricity and therefore the price of renewable hydrogen.

Australian Hydrogen Supply Chain Development

- Establish a supply chain for the support and maintenance of HFCBs and the associated fuelling systems in Australia;
- Monitor the bus operations to prove the overall technical, economic and environmental case for the technology;
- Disseminate the potential of hydrogen in the transport sector to a wide community of investors, industry participants and decision makers; and
- Actively encourage local experts and other hydrogen industry players to become suppliers to the project and to learn from the deployment

Route Selection

The criteria for site and route selection will include:

- availability of relevant city-level policies requiring zero, or low emission buses;

- suitability of the route for hydrogen, with a preference for operating the hydrogen vehicle on a more demanding routes to demonstrate the versatility of the technology;
- local energy landscape and value attached to energy storage through hydrogen;
- size of the local market to expand the initial facilities;
- size of the existing Transit Systems operation in areas;
- ease of fitting within the local route contracting regime;
- collocating with other Hydrogen Projects; and
- likelihood of attracting public funding to help underpin the financing of the scheme.

Training

- Develop the technical skills base through a national training programme from each deployment;
- Training for support, maintenance and operation activities for fuel cell buses in Australia; and
- Depot management, safety, workshop activities.

Taken together, these objectives will demonstrate a pathway to affordable zero emission bus operation in Sydney.

Below is a Risk matrix for the Deployment of Hydrogen Fuel Cell Buses into Sydney.

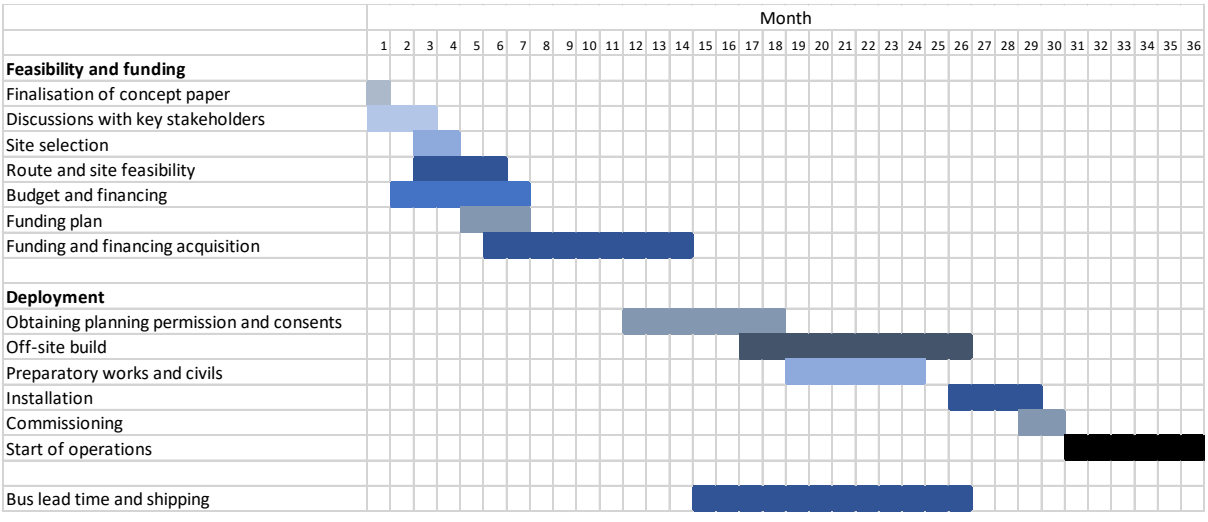
Risk Matrix

Bus Project Delivery	Risk	Likelihood (L/M/H)	Impact (L/M/H)	Mitigation
Planning, Competence & Organisation	Prospective	Low	High	The Project Concept has been researched and active engagement made with State Government departments and public transport stakeholders through a series of Hydrogen and Fuel Cell Bus Workshops, delivered by the Consortium partners in cities across Australia in 2018, with follow-up discussions held in 2019.
Ability to deploy successful projects Knowledge and Experience	Project Not Completed	Low	High	All Consortium Partners have a demonstrated track record in the successful integration, deployment and operation of their respective technologies, through collaborative projects at the scale required for timely delivery and operation to the project description.
Site Infrastructure	Site selection changes part way though the Project	Low	Med	The electrolyser design will remain largely the same even if the final site changes (although layout will change), however the interfaces between the electrolyser and the site (electrical connection, hydrogen transport and storage) are site dependant, and will impact the final costing and business case analysis. All modelling and costings will list assumptions, so that they can be used for new scenarios in the event that the site changes.
Site Feasibility and Design	Technical issues preventing project development	Low	High	Experience of staff and company involved which will mitigate the risk.
Site Feasibility and Design	Insufficient funds in budget to complete tasks	Low	High	If necessary additional resources will be sourced from third party funding bodies supporting this project
Electrolyser and Power Electronics Design	Technical issues preventing project development	Low	High	Experience of staff and company involved which will mitigate the risk.

Bus Project Delivery	Risk	Likelihood (L/M/H)	Impact (L/M/H)	Mitigation
Funding for Buses and Hydrogen Refuelling Infrastructure	Insufficient funds in budget to complete tasks	Low	Med	If necessary additional resources will be sourced from third party funding bodies supporting this project
Maintenance & Support	Availability and reliability	Low	High	Experienced support staff to be deployed to respond to any unplanned maintenance requirements.
Project Management	Project exceeds budget	Low	Med	Experienced project partners and project management practices used to oversee Project and individual Work Packages by each project partner and overall project manager will reduce this risk, along with quarterly financial review to assess and plan for next quarter's expenditures.
Project Management	Insufficient technical resources. Delayed deliverables	Low	Med	The technical scope of the Project has been thoroughly considered and agreed with all Project Partners. The experience and technical skills within the Consortium will ensure successful completion of the Project. Progress will be monitored in terms of delivery and spend to identify any issues.
Project Management	Project Partner withdrawal	Low	High	The Project Consortium builds upon existing working relationships between Project Partners. Each Partner's project tasks align with their company's core objectives.

Timescales

The timescales leading up to the deployment are provided below:



6. Opportunities and Challenges

Zero Emission Buses – Electric Battery Charging Buses vs Hydrogen Fuel Cell Buses

- Both vehicle types are “Electric Buses”
- Both have zero tailpipe emissions
- Both require additional skills training for drivers and mechanics

Electric Battery Charging Buses (EBBs)

- Well suited to local bus deployment requiring up to 250 klms between charges
- Battery performance is improving and may not have reached full potential
- Additional Buses may be required to meet PVR
- Relatively long charging times of 2-5 hours
- Grid issues for large scale electric bus charging deployment
- Depot upgrade could be costly for Depot Charging
- Limited redundancy if there is an extended electricity outage

Hydrogen Fuel Cell Buses (HFCBs)

- Drop-in replacement for Diesel and CNG buses
- No additional fleet requirements, or operational constraints
- Similar refueling times to Diesel and CNG
- Workshop adaptation required for hydrogen – similar to CNG Safety Systems
- Limited redundancy if there is a supply issue