Noosa Council & TransLink Division

Prefeasibility Study of Electric Bus Routes in Noosa

Planning Report

GHD

December 2014

Executive Summary

Objectives

Noosa Council has a track record of innovative approaches to the provision of public transport and currently provides subsidised (free) public transport in partnership with TransLink and Sunbus during peak holiday periods in an attempt to alleviate congestion and parking issues, particularly in the heavily visited tourism hotspots around Noosa.

Council has been following and researching the increasingly successful incidences of electric bus trials within Australia and across the globe, and believes that this technology is sufficiently mature and will offer significant economic and community benefits to the area. Noosa Council and the TransLink Division of Transport and Main Roads have therefore commissioned a joint feasibility study into electric buses in Noosa.

There are a number of electric bus trials and services in operation around the world and they are demonstrating that following initial investment, there are significant savings arising through reductions in fuel consumption and maintenance whilst also providing economic and social benefits including:

- Reduced or zero emissions from buses
- Supporting the development of renewable energy
- Improved urban amenity and reduce noise pollution
- Increased patronage and public transport mode share
- Reduced operational costs, increase fare revenue, improve cost recovery and better value for money for tax and rate payers
- Reduced traffic congestion
- Increased economic development and tourism visitation in Noosa
- Improved social capital

To this end, Council is considering the use of electric buses as a “point of difference” for Noosa in the tourism market and also as an innovative approach towards the provision of clean and environmentally friendly public transport.

GHD has been commissioned to assess the feasibility of electric bus routes in the Noosa area in order to provide sufficient evidence to justify a decision to progress the project further. The study entailed an assessment of the available technology, required infrastructure, network planning and passenger utilisation needed to determine the future costs and operational effectiveness of such a service. A Strategic Outline Case (SOC) in order to assess the feasibility of a 6 month trial electric bus service in the Noosa area has been prepared including indicative whole of life costing.

Market Research

The market research found that there were many companies involved either directly or indirectly in the electric bus industry. Companies that were researched were found to originate from New Zealand, Asia (China), Europe (Germany,

Luxemburg, Netherlands, Italy, and Poland) and the Americas (United States and Canada).

In total twenty six (26) electric bus manufacturers were researched to develop comparative product (fleet) profiles comprising of twenty (19) international and seven (7) locally based manufacturers. To evaluate the companies that offer electric buses, a number of essential factors were required to be met to first shortlist companies for further evaluation. The essential factors included:

- Reputation of the company and tenure in the industry
- Proven electric bus technology with buses implemented in the field
- Availability to provide a vehicle for the 6-month trial expected in August 2015
- Ability to complete the electric bus route with an approximate range of 280 km per day (23 trips @ 23.7 km round trip)
- Proven right-hand drive vehicles to suit the Australian driving conditions which minimises the additional cost of customising the electric bus
- Easily able to provide the after sales support, parts replacement and training of drivers
- Compliance with Australian Standards in terms of vehicle specifications including Australian Design Rules (ADR) standards and Disability Discrimination Act requirements

Selection of the Preferred Electric Bus Solution

Using the above mentioned selection criterion, four (4) electric bus manufacturers were shortlisted for further evaluation using a Multiple-Criteria Analysis (MCA) approach as below:

- Solaris (Poland)
- BYD (through Carbridge an Australia largest aviation bus company with operations in Brisbane, Sydney, Melbourne, Adelaide and Perth airports)
- Optare (through PATICO Automotive who are the Australian distributors for Optare headquartered in Dandenong, Melbourne and have been operating in Australia for 10 years)
- Olev (through Australian Electric Infrastructure Transport (AEIT) with an office located in Brisbane, Queensland. AEIT is a Brisbane based company established in 2012 to commercialise the Olev electric vehicles in Australia)

A Multi-Criteria Analysis (MCA) approach has been used to inform the selection of the preferred electric bus manufacturer. The MCA results were presented at a workshop with Council/TransLink on the 18 September 2014 and it was decided that the top two (2) manufacturers (i.e. Optare and BYD) would be invited through an expression of interest (EOI) to participate in a 6 month trial. More detailed information was gathered through the EOI process to select a preferred manufacturer.

Most Appropriate Solution for Noosa

The analysis conducted showed that Route 627 is most suitable for the electric bus trial. The location for the proposed layover and fast recharging station is in Pelican Street at Tewantin, next to Council's office. This site is convenient for the western

terminus of Route 627 to use and has minimal impact on parking with approximately three spaces to be removed in Pelican Street. There are many on-street parking spaces available along Pelican Street (next to Council's office) which could be used as a fast charging station location.

Overnight storage and slow charging for the electric bus could be undertaken at the existing Sunbus depot (Beech Street) at Marcoola, which is approximately 30 km south of the eastern terminus (start point of Route 627) at Sunshine Beach. Drivers can start their first trip on Route 627 from Sunshine Beach (Ed Webb Park)

The Marcoola location is preferred because it is an existing secure fenced facility with surveillance systems and it will minimise the dead running and the significant cost of additional driver relief trips (compared to the Noosa Council depot at Bartlett Road). In addition, repairs and maintenance of the electric bus could be done at Marcoola similar to current diesel buses.

Cost of the 6 Month Trial

The trial is about assessing the technology and discovering the "actual" capability and performance of the electric bus under local conditions in Noosa. If the trial is found to be successful, decisions can be made to consider implementing the electric bus in full.

The cost to run the trial is estimated to be **$452,700 for Optare and $407,200 for BYD**. This is the net cost after the cost of operating the standard two (2) diesel buses on Route 627 is considered.

The findings show that the trial would cost more than the current cost to operate the two (2) diesel buses on Route 627. This is primarily because of the cost incurred in providing the fill-in and standby diesel buses and driver relief trips to ensure service reliability. **An initial capital investment will be required to "ground truth" the technology. It is recommended that both Optare and BYD are considered for the trial.** Optare has the advantage of scale and expertise in the manufacturing of buses with a strong and reputable international brand, and have a presence in Australia. BYD are global leaders in the development of battery technology and battery management systems (BMS). Their battery technology has shown a continuous improvement. The new generation of batteries is already exceeding the older batteries in capacity, which is currently installed in buses around the world.

Strategic Outline Case

A Strategic Outline Case (SOC) has been developed to identify and compare the indicative longer term costs of the recommended electric bus options which are likely to proceed to a live trial, together with consideration of potential funding sources.

A financial model has been designed to provide an indicative cost comparison of Optare and BYD buses over a 15 year investment horizon. It is designed to evaluate and compare the upfront purchase costs of a single bus and the anticipated energy and maintenance costs on a 'like-for-like' basis.

An operational model has been developed to compare the indicative costs of running the selected electric bus options (Optare and BYD) as a fleet on Route 627 against the indicative costs of running the current Sunbus diesel buses. The time period for the operational model is 10 years (based on TransLink's initial leasing

period) which allows for a longer term operational comparison of the current Sunbus diesel bus with both electric bus models.

Financial Model Results

Over the investment horizon of 15 years, the **BYD bus has been found to be the cheapest in terms of upfront purchase costs** (Optare +12%). However, the Optare Solo 10M is likely to be the **most cost effective option to run in terms of maintenance and servicing.**

There are **marginal differences in fuel efficiency between the two buses**, it was surmised that **fuel efficiency is not a good basis to distinguish electric bus options**.

Over the investment horizon of 15 years, the total NPC discounted costs for the Optare electric bus came to an estimated -$624,849 and -$1,074,230 for BYD. The total NPC discounted cost per kilometre came to -$0.33 for Optare and -$0.56 for BYD, respectively. **The cost analysis indicates that the Optare solution to be lower from a total NPC discounted cost and cost per kilometre standpoint.** This outcome is due mainly to the extended operational life of the Optare with a stated operational life of 25 years as against the BYD at 15 years.

Operational Model Results

The operational model shows discounted fuel savings of $269,866 and $214,049 for Optare and BYD fleet deployment over the standard Sunbus diesel fleet for the 10 year leasing period. However, these **savings were not sufficient to offset the additional operational costs incurred in deployment of electric buses on Route 627.** The charging and scheduling limitations of the electric buses – requiring an additional bus to be run on the route – make electric bus deployment an expensive option.

Project Risks

Identified risks for the project include:

- New technology - The introduction of an electric bus brings higher degrees of technical and financial uncertainty due to higher up front capital costs combined with the implementation of new technologies
- Uncertainty surrounding battery life and the performance
- Uncertainty surrounding “real-world” performance outcomes during the trial given location specific variations in ambient temperatures, braking intensity, and accommodation of air-conditioning load
- Uncertainty surrounding the Green House Gas (GHG) performance of electric vehicles when powered using electricity generated by non-renewable energy sources
- Any loss of passenger carrying capacity given final configuration of the chosen bus option and capacity to accommodate unexpected fluctuations in route demand
- For the above reasons a trial is recommended to test this new technology

Study Recommendations

- Route 627 is recommended to be used as the electric bus trial route

- Two (2) electric buses and one (1) diesel bus will be required to maintain the current 30 minute headway and 60 minute circuit time. A standby diesel bus is recommended to attend to any breakdowns in order to ensure service reliability. The existing diesel buses in the Sunbus fleet should be used as stand-by spares should there be any breakdowns, accidents and other service continuity issues
- Overnight storage and slow charging of the electric bus is recommended to be at the existing Sunbus depot at Marcoola. Layover and fast charge of the electric bus recommended to be at Pelican Street (in front of Council office and would involve the loss of approximately three (3) car parking spaces. Repairs and maintenance proposed to be conducted at existing Sunbus depot at Marcoola
- Route 627 should be exempt from the TransLink Contract Performance Management Framework during the trial whilst an unproven technology is being tested
- A driver relief vehicle is hired (2 Nos) and included in trial costs, to transport Sunbus drivers between the Marcoola depot and Noosa Junction to facilitate driver shift changeovers
- Dedicated electricity meters to be used for the trial to verify battery usage and performance of the bus
- It is recommended that both Optare and BYD buses are considered for the 6 month trial to confirm performance in the field and is estimated to cost $859,900 (excluding contingencies)
- Should the trial succeed the permanent cost of operating the electric bus would be less than the trial cost as standby buses and drivers would not be required as the technology is proven as reliable. Consideration may also be given to using more permanent recharging options that may negate the need for a third bus
- Potential funding sources include:
  - National Stronger Regions Fund (NSRF)
  - Introduce a Council Public Transport levy to fund the trial
  - Seek a portion of the total funding from TransLink
  - Advertising revenue
- Electric buses for the trial will need to comply with all State and Commonwealth government laws in in particular the Disability Standards for Accessible Public Transport (DSAPT) 2002 and Commonwealth Disability Discrimination Act 2002 (DDA), and Australian Design Rules (ADR)
- Council/TransLink should consider the involvement of Sunbus in the trial as early as possible

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1. Introduction

1.1 Background

Noosa Council has a track record of innovative approaches to the provision of public transport and currently provides subsidised (free) public transport in partnership with TransLink and Sunbus during peak holiday periods in an attempt to alleviate congestion and parking issues, particularly in the heavily visited tourism hotspots around Noosa.

The Council has been following and researching the increasingly successful incidences of electric bus trials within Australia and across the globe, and believes that this technology is sufficiently mature and will offer significant economic and community benefits to the area. Noosa Council and the TransLink Division of Transport and Main Roads have commissioned a joint feasibility study into electric buses in Noosa.

There are a number of electric bus trials and services in operation around the world and they are demonstrating that following initial investment, there are significant savings arising through reductions in fuel consumption and maintenance whilst also providing economic and social benefits including:

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- Supporting the development of renewable energy
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- Increased economic development and tourism visitation in Noosa
- Improved social capital

Towards this end, Council is considering the use of electric buses as an innovative approach towards the provision of clean and environmentally friendly public transport. The main drivers for the service are:

- To provide a public transport point of differentiation as a tourism destination in order to increase visitation and economic activity in the Noosa Shire area
- To facilitate a modal shift in travel behaviour in order to mitigate significant planning and environmental issues such as air pollution, congestion and parking

GHD has been commissioned to assess the feasibility of electric bus routes in the Noosa area in order to provide sufficient evidence to justify a decision to progress the project further. The study entailed an assessment of the available technology, required infrastructure, network planning and passenger utilisation needed to determine the future costs and operational effectiveness of such a service. A Strategic Outline Case (SOC) in order to introduce a 6-month trial electric bus service in the Noosa area has been prepared. This report presents the findings of the study and presents recommendations for a potential electric bus provider for Noosa.

1.2 Study scope

The scope of this study is to:

- Determine the preferred operating environment for an electric bus service within the Noosa area focusing in particular on topography, patronage history, population, tourism visitation (peak and off-peak season) and route alignment planning
- Undertake a market sounding exercise to understand the Australian and international electric bus market including interviewing electric bus manufacturers to develop comparative product (fleet) profiles
- Interview clients (bus operators and transit agencies) using electric buses to understand costs and benefits, risks, opportunities, issues and lessons learnt
- Determine the most appropriate solution for Noosa based on fleet size, and recharging options
- Develop an assessment criteria framework to guide decision making on fleet procurement options
- Undertake a literature review of legislation, policy, standards, regulations and contracts to understand the parameters in which such a service may be deployed
- Develop a Strategic Outline Case (SOC) identifying indicative costs of establishment and operations of a recommended fleet options to proceed to a live trial, together with potential funding
- Recommend one or more potential electric buses that should be part of a live trial in Stage 2

1.3 Scope and qualifications

This report: has been prepared by GHD for Noosa Council & TransLink Division and *may only be used and relied on by Noosa Council & TransLink Division for the purpose agreed between GHD and the Noosa Council & TransLink Division as set out in Section 1.2 of this report.*

GHD otherwise disclaims responsibility to any person other than Noosa Council & TransLink Division arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Noosa Council & TransLink Division and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has prepared a Strategic Outline Case (SOC) set out in Section 7 of this report using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD.

The SOC has been prepared for the purpose of providing indicative costs of establishment and operations of a recommended electric bus to proceed to a live trial, together with potential funding options and must not be used for any other purpose.

The Strategic Outline Case is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the SOC and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the works/project can or will be undertaken at a cost which is the same or less than the SOC.
Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

1.4 Approach

A review of transport plans of Noosa was conducted to provide the transport planning context for the study including an assessment of the demographic profiles in Noosa.

A review of the existing TransLink bus network in Noosa was undertaken in order to select the most appropriate bus route for the trial in 2015. If proven feasible, a 6-month trial for the electric bus is proposed in August 2015. A review was conducted of the current bus routes and service, patronage, location of layovers and maintenance location and bus driver amenities (toilets and meal rooms). Various bus route options were assessed for the electric bus with a recommended bus route including location of layover and charging stations.

A comprehensive market research of the current electric bus technology, manufacturers and the users of electric buses both in Australia and internationally was conducted. The market research was conducted via the internet and telephone interviews (where possible) with electric bus manufacturers and included:

- Key local and global manufacturers and bus deployments in cities similar to Noosa
- Transport agencies and bus operators operating electric buses
- Background on electric bus vehicles
- Battery and charging technology review – latest trends
- Performance characteristics including issues with after sales support, operations, maintenance and power supply
- Associated infrastructure required to implement the use of the electric buses
- Indicative cost and financing of electric buses

In total, twenty six (26) manufacturers were researched comprising of 19 international manufacturers and seven (7) local manufacturers with a base in Australia. A comparison of their product profiles was conducted which involved a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis of electric

bus technology options. The finding of the SWOT was used to inform the Multi-Criteria Analysis (MCA) to determine the most appropriate solution for Noosa.

In addition, telephone interviews were conducted with transit agencies and bus operators to understand actual implementation issues, potential risks and lesson learnt, which could inform the electric bus for Noosa. The case studies included:

- Tel Aviv, “Dan” bus operator, BYD pilot
- Greater Manchester Integrated Transport Authority – Optare e-bus pilot
- Schiphol airport pilot program – BYD K-9
- Adelaide City Council -Tindo E bus
- Brisbane City Council

To supplement the market research, an email questionnaire was sent to selected manufacturers, transit and government agencies in the electric bus Industry whom were based locally and abroad. A copy of the questionnaire and the responses are attached in **Appendix A.**

A review was also undertaken of relevant State and Federal Transport policy, standards, regulations and contract which may potentially influence the implementation of the electric bus project. The review also involved consulting with key industry stakeholders to understand potential changes or directions in policy and regulations that may support the Strategic Outline Case.

An assessment criteria framework was developed to identify factors which influenced the project’s success and included Council’s/TransLink’s financial priorities, financing requirements, CAPEX, OPEX, potential funding sources, optimal fleet size considerations, availability of preferential interest rates, age of the current fleet and maintenance cost, etc. The assessment criteria framework was used to inform the SOC which consisted of a:

- Project financial model with key assumptions and variables including the CAPEX, OPEX and funding arrangements
- Cost-Benefit Analysis (CBA) highlighting the potential benefits and constraints of the preferred option
- Project risk assessment identifying project strengths and weaknesses which will assist in development of a successful future funding application.
- A project schedule will be developed to outline the key next steps to take the project to a live trial.

1.5 Report Structure

This report is comprised of the following sections:

- Section 2 – Transport planning framework
- Section 3 – Electric bus route selection for the trial
- Section 4 – Review of electric bus technologies
- Section 5 – Review of legislation, policy standards, regulations and contracts
- Section 6 – Developing the most appropriate solution for Noosa
- Section 7 – Strategic outline case
- Section 8 – Conclusions and recommendations

2. Transport planning framework

2.1 Strategic planning

Noosa is located at the northern end of the South East Queensland region, approximately 130 kilometres (km) north of Brisbane. The level of development in Noosa is less intensive when compared to other coastal settlements in the region as a greater emphasis has been placed on the conservation and preservation of open space. This approach to development is generally reflected in the strategic planning documents prepared for the Noosa area.

The *Noosa Plan 2006* outlines Council's overall vision for the Noosa area to 2015. According to this area-wide planning document, it is envisaged that Noosa will be:

"…an inclusive community renowned for its creativity, innovation, vision and entrepreneurship where sustainability underpins excellence."

Underpinning this vision are the following seven key principles:

- Social cohesion and community well-being
- A strong sustainable economy
- Environmental excellence and sustainability
- Artistic and cultural diversity and excellence
- A commitment to maintaining a sustainable population
- Quality, innovative and reliable infrastructure
- Maintaining the "Noosa Style"

In addition to Council's overall vision, the Plan also provides specific visions to 2015 for the Arts & Heritage, Economic, Environment, Social and Tourism sectors.

2.1.1 Noosa transport plans

The following transport plans guide the development of Noosa's transport network:

- Noosa Integrated Local Transport Plan 2016
- Connecting SEQ 2031

The *Noosa Integrated Local Transport Plan 2016* (ILTP) aims to ensure that by the year 2016 there are a variety of safe, efficient and effective transport options available that meet or exceed Noosa Council's transport objectives and targets. To achieve this aim, the ITLP is comprised of nine (9) policy objectives – ranging from the integration of transport and land uses through to the provision of attractive walkable environments – which seek to guide the development of Noosa's transport network up to 2016.

As South East Queensland's official Integrated Regional Transport Plan, *Connecting SEQ 2031* establishes a long-term plan to develop a sustainable transport system in the region. With respect to Noosa, a TransitWay corridor has been proposed which is expected to provide a direct public bus link between Noosa to the north and Caloundra (via *CoastConnect*) to the south. TransitWay prioritises buses in an attempt to provide frequent, fast, efficient and reliable services along the identified corridors.

2.1.2 Queensland Plan Queensland's 30 Year Vision

The Queensland Plan is a shared 30-year vision for the state – a roadmap to growth and prosperity. The 30-year vision for Queensland is to:

- Be home to vibrant and prosperous communities
- Be well planned with the right infrastructure in the right places, to support a population that has grown across every region
- Value education as a lifelong pursuit to enrich lives to be able to find secure jobs and improve the competitiveness of the economy
- Be the greatest state in which to live, work and play, and guardian of a sustainable natural environment that inspires an active lifestyle and supports healthy communities
- Have community spirit that embraces our diversity and unique culture and gives everyone the opportunity to shine
- Preserve and protect the environment so it continues to underpin the Queensland lifestyle and economy
- Encourage sustainable practices including green energy solutions and the responsible management of our growing communities
- Invest in and adopting sustainable and renewable solutions

The Queensland government has identified tourism as one of the four pillars of the Queensland economy. The electric bus is a positive step towards the use of renewable transport solutions.

2.2 Demographic trends

2.2.1 Population and employment

According to the *Queensland Government's Statistician's Office,* Noosa Shire had an estimated resident (2011) population of 51,038 people[1]. By 2016 this was estimated to increase by 4,382 people with a total population of 55,419 people. The population is forecast to increase to 61,824 by 2036. This represents an average annual increase of 0.77% per annum over the 25 years from 2011 to 2036.

The forecast population will be housed in the existing urban settlements of Boreen Point, Castaways Beach, Cooran, Cooroibah, Cooroy, Kin Kin, Marcus Beach, Noosa Heads, Noosaville, Peregian Beach, Pomona, Sunrise Beach, Sunshine Beach, Teewah and Tewantin.

In conjunction with this population growth, modest growth in employment is also anticipated for Noosa. The total number of jobs in Noosa is expected to increase from an estimated 20,586 in 2011 to 22,432 in 2021. This represents an average annual increase of 0.86% per annum over the 20 years from 2011 to 2021. According to the *Noosa Plan 2006*, this growth is expected to primarily be confined to existing business centres, neighbourhood/village centres and mixed use areas along Hastings Street and Gympie Terrace as well as at Sunshine Beach, Noosa Junction, Noosaville, Tewantin and Cooroy.

In addition to the consolidation and infill of existing business centres and commercial areas, a new Shire Business Centre off Eenie Creek Road in Noosaville has been earmarked in the *Noosa Plan 2006*. Similarly, the *South East Queensland Regional Plan 2009-2031* identifies the Noosa Business Centre Technology and Industrial Hub as a key employment area and has recognised the potential to expand science and technology opportunities in the area.

Modest population and employment growth, primarily located in existing urban areas, is expected in Noosa over the next 20 years. Future development in Noosa is expected to be characterised by the consolidation of existing residential and commercial areas through infill development in order to maintain the economic viability as well as the unique social and environmental features of the area.

2.2.2 Visitors

The Noosa region is one of Australia's most popular tourist destinations, with 2.2 million people visiting the region between September 2011 and September 2012[2]. Tourism is the single biggest contributor to Noosa's local economy with approximately $850 million being spent in the region for the year to September 2012[2]. Domestic growth was predominantly from regional NSW, Melbourne and Brisbane, whilst international growth was from New Zealand, UK, Germany and the USA[2]. According to the *Noosa Plan 2006*, Noosa Heads and Noosaville will remain the principal focus of visitor accommodation growth with some sites protected for the exclusive use of visitor accommodation. In particular, Visitor Mixed Use Zones have been identified at Hastings Street, Noosa Heads; Gympie Terrace, Noosaville; Duke Street, Sunshine Beach; Heron Street, Peregian Beach and the holiday accommodation centre at Beach Road, Noosa North Shore.

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[1] http://www.qgso.qld.gov.au/subjects/demography/population-projections/

[2] www.visitnoosa.com.au/_literature_118490/End_of_year_report_2012

3. Electric bus route selection for the trial

3.1 Existing bus network

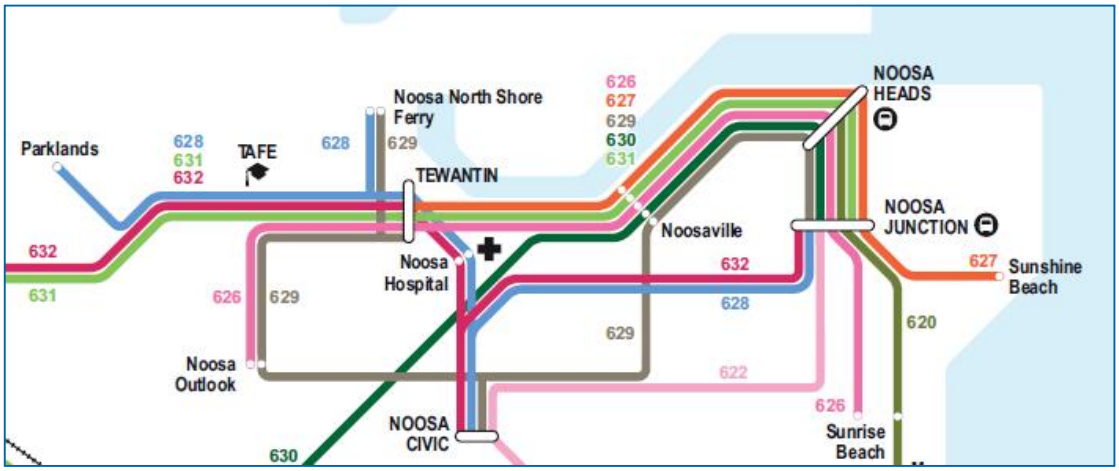
For the electric bus trial, a review of the existing TransLink bus network in Noosa was undertaken in order to select the most appropriate bus route for the trial in 2015.

The existing bus network in the Noosa area is part of the Sunshine Coast contract area planned and managed by TransLink and operated by Sunbus or Transit Australia Group (TAG) from a bus depot at 9 Bonanza Court in Marcoola.

3.1.1 Bus routes and services

Nine (9) bus routes currently operate in the Noosa area in the TransLink bus network as shown in Figure 1 and are listed in Table 1. Four (4) of these routes operate exclusively in the Noosa area.

Figure 1 Existing Bus Routes in the Noosa area



Source: TransLink website, 2014

Table 1 Existing Bus Routes and Services in Noosa

Route	Description	Route Type	Service Frequency
620	Noosa Heads to Maroochydore via Peregian Beach	Cross-regional	Every 30 minutes from 6 am to 7 pm and hourly after 7 pm until midnight daily (late evening trips to Tewantin)
622	Maroochydore to Noosa Junction via Airport, Coolum	Cross-regional	Hourly from 6 am to 7 pm daily
626	Tewantin to Sunrise Beach via Noosa Heads	Local	Every 30 minutes from 7 am to 7 pm daily
627	Tewantin to Sunshine Beach via Noosa Heads	Local	Every 30 minutes from 7 am to 7 pm daily
628	Parklands to Noosa Junction via Noosa Civic	Local	Hourly from 7 am to 7 pm daily
629	Tewantin to Noosa Junction via Noosa Civic	Local	Hourly from 8 am to 6 pm weekdays; hourly from 9 am to 6 pm weekends
630	Noosa to Nambour via Eumundi	Cross-regional	Limited trips on weekdays and Saturdays; no Sunday services

Route	Description	Route Type	Service Frequency
631	Noosa to Nambour via Eumundi and Cooroy	Cross-regional	Limited trips on weekdays, Saturdays and Sundays
632	Noosa to Cooran via Cooroy and Pomona	Cross-regional	2 to 3 trips daily in each direction

The numbers of bus services in each direction for the four (4) local bus routes in Noosa are given in Table 2. Routes 626 and 627 provide the higher number of services operating between 7.00 am and 7.00 pm daily. All of these local routes operate within TransLink Fare Zone 23 so that bus customers have a single zone fare for local trips between Tewantin and Noosa Junction and within the Noosa Shire Council area.

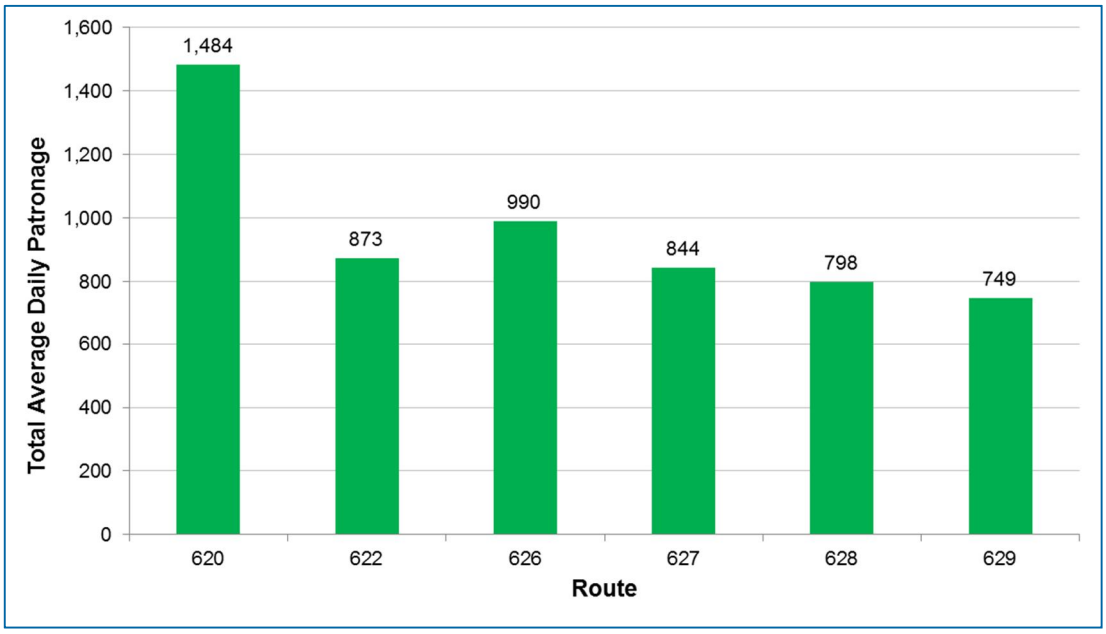
Table 2 Existing Number of Services for the Local Bus Routes in Noosa

Route	Weekday	Saturday	Sunday
626	24 trips in each direction	24 trips in each direction	24 trips in each direction
627	23 trips in each direction	23 trips in each direction	23 trips in each direction
628	12 trips in each direction	12 trips in each direction	12 trips in each direction
629	11 trips in each direction	9 trips in each direction	9 trips in each direction

3.1.2 Bus patronage

The average daily bus patronage by route for the six (6) most regular and frequent bus routes in Noosa, namely Routes 620, 622, 626, 627, 628 and 629, is shown in Figure 2. Route 620 has the highest patronage because it has the highest frequency, the greatest span of service hours and the longest route between Noosa Heads and Maroochydore. The four (4) local bus routes (626, 627, 628 and 629) have an overall average of 850 daily passengers with an average of six passengers per trip over the entire service period.

Figure 2 Total Average Daily Patronage on the Noosa Bus Routes

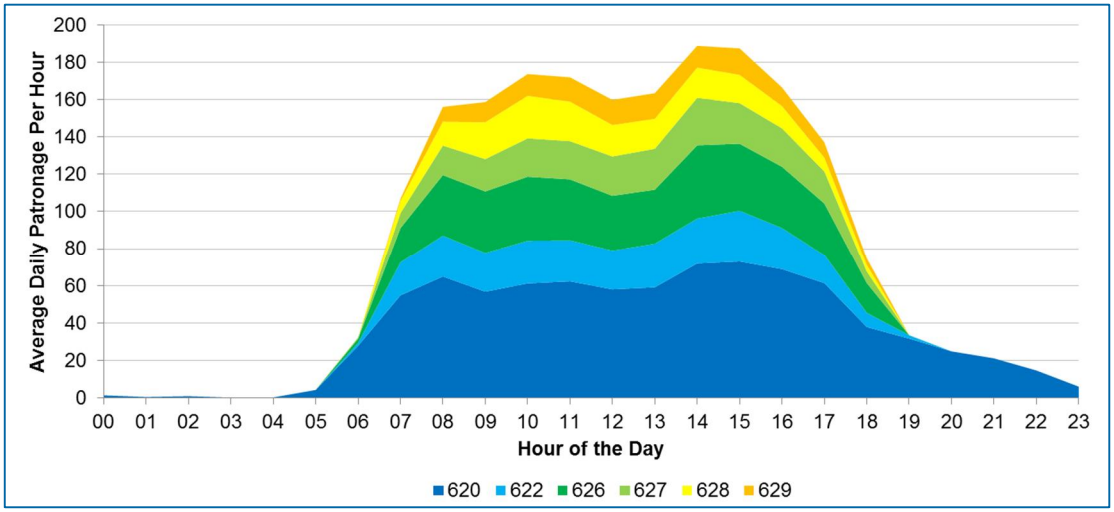


Source: TransLink GoCard ticketing data, March 2014

The average daily patronage for these six (6) bus routes by hour of the day is shown in Figure 3. The patronage which is the sum of total boarding's and alighting's at all stops along

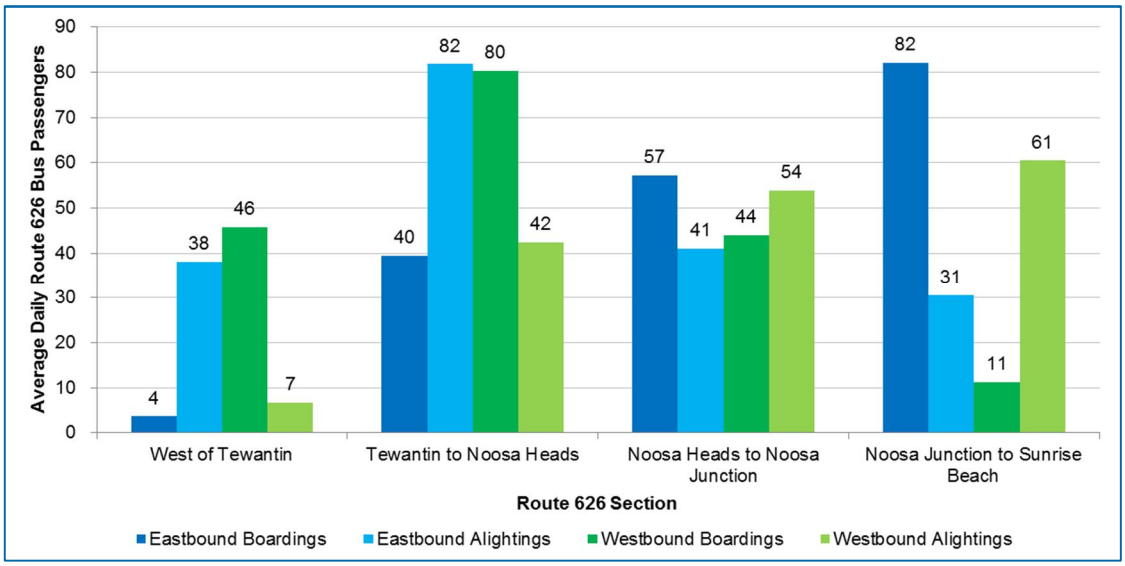
each route is relatively even between 7.00 am and 6.00 pm with the highest patronage occurring between 2.00 pm and 4.00 pm which includes the school peak.

Figure 3 Average Daily Patronage by Hour and Bus Routes



The average daily patronage on Route 626 is shown by section in Figure 4. The busiest section of the route occurs between Tewantin and Noosa Heads. The busiest boarding locations are located at the Noosa Heads bus station, which is close to the Hastings Street tourist precinct, and at the Noosa Junction bus station which is at the Noosa Plaza shopping centre with 15 and 10 percent of the patronage respectively. Tewantin Central in Poinciana Street has 10 percent of the eastbound patronage. The bus stops at Noosa Plaza in Sunshine Beach Road and the Noosa Junction bus station have about 20 percent of the boarding's travelling to Sunrise Beach.

Figure 4 Average Daily Patronage on Route 626 by Section



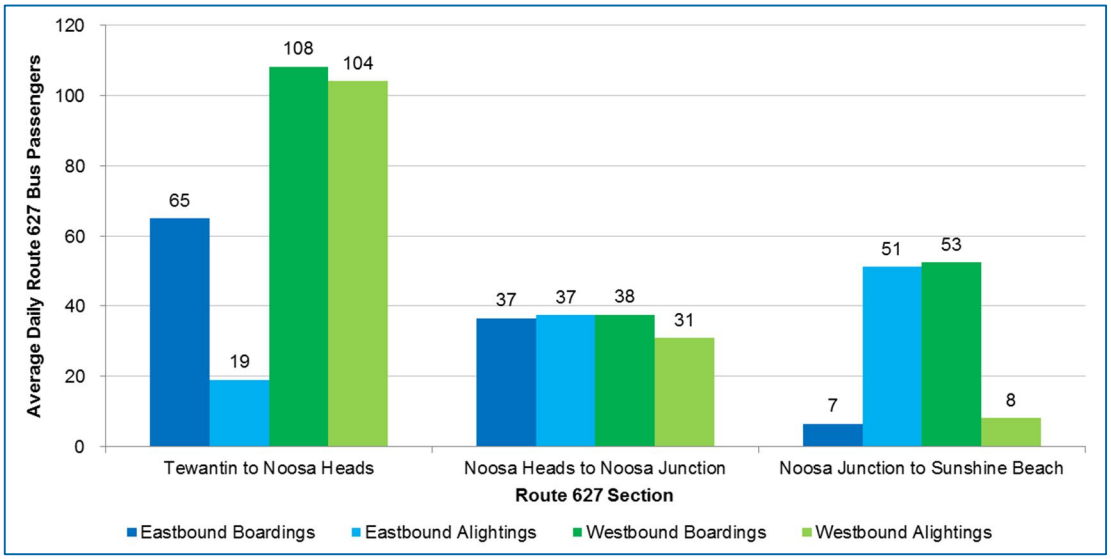
The average daily patronage on Route 627 by section is shown in Figure 5.

The busiest section of the route occurs between Tewantin and Noosa Heads. The busiest bus stops are located at:

- Noosa Heads bus station with 20 percent of the patronage
- Noosa Junction bus station with 10 percent of the patronage
- Noosa Plaza in Sunshine Beach Road with 10 percent of the patronage

- Tewantin Central in Poinciana Street with 10 percent of the patronage

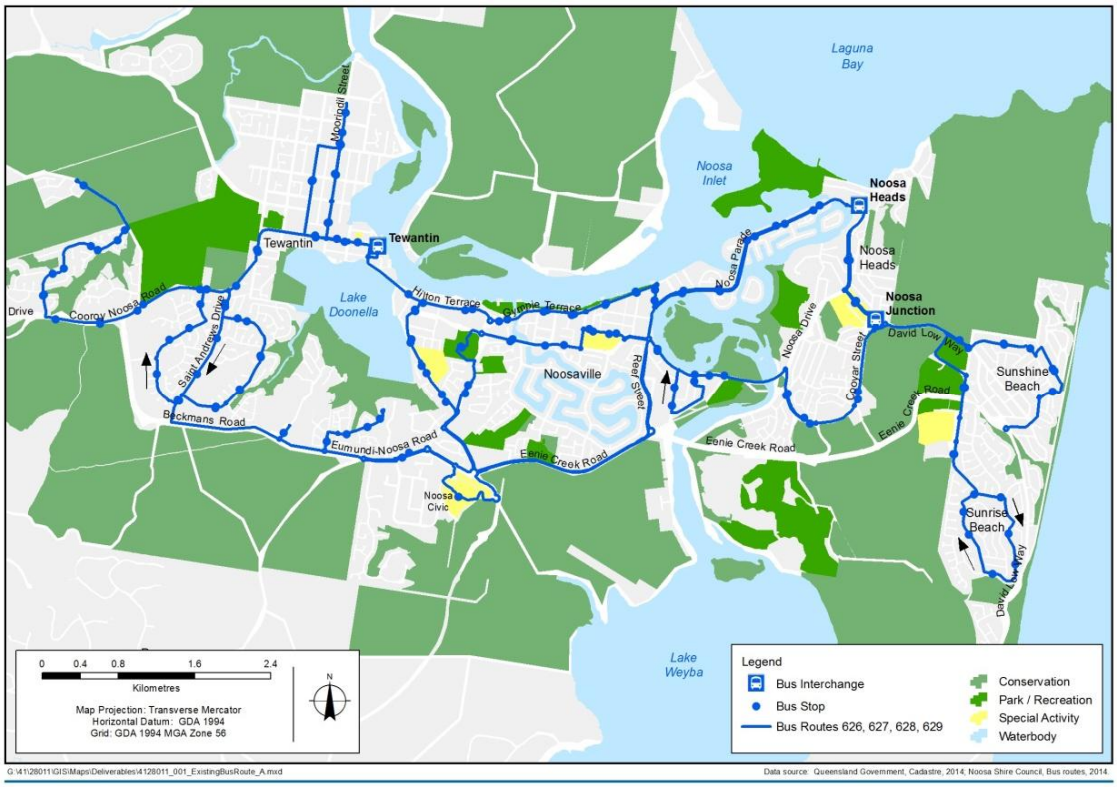
Figure 5 Average Daily Patronage on Route 627 by Section



3.2 Route options for the electric bus trial

Routes 626, 627, 628 and 629, that are shown in Figure 6 are more suitable for an electric bus trial than other longer routes because they service the local suburbs connecting the key local destinations of Tewantin, Noosa Civic, Noosa Heads and Noosa Junction. Since they operate entirely within the Noosa Shire Council area, they would be patronised mostly by Noosa residents, tourists and visitors. An electric bus operating on these routes would have higher visibility and access than the cross-regional routes to Maroochydore and Cooroy. The longer routes would require multiple charging stations with higher implementation, operational and maintenance costs for the trial and therefore they were excluded from the trial assessment.

Figure 6 Four Local Bus Routes in Noosa



Three (3) bus route options were developed and assessed for the electric bus trial. They are described with the advantages and disadvantages in the following sections.

The key criteria that were considered in the assessment of the route options for the trial are:

- Maximise patronage for local residents, tourists and visitors with a route that connects key local destinations, such as Tewantin, Noosa Heads and Noosa Junction
- Maximise the exposure for the general public to promote Noosa as a Shire with sustainable transport values and attract new patronage
- Minimise installation costs of the trial to be attractive for electric bus suppliers
- Support operational efficiency with the location of the recharging stations
- Minimise disruption to the existing bus routes and passengers with requirements to change timetables for only the trial period
- Minimise impacts on driver shifts, rosters and depot operations
- Test the physical capability of the electric bus with a mix of operating environments, terrains and street types and speed limits with and without traffic calming devices
- Minimise operational costs for the trial

3.2.1 Option 1 - Redesign local bus network

Option 1 is a redesigned local bus network that includes a reconfiguration of Routes 626, 627, 628 and 629 to create a new dedicated high frequency route between Tewantin, Noosa Heads and Noosa Junction via Pelican Street, Memorial Drive, Hilton Terrace, Gympie Terrace, Weyba Road, Noosa Parade, Noosa Drive and Sunshine Beach Road. This new Route 625 would be a merger of the sections of Routes 626 and 627 between Tewantin and Noosa Junction via Noosa Heads into one route. It would operate every 15 minutes from 7 am to 7 pm daily, which is the same as the existing combined service frequency of Routes

626 and 627 (currently each at every 30 minutes). However, customers in the Sunshine Beach and Sunrise Beach areas and in the St Andrews Drive/Furness Drive sections (Route 626) would have a reduced service frequency from every 30 minutes to hourly. It could also be extended north along Moorindil Street to service the Noosa-Tewantin Caravan Park if the demand warranted.

The remaining sections of Routes 626 and 627 could operate as separate routes or be merged into Routes 628 and 629 to cover the Sunshine Beach, Sunrise Beach and St Andrews Drive sections that would be excluded from the new Route 625.

Advantages

- A single route would cover the Tewantin to Noosa Heads and Noosa Junction section making it more legible for customers
- The electric bus would operate through the busiest section of the tourist and visitor precinct in Noosa every 15 minutes
- Recharging stations could be installed at multiple locations along the route at the Council office in Tewantin, and at the bus stations at Noosa Heads and Noosa Junction, negating the need for a charging station at the eastern terminus in a residential area

Disadvantages

- A redesign of the TransLink bus network in Noosa will require extensive community consultation on the route changes, especially for the other local routes to Sunshine Beach and Sunrise Beach
- Some passengers would be forced to transfer between a high frequency and low frequency route
- New timetables would need to be designed and printed which is an additional cost for the trial
- New driver shifts and rosters would be required for all of the Noosa bus routes operated by Sunbus
- Since the patronage on Routes 626 and 627 is relatively evenly spread with 20 to 30 percent of the patronage on the sections east of Noosa Junction, any change to the local bus routes will have a major impacts on bus customers and would require detailed assessments, community and stakeholder consultation
- Bus drivers need to be trained on all affected bus routes, not only the electric bus route

3.2.2 Option 2 – Alternate electric bus on Routes 626 and 627

Option 2 is to operate an electric bus alternately on Routes 626 and 627 which both operate every 30 minutes, seven days a week, whereas Routes 628 and 629 operate hourly.

Route 626 currently requires three (3) buses operating every 30 minutes on a 90 minute circuit. Route 627 requires two (2) buses operating every 30 minutes on a 60 minute circuit. Therefore, five (5) buses are operating on these two (2) routes that are currently interlined with other bus routes in Noosa. The two (2) routes have a combined headway of every 15 minutes between Tewantin and Noosa Junction via Noosa Heads.

Advantages

- Both routes cover the busy tourist and visitor precincts between Tewantin, Noosa Heads and Noosa Junction with the same streets

- A single electric bus would operate through the busy tourist and visitor precinct in Noosa with 1 in 5 trips (as the existing Routes 626 and 627 require five (5) buses)
- A high frequency of every 15 minutes exists between Tewantin and Noosa Junction via Noosa Heads increasing the visibility for the general public if multiple electric buses are available in the trial
- By trialling the electric bus on both Routes 626 and 627, a variety of street types with roundabouts and terrains will be traversed providing a rigorous test of the electric bus
- Recharging stations could be installed at multiple locations along the route at the Council office in Tewantin, and at the bus stations at Noosa Heads and Noosa Junction
- New timetables would not need to be printed, saving on the implementation cost. Only a promotional flyer would be required
- No bus network changes are required after the trial if the electric bus is not continued after the trial period
- No community consultation on route changes is needed
- Bus drivers do not need to be trained on new routes; only the use of the electric bus

Disadvantages

- The electric bus operating on multiple routes makes it less legible for the public and harder to have a recognisable service brand and livery
- Routes 626 and 627 are currently interlined with other TransLink routes which has a greater impact on the driver shifts and rosters

3.2.3 Option 3 – Only use Route 627

Option 3 is to only use Route 627 for the electric bus trial with no changes to the TransLink bus network or timetables.

Advantages

- A single route makes it easier to inform customers which route will have the electric bus
- Route 627 has a mixture of street types with roundabouts and terrains to provide a rigorous test of the electric bus, including the local streets in Sunshine Beach
- Route 627 services the busy tourist areas between Tewantin, Noosa Heads and Noosa Junction
- Recharging stations could be installed at multiple locations along the route at the Council office in Tewantin, and at the bus stations at Noosa Heads and Noosa Junction
- New timetables would not need to be printed, saving on the implementation cost. Only a promotional flyer would be required
- No bus network changes are required after the trial if the electric bus is not continued to be operated after the trial period
- No community consultation is required for the bus route changes
- Easy to implement with no changes to timetables or public information
- With 30 minute headway on a 60 minute circuit time, two (2) electric buses and one (1) diesel bus would be adequate to allow recovery time to recharge, driver breaks and to ensure service reliability
- Bus drivers do not need to be trained on new routes; only the use of the electric bus

- The average speed and therefore travel time does not need to be adjusted to accommodate the electric bus technology

Disadvantages

- Since Route 627 only operates every 30 minutes, a high frequency service of every 15 minutes would not operate between Tewantin and Noosa Junction even if multiple electric buses were available for the trial
- Vehicle block is linked to other routes so there will be some de-optimisation of the Sunbus network to have a separate fleet and driver shifts designated to Route 627

3.3 Assessment of the route options for the electric bus trial

A high-level assessment of the three route options for the electric bus trial was conducted using a Multi-Criteria Analysis (MCA) approach with the following key criteria:

- Potential to maximise service coverage and patronage on the electric bus
- A range of operating environments with different terrains, street types and speed limits to test the physical capacity of the electric bus
- Operational efficiency with suitable locations for recharging stations and layovers
- Minimise network changes and implementation costs without community consultation
- Ease of implementation for the bus operator with driver training and for the electric bus supplier to install the recharging infrastructure

The results of the assessment are provided in Table 3. Option 3 has the most criteria scored as Good and Option 1 is the least desirable.

Table 3 Assessment of the Routes for the Electric Bus Trial

Key Criteria	Option 1 Network Redesign	Option 2 Routes 626 and 627	Option 3 Route 627 Only
Service coverage and patronage	🟢	🟢	🟢
Range of operating environments	🟢	🟢	🟢
Operational efficiency	🟡	🟡	🟢
Minimise network change	🔴	🟢	🟢
Ease of implementation	🔴	🟡	🟢

Legend

Score	Description of Scoring
🟢	Good
🟡	Average
🔴	Poor or not acceptable

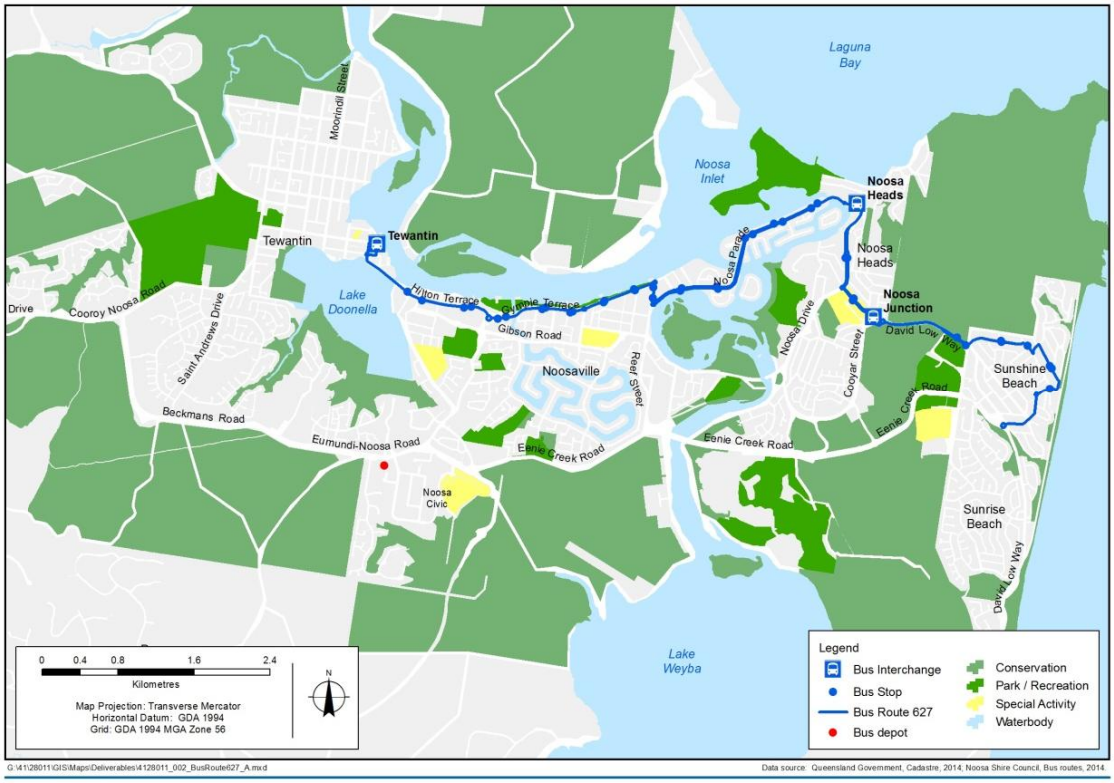
3.4 Recommended bus route for the electric bus

Route 627 as shown in Figure 7 is recommended for the electric bus trial because:

- It is an existing route that already services the busy tourist and visitor precincts connecting Tewantin, Noosa Heads and Noosa Junction with no requirement for the rest of the TransLink bus network to be modified. Community consultation on the route is not required as the existing route, bus stops and service frequencies are not affected

- It is the shortest route with less daily service km than Route 626 and it would be easier to implement with a lesser impact on driver shifts and rosters
- It has a 30 minute running time with a 60 minute circuit time, and it terminates at the western end at Tewantin Central next to the Council office, not in suburban streets
- It requires only two (2) diesel buses on a 30 minute frequency. It is shorter than Route 626 with less distance which has a 40 minute running time and requires three (3) diesel buses to maintain a 30 minute frequency. It operates with a shorter distance through suburban streets than Route 626
- It operates over a mixture of operating environments, street types and terrains to test the physical capability and range of the electric bus
- It provides multiple locations for potential recharging stations and is easier for an electric bus supplier to trial a vehicle than with multiple routes

Figure 7 Route 627 as the Recommended Route for the Electric Bus Trial



The daily operational requirements to operate two (2) electric buses for all services on the existing Route 627 timetable are shown in the calculations in Table 4. The proposed location of the overnight storage is at the existing Sunbus depot at Marcoola. The estimated daily distance per bus is approximately 350 km, including the dead running distance to reposition for layovers and breaks each day.

Table 4 Estimated Daily Operational Requirements for Route 627

Description	Distance (km)	Number of Trips
Eastbound to Sunshine Beach	11.2	23
Westbound to Tewantin	12.5	23
Distance from Marcoola to Sunshine Beach	30	4
Total Distance with Marcoola depot	665	
Daily Distance per bus with Marcoola depot with allowance for	350	

Description	Distance (km)	Number of Trips
repositioning/layovers, etc.		

3.5 Layover, storage and maintenance facilities

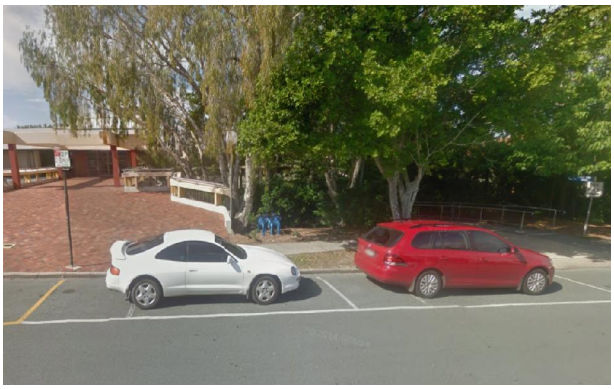
Options for the electric bus to layover between trips with a quick recharging station and for secure overnight storage and maintenance activity were identified and assessed.

3.5.1 Layover locations

Two layover options at Tewantin near the Council office in Pelican Street and at Noosa Junction bus station were identified. The location for the layover and recharging station in Pelican Street at Tewantin is shown in Figure 8. This site is convenient for the western terminus of Route 627 to use and has minimal impact on on-street car parking with approximately three (3) car parking spaces to be removed in Pelican Street. This location is located close to the western terminus of Route 627 at Tewantin.

Figure 8 Terminus in Pelican Street at Tewantin

Potential layover terminus in Pelican Street in front of the Noosa Council offices



On-street parking spaces to be removed for electric bus layover area (Google maps image)

The location for the layover at the Noosa Junction bus station is shown in Figure 9. This site is not at the terminus of Route 627 so a recharging station would have to be for a quick charge only so as not to inconvenience customers on board the bus travelling beyond Noosa Junction.

Noosa Junction is not a suitable location for a charging station because it would not be a “terminus” or layover location for the Route 627 which terminates at Sunshine Beach or Tewantin. It would be more costly to hold a bus at Noosa Junction that is at a midpoint on the trip. Also, the configuration of the layover at Noosa Junction is “off line”, i.e., the bus must loop around to access it away from the street. It is not as convenient as an “in-line” or on-street charging station (say at Tewantin) where the bus simply pulls around to the first stop.

Figure 9 Terminus for Layovers at Noosa Junction Bus Station

Off-street layover area

High quality driver facilities for short breaks

3.5.1 Overnight storage and maintenance facility options

Overnight storage and charging and maintenance activity for the electric bus could be undertaken at the existing Sunbus depot at Beech Street, Marcoola, as shown in Figure 10. It is located approximately 28 km south of the Noosa Junction bus station and approximately 35 km south of Tewantin which is the western terminus of the Route 627. This location would generate additional dead running time and distance of at least 60 km daily if the electric bus was to be stored overnight at Marcoola. However, there would be significant savings in additional driver relief cost (for driver breaks) with the depot at Marcoola (compared to a Noosa Council depot at Bartlett Road).

Figure 10 Sunbus Depot at Marcoola

Maintenance facility at Marcoola depot

Overnight bus storage for up to 63 buses in the current fleet

Overnight storage and charging for the electric bus could be undertaken at the Noosa Council depot in Bartlett Road, Noosaville, as shown in Figure 11. It is located in an industrial precinct in Noosaville, which is approximately 3.7 km south of the Noosa Council offices in Pelican Street, Tewantin. This is an existing secure fenced facility with surveillance systems. This location is not preferred due to the significant additional driver relief costs and additional dead running between the Council depot in Bartlett Road and Sunshine Beach (Ed Webb Park) as the first service starts at the eastern end of the route. In addition any major maintenance/repairs would likely have to be done at the Sunbus depot in Marcoola.

Figure 11 Noosa Council Depot

Minor servicing facility at Council depot

Secure space for the electric bus to be stored overnight

4. Review of electric bus technologies

4.1 Selection of electric bus suppliers and manufacturers

To assess the feasibility of electric bus routes in the Noosa area (in order to provide sufficient evidence to justify a decision to progress the project further) a market research exercise was undertaken to understand the Australian and International electric bus market.

The market research gathered information about vehicle general specifications, battery details and associated charging infrastructure, procurement parameters, training support, warranty and servicing details and finally costs.

Components of an Electric Bus

An electric bus uses electric motors and motor controllers in lieu of an internal combustion engine. A key component of the electric bus is the battery which is charged through a combination of an internal regenerative braking system (whereby some of the energy that would normally be lost is recovered by the braking system) and "topped up" using an external charging system on-route or at specific charging stations. These can be fast or slow charge in nature.

Electric Bus Battery

Technology is advancing quickly in the development of electric bus batteries with batteries becoming lighter and more efficient but is still considered to cost a significant proportion of the capital outlay of the bus. For example, Adelaide City Council's deployment of "Tindo" required 11 Swiss made Zebra batteries (Sodium/Nickel Chloride technology) which weighed 160 kg and ran up to 200 km on a single charge. More recent buses use lithium iron or in many cases lithium iron phosphate (LiFePO 4) batteries which offer a longer battery lifetime and an improved battery density providing a longer driving range. Electric buses also commonly have advance regeneration braking systems. Regenerative braking is an energy recovery mechanism which slows down a vehicle by converting its kinetic energy into another form, which can be used immediately or stored until needed. This contrasts with conventional braking systems, where the excess kinetic energy is converted to heat by friction in the brake linings and therefore wasted. Regenerative braking is ideal for hilly terrains such as Noosa to recharge the batteries as they are going down the declines. This also reduces brake wear and tear as the brake pads are used significantly less than a diesel bus and therefore requires significantly less maintenance than a normal system.

Figure 12 8-Month Old Break Pads on a BYD Bus

Figure 13 Location for Batteries in an Electric Bus

Source: Battery packs of electric vehicle bus. (Photo: Guangzhou Daily/Chen www.lifeofguangzhou.com)

Range of Electric Buses

The ranges of electric buses can vary depending on the battery capacity, number of batteries, the terrain of the bus route, the size of the bus, opportunities for charging en-route and battery technology used to deploy the bus. Generally, most electric buses on urban routes have a range of between 100 km and 200 km. The bus can be charged overnight to 100% capacity via depot based slow chargers (traditionally vary from 3-60 kW) and/or be charged en-route or at the terminus of a route by fast chargers (ranging between 60-400kw)

Electric Bus Charging Infrastructure

Charging of the electric bus can be continuous during operation, at dedicated stations or along the bus route. As indicated in Section 3.4, to accommodate the bus route proposed for Noosa will require a range of approximately 280km per day (including “dead” running time) which will require a fast charge during the day to make sure that the bus can complete the required route. In general, a fast charge provides approximately 1 km of extra range per 1 minute of charge (rule of thumb). This means that during the day, a quick charge may be required for a few hours in order to accommodate the suggested route (the exact time will depend on the charger type and the battery capacity). Some buses can be charged via either an overhead quick charger or an inductive underbody charger using a super charger (between 200-400kW). This allows the bus to top up its charge in just a few minutes at each charging point. It should be noted that the capital outlay for such systems is in the order of $200,000-$300,000 and usually required a network of buses in order to support a business case.

Image of Overhead Super Charger

Image of Inductive Charger

Wireless charging communications system between the bus and charging infrastructure enables fully autonomous charging where no driver input is required and is up to 10 times quicker than the traditional “plug in” slow charging systems.

Image of Plug-in Charging System

Passenger Capacity

The electric bus has been designed with varying passenger capacities and is able to meet the requirements of most transit agencies. The current capacity of the TransLink buses (12.5m) in Noosa has a capacity for 58 passengers. A smaller bus would be able to meet current demands at a lower operational cost to Noosa Council. However, it may not be able to meet the demand during peak seasons and need to be considered in the evaluation of options available.

Shortlist of Electric Bus Manufacturers

The market research found that there were many companies involved either directly or indirectly in the electric bus industry. Companies that were researched were found to originate from New Zealand, Asia (China and Korea), Europe (Germany, Luxemburg, Netherlands, Italy, and Poland) and the Americas (United States and Canada).

In total twenty six (26) electric bus manufacturers were researched to develop comparative product (fleet) profiles comprising of twenty (19) international and seven (7) locally based manufacturers as provided in Table 5 and Table 6, respectively.

To evaluate the companies that offer electric buses, a number of essential factors were required to be met to first shortlist companies for further evaluation. The essential factors included:

- Reputation of the company and tenure in the industry. This was an important consideration specifically to make sure that we are dealing with an OEM that is capable and reliable in delivery and quality. The nature of a new technology deployment comes with a given level or risk and for this reason efforts have been made to mitigate the level of risk by selecting reputable manufacturers that have the ability to overcome any challenges of deployment of the new bus. . During the research process it was found that some companies were slow to respond and unable to deliver the required specifications – this was a process that helped to eliminate OEMs that are not likely to deliver the appropriate level of service and product
- Proven electric bus technology with buses implemented in the field (minimum 12 months)
- Availability to provide a vehicle for the 6-month trial expected in August 2015
- Ability to complete the electric bus route with an approximate range of 280 km per day (23 trips @ 23.7 km round trip). It was found that the quoted range of the electric vehicles by electric bus manufacturers tended to be over-stated (compared to actual performance in the field). As a minimum, a quoted range of 150 km was considered acceptable which would yield an operating range of 100 km. This would require 3 (three) charges per day as a maximum. If the bus range was at the higher range bracket of 150km of range this would require only one full charge per day or 2 partial chargers (which would reduce operational complexity)
- Proven right-hand drive vehicles to suit the Australian driving conditions which minimises the additional cost of customising the electric bus
- Easily able to provide the after sales support, parts replacement and training of drivers
- Compliance with Australian Standards in terms of vehicle specifications including Australian Design Rules (ADR) standards and Disability Discrimination Act requirements
- A summary of the findings from the market research is provided in **Appendix B.** Manufacturer's brochures are provided in **Appendix B**. A summary of the comparison of the electric bus technology considered is provided in **Appendix C**.

Using the above mentioned selection criterion, four (4) electric bus manufacturers were shortlisted for further evaluation using a Multiple-Criteria Analysis (MCA) approach as below:

- Solaris (Poland)
- BYD (through Carbridge the largest Australia aviation bus company with operations in Brisbane, Sydney, Melbourne, Adelaide and Perth airports)
- Optare (through PATICO Automotive who are the Australian distributors for Optare headquartered in Dandenong, Melbourne and have been operating in Australia for 10 years)
- Olev (through Australian Electric Infrastructure Transport (AEIT) with an office located in Brisbane, Queensland. AEIT is a Brisbane based company established in 2012 to commercialise the Olev electric vehicles in Australia)

Table 5 List of International Electric Bus Manufacturers contacted for Market Research

Name	Model	Origin	Range	Vehicle Length	Battery	Assessment outcome
Designline Bus Pacific	Various	United Arab Emirates / New Zealand	200km	12m	Sodium/Nickel/Chloride	Tried to contact on several occasions but no response (no longer running out of NZ. Solely in Middle East. Not shortlisted
Zonda	Model YCK6128HEC	China	200km	12m	Lithium–ion	Tried to contact on several occasions but no response. Not shortlisted
Thundersky	Thunder Sky – EV010	China	200km	11.2m	Lithium–ion	Tried to contact on several occasions but no response. Not shortlisted
AMZ-Kutno	City Smile CS12	Poland	na	12m	na	Tried to contact on several occasions but with minimal interaction and limited interest in being involved. Not shortlisted
IVECO	na	Italy	na	na	na	Tried to contact on several occasions but no response. Not shortlisted
VDL Bus/Coach	na	Luxemburg	na	na	na	Had detailed discussion with them and they are currently not looking to

Name	Model	Origin	Range	Vehicle Length	Battery	Assessment outcome
						service the Australian market. Not shortlisted
EBUSCO Electric Buses	EBUSCO YTP1	Netherlands /China	250km	12m	Lithium–ion	No proven experience in right hand drive vehicles. Not shortlisted
Eurobus	EuroBus 2.0	Germany	250km	12m	Lithium–ion	Had detailed discussion with them and they are unlikely to be able to support the Australian market. Not shortlisted.
Skoda Perun Electric	Pure Electric RUNner	Czech	200km	12m	na	No proven experience in right hand drive electric vehicles. Not shortlisted.
Proterra	Eco Ride BE35	US	46 – 65km	12m	na	Short range (65km). Small bus. No proven experience in right hand drive vehicles. Not shortlisted.
Bombardier + Primove	na	Canada	Variable	12m	na	Do not manufacture buses so they need to work with a bus manufacturer. Involved in the manufacture of PRIMOVE on-board equipment and batteries. Bombardier together with Solaris (as bus manufacturer) was considered. But Solaris was not shortlisted and the opportunity to work with Bombardier as less likely for this specific project Not shortlisted.
New Flyer (JV Mitsubishi)	na	Canada	na	12.1m	Lithium–ion	No proven experience in right hand drive vehicles. Not shortlisted

Name	Model	Origin	Range	Vehicle Length	Battery	Assessment outcome
Volvo/ABB	Only Hybrid or Trolley Bus	Sweden	na	na	na	Only offer hybrid or trolley bus. Not shortlisted
Techno bus	Gulliver	Italy	100km	5.3m	na	Short range (100 km). Small bus. No proven experience in right hand drive vehicles. Not shortlisted.
Solaris	Urbino electric	Poland	Various ranges	12m	Lithium–ion	Met essential criteria **Shortlisted**.
Seimens - Rampini	Trolley bus	Italy/ Germany	150km	8m	Lithium–ion	Trolley bus only – not shortlisted
Bredamenarini	Bus E Vivacity	Italy	200km	8m	Lithium–ion	Tried to contact on several occasions but no response. Not shortlisted
Salavador-Caetano	Eco Bus electric	Portugal	100km	13.9m	Lithium–ion	Short range (100 km). Not shortlisted

Note: na – information not readily available or provided by manufacturer

Table 6 List of Electric Bus Manufacturing Companies with a base in Australia contacted for Market Research

Name	Model	Origin	Range	Vehicle Length	Battery	Assessment outcome
BCI	Energy Series E Bus	China	150km	8.2m	Lithium–ion	Company no longer involved in electric bus manufacture as too cost prohibitive. Not shortlisted
BYD (through Carbridge)	E Bus	China	250km	12m	Lithium–ion	Met essential criteria **Shortlisted**.
Varley YTP	EV Citibus	China	200 - 250km	12m	Lithium– ion magnesium phosphate	Tried to contact on several occasions but no response. Not shortlisted
Optare (through	Solo	United Kingdom	150 - 180	7.2m – 10m	Lithium– ion magnesium	Met essential criteria **Shortlisted**

Name	Model	Origin	Range	Vehicle Length	Battery	Assessment outcome
PATICO)			km		phosphate	
Bustech	na	Australia	na	na	na	Tried to contact on several occasions but no response. Not shortlisted
Scania	No longer Manufacture EV	Australia	Nil	Nil	Nil	No longer manufacture electric bus Not shortlisted
OLEV (through AEIT)	OLEV W Bus	South Korea	150-200km	12m	Lithium– ion phosphate	Met essential criteria **Shortlisted**

4.2 Electric bus questionnaire

To supplement the market research, a tailored email questionnaire was sent to selected manufacturers, transit and government agencies in the electric bus Industry whom were based locally and abroad. A copy of the questionnaire and the responses are attached in **Appendix C.**

4.3 Case studies of shortlisted electric bus manufacturers

4.3.1 Review of BYD E electric bus series

BYD is a Chinese automobile manufacturer based in Shenzhen, Guangdong Province. It was founded in 2003 initially as a major battery manufacturer. Today its principal activity is the design, development, manufacture and sale of passenger cars and buses under the BYD brand.

Vehicle Performance

- BYD's K-9 E-bus series is listed with an urban range of 250 km per charge. However, this can vary depending on the size of the battery installed in the vehicle (battery size varies between 220-324 kWh). Based on our experience with other BYD buses it should be assumed that an operational range of 150-160 km range per charge would be achieved
- Full range of 193km was tested by the bus operator (Dan, Tel Aviv) until the bus stopped. This is with the 324kWh battery pack but the new technology batteries are expected to be significantly better - probably 20% improvement
- The current bus is fourteen (14) tonnes which includes the weight of three (3) battery packs. The new BYD buses have only two (2) packs with their newer technology batteries
- Charge is 5 hours based on a 60kw charge for a 300 kwh battery
- Top speed of BYD buses are 70km/h powered by an 180kW electric motor. The bus has a grade limitation of 15% and a capacity of 30 seated passengers. The battery technology on the BYD bus is state of the art Lithium-ion Phosphate manufactured and under warranty by BYD

- Preferred operating environment for the bus is urban/city roads. The range drops significantly outside the city with these buses mostly because of their additional battery load (about 3 tonnes)
- It is estimated that average electricity consumption per/km is 1.3 – 1.6 kWh/km (based on a 324 kWh pack and a range of 250 km)
- Right-hand drive (RHD) experience in the UK

Infrastructure Needs

- Charging of the batteries will vary based on the equipment but with standard BYD equipment they can be charged at 60kW which would take approximately 5 hours to fully charge (based on an assumed 300 kWh battery pack)
- Power supply for the BYD wall mounted charging station is 380V/400V (3 phase) for a dual 30kw charger (total 60kW). The unit is a touch-screen pod with Radio Frequency Identification (RFID) security features and a LED indicator and emergency stop button

Cost

- Vehicle cost is $625,000 for one (1) electric bus. The price of a charging station (fast and slow) is $10,000 each. This price is competitive with other buses on the market

Benefits

- No bus emissions
- Low noise (common to all electric buses)
- BYD has significant experience in the deployment of electric buses around the world. They are well resourced and are expected to be able to provide support for Australia. They are looking to enter the Australian market and establish operations locally

Disbenefits

- No presence currently in Australia
- BYD will need to build a fully ADR compliant bus for the trial

Emerging Innovations

- BYD are global leaders in the development of battery technology and battery management systems (BMS). Their battery technology has shown a continuous improvement. The new generation of batteries is already exceeding the older batteries in capacity, which is currently installed in buses around the world. BYD are also focused on the development of a eco-friendly systems for their buses and are working to optimize air-conditioning and heating systems as well as improved bus telematics and diagnostics

Countries Deployed

- Netherlands (Schiphol airport), Chile, Brazil, Mexico, Malaysia, India, Hong Kong, China, Israel, Italy, London, Finland, Spain, Denmark, Hungary
- Electric bus soft launch confirmed (18 November 2014) for Sydney Airport, Australia

4.3.2 Review of Solaris Urbino 12M electric bus

Solaris Bus & Coach SA is a bus, coach, trolleybus and tram manufacturer based in Bolechowo near Poznań, Poland. It is a family-owned business that has recently moved into the manufacturing of electric buses.

Vehicle performance

- The Solaris Urbino Electric 12M bus has a range of over 100 km. However, the range can vary depending on the size of the battery installed in the vehicle. The top speed of the bus is 70km/h powered by a 160kw electric motor. Capacity of the bus is up to 41 passengers. Battery technology is Lithium-ion. Estimated average electricity consumption per kilometre is between 0.9-1.34 kWh/km

Infrastructure needs

- Charging of the batteries will vary based on the equipment and can be done inductively through a rapid overhead charger or through a simpler quick or slow plug-in style-charger
- Power supply is standard for quick charge units. Specifications will depend on the specific unit chosen

Cost

- Vehicle cost is $850,000 per unit. Charging infrastructure cost is approximately $20,000 for a quick and slow plug-in charger. Quotes for inductive charging are based on inspection of route and electricity connection. This can be done with Bombardier and is estimated to cost $200,000 per unit with an expected three (3) units required to complete the electric bus route

Benefits

- No emissions, low noise (common to all electric buses). Solaris has the advantage of scale and expertise in the manufacturing of buses with a strong and reputable international brand

Disbenefits

- No presence currently in Australia

Emerging innovations

- Solaris is involved in the latest innovations in the world of electric buses; specifically they are ensuring their buses are compatible with all infrastructure solutions in order to ensure they are aligned with the latest cutting edge innovation in this space this includes both inductive and conductive

Countries deployed

- Germany, France, Poland, Australia, Sweden

4.3.3 Review of Optare (Versa and Solo) electric bus series

Optare is a bus and coach manufacturer with headquarters in Leeds, United Kingdom. They have an Australian agents (PATICO Automotive) based in Dandenong Victoria. The Company has been formed out of the former Leyland bus business in 1985. In recent times they have been trialling non-electric buses with various TransLink bus operators in SEQ.

Vehicle performance

- The Optare Solo Electric buses vary in lengths from 7.2m to 10m and have a range of 150 to 180km. However, this can vary depending on the size of the battery installed in the vehicle. Top speed of the bus is 95km/h powered by a 205kw electric motor. Passenger capacity of 65 with seating capacity of up to 35 passengers. Battery technology is Lithium-ion / Magnesium Phosphate. Charging of the batteries will vary based on the

equipment and can be done inductively or plug-in (i.e. through a rapid 60 minute charger or a 6 hour slow plug-in charge). The on-board charger has dual compatibility mode. Estimated average electricity consumption per kilometre is projected to be 0.8-1.0 kWh/km

Infrastructure needs

- Power supply is standard for quick charge units. Specifications will depend on the specific unit chosen

Cost

- Vehicle cost is $595,000 per single unit. Combined slow and fast charging infrastructure cost is approximately $30,000 per unit. The charger is built into the bus and only requires a three phase connection

Benefits

- No bus emissions
- Low noise (common to all electric buses)
- Optare also has the advantage of scale and expertise in the manufacturing of buses with a strong and reputable international brand
- Already have a presence in Australia
- Availability of 10m buses to negotiate tight corners at intersections

Disbenefits

- Fast charge of 60 minutes is too long for en-route without needing to inject a new bus into the cycle to maintain a 30 minutes headway

Emerging innovations

- The only ISO9241 certified driver area with proven reduction in driver fatigue and class leading fuel consumption in metropolitan and regional areas

Countries deployed

- England, Scotland, Belgium, Switzerland, Holland and Korean and Chinese orders on the way

4.3.4 Review of OLEV electric bus series

OLEV is a bus and coach manufacturer originated in Korea but represented by Australian agents (AEIT) based in Brisbane. It is has been involved in the manufacture of electric buses since 2009.

Vehicle performance

- The OLEV WBus Electric Bus is 12m in length and has a range of 150 to 180km from a single charge. However, the OLEV buses has unlimited mileage when both the “In-Motion” charging and stationary charging strategies are adopted. Effectively, the vehicle does not really have to stop and plug in to charge as the bus wirelessly charges as it passes over road embedded charging infrastructure
- Top speed of the bus is 90 km/h powered by a 120 kW electric motor
- Passenger capacity of 66 passengers with seat capacity of 51 seats and provision for three (3) wheelchair spaces. Battery technology is Lithium-ion / Phosphate. Charging of

the batteries will vary based on the equipment and can be done inductively through a fast 45 minute charger or through a simpler slow plug-in charger. Estimated average electricity consumption per kilometre is 1.5kWh/km

Infrastructure needs

- Power supply is standard for quick charge units. Specifications will depend on the specific unit chosen

Cost

- Vehicle cost is $680,000 per unit. Wireless charging infrastructure cost is approximately $300,000 per unit. However, this technology is not essential and as charging can occur via the traditional “plug in” method and would cost in the order of $8,000. This can be connected to a standard 15A power point

Benefits

- No emissions, low noise (common to all electric buses). OLEV also has the advantage of scale and expertise in the manufacturing of buses with a strong and reputable international brand

Disbenefits

- Fast charge of 45 minutes is too long for en-route without needing to inject a new bus into the cycle to maintain a 30 minutes headway
- Imbedded recharging technology not good for a short term trial

Emerging innovations

- Similar to other companies, OLEV is involved in the latest innovations in the world of electric buses; specifically the road embedded wireless charging infrastructure and other solutions in order to ensure they are aligned with the latest cutting edge innovation in this space this includes both inductive and conductive

Countries deployed

- South Korea,(Seoul City, Gumi City and Daejeon City)

4.4 Case studies of selected electric bus operators and transit agencies

In addition, telephone interviews were conducted with transit agencies and bus operators to understand actual implementation issues, potential risks and lesson learnt, which could inform the electric bus for Noosa. The case studies included:

- Tel Aviv, ‘Dan’ bus operator, BYD pilot
- Greater Manchester Integrated Transport Authority – Optare e-bus pilot
- Schipol airport pilot program – BYD K-9
- Adelaide City Council -Tindo E bus
- Brisbane City Council

The findings of this assessment are presented below.

4.4.1 Tel Aviv, 'Dan' bus operator, BYD pilot

Dan is the second largest bus operator in Israel. It is the principal operator within metropolitan of Tel Aviv area (Gush Dan), and also several intercity lines to Jerusalem.

Pilot details and feedback

- Currently running Dan Route 5 (Tel Aviv) and route 61 (Ramat Gan-Tel Aviva)
- Focused on two (2) key routes that are inner city very high load routes. Bus goes approximately 160km per day on this route
- This is the first pilot bus for Dan. Planning on expanding the electric fleet
- Current trial is 12 months. 8 months already conducted
- Considered Solaris and VDL, but both were more costly than the BYD vehicle and could not compete with the specs and the service levels
- No indication of price they paid, but cheaper than European models
- Key criterion was based on the current performance of the diesel bus on the same route. Key was to provide a reliable bus with a good experience for the driver and passengers
- **Maintenance has been very low cost. Expected to be a significant saving compared to diesel fleet**
- Driver training is critical – for the same bus route, some drivers returned the bus with 7% and others with 40% residual charge. **Training is critical in order to maximize range and create more consistency across the fleet**
- Target of pilot is reduction of emissions and improvement in maintenance cost - so far this is being achieved
- Key issues and problems with the bus related to the **development of specific** requirements **to fit Israeli standards**. Significant modifications were required on this front. Important to note that BYD were very good with dealing with these modifications and were actively flying people over to manage the process in a very proactive and professional way
- **Air-conditioning can be an issue as it is quite energy intensive** (i.e. 10-15 kW). Some issues with the air conditioning system were repaired. **The system is generally very energy intensive** and BYD are working to develop an improved system
- Maintenance teams were very responsive often flying people to Israel within 24 hours

Infrastructure

- A 60 kW charger (2x30kW) is deployed at the depot. This is charged at the end of the day with an overnight charge. Drivers are responsible for charging. There have been some issues with drivers not plugging in properly, so there is need for training on this front. The system provided by BYD is quite advanced with automatic and pre-set timers, but the experience is that the system should be used in its simplest form so that the driver gets a real time confirmation of charging. Generally a simple and effective charging solution
- There has been an **issue with the accuracy of the charging unit metering devise**. Therefore, the operator has deployed an external meter provided by the utility to measure the exact amount of electricity being charged
- Some **issues with deploying charging infrastructure in public areas**, but the depot installation was smooth

4.4.2 Greater Manchester Integrated Transport Authority – Optare e-bus pilot

The Greater Manchester Combined Authority (GMCA) is the top-tier administrative body for the local governance of Greater Manchester, England. It is a strategic authority with powers over public transport, skills, housing, regeneration, waste management, carbon neutrality and planning permission.

Pilot details and feedback

- Information provided was from Head of Electric Vehicle programme for Manchester Greater Transport Services
- Pilot conducted is with Optare Versa (current model)
- Conducted for both environmental reason and to save costs compared to diesel models
- The **batteries provide only about 100km instead of the expected 130-140 km presented** to the authority as the available range
- Three (3) buses currently in the network. Very similar to the hybrid version currently in operation with Manchester
- Route of the pilot is Orange Metroshuttle 1 route, which links to Piccadilly station
- Manchester Council ran a survey to understand customer satisfaction as well as driver feedback
- Bus drivers were generally happy with the new electric bus. They pushed back on the training, but once it was done, the process was very smooth. Note that Manchester has an identical bus already in a hybrid version which is exactly the same experience but without the need to charge. This made the transition to the Optare electric easier and smoother
- The authority had some **issues with the auxiliary battery not charging and battery** going flat constantly
- Note that significant changes and modifications were required as part of this process

Infrastructure

- Pilot conducted using electricity from the depot. Slow overnight charge or plug-in quick charger along the route
- The authority had some **issues with the cable compatibility and also an issue with the software of the bus which was preventing from charging**. All teething issues were fixed quickly, however, for a short while they were required to have a backup bus available
- Manchester **recommends using a separate meter for the charging point** to ensure accuracy of electricity consumption

4.4.3 Schipol airport pilot program – BYD K-9

Amsterdam Airport Schiphol is the main international airport for the Netherlands, located 20 minutes southwest of Amsterdam. It is the fourth busiest airport in Europe in terms of passengers.

Pilot details and feedback

- 40 diesel buses currently operating at the airport. Bus network covers very small 900m distances at slow speed (17km/h) and distances (50km per day). The engine never warms

and costly due to extra fuel and wear and tear (estimated to cost $200,000 over 10 years). Therefore, needed to upgrade to new technology. Airport decided to review new technology. After conducting a cost and benefit analysis and taking into account the environmental and social benefits the electric bus was determined as the best option

- Route is 50km per day (i.e. 900 meter routes @ 50 trips a day)
- Pilot was conducted with two (2) buses with the key criteria being kWh/km. Two manufacturers participated namely; BYD and contract buses
- 6 week trial period with two (2) buses
- Passengers were engaged to get feedback – overall very positive response
- Key criteria was reliability of buses, ability to operate daily without any issues, use of power, noise, size of the bus to be suitable for airport bus dimensions (wider and longer than standard buses), driver and passenger experience
- **Cultural difference dealing with BYD in China.** Some training was undertaken to deal with cultural differences between the authority and BYD
- **Experienced significant delays in prototype** (i.e. 7 months late). 35 remaining buses due in December were 4 months late. However, the delay was not just BYD as there were modifications to interior/exterior requirements which had to be addressed
- **BYD had difficulty meeting demands for the exterior of the bus** and this required additional modifications and follow up
- Airport staff has visited BYD five (5) times and another further two (2) visits were required
- In Netherlands, there is a strong advantage for purchasing bus compared to leasing due to government incentives
- Tender included maintenance for next 10 years (responsibility of BYD), local maintenance company to carry this out. Airport supplied nearby maintenance contacts to BYD

Infrastructure

- Tender included installation of charger poles, underground electrical infrastructure installed by local company (charging capacity – 60kW)
- Chargers were not deployed along the route. Airport used overnight charges at the base
- Airport has moderate sea climate. Generally between 15°C and 30°C, so climate impacts on the bus or infrastructure could not be accounted for
- Solar field at the airport powers the buses. Solar field is large enough to power all buses. There was **no business case for solar panels on roof as no profits generated**

4.4.4 Adelaide City Council -Tindo E bus

The Adelaide City Council is the capital city's administrative body for local governance in South Australia. It commenced operating an electric community bus in February 2008 following tests conducted during 2007. This was the first electric vehicle in the world to be charged using solar power. Council's electric bus was named "Tindo" based upon a local indigenous Kaurna term for the sun.

Pilot details and feedback

- Information provided was from Council's project team members involved in the set up and operation of the electric bus

- Pilot was conducted with a Designline electric bus manufactured in New Zealand based on specifications originating from the United Arab Emirates
- Conducted for both social and environmental reasons to enhance its community bus services
- The route is a circuit through North Adelaide and the Adelaide CBD linking key retail, commercial, cultural and transport nodes
- Adelaide City Council conducted surveys to understand customer satisfaction as well as driver feedback
- Bus drivers were generally very happy with the new electric bus (Single Unit Only). They received comprehensive training similarly to the Council maintenance staff; however the **procurement of parts when required has been problematic** and meant the vehicle has been off line for weeks at a time. During these periods a lease vehicle was required
- Council has had some **issues with the battery charging software** not distributing an even coverage and as such life span of batteries has been inconsistent. **Batteries lasted about 4.5 years in lieu of the 10 year expectation**

Infrastructure

- Recharging was via a solar electric charge at the bus depot. Slow overnight charge using a 35kW system designed by the manufacturer Designline. Although a fast charge of 70kW was also obtained; however not used to date. The bus has been off the road since January 2014 as new operation procedures are being negotiated with the State Government to take over ownership and operation of the bus
- **Air conditioning drained power significantly** and the vehicle was taken off the road on consecutive days over 40 degrees
- **Vehicle is currently off the road due to DDA compliance not being met** (including the fact that the wheelchair space 100mm too narrow) as such a DDA Audit has been undertaken to seek advice about what improvements need to be undertaken
- **Inverter capacity has been an issue at times**. More power to weight ratio provides excellent torque
- At a 20% charge, the bus is limited to speeds of 25 -30 km/h (safety mode) which was adequate only to get back to depot for recharging. This is to **ensure that the batteries are not fully depleted and reducing their longevity**

4.5 Assessment of selected electric bus manufacturers

4.5.1 Multiple-Criteria Analysis of electric bus manufacturers

The MCA process forms part of the overall methodology of options filtering. MCA is a technique that is commonly used to evaluate a project whereby project performance is not solely measured in single monetary units but on the basis of performance against multiple assessment criteria. It is a widely accepted evaluation method where all the impacts cannot be fully quantified in monetary terms and objectives may be in conflict. The MCA process measures the effectiveness i.e. efficiency and not the absolute worth of an option, and makes use of quantitative and qualitative measures.

The form of the MCA proposed for this study is known as the Goals Achievement Matrix (GAM) method. GHD has used this approach on many other jobs with satisfactory outcomes. The primary focus of the GAM method is on the selected project outcomes as opposed to the effects of the project per se.

The approach does not seek specifically to focus on sectoral interests, and does not require effects to be expressed in monetary values. Objectives can be weighted to reflect their relative importance to the central task of developing a feasible heavy vehicle alternative route option. Weights for an MCA are assigned for each of the criteria to reflect their relative importance to the decision and scored in terms of priority. These scores and weights were combined for each route option to derive a ranking for the route.

A Multi-Criteria Analysis (MCA) approach has been used to inform the selection of the preferred electric bus manufacturer. The following criteria and weighting were agreed and adopted for the assessment. The assessment criteria and weighting for the assessment was developed and refined through consultation with Noosa Council/TransLink.

- Vehicle performance (Motor Power nominal, Motor Power peak, Max Speed, Gradeability) – 15% weighting
- Battery Performance (kWh/km) – 15% weighting
- Charging infrastructure (i.e. complexity of deployment, flexibility of network, proven reliability of charging equipment, speed of charging, simplicity of operation) – 15% weighting
- Capital cost (Capex) of the electric bus – 25%
- Operating cost (Opex) of the electric bus – 5%
- Cost of charging infrastructure (Capex and Opex) – 10% weighting
- After sales support and warranty – 15% weighting

A ranking system with a rank of 1 lowest score and rank of 4 highest score was adopted. Ranking is on a 1 to 4 scale with a higher overall weighted score indicative of a preferred technology.

Vehicle Performance – 15% weighting

The average gradient of Route 627 is between 2.4% to 2.5% with the steepest sections at 12%. All four electric buses technologies have the capability to negotiate this gradient and is not a differentiator. In order to differentiate between the manufacturers, the top speed of the bus was used with a preference for a higher speed indicative of motor power.

- Top speed of the Optare bus is 95km/h powered by a 205kw electric motor (Rank=4)
- Top speed of the Olev bus is 90 km/h powered by a 120 kW electric motor (Rank= 3)
- Top speed of the BYD bus is 70km/h powered by an 180kW electric motor (Rank=1)
- Top speed of the Solaris bus is 70km/h powered by a 160kw electric motor (Rank=1)

Battery Performance (kWh/km) – 15% weighting

The batteries are an essential component of the electric bus and its performance is an important consideration. Battery performance per kilometre travelled was used to compare between manufacturers.

- Optare bus average electricity consumption is 0.9 kWh/km (Rank=4)
- Solaris bus average electricity consumption is 1.14 kWh/km (Rank=3)
- BYD bus average electricity consumption is 1.45 kWh/km (Rank=2)
- Olev bus average electricity consumption per kilometre is 1.5 kWh/km (Rank=1)

Charging infrastructure – 15% weighting

Optare, BYD and Solaris buses can be charged using a plug-in connection via DC Connection with external charger or AC connection with on-board charger. Therefore, all three (3) manufacturers were ranked equally. A wireless charging system is proposed by Olev which limits flexibility of deployment and has been scored lowest at 1.

Capex of the electric bus – 25% weighting

Capital cost is a key consideration in the selection of a preferred manufacturer with the lower cost preferred.

- BYD vehicle cost is $651,000 (Rank=4)
- Optare vehicle cost is $741,000 (Rank=3)
- Olev vehicle cost is $782,000 (Rank=2)
- Solaris vehicle cost is $850,000 (Rank=1)

Opex of the electric bus – 5% weighting

Maintenance cost of the electric bus has been assumed to be similar between the electric bus manufacturers as there are not many moving mechanical parts in the power train. Therefore, all manufacturers were ranked equally.

Capex and Opex of charging infrastructure – 10% weighting

The capital cost of the charging infrastructure has been taken into account for each manufacturer excluding the maintenance cost. Once constructed the maintenance cost of the charging infrastructure is likely to be minimal and unlikely to be material to the final decision outcome.

- BYD cost is $26,000 (Rank=4)
- Olev cost is $32,000 (Rank=3)
- Optare cost is $76,000 (Rank=2)
- Information not provided assume Solaris cost is same as BYD (Rank=4)

After sales support and warranty – 15% weighting

After sales support is critical for the successful implementation of the project particularly given the new technology aspect of the electric bus. After sales support will be needed to address bus operational and performance issues, vehicle customisation to comply with Australian Standards, road worthiness, driver training, replacement parts, and so on. All manufacturers offer comparable warranties which can be bought at a cost so unlikely to impact the outcome.

- Solaris (Poland). Company has no representatives in Australia and is ranked the lowest at 1
- BYD (through Carbridge an Australia largest aviation bus company with operations in Brisbane, Sydney, Melbourne, Adelaide and Perth airports) (Rank=3)
- Optare (through PATICO Automotive who are the Australian distributors for Optare headquartered in Dandenong, Melbourne and have been operating in Australia for 10 years) (Rank=4)

- Olev (through Australian Electric Infrastructure Transport (AEIT) with an office located in Brisbane, Queensland. AEIT is a Brisbane based company recently established in 2012 to commercialise the Olev electric vehicles in Australia) (Rank=3)

A summary of the MCA results is shown in Table 7.

Table 7 MCA of Electric Bus Manufacturers

	Vehicle Performance	Battery Performance	Charging Infrastructure Deployment	Costs of EB Capex	Costs of EB Opex	Cost of Charging Infrastructure	After Sales Support	Weighted MCA Score
Optare	4	4	3	3	1	2	4	3.25
BYD	1	2	3	4	1	4	3	2.80
Olev	3	1	1	2	1	3	3	2.05
Solaris	1	3	3	1	1	4	1	1.90

Note: Rank of 1 lowest score, Rank of 4 highest score. Ranking is on a 1 to 4 scale with a higher overall weighted score indicative of a preferred technology.

4.5.2 Selection of electric bus manufacturers

A Multi-Criteria Analysis (MCA) approach has been used to inform the selection of the preferred electric bus manufacturer. A ranking system with a rank of 1 lowest score and rank of 4 highest score was adopted. Ranking is on a 1 to 4 scale with a higher overall weighted score indicative of a preferred technology.

The results showed that Optare scored highest with a weighted score of 3.25, followed by BYD with a weighted score of 2.80 and Olev with a weighted score of 2.05. Solaris scored the lowest at 1.90. The technology employed by Olev (i.e. wireless road-embedded charging) is new technology which still has to be proven in terms of performance and will be cost prohibitive to implement for the trial (i.e. multiple road-embedded charging stations will be required en-route to fast charge the battery) and was discounted.

The MCA results were presented at a workshop with Council/TransLink on the 18 September 2014 and it was decided that the top two (2) manufacturers (i.e. Optare and BYD) would be invited through an expression of interest (EOI) to participate in a 6 month trial. More detailed information was gathered through the EOI process to select a preferred manufacturer.

5. Review of legislation, policy standards, regulations and contracts

5.1 Electric heavy vehicle standards in Australia

A literature review was undertaken to review all relevant State and Federal Transport policy, standards and regulations which will potentially influence the project. The review also involved consultation with key industry stakeholders to understand potential changes or directions in policy and regulations that will support the Strategic Outline Case (SOC).

There are seven (7) Australian Standards related to electric vehicles that specify a number of safety and electric charging requirements (listed below). The Australian Standards (AS) is based on standards developed by the International Organization for Standardization and the International Electrotechnical Commission and hence contains requirements that are familiar to international electric vehicle manufacturers. Confirmation will need to be sought from the bus provider that the electric bus and recharging station for the trial will be compliant with relevant Australian and international standards. The current standards are as follows.

- AS ISO 6469.1:2014 Electrically propelled road vehicles - Safety specifications - On-board rechargeable energy storage system (RESS)
- AS ISO 6469.2:2014 Electrically propelled road vehicles - Safety specifications - Vehicle operational safety means and protection against failures
- AS ISO 6469.3:2014 Electrically propelled road vehicles - Safety specifications - Protection of persons against electric shock
- AS ISO 8713-2012 Electric road vehicles - Terminology
- AS IEC 61851.23:2014 Electric vehicle conductive charging system - D.C. electric vehicle charging station
- AS IEC 61851.24:2014 Electric vehicle conductive charging system - Digital communication between a direct current (DC) electric vehicle charging station and an electric vehicle for control of DC charging
- AS IEC 62196.2:2014 Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Dimensional compatibility and interchangeability requirements for alternating current (AC). pin and contact-tube accessories

Beyond the seven (7) existing Australian standards, electric vehicle standards are still being developed in Australia. As yet there are no specific standards regulating the use of electric buses. In 2014, Standards Australia released standards on key definitions relating to electric vehicles, many of which relate to safety and the protection of users against electric shock. The standards were adopted from *ISO 8713:2005; Electric road vehicles – Vocabulary, AS/NZS 3000; Vehicle Standards Bulletin 14, Australian Design Rules and UN-ECE Regulation 100.*

In a process funded by the Victorian Government, the new standards were released with an announcement which progresses Australia towards a uniform set of operating standards in this area. The standards specifically dealt with:

- Vehicle standards and occupant protection in a crash
- Electrical safety

- Standards for aftermarket electric vehicle conversions
- Standards for recharging infrastructure
- Energy efficiency of electric vehicles
- Batteries and their supporting supply chain

A study for the Victorian Department of Transport (2010) highlighted the need for standards regarding electric vehicles to be developed in order to ensure success of electric buses and charging infrastructure in Australia. The three points it mentioned were:

- Development of standards surrounding the safe and efficient operation of electric vehicle batteries
- The acceleration in development of renewable electricity supplies in Victoria
- The development of standards and regulations for electric vehicle charge points

Likewise, the Queensland 30-year Electricity Strategy (2012) identified the need for efficient regulatory frameworks to create efficient supply chains that accommodate innovative technology, such as embedded generation technology, battery storage and electric vehicles. It also discussed the need for addressing the impact that electric vehicles have on network infrastructure.

5.2 Review of Legislation, Regulation and Policies

A literature review was undertaken to identify any electric vehicles specific requirements and standards that would be applicable for the trial. The following legislation and regulations were reviewed:

- Transport Operations (Passenger Transport) Act 1994
- Transport Operations (Passenger Transport) Regulation 2005
- Transport Operations (Passenger Transport) Standard 2010
- Transport Operations (Road Use Management) Act 1995
- Traffic Regulation 1962
- Transport Operations (Road Use Management—Accreditation and Other Provisions) Regulation 2005
- Transport Operations (Road Use Management—Dangerous Goods) Regulation 2008
- Transport Operations (Road Use Management—Driver Licensing) Regulation 2010
- Transport Operations (Road Use Management—Road Rules) Regulation 2009
- Transport Operations (Road Use Management—Vehicle Registration) Regulation 2010
- Transport Operations (Road Use Management—Vehicle Standards and Safety) Regulation 2010
- Heavy Vehicle National Law Act 2012
- Heavy Vehicle National Law (Queensland)
- Heavy Vehicle (Fatigue Management) National Regulation
- Heavy Vehicle (General) National Regulation
- Heavy Vehicle (Mass, Dimension and Loading) National Regulation
- Heavy Vehicle National Law Regulation 2014

- Heavy Vehicle (Transitional) National Regulation
- Heavy Vehicle (Vehicle Standards) National Regulation
- Motor Vehicle Standards Act 1989
- Motor Vehicle Standards Regulations 1989
- Australian Design Rules

The above legislation and regulations above contain numerous requirements for buses. However, specific requirements for electric buses were not identified. A broad definition of a bus is used in the legislation i.e. “motor vehicle with seating capacity for 9 or more passengers”. Buses in the legislation are not defined on the basis of fuel type or propulsion system (e.g. battery).

The electric bus for the trial will also need to comply with all State and Commonwealth government laws in relation to vehicle accessibility standards and vehicle emission standards, and in particular with the Disability Standards for Accessible Public Transport (DSAPT) 2002 and accompanying guidelines under the Commonwealth Disability Discrimination Act 2002 (DDA).

International Jurisdictions

The situation in international markets in terms of legislation is more advanced, with selected legislation available and roadmaps regarding light duty electric vehicles in development. In the United States, the American National Standards Institute (ANSI) has established a standardisation roadmap for electric vehicles, with version 2.0 published in 2013. The roadmap, which is only concerned with light duty vehicles, aims to develop standards in the safety, performance and interoperability surrounding electric vehicles and their supporting charging infrastructure.

In 2002, the State of California issued an interim certification procedure for model hybrid-electric vehicles in the urban bus and heavy-duty vehicle classes. However, regulations for heavy-duty zero-emission vehicles are still in development. During the interim, manufacturers are permitted to sell hydrogen fuel cell or electric battery heavy-duty vehicles in California without an Executive Order from the Air Resources Board.

In the European Union, a draft directive endorsed by the Transport and Tourism Committee in 2013 requires that member states install a specified number of electric vehicle, hydrogen and natural gas stations by 2020. Electric vehicle charging point targets for Germany are 86,000, Italy – 72,000 and the UK – 70,000.

The operation and maintenance of electric road vehicles are regulated usually at national levels but also on the EU level such as through Regulation No. 100 of the Economic Commission for Europe of the United Nation (UNECE) which is concerned with the approval of battery electric vehicles. However, EU legislation largely tends to avoid differentiating between different types of fuels or vehicle types. Reports have noted that electric vehicles are largely compatible with regulation for convention fossil fuel vehicles with exception in the electrical and fire safety regarding batteries

5.3 Consultation with industry stakeholders

Industry consultation informed the study in regard to the electric vehicle standards, legislation and policy described above. As the trial is taking place in Queensland we also contacted the Queensland Department of Transport and Main Roads (Transport Regulation Branch). They noted that any electric bus used in the trial will need to comply with the requirements for buses under the relevant legislation. Additionally, they noted that the

electric bus may need to satisfy any performance levels outlined in a services contract as per Chapter 6 of the Transport Operations (Passenger Transport) Act 1994. As noted above, we were not able to locate any additional requirements that an electric vehicle must meet under Passenger Transport legislation to provide a public passenger service at this time. The only further consideration arising from our consultation being that bus operators must ensure that their drivers are provided with appropriate training to operate an electric vehicle (if the function of the vehicle is different to existing vehicles).The intent of the training would be to ensure drivers could operate the vehicle in a safe manner.

5.4 Review of Sunbus contract

We undertook a review of some of the existing arrangements with Sunbus who operate public transport buses in the Noosa area under a contract arrangement with the Department of Transport and Main Roads (TMR). This was not a full legal review of these arrangements but the following operational points are worth considering for the purposes of the feasibility of an electric bus trial at Noosa:

- The current arrangements establish Sunbus as the incumbent provider of urban bus services in Noosa and BusLink as the provider of school bus services. Therefore, the council should consider the involvement of Sunbus in the trial as early as possible
- Sunbus maintain existing infrastructure that the electric bus will require in its operations such as depots and maintenance facilities
- Sunbus employ drivers familiar with the routes and who hold all the necessary approvals and accreditations to operate buses in the Noosa area
- Under current arrangements Sunbus must maintain any vehicle in its fleet in accordance with certain mandated DoT standards, these standards
- It should be noted from late December 2014, all Sunbus buses must with fitted out with new CUBIC DCU3 models to support the Passenger Plus Project (real-time passenger information). As such any electric buses being trialled will also need to be fitted out with CUBIC ticketing and GPS equipment
- Under current arrangements, Sunbus must maintain each vehicle used to provide their services in a safe and roadworthy condition and in accordance with all applicable laws
- Sunbus must seek approval from TMR under current arrangement to replace or acquire a new vehicle to provide public transport services
- Sunbus must meet certain performance standards such as serviced delivered and on-time running or they are penalised
- The Sunbus contract is due to expire in September 2015
- The Queensland Government is committed to the recommendations of The Costello Report which recommends contestability of bus services. No further detail has been provided by government at this time

6. Developing the most appropriate solution for Noosa

6.1 Preferred operating environment for Noosa

The development of an appropriate solution for Noosa has focused on the selection of a suitable electric bus route, storage and layover location, slow and fast charging station locations, maintenance facility and a preferred manufacturer.

Route 627 is recommended for the electric bus trial because:

- It is an existing route that already services the busy tourist and visitor precincts connecting Tewantin, Noosa Heads and Noosa Junction with no requirement for the rest of the TransLink bus network to be modified. Community consultation on the route is not required as the existing route, bus stops and service frequencies are not affected
- It is the shortest route with less daily service kilometres compared to Route 626 and it would be easier to implement with a lesser impact on driver shifts and rosters
- It has a 30 minute running time with a 60 minute circuit time, and it terminates at the western end at Tewantin Central (next to the Council office) and at Sunshine Beach at the eastern end, not in suburban streets
- It requires only two (2) electric buses and (1) one diesel bus on a 30 minute frequency. As the technology is unproven, it is recommended that at least one existing Sunbus diesel bus be on stand-by at Noosa Junction bus stations, should there be any breakdowns of the electric bus
- It operates over a mixture of operating environments, street types and terrains to test the physical capability and range of the electric bus
- It provides multiple locations for potential recharging stations and is easier for an electric bus supplier to trial a vehicle than with multiple routes

The average gradient of Route 627 is between 2.4% to 2.5% with the steepest sections at 12% as per the Google Earth elevation profile below. The electric bus has the capability to negotiate these gradients.

Google Earth elevation profile of Route 627

The location for the proposed layover and fast recharging station is in Pelican Street at Tewantin, next to Council's office. This site is convenient for the western terminus of Route 627 to use and has minimal impact on parking with approximately three (3) car park spaces to be removed in Pelican Street.

Overnight storage and slow charging for the electric bus could be undertaken at the existing Sunbus depot (Beech Street) at Marcoola, which is approximately 30 km south of the eastern terminus (start point of Route 627) at Sunshine Beach. The Marcoola location is preferred because it is an existing secure fenced facility with surveillance systems and it will

minimise the dead running and the significant cost of additional driver relief trips (compared to the Noosa Council depot at Bartlett Road). In addition, repairs and maintenance of the electric bus could be done at Marcoola similar to current diesel buses.

6.2 Expression of Interest (EOI) for the electric bus trial

Council/TransLink decided that the top two (2) manufacturers (i.e. Optare and BYD) would be invited through an expression of interest (EOI) to participate in a 6 month trial. The purpose of the EOI was to obtain more detailed information from the two manufacturers to understand the cost incurred with a 6 month trial **(Appendix E).**

For the trial, two (2) electric buses, a fill-in diesel bus (to be injected into the service when one of the electric buses is charging at Pelican Street) and a standby diesel bus (should the electric bus breakdown) has been assumed.

The following elements have been included in developing the cost comparison to run the trial for 6-months with the electric buses:

- Cost of leasing the electric bus and diesel bus
- Cost of the plug-in charging infrastructure including installation costs
- Cost of installation of the CUBIC ticketing and GPS equipment on the electric bus
- Vehicle registration and insurance costs
- Cost of training drivers and mechanics
- Bus driver costs
- Driver relief cost for the electric bus (e.g. hire car, wages and fuel). Relief trips will be required from Marcoola to Noosa junction to allow for driver meal breaks (every 4 hours)
- Electricity and fuel costs
- Cost of general repairs & maintenance (i.e. wages for mechanics)
- Marketing and communication costs
- Schedule of electric bus deployment on Route 627 as shown in Figure 14 and Figure 15 for Optare and BYD, respectively

Table 8 summarises the estimated cost to run the trial for the Optare and BYD electric buses. It is estimated that the cost to conduct the 6-month trial with Optare is $838,100 and $792,600 with BYD (excluding contingencies). BYD is cheaper mainly due to the lower lease cost and charging infrastructure which has been heavily discounted for the trial. However, drivers and mechanics require significant more training (and cost) with the BYD bus. The cost to run the existing two (2) diesel buses were provided by TransLink and is estimated to cost approximately $385,400 for 6 months. Therefore, the “actual” cost to run the trial is estimated to be $452,700 for Optare and $407,200 for BYD. This is the net cost after the cost of operating the standard two (2) diesel buses on Route 627 is considered.

It should be noted that the cost estimates provided herein are high level (indicative) and may vary when compared to the actual cost to run the electric and diesel buses. Contingencies should be allowed to cover unforseen costs

Figure 14 Schedule of deployment on Route 627 – Optare Electric Bus

START at 6.52 AM with 70% Charge (70 kW)

	Residual Battery Charge at end of trip:	46%	34%	88%	64%	40%	28%	88%	64%	52%	88%	64%	40%
		Bus 1	Bus 1	Bus 1	Bus 1	Bus 1	Bus 1	Bus 1	Bus 1	Bus 1	Bus 1	Bus 1	Bus 1
Westbound- 12.5km	Sunshine Beach	6.52	7.52	8.52 Diesel bus	9.52	10.52	11.52	12.52 Diesel bus	1.52	2.52	3.52 Diesel bus	4.52	5.52
	Noosa Junction	7.01	8.01	9.01 Diesel bus	10.01	11.01	12.01	1.01 Diesel bus	2.01	3.01	4.01 Diesel bus	5.01	6.01
	Noosa Heads	7.06	8.06	9.06 Diesel bus	10.06	11.06	12.06	1.06 Diesel bus	2.06	3.06	4.06 Diesel bus	5.06	6.06
	Pelican Beach Park	7.13	8.13	9.13 Diesel bus	10.13	11.13	12.13	1.13 Diesel bus	2.13	3.13	4.13 Diesel bus	5.13	6.13
	Tewantin Central	7.18	8.18 Diesel bus	9.18	10.18	11.18	12.18 Diesel bus	1.18	2.18	3.18 Diesel bus	4.18	5.18	6.18
Eastbound- 11.2km	Tewantin Central	7.20	8.20 Diesel bus	9.20	10.20	11.20	12.20 Diesel bus	1.20	2.20	3.20 Diesel bus	4.20	5.20	6.20
	Pelican Beach Park	7.25	8.25 Diesel bus	9.25	10.25	11.25	12.25 Diesel bus	1.25	2.25	3.25 Diesel bus	4.25	5.25	6.25
	Noosa Heads	7.32	8.32 Diesel bus	9.32	10.32	11.32	12.32 Diesel bus	1.32	2.32	3.32 Diesel bus	4.32	5.32	6.32
	Noosa Junction	7.37	8.37 Diesel bus	9.37	10.37 meal break	11.37	12.37 Diesel bus	1.37	2.37	3.37 meal break	4.37	5.37	6.37
	Sunshine Beach	7.47	8.47 Diesel bus	9.47	10.47	11.47	12.47 Diesel bus	1.47	2.47	3.47 Diesel bus	4.47	5.47	6.47

START at 7.22 AM with 70% Charge (70 kW)

	Residual Battery Charge at end of trip:	46%	22%	10%	88%	64%	40%	28%	88%	64%	52%	88%
		Bus 2	Bus 2	Bus 2	Bus 2	Bus 2	Bus 2	Bus 2	Bus 2	Bus 2	Bus 2	Bus 2
Westbound- 12.5km	Sunshine Beach	7.22	8.22	9.22	10.22 Diesel bus	11.22	12.22	1.22	2.22 Diesel bus	3.22	4.22	5.22 Diesel bus
	Noosa Junction	7.31	8.31	9.31	10.31 Diesel bus	11.31	12.31	1.31	2.31 Diesel bus	3.31	4.31	5.31 Diesel bus
	Noosa Heads	7.36	8.36	9.36	10.36 Diesel bus	11.36	12.36	1.36	2.36 Diesel bus	3.36	4.36	5.36 Diesel bus
	Pelican Beach Park	7.43	8.43	9.43	10.43 Diesel bus	11.43	12.43	1.43	2.43 Diesel bus	3.43	4.43	5.43 Diesel bus
	Tewantin Central	7.48	8.48	9.48 Diesel bus	10.48	11.48	12.48	1.48 Diesel bus	2.48	3.48	4.48 Diesel bus	5.48
Eastbound- 11.2km	Tewantin Central	7.50	8.50	9.50 Diesel bus	10.5	11.50	12.50	1.50 Diesel bus	2.50	3.50	4.50 Diesel bus	5.50
	Pelican Beach Park	7.55	8.55	9.55 Diesel bus	10.55	11.55	12.55	1.55 Diesel bus	2.55	3.55	4.55 Diesel bus	5.55
	Noosa Heads	8.02	9.02	10.02 Diesel bus	11.02	12.02	1.02	2.02 Diesel bus	3.02	4.02	5.02 Diesel bus	6.02
	Noosa Junction	8.07	9.07	10.07 Diesel bus	11.07 meal break	12.07	1.07	2.07 Diesel bus	3.07	4.07 meal break	5.07 Diesel bus	6.07
	Sunshine Beach	8.17	9.17	10.17 Diesel bus	11.17	12.17	1.17	2.17 Diesel bus	3.17	4.17	5.17 Diesel bus	6.17

LEGEND:

	EB in-service
	EB Charging and DB in-service
	Total of 23 return trips
Meal Break	Every 4 hours
EB Battery	120 kWh (assume 100 kWh actual)
Charger capacity	100kW charger

Figure 15 Schedule of deployment on Route 627 – BYD Electric Bus

START at 6.52 AM with 90% Charge (270 kW)

Residual Battery Charge at end of trip:		82%	74%	66%	58%	50%	42%	34%	30%				96%	88%
		Bus 1	Bus 1	Bus 1	Bus 1	Bus 1	Bus 1	Bus 1	Bus 1	Bus 1	Bus 1		Bus 1	Bus 1
Westbound-12.5km	Sunshine Beach	6.52	7.52	8.52	9.52	10.52	11.52	12.52	1.52	2.52 Diesel bus	3.52 Diesel bus		4.52 Diesel bus	5.52
	Noosa Junction	7.01	8.01	9.01	10.01	11.01	12.01	1.01	2.01	3.01 Diesel bus	4.01 Diesel bus		5.01 Diesel bus	6.01
	Noosa Heads	7.06	8.06	9.06	10.06	11.06	12.06	1.06	2.06	3.06 Diesel bus	4.06 Diesel bus		5.06 Diesel bus	6.06
	Pelican Beach Park	7.13	8.13	9.13	10.13	11.13	12.13	1.13	2.13	3.13 Diesel bus	4.13 Diesel bus		5.13 Diesel bus	6.13
	Tewantin Central	7.18	8.18	9.18	10.18	11.18	12.18	1.18	2.18 Diesel bus	3.18 Diesel bus	4.18 Diesel bus		5.18	6.18
Eastbound-11.2km	Tewantin Central	7.20	8.20	9.20	10.20	11.20	12.20	1.20	2.20 Diesel bus	3.20 Diesel bus	4.20 Diesel bus		5.20	6.20
	Pelican Beach Park	7.25	8.25	9.25	10.25	11.25	12.25	1.25	2.25 Diesel bus	3.25 Diesel bus	4.25 Diesel bus		5.25	6.25
	Noosa Heads	7.32	8.32	9.32	10.32	11.32	12.32	1.32	2.32 Diesel bus	3.32 Diesel bus	4.32 Diesel bus		5.32	6.32
	Noosa Junction	7.37	8.37	9.37	10.37 meal break	11.37	12.37	1.37	2.37 Diesel bus	3.37 meal break	4.37 Diesel bus		5.37	6.37
	Sunshine Beach	7.47	8.47	9.47	10.47	11.47	12.47	1.47	2.47 Diesel bus	3.47 Diesel bus	4.47 Diesel bus		5.47	6.47

START at 7.22 AM with 90% Charge (270 kW)

Residual Battery Charge at end of trip:		82%	74%	70%		96%	88%	80%	72%	64%	56%	48%
		Bus 2	Bus 2	Bus 2	Bus 2	Bus 2	Bus 2	Bus 2	Bus 2	Bus 2	Bus 2	Bus 2
Westbound-12.5km	Sunshine Beach	7.22	8.22	9.22	10.22 Diesel bus	11.22 Diesel bus	12.22	1.22	2.22	3.22	4.22	5.22
	Noosa Junction	7.31	8.31	9.31	10.31 Diesel bus	11.31 Diesel bus	12.31	1.31	2.31	3.31	4.31	5.31
	Noosa Heads	7.36	8.36	9.36	10.36 Diesel bus	11.36 Diesel bus	12.36	1.36	2.36	3.36	4.36	5.36
	Pelican Beach Park	7.43	8.43	9.43	10.43 Diesel bus	11.43 Diesel bus	12.43	1.43	2.43	3.43	4.43	5.43
	Tewantin Central	7.48	8.48	9.48 Diesel bus	10.48 Diesel bus	11.48	12.48	1.48	2.48	3.48	4.48	5.48
Eastbound-11.2km	Tewantin Central	7.50	8.50	9.50 Diesel bus	10.50 Diesel bus	11.50	12.50	1.50	2.50	3.50	4.50	5.50
	Pelican Beach Park	7.55	8.55	9.55 Diesel bus	10.55 Diesel bus	11.55	12.55	1.55	2.55	3.55	4.55	5.55
	Noosa Heads	8.02	9.02	10.02 Diesel bus	11.02 Diesel bus	12.02	1.02	2.02	3.02	4.02	5.02	6.02
	Noosa Junction	8.07	9.07	10.07 Diesel bus	11.07 meal break	12.07	1.07	2.07	3.07	4.07 meal break	5.07	6.07
	Sunshine Beach	8.17	9.17	10.17 Diesel bus	11.17 Diesel bus	12.17	1.17	2.17	3.17	4.17	5.17	6.17

LEGEND:

	EB in-service
	EB Charging and DB in-service
	Total of 23 return trips
Meal Break	Every 4 hours
EB Battery	324 kWh (assume 300 kWh actual)
Charger capacity	80 kW charger

Table 8 Comparison of Optare and BYD for a 6-month trial

Table 1: Comparison of EB Manufacturers for 6-Months Trial

Version: 5

Dated: 15 Dec 2014

Qualification:

The cost estimates provided herein are indicative and may vary when compared to the actual cost to run the electric and diesel buses. The cost estimates have been prepared based on information provided by TransLink and electric bus which have not been verified.

COST TO TRIAL OPTARE BUS FOR 6 MONTHS (2 Electric Bus and I Diesel Bus)	OPTARE Solo EB	COST TO TRIAL BYD BUS FOR 6 MONTHS (2 Electric Bus and I Diesel Bus)	BYD EB
Monthly Lease Cost (@$10k per month for 6 months - 2 EB buses)	$ 120,000.00	Monthly Lease Cost (@$7k per month for 6 months - 2 EB buses)	$ 84,000.00
Leasing cost @ $56k pa per bus (2 diesel bus)	$ 56,000.00	Leasing cost @ $56k pa per bus (1 diesel bus)	$ 56,000.00
Ticket Machine Wiring for CUBIC system (1)	$ 2,000.00	Ticket Machine Wiring for CUBIC system (1)	$ 2,000.00
CirControl Fast Charge System (@$30k each for 2 nos) (2)	$ 60,000.00	Charging Station System(@$10k each 2 nos) (5)	$ 20,000.00
CirControl Fast Charge System (@$8k each for 2 nos) - installation	$ 16,000.00	Charging Station System(@$8k each 2 nos) - installation	$ 16,000.00
On-board Slow Charge System - installation	$ 1,000.00	Insurance under TransLink/Sunbus (3)	$ 10,000.00
Insurance under TransLink/Sunbus (3)	$ 10,000.00	BYD to register bus	$ 6,000.00
Driver Training Time Costs (2 days)- 6 hrs for drivers and 12 hours for mechanics (6)	$ 14,364.00	Driver Training Time Costs (6 days) - 5 hrs for drivers and 45 hours (6 days)for mechanics (6)	$ 35,490.00
		Driver Training (4 days) @ $120/hr	$ 3,600.00
EB Driver Cost (2 Nos) (11)	$ 144,144.00	EB Driver Cost (2 Nos) (11)	$ 144,144.00
EB Electricity costs @ 6c/kW and 20.8c/kW and 1.5kW/km (Bus 1)	$ 14,651.44	EB Electricity costs @ 6c/kW and 20.8c/kW and 1.6kW/km (Bus 1)	$ 15,628.20
EB Electricity costs @ 6c/kW and 20.8c/kW and 1.5kW/km (Bus 2)	$ 15,921.00	EB Electricity costs @ 6c/kW and 20.8c/kW and 1.6kW/km (Bus 2)	$ 16,982.40
Fill-in service Diesel Driver Cost (1 Nos) - operate when EB is charging	$ 72,072.00	Fill-in service Diesel Driver Cost (1 Nos) - operate when EB is charging	$ 72,072.00
Fill-in service Diesel Bus Fuel Cost (1 Nos) - operate when EB is charging (8)	$ 8,294.00	Fill-in service Diesel Bus Fuel Cost (1 Nos) - operate when EB is charging (9)	$ 7,018.00
Standby Driver Cost (1 Nos) - diesel bus (respond to EB breakdown)	$ 72,072.00	Standby Driver Cost (1 Nos) - diesel bus (respond to EB breakdown)	$ 72,072.00
Standby Diesel Bus Fuel Cost (assume $10k) (respond to EB breakdown)	$ 10,000.00	Standby Diesel Bus Fuel Cost (assume $10k) (respond to EB breakdown)	$ 10,000.00
Car Relief Hire (2 Nos) @$100/day	$ 36,600.00	Car Relief Hire (2 Nos) @$100/day	$ 36,600.00
Relief Driver Costs (assume 2 return trips per day per bus)	$ 68,442.00	Relief Driver Costs (assume 2 return trips per day per bus)	$ 68,442.00
Relief Bus Driver Cost (2 drivers per day per bus) (10)	$ 68,442.00	Relief Bus Driver Cost (2 drivers per day per bus) (10)	$ 68,442.00
General Repairs & Maintenance (once a week per bus) (4)	$ 29,952.00	General Repairs & Maintenance (once a week per bus) (4)	$ 29,952.00
Marketing & Comms	$ 50,000.00	Marketing & Comms	$ 50,000.00
Sub-Total	**$ 869,954.44**	Sub-Total	**$ 824,442.60**
Included Items		**Included Items**	
Vehicle Registration Cost (for trial)	included	Bus maintenance	
Driver Training (2 days)	included	Driver Training (2 days) - but if unsuccessful will charged Council at cost	included
Service & Maintenance Training (2 days)	included	Service & Maintenance Training - but if unsuccessful will charged Council at cost	included
Trial reports with Optare Telematics System	Included		
1st month trial review	Included		
2nd month trial review	Included		
Final trial review	Included		
Local support	Brisbane office		
Excluded Items		**Excluded Items**	

Notes:

(1) Qubic Ticketing System supplied by TransLink

(2) 2 Nos charging Infrastructure at Pelican St and Marcoola (Beech St)

(3) Listed on TransLink/Sunbus insurance policy. $10k based on current TL costings. Manufacturer to register the bus so that it is ADR compliant. TL to lease bus from manufacturer and insure bus.

(4) Minimal maintenance required for 6 month trial - require lubricants only and daily checks part of SOP

(5) BYD agree to buy back equipment at market rate if trial unsuccessful

(6) Training time cost for 30 drivers and 14 mechanics

(7) Mileage = 273 (Route 627) + 61 (to/from Marcoola) + 16 (layover) = 350 km

(8) 6 out of 23 trips (26%) based on EB recharging schedule

(9) 5 out of 23 trips (22%) based on EB recharging schedule

(10) Asumes no relief required for diesel bus as sufficient breaks in-between service

(11) Asumes average weighted driver cost ($33/hr) with 18% for on costs e.g. insurance, super, etc.

(12) Includes fuel, labour and maintenance, lease costs - data from TransLink

FUEL SAVINGS FROM THE 6 MONTH TRIAL (One less Diesel Bus)		**FUEL SAVINGS FROM THE 6 MONTH TRIAL (One less Diesel Bus)**	
Diesel Bus Fuel (1 Nos) @ $31.9k per bus for 6 months (7)	$ 31,900.00	Diesel Bus Fuel (1 Nos) @ $31.9k per bus for 6 months (7)	$ 31,900.00
Sub-Total	**$ 31,900.00**	Sub-Total	**$ 31,900.00**
TOTAL COST TO RUN 2 ELECTRIC BUS AND 1 DIESEL BUS - 6 MONTHS		**TOTAL COST TO RUN 2 ELECTRIC BUS AND 1 DIESEL BUS - 6 MONTHS**	
Total(Excluding Contingency):	**$ 838,054.44**	Total(Excluding Contingency):	**$ 792,542.60**
COST TO RUN EXISTING 2 DIESEL BUS - 6 MONTHS		**COST TO RUN EXISTING 2 DIESEL BUS - 6 MONTHS**	
Operations and Maintenance Cost (2 buses) (12)	**$ 385,397.00**	Operations and Maintenance Cost (2 buses) (12)	**$ 385,397.00**

7. Strategic outline case

7.1 Assessment criteria framework

A Strategic Outline Case (SOC) has been developed to identify and compare the indicative longer term costs of the recommended electric bus options which are likely to proceed to a live trial, together with consideration of potential funding sources.

Within the SOC, costs are assessed on a financial basis using a Net Present Cost (NPC) approach. NPC is used rather than Net Present Value (NPV) because it is assumed that ticket revenues would be the same for all bus types.

Within the SOC, the **financial model** is designed to provide an indicative cost comparison of Optare and BYD buses over a 15 year investment horizon. It is designed to evaluate and compare the upfront purchase costs of a single bus and the anticipated energy and maintenance costs on a 'like-for-like' basis. Accordingly, where the 15 year investment horizon (corresponding to the shortest operational bus lifetime) results in a residual value, this value is deducted from the final NPC figures. In this way, residual value can be thought of as an allocation of value for the increased expected operational life of one electric bus against another. Within the financial model, the deprecation of upfront purchase costs and anticipated fuel, maintenance and servicing cash flows are discounted (at 7%) over this 15 year time period. This allows for aggregated costs of each bus option to be compared as a net present cost.

The financial model does not take into account some costs that whilst significant are not subject to considerable variation across bus options such as insurance, registration costs, wages of drivers and maintenance staff. Other factors that are not currently incorporated into the financial model but which may have significant project cost impacts include:

- The choice to purchase or lease of the electric vehicle
- Any non-routine vehicle maintenance
- Vehicle storage and security requirements to lease space from the bus depot or allocate space at the Council depot in Noosa
- Driver training and operations
- Branding and marketing of the trial

The SOC **operational model**, compares the indicative costs of running selected electric bus options (Optare and BYD) as a fleet, on Route 627 against the indicative costs of running the current Sunbus diesel buses only. Optare and BYD were selected as the final two (2) electric buses likely to be deployed for the trial following a presentation and meeting with Noosa Council. The time period for the operational model is 10 years (based on TransLink's initial leasing period) which allows for a longer term operational comparison of the current Sunbus diesel buses with both the Optare and BYD electric bus models. Based on data provided by TransLink as well as the electric bus providers, this analysis include comparisons with some of the major operational costs of running buses on the current Route 627. Data on the operation of a diesel bus on Route 627 is also helpful as the roll out of electric bus options on the route requires the support (and related costs) of at least one diesel bus due to charging and electric bus operating constraints. Operational model costs include estimates of repair, maintenance and driver costs per kilometre. Excluded costs include but are not limited to, wear and tear and staff training costs.

It should be noted that, although the models seek to achieve the most accurate figures for comparison of options that are currently available, an NPC analyses using actual performance data from the trial will be the most reliable indicator of the long term commercial viability of an electric bus service for Noosa. This is due to the NPC's reliance on data from providers in the present case, who do not have the benefit of experience in operating their bus on Route 627. Fuel or energy consumption in particular will be highly dependent upon the bus design specifics and their interaction with the route, drivers and operating conditions in Noosa. Accordingly, actual results may vary significantly to the estimates generated by the financial and operational models.

7.2 Financial model

The main cost driver delaying the widespread adoption of electric vehicles in Australia has been the upfront purchase costs of the technology, particularly the battery technology relative to diesel alternatives[1]. As battery technology evolves and increasingly becomes proven in Australian operating conditions the costs and financial risks associated with the significant upfront investment in an electric bus is reduced. In the present case, an alternative financial arrangement to mitigate upfront battery costs might be to arrange for leasing of batteries from providers as part of the electric bus trial negotiations.

The cost benefits to be found in the operation of electric buses usually manifest in terms of reduced operating and maintenance costs over the longer term life of the vehicle[2]. Therefore, the longer an electric bus is able to be operational, without significant maintenance (e.g. battery replacement), the more significant these benefits become in terms of the lifetime costs.

Upfront purchase costs and estimated maintenance and servicing costs were calculated in the financial model based on data received from manufacturers in response to the EOI. The results of the NPC on these data are tabulated in Table 9. These costs were discounted (at 7%) for ease of comparison. Upfront purchase costs include capitalised costs of necessary infrastructure installation for each bus (e.g. two charging stations).

BYD was found to be the cheapest upfront purchase option (Optare +12%) but this was only after accounting for additional battery capacity (provided as an option for Optare).

Table 9 Breakdown of Upfront Purchase Costs - 2014

Upfront purchase costs	Optare	BYD
Bus	$595,000	$625,000
Additional Battery Costs	$70,000	
Charging station 1	$30,000	$10,000
Charging station 2	$30,000	$10,000
Charging station 1 - Install	$5,500	$5,500
Charging station 2- Install	$5,500	$5,500
TOTAL	$736,000	$656,000

Note:- *Additional battery cost and charging station installs assumed from Optare costs due to non-provision of cost data

[1] Forecast Uptake and Economic Evaluation of Electric Vehicles in Victoria, AECOM, 6 May 2011
[2] Assessment of alternative fuels and vehicle technologies for the Victorian bus fleet, a discussion paper, Rare Consulting Pty Ltd, January 2011

NPC maintenance and servicing costs over the investment horizon were cheapest for Optare compared BYD (+15%) - see Table 10.

In summary, the final comparative costs provided by the financial model indicated that the Optare Solo 10M is likely to be the most cost effective option to run in terms of maintenance and servicing and BYD the best choice in terms of upfront purchase costs.

Table 10 Upfront Purchase Costs and Estimated Maintenance and Servicing[1]- 2014

Provider	Model	Upfront Purchase Cost	Estimated Maintenance & Servicing Costs
Optare	Solo	$736,000	**$79,674**
BYD	E Bus	**$656,000**	$91,338

Estimated direct and indirect electricity costs were calculated in the financial model, based on input data provided by bus manufacturers, these data are tabulated in Table 11. Bottom of the range fuel efficiency was equivalent for both Optare and BYD buses. Cost per kilometre for all options was calculated as $0.09 over the 15 year investment horizon. As such, the derived nature of indirect electricity costs results in an equal first ranking against these cost criteria for Optare with BYD only slightly behind. In the absence of actual performance data and given the marginal differences in fuel efficiency between all three buses, it was surmised that fuel efficiency is not a good basis to distinguish these electric bus options.

Table 11 Estimated Direct and Indirect Electricity Costs[2] - 2014

Provider	Model	Estimated direct and indirect electricity costs	Estimated direct and indirect electricity costs/km
Optare	Solo	$168,573[3]	$0.09/km
BYD	E Bus	$179,811	$0.09/km

Over the investment horizon of 15 years, the total NPC discounted costs for the Optare electric bus came to an estimated -$624,849 and -$1,074,230 for BYD. The total NPC discounted cost per kilometre came to -$0.33 for Optare and -$0.56 for BYD, respectively. As shown in Table 12 below, the cost analysis indicates that the Optare solution to be lower from a total NPC discounted cost and cost per kilometre standpoint. This outcome is due mainly to the extended operational life of the Optare with a stated operational life of 25 years as against the BYD at 15 years. It should be noted however, the stated operational life of each bus is proposed by the manufacturer and has yet to be tested under operating conditions in Noosa.

This NPC assessment is made on the basis of manufacturer inputs and the best available data provided to date. As costs are assessed over the 15 year horizon, this assessment provides some degree of comfort if the decision is made to extend the operation of the chosen bus beyond the end of the trial period. However, as noted above, these estimates are indicative only and the best measure of the commercial viability of running an electric

[1] Over a common investment horizon of 15 years.
[2] Over a common investment horizon of 15 years.
[3] Energy consumption may increase with additional battery due to additional battery weight.

bus on Route 627 should be based on actual performance in Noosa operating conditions during the proposed trial period.

Table 12 Financial Model Estimated Discounted Costs of Bus Options[1]

Summary of Analysis	BYD eBus	Optare Solo 10M
Expected bus lifetime[2]	15 years	25 years
Assumed common investment horizon	15 years	15 years
Cost comparison (Not discounted)		
Investment cost	-$1,868,551	-$1,761,502
Residual value	$108,000	$1,428,800
Total investment Cost (Not discounted)	-$1,760,551	-$332,702
Discounted costs		
Discounted investment cost	-$1,109,244	-$1,040,566
Discounted residual value	$35,014	$415,717
Total discounted investment cost	-$1,074,230	-$624,849
Discounted cost per km (2014 dollars)	-$0.56	-$0.33

The model assumptions relied upon in the cost analysis is detailed below in Table 13.

Table 13 Upfront Purchase Costs and Maintenance and Servicing Cost Assumptions[3]

Summary of Assumptions	Per Annum
General Assumptions	
Interest rate	5.00%
Discount rate	7.00%
Specific Assumptions (Annual increases)	
Maintaining plant	4.30%
Bus maintenance	4.30%
Bus servicing	4.30%
Wear and tear	6.00%
Fuel price	6.00%

7.3 Operational model

The SOC operational model, compares the indicative costs of running selected electric bus options (Optare and BYD) as a fleet on Route 627 against the indicative costs of running a fleet of current Sunbus diesel buses.

The time period for the operational model is 10 years (based on TransLink's initial leasing period) which allows for a longer term operational comparison of the current Sunbus diesel fleet on Route 627 with both the Optare and BYD electric bus fleet options. The operational model assumes that all buses are subject to a standard TransLink lease of 10 years with a 20% residual. Other model parameters such as assumed fuel consumption and kilometres travelled per annum remain the same as used in the financial model.

[1] Over a common investment horizon of 15 years.
[2] Common assumed investment horizon of 15 years
[3] Over a common investment horizon of 15 years.

An estimated repair and cost per kilometre of $0.37 has been applied to all model instances of Sunbus diesel buses in fleet calculations. This figure is based on information provided by TransLink. A cost figure of $0.10 per kilometre has been applied to electric buses based on data provided by manufacturers. A driver cost per kilometre of $1.41 has been provided by TransLink, this has been applied across all of the modelled fleet options. All costs have been discounted (at 7%) for ease of comparison.

As with the financial model, upfront purchase costs and estimated maintenance and servicing costs were calculated in the financial model based on data received from manufacturers in response to the EOI. The results of the 10 year operational model NPC on these data are tabulated in Table 14. Once again, the upfront purchase costs include capitalised costs of necessary infrastructure installation for each electric bus (e.g. two charging stations).

Table 14 Operational Model Estimated Discounted Costs of Bus Options[1]

Fleet	Sunbus Rigid Optare Solo 10m Optare Solo 10m BYD eBus	Sunbus Rigid BYD eBus BYD eBus	Sunbus Rigid Sunbus Rigid
Expected lease lifetime	10 years	10 years	10 years
Number of Refuelling / Charging Stations	2	2	
Total Estimated Fleet Cost (discounted)	$6,730,264	$6,806,152	$5,063,627
Total Estimated Fleet Saving (discounted)	-$1,666,638	-$1,742,525	$0
Total Estimated Fleet Fuel Costs (discounted)	$716,401	$772,218	$986,266
Total Estimated Fleet Fuel Saving (discounted)	$269,866	$214,049	$0

The model assumptions relied upon in the cost analysis is detailed below in Table 15.

Table 15 Upfront Purchase Costs and Maintenance and Servicing Cost Assumptions[2]

Summary of Assumptions	Per Annum
General Assumptions	
Interest rate	5.00%
Discount rate	7.00%
Specific Assumptions (Annual increases)	
Charging station electricity inefficiency	8.00%
Fuel prices	6.00%

[1] Over an assumed lease period of 10 years with 20% residual. Costs include estimates of repair, maintenance and driver costs per km. Excluded costs include but are not limited to, wear and tear, staff training and operating costs, vehicle storage and security requirements to lease space from the bus depot or allocate space at the Council depot in Noosa, support labour costs, meal allowance and various labour on costs.
[2] Over an assumed lease period of 10 years with 20% residual.

In summary, the operational model shows discounted fuel savings of $269,866 and $214,049 for Optare and BYD fleet deployment over the standard Sunbus diesel fleet for the 10 year leasing period. However, these savings were not sufficient to offset the additional operational costs incurred in deployment of electric buses on Route 627. The charging and scheduling limitations of the electric buses – requiring an additional bus to be run on the route – make electric bus deployment an expensive option.

As costs are assessed over the 10 standard leasing period, this assessment provides some degree of comfort if the decision is made to extend the operation of the chosen bus beyond the end of the trial period. However, as noted above, these estimates are indicative only and the best measure of the commercial viability of running an electric bus on Route 627 should be based on actual performance in Noosa operating conditions during the proposed trial period.

A copy of the financial model is enclosed in **Appendix F** of this report.

7.4 Benefits

The potential benefits of an electric bus on Route 627 for Noosa include:

Greenhouse gas (GHG) emission reductions

Fully electric drivetrains, as opposed to diesel powered combustion engines, can achieve fuel and emissions reductions of up 80% for electric buses if the electricity is sourced from renewable sources[1].

Ambient noise reduction

Electric buses typically reduce operational noise by up to 70 dB. Urban areas of Noosa will benefit significantly where traffic noise may already be acknowledged problem. Mixed use developments along Route 627, with residences built above commercial premises in closer proximity to major transport routes and hubs, will similarly benefit from noise reduction.

Air quality and odour reductions for populated areas due to the zero tailpipe emissions

In addition to CO2 emissions reduction, the elimination of black diesel exhaust smoke, soot and odour is a significant benefit to the community's enjoyment of our urban areas.

Fatigue related transport incidents

Drivers of electric buses report significant reductions in fatigue due to elimination of the vibration and noise caused by a diesel engine. Given that fatigue is identified as a significant cause of road incidents and accidents, any reduction in fatigue for the drivers of vehicles which are heavy road users can be expected to have a positive impact.

Improved OH&S outcomes for drivers

As much as the factors of noise, air quality and odour and in-cab noise and vibration described above have positive environmental impacts, they also make a very strong contribution to the OH&S outcomes for operators and their drivers.

Additional social and community benefits

Additional social and community impacts should be assessed during the trial period, perhaps using targeted market research of the passenger base. Market research will assess the

[1] Assessment of alternative fuels and vehicle technologies for the Victorian bus fleet, a discussion paper, Rare Consulting Pty Ltd, January 2011

experience and perceptions of the bus passengers, along with the outlook towards the introduction of new technologies into public transport applications.

Supporting the development of renewable energy

In line with the government's plan to encourage sustainable practices including green energy solutions by investing and adopting sustainable and renewable solutions

Increased economic development and tourism visitation in Noosa

Enhance Noosa as a tourism destination with a strong environmental focus which may increase visitation and economic activity in the Noosa Shire area

7.5 Risk assessment

A risk assessment was undertaken as part of the SOC. Risks were first identified and then ranked in a risk matrix (Table 16) to qualitatively assess the relative likelihood and consequences of risk eventuating during the trial of an electric bus at Noosa on Route 627.

7.5.1 Risk identification

Identified risks include:

- New technology - The introduction of an electric bus brings higher degrees of technical and financial uncertainty due to higher up front capital costs combined with the implementation of new technologies
- Uncertainty surrounding battery life and the performance
- Uncertainty surrounding "real-world" performance outcomes during the trial given location specific variations in ambient temperatures, braking intensity, and accommodation of air-conditioning load
- Uncertainty surrounding the GHG performance of electric vehicles when powered using electricity generated by non-renewable energy sources
- Any loss of passenger carrying capacity given final configuration of the chosen bus option and capacity to accommodate unexpected fluctuations in route demand
- Untested design life - none of the electric buses have been in operation for 15 years so the life of the bus is untested

Table 16 Electric Bus Trial Risk Matrix

Descriptors	Rare	Unlikely	Moderate	Likely	Almost Certain
Catastrophic					
Major				New Technology	Battery Performance
Moderate				Operational Risks	
Minor		Bus Capacity Risk			
Insignificant		Not Realising Positive GHG Impacts			

7.6 Potential funding sources

In recent years, the scale of available grants and funding to support initiatives such as the Noosa electric vehicle trial has been scaled back considerably. Entities which may have previously provided grants or funding such as Australian Renewable Energy Agency (ARENA) or the Commonwealth Department of Industry are responding to increased budgetary pressures and a reduced emphasis on carbon mitigation policy in recent years.

Although more general in nature, the following recently announced grant may be available for the trial and is worth exploring:

National Stronger Regions Fund (NSRF)

The NSRF offers $1 B over the next five (5) years to support investment in priority economic and infrastructure areas. The fund is targeted at local government and incorporated not-for-profit organisations. The NSRF is the successor to the Regional Development Australia Fund (RDAF), the comparable nature of the two programs means it may be rolled out as follows:

- RDAF provided $438.5M averaging just over $200M per year, and the new NSRF looks to continue this with $1B over 5 years
- Under NSRF, the grants will be between $20,000 and $10M. Under RDAF, the smallest grant was $69,870 and the largest grant was $15M with the overall average being just over $2.5M[1]

Noosa Council Public Transport Levy

The option of a Public Transport levy to fund the trial is also open to Council. However, as this is for provision of new technology on an existing bus route, it may be difficult to gain

[1] GrantReady http://community.grantready.com.au/Find_Grants/Search/index.aspx?itemDetails=11189&cId=&itemDetailsSubTopic=228

community support for this option. The option of user-pays charging would also be difficult for the same reasons.

TransLink funding

Another option may be to seek a portion of the total funding from TransLink based on the differential between the lifetime costs of the new electric vehicle and the current diesel vehicle. That is TransLink would be asked to reinvest savings from fuel back into the trial to effectively be a cost neutral outcome for Queensland taxpayers. Building this case may be assisted by analysis already completed as part of this SOC.

Advertising

There is the option to sell advertising on the electric bus to generate revenue.

7.7 Recommendations for an electric bus to be part of a live train in Stage 2

The trial is about assessing the technology and discovering the “actual” capability and performance of the electric bus under local conditions in Noosa. If the trial is found to be successful, decisions can be made to consider implementing the electric bus in full.

The cost to run the trial is estimated to be **$452,700 for Optare and $407,200 for BYD**. The findings show that the trial would cost more than the current cost to operate the two (2) electric buses on Route 627. This is primarily because of the cost incurred in providing the fill-in and standby diesel buses and driver relief trips to ensure service reliability. To match the performance of the two (2) diesel bus, inductive charging and/or supercharging technology en-route is likely to be required. However, inductive charging and/or supercharging technology are yet to be proven and too costly to implement for the trial.

An initial capital investment will be required to “ground truth” the technology. It is recommended that both Optare and BYD are considered for the trial. Optare has the advantage of scale and expertise in the manufacturing of buses with a strong and reputable international brand, and have a presence in Australia. BYD are global leaders in the development of battery technology and battery management systems (BMS). Their battery technology has shown a continuous improvement. The new generation of batteries is already exceeding the older batteries in capacity, which is currently installed in buses around the world.

Over the investment horizon of 15 years, the total NPC discounted costs for the Optare solution came to an estimated -$601,284 and -$922,730 and -$1,049,093 for Olev and BYD, respectively. The total NPC discounted cost per kilometre came to -$0.37, -$0.56 and -$0.64 for Optare, Olev and BYD, respectively.

The cost analysis indicates that the Optare solution to be the lowest from a total NPC discounted cost and cost per kilometre standpoint. This is outcome is due mainly to the extended operational life of the Optare with a stated operational life of 25 years as against the Olev at 20 years and the BYD at 15 years.

The analysis conducted showed that Optare Solo 10M is the most cost effective option to run and the best choice on a theoretical whole of life cost basis, and is recommended for the 6-month trial.

8. Conclusions and Recommendations

8.1 Conclusions

The analysis conducted showed that Route 627 is most suitable for the electric bus trial. The location for the proposed layover and fast recharging station is in Pelican Street at Tewantin, next to Council's office. This site is convenient for the western terminus of Route 627 to use and has minimal impact on parking with approximately three (3) car park spaces to be removed in Pelican Street.

Overnight storage and slow charging for the electric bus could be undertaken at the existing Sunbus depot (Beech Street) at Marcoola, which is approximately 30 km south of the eastern terminus (start point of Route 627) at Sunshine Beach. The Marcoola location is preferred because it is an existing secure fenced facility with surveillance systems and it will minimise the dead running and the significant cost of additional driver relief trips (compared to the Noosa Council depot at Bartlett Road). In addition, repairs and maintenance of the electric bus could be done at Marcoola similar to current diesel buses.

The market research found that there were many companies involved either directly or indirectly in the electric bus industry. Companies that were researched were found to originate from New Zealand, Asia (China), Europe (Germany, Luxemburg, Netherlands, Italy, and Poland) and the Americas (United States and Canada).

In total twenty six (26) electric bus manufacturers were researched to develop comparative product (fleet) profiles comprising of twenty (19) international and seven (7) locally based manufacturers. To evaluate the companies that offer electric buses, a number of essential factors were required to be met to first shortlist companies for further evaluation. The essential factors included:

- Reputation of the company and tenure in the industry.
- Proven electric bus technology with buses implemented in the field
- Availability to provide a vehicle for the 6-month trial expected in August 2015
- Ability to complete the electric bus route with an approximate range of 280 km per day (23 trips @ 23.7 km round trip)
- Proven right-hand drive vehicles to suit the Australian driving conditions which minimises the additional cost of customising the electric bus
- Easily able to provide the after sales support, parts replacement and training of drivers
- Compliance with Australian Standards in terms of vehicle specifications including Australian Design Rules (ADR) standards and Disability Discrimination Act requirements

Using the above mentioned selection criterion, four (4) electric bus manufacturers were shortlisted for further evaluation using a Multiple-Criteria Analysis (MCA) approach as below:

- Solaris (Poland)
- BYD (through Carbridge an Australia largest aviation bus company with operations in Brisbane, Sydney, Melbourne, Adelaide and Perth airports)
- Optare (through PATICO Automotive who are the Australian distributors for Optare headquartered in Dandenong, Melbourne and have been operating in Australia for 10 years)

- Olev (through Australian Electric Infrastructure Transport (AEIT) with an office located in Brisbane, Queensland. AEIT is a Brisbane based company established in 2012 to commercialise the Olev electric vehicles in Australia)

A Multi-Criteria Analysis (MCA) approach has been used to inform the selection of the preferred electric bus manufacturer. The MCA results were presented at a workshop with Council/TransLink on the 18 September 2014 and it was decided that the top two (2) manufacturers (i.e. Optare and BYD) would be invited through an expression of interest (EOI) to participate in a 6 month trial. More detailed information was gathered through the EOI process to select a preferred manufacturer.

The trial is about assessing the technology and discovering the "actual" capability and performance of the electric bus under local conditions in Noosa. If the trial is found to be successful, decisions can be made to consider implementing the electric bus in full.

The cost to run the trial is estimated to be **$452,700 for Optare and $407,200 for BYD**. This is the net cost after the cost of operating the standard two (2) diesel buses on Route 627 is considered.

The findings show that the trial would cost more than the current cost to operate the two (2) diesel buses on Route 627. This is primarily because of the cost incurred in providing the fill-in and standby diesel buses and driver relief trips to ensure service reliability. To match the performance of the two (2) diesel bus, inductive charging and/or supercharging technology en-route is likely to be required. However, inductive charging and/or supercharging technology are yet to be proven and too costly to implement for the trial.

An initial capital investment will be required to "ground truth" the technology. **It is recommended that both Optare and BYD are considered for the trial.** Optare has the advantage of scale and expertise in the manufacturing of buses with a strong and reputable international brand, and have a presence in Australia. BYD are global leaders in the development of battery technology and battery management systems (BMS). Their battery technology has shown a continuous improvement. The new generation of batteries is already exceeding the older batteries in capacity, which is currently installed in buses around the world.

A Strategic Outline Case (SOC) has been developed to identify and compare the indicative longer term costs of the recommended electric bus options which are likely to proceed to a live trial, together with consideration of potential funding sources.

A financial model has been designed to provide an indicative cost comparison of Optare and BYD buses over a 15 year investment horizon. It is designed to evaluate and compare the upfront purchase costs of a single bus and the anticipated energy and maintenance costs on a 'like-for-like' basis.

An operational model has been developed to compare the indicative costs of running the selected electric bus options (Optare and BYD) as a fleet on Route 627 against the indicative costs of running the current Sunbus diesel buses. The time period for the operational model is 10 years (based on TransLink's initial leasing period) which allows for a longer term operational comparison of the current Sunbus diesel bus with both electric bus models.

Financial model results

Over the investment horizon of 15 years, the **BYD bus has been found to be the cheapest in terms of upfront purchase costs** (Optare +12%). However, the Optare Solo 10M is likely to be the **most cost effective option to run in terms of maintenance and servicing.**

There are **marginal differences in fuel efficiency between the two buses**, it was surmised that **fuel efficiency is not a good basis to distinguish electric bus options**.

Over the investment horizon of 15 years, the total NPC discounted costs for the Optare electric bus came to an estimated -$624,849 and -$1,074,230 for BYD. The total NPC discounted cost per kilometre came to -$0.33 for Optare and -$0.56 for BYD, respectively. **The cost analysis indicates that the Optare solution to be lower from a total NPC discounted cost and cost per kilometre standpoint.** This outcome is due mainly to the extended operational life of the Optare with a stated operational life of 25 years as against the BYD at 15 years.

Operational model results

The operational model shows discounted fuel savings of $269,866 and $214,049 for Optare and BYD fleet deployment over the standard Sunbus diesel fleet for the 10 year leasing period. However, these **savings were not sufficient to offset the additional operational costs incurred in deployment of electric buses on Route 627.** The charging and scheduling limitations of the electric buses – requiring an additional bus to be run on the route – make electric bus deployment an expensive option.

The review of relevant State and Federal Transport policy, standards and regulations which will may potentially influence the project yielded the following:

- As yet there are no specific standards regulating the use of electric buses
- Specific requirements for electric buses were not identified in the review of current legislation and regulations
- Queensland 30-year Electricity Strategy (2012) identified the need for efficient regulatory frameworks to create efficient supply chains that accommodate innovative technology, such as embedded generation technology, battery storage and electric vehicles. It also discussed the need for addressing the impact that electric vehicles have on network infrastructure
- Electric bus for the trial will need to comply with all State and Commonwealth government laws in in particular the Disability Standards for Accessible Public Transport (DSAPT) 2002, Commonwealth Disability Discrimination Act 2002 (DDA) and Australian Design Rules (ADR)
- Qld Department of Transport and Main Roads (TMR) - need to satisfy any performance levels outlined in a services contract as per Chapter 6 of the Transport Operations (Passenger Transport) Act 1994
- Bus operators must ensure that their drivers are provided with appropriate training to operate an electric bus. The intent of the training would be to ensure drivers could operate the vehicle in a safe manner

Identified risks for the project include:

- New technology - The introduction of an electric bus brings higher degrees of technical and financial uncertainty due to higher up front capital costs combined with the implementation of new technologies
- Uncertainty surrounding battery life and the performance
- Uncertainty surrounding “real-world” performance outcomes during the trial given location specific variations in ambient temperatures, braking intensity, and accommodation of air-conditioning load
- Uncertainty surrounding the GHG performance of electric vehicles when powered using electricity generated by non-renewable energy sources

- Any loss of passenger carrying capacity given final configuration of the chosen bus option and capacity to accommodate unexpected fluctuations in route demand
- Untested design life - none of the electric buses have been in operation for 15 years so the life of the bus is untested
- For the above reasons a trial is recommended to test this new technology

8.2 Recommendations

- Route 627 is recommended to be used as the electric bus trial route
- Two (2) electric buses and one (1) diesel bus will be required to maintain the current 30 minute headway and 60 minute circuit time. A standby diesel bus is recommended to attend to any breakdowns in order to ensure service reliability. The existing diesel buses in the Sunbus fleet should be used as stand-by spares should there be any breakdowns, accidents and other service continuity issues
- Overnight storage and slow charging of the electric bus is recommended to be at the existing Sunbus depot at Marcoola. Layover and fast charge of the electric bus recommended to be at Pelican Street (in front of Council office and would involve the loss of approximately three (3) car parking spaces. Repairs and maintenance is proposed to be conducted at existing Sunbus depot (Beech Street) at Marcoola
- Route 627 should be exempt from the TransLink Contract Performance Management Framework during the trial whilst an unproven technology is being tested
- A driver relief vehicle is hired (2 Nos) and included in trial costs, to transport Sunbus drivers between the Marcoola depot and Noosa Junction to facilitate driver shift changeovers
- Dedicated electricity meters to be used for the trial to verify battery usage and performance of the bus
- It is recommended that both Optare and BYD buses are considered for the 6 month trial to confirm performance in the field and is estimated to cost $859,900 (excluding contingencies)
- Should the trial succeed the permanent cost of operating the electric bus would be less than the trial cost as standby buses and drivers would not be required as the technology is proven as reliable. Consideration may also be given to using more permanent recharging options that may negate the need for a third bus
- Potential funding sources include:
  - National Stronger Regions Fund (NSRF)
  - Introduce a Council Public Transport levy to fund the trial
  - Seek a portion of the total funding from TransLink
  - Advertising revenue
- Electric buses for the trial will need to comply with all State and Commonwealth government laws in in particular the Disability Standards for Accessible Public Transport (DSAPT) 2002 and Commonwealth Disability Discrimination Act 2002 (DDA), and Australian Design Rules (ADR)
- Council/TransLink should consider the involvement of Sunbus in the trial as early as possible