Hydrogen Buses for Victoria's Transport

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Proposal for the Development, Building and Demonstration of Hydrogen Fuel Cell Electric Buses (FCEBs) in Victoria

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This document is a submission proposal prepared for Victorian Hydrogen Investment Program to develop Hydrogen Fuel Cell Electric Buses (FCEBs) in Victoria, for the Victoria transport system.

The document is a project plan for the prospective development of the Hydrogen Fuel Cell Electric Buses in Victoria for public transport, private transport operators and the uptake of hydrogen in Australia's transport sector. In the state of Victoria there is sufficient expertise to develop the technology to design, develop and manufacture Hydrogen Fuel Cell Electric Buses with small dependency from overseas service providers.

The document contains VHIP program questions answered regarding the hydrogen use in transportation in Victoria.

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1. EXECUTIVE SUMMARY

The development of fuel cell systems for electricity generation has grown exponentially in the last 15 years, the research and development has been centred on high temperature Solid Oxide Fuel Cell (SOFC) for stationary applications and low temperature Proton-exchange Membrane Fuel Cell (PEMFC), also known as polymer electrolyte membrane fuel cell developed for transport and mobile applications.

Fuel cell developing companies around the world went through the important pathway from Research and Development (R&D) to Research Development and Demonstration (RD&D) of products. They carried out the scientific experimentations of purification of electrochemical materials and at the same level they develop systems that can be safe, with high stable energy output, compliant with regulations and attractive to the potential customers.

Australia was not estranger to the R&D of fuel cells in the past. The CSIRO fuel cell program in Clayton, Victoria grew substantially to justify the establishment of Ceramic Fuel Cell Ltd (CFCL), a consortium company leading by CSIRO and stakeholders of electricity trust in all Australian States, New Zealand and BHP.

The research program of fuel cells at CFCL provided valuable outcomes to the fuel cell scientific area, to business opportunities and to future technology applications. At CFCL there were system developed from 1 single fuel cell up to 25 kW system (Genesys) made of thousands of fuel cells.

I was proud of being part of the group of engineers and scientists at CFCL to develop many fuel cell systems. I was in charge of the electrical, control and instrumentation group developing fuel cell systems and testing stations, I made myself an expert in fuel cell system development.

Over the years I was strongly working and developing electric vehicles EV, mainly heavy electric vehicles that are important for the Australian transport industry.

Currently an important project of electric buses in Australia is the Brisbane Metro project managed by Brisbane City Council BCC. Being a specialist in electric buses I was the main EV consultant and advisor to BCC for developing the electric buses requirements and tenderer revisions. Then BCC was overwhelmed with the tenderer's response of supplying electric vehicles for this project.

I am proud that BCC awarded the Metro Project vehicle supply to the electric buses supplier, thanks to my contribution. My involvement with the Brisbane Metro project also includes the development of infrastructure requirements, for the garage and maintenance facility to service the electric buses, work of energy consumption and simulations. Recommendations about the use of green energy solutions for decreasing the grid dependency and proposing green energy generation to supplement the peak energy consumption for the fleet of 60 bi-articulated electric buses when the Brisbane Metro starts its operation in a couple of years.

Back in 2015 I led a dedicated team at Swinburne University of Technology to develop and demonstrate an international electric bus (E-Bus) of 12.5 m for Malaysian Automotive Institute MAI. The electric bus E-Bus received many accolades as being the first designed and built electric bus for Malaysian government.

My extensive experience in electric vehicles also included being the engineering manager at SEA Electric, where I improved the EV technology and safety of the electric trucks that SEA electric develops by second stage of manufacture.

Being part of General Motor Holden I was in charge of the training and maintenance facility setup for the companies' fleet electric vehicle VOLT when the company introduced this extended range electric vehicle in Australia.

As an expert in electric vehicles design, I am very enthusiast to provide clean energy to the Victorian transport system. I already have designs of electric buses running on Hydrogen fuel cells technology ready for development and demonstration, including required supporting system, such as charging and hydrogen supply infrastructure to support initial launch of hydrogen buses in a dedicated route.

This submission document is a project plan to start the introduction of Hydrogen Fuel Cell Electric Buses (FCEBs) to the public transport in Victoria and/or private operators. The development of these FCEBs locally in Victoria will bring low cost of ownership, generates local jobs creation, it will increase the workforce technology knowledge by training, and it will create business opportunities, importantly it will reduce the transport system emissions.

I believe that the proposed locally developed hydrogen buses will be running before overseas buses companies try to introduce their expensive technology in Australia. However, the advantage to have the Hydrogen Fuel Cell Electric Buses (FCEBs) locally produced in Victoria will make the technology suitable to meet the Australian regulations from the very beginning. For example a bus of standard 12.5 m length compliant with the Australian Design Rules ADR is Right Hand Drive RHD, is up to 2.5 m wide and lower floor, these buses differ to overseas buses offered by manufacturers that can't meet ADR regulations due to the dimensions.

This project plan provides few simple milestones to achieve the establishment of the Hydrogen buses for the public transport in Victoria. The main milestones are time to deliver, budget requirements, industry partner engagement, stakeholder contribution, supplier engagement, local human resources requirements and their training.

All these milestones in the project plan must be supported by the Victorian Government

The project plan scope is the development and demonstration of 3 FCEBs over an estimated period of 3.5 year. The first Hydrogen Bus prototype will be ready in 2 years period, subsequently the Hydrogen Bus#2 which will be a pre-production model ready in 9-12 months and finally the delivery of the Hydrogen Bus#3, a production model in the short time of 6 months.

The document project plan extends the options of the Hydrogen buses development in Victoria to suit different business investment and existing manufacturing infrastructure of the investors.

Even my expertise in fuel cell and electric vehicles is practically unique in Australia, there are many specialists in Victoria expecting to be part of the great journey to utilize the hydrogen as a source of energy for the transport system. I recognise this is a long road to transform the entire public transport buses to zero emission using Hydrogen Fuel Cell Electric Buses (FCEBs), but my vision is to start as soon as practical, otherwise will be extremely cumbersome to achieve this.

This document also provides the total cost for the project and per vehicle delivery, including the initial requirements of the supporting infrastructure facility.

A brief history of my expertise including examples of the recent electric vehicles and hydrogen fuel cell capability is after the project proposal section.

The Victorian Hydrogen Investment Program (VHIP) discussion paper released by Victorian Government in November 2019 is the main incentive for this submission proposal. The VHIP requests the expert opinions about the use of hydrogen in Victoria rising 17 questions through the National Hydrogen Strategy consultations and what Victoria Government learnt from the request of industry submissions. This document addresses almost all 17 questions providing my point of view by answering the questions with relation of the hydrogen utilization in the transport system.

However, the main answer to reduce the transport emissions and the utilization of the hydrogen in transport Victoria is the project proposed in this submission document.

2. INTRODUCTION

This document submission provides detailed information about the development of Hydrogen buses for Victoria public transport and/or for buses developers that are willing to engage in the Hydrogen energy propulsion project to reduce the emissions of the transport system.

The first part of this document is the Hydrogen buses development project plan comprising the timing of development, budget requirements and the conditions imposed to the development and build of the FCEBs for Victoria.

The project plan scope is the development and demonstration of 3 FCEBs over an estimated period of 3.5 year. The first Hydrogen Bus#1 is a prototype FCEB that will be ready in 2 years period approximately.

After the Hydrogen Bus#1 the second vehicle starts its development and manufacturing, this Hydrogen Bus#2 will be a pre-production model and estimated be ready in 9-12 months.

The project plan includes the development of the third hydrogen bus, Hydrogen Bus #3, a production model in the short time of 6 months.

The project plan is open to extend the development of subsequent FCEBs vehicles beyond the production model Hydrogen Bus#3. However, this is not included in this proposal.

The FCEBs vehicles in this proposal are fully electric buses that will produce zero emissions, low noise and low vibration in comparison with diesel buses. They will run using hydrogen as a source of energy, but they will be flexible enough to be electrically conductive charged to supplement the lack hydrogen. The expected energy range to cover about 400 km of run per hydrogen capacity and battery system energy capacity.

The second part of the document provides the answers to the questions posed by Victorian government in the Victorian Hydrogen Investment Program (VHIP), related to the use of hydrogen in the transport system and related areas.

The document finalises with my brief biography describing the experience and achievement in the hydrogen fuel cell and electric vehicles area.

3. PURPOSE

The document proposal highlights of the fact that the development of Hydrogen buses locally in Victoria is 100% viable and it could be done in a short time frame spaning up to 2 years for a prototype Hydrogen bus, but 3 Hydrogen buses in 3.5 years as specified in this proposal. This document submission demonstrates that we Australians should wait for the complete Hydrogen vehicles importation is completely incorrect.

The amount of knowledge, experience and desires to develop the Hydrogen vehicles locally is today a reality and this document should be taken into consideration to support the beginning of decarbonisation of the Victorian public transport.

We need to coordinate and act cooperatively to achieve the proposed goal. This document is an invitation as well for interested vehicle manufacturer parties and investors willing to develop the technology for their own manufactured buses.

My Vision is that the immediate development of the Hydrogen Buses in Victoria will attract interest for many sectors to develop plans for sustainable transport. Mainly state councils and operators are actually educating themselves with the electro mobility technology, looking at the benefits of this if the technology finally is established with their operations.

Case example is the Brisbane Metro (BM) project managed by Brisbane City Council team and consultants/ advisors. Initially the BM vehicles requirements was focused in the diesel technology. However, after my inputs and advices acting as a consultant, the task of re-writing the technical requirements adding Electric vehicles and hydrogen technology to the specifications, then Brisbane City Council team not only educated themselves, the results showed that 67% of proponents came back with Battery Electric Buses BEBs. Brisbane City Council studied and performed the sensitive analysis to finally award the vehicle supply for a 24 m bi-articulated Electric Buses manufactured by Hess in Switzerland and in collaboration with Australian company Volgren.

The acceleration of developing Hydrogen buses in Victoria will provide extensive business opportunities not only for transport sector, the hydrogen buses technology will provide opportunities for supporting business even outside of its technical areas, such as logistics, telecommunications (telematics), operational centres, education and ticketing.

It will also create direct business opportunities to the hydrogen vehicles, such as opening market for overseas OEM part suppliers, opportunities for the Hydrogen infrastructure production and supply, system development for the green Hydrogen production, Depots and Garage development, specialized maintenance, skills development and local jobs creation. New regulations for safety, Hydrogen stations and products for Hydrogen handling for transport is also added value.

Also I am expecting that Australia will provide incentives to the hydrogen buses developers and customer of these buses

I am calling and knocking the doors of the Victorian Government to seriously take this paper in consideration for the Victorian Hydrogen Investment Program (VHIP) seeking support and

investment for the development of the Hydrogen Fuel Cell Electric Buses (FCEBs) for Victoria.

4. SCOPE

This submission paper detailing a proposed project development of the Hydrogen Fuel Cell Electric Buses (FCEBs) has the following scope of delivery and outcomes:

- The initial project stage is the setup of the FCEBs project and engagement of industry partners and stakeholders, together with the legal documentation signed for the successful project. This stage requires the Victorian Government engagement either directly, via VHIP or other avenues to establish extents of requirements.
- The second and main stage is the development of the Hydrogen Fuel Cell Electric Bus number 1, which will take about 2 years of development. This Hydrogen Bus#1 will be the main prototype of the Hydrogen buses for the Victorian conditions and requirements of operation.
- After the completion of the Hydrogen Bus#1 the development of the Hydrogen Fuel Cell Electric Bus number 2 is initiated, the development of the Hydrogen Bus#2 could be overlapping the timing of the Hydrogen Bus#1 development. The Hydrogen Bus#2 will be completed in 9 to 12 months as estimation. The estimation is based on the regulations and availability of the Hydrogen tanks for transport. This Hydrogen Bus#2 will be an improved hydrogen electric bus from the prototype bus #1 and it will be the pre-production model.
- The third stage is the full production model Electric bus represented by the development of the Hydrogen Bus#3. This Hydrogen Bus#3 will take 6 months or even less for its development.

The present submission document provides detailed plan of timing and budget forecasts for the development of Hydrogen Fuel Cell Electric Bus number 1. The development of the Hydrogen Bus#2 and #3 referencing the timing and budget is more or less general rather detailed, because these last two Hydrogen buses development are subject to the type of engagement with the industry partners and stakeholders, it will be defined at the project engagement stage.

5. HYDROGEN FUEL CELL ELECTRIC BUSES (FCEBs) PROJECT

This submission paper describes the stages necessary for the development of the Hydrogen Fuel Cell Electric Buses (FCEBs) in Victoria for public and private transport system.

5.1 Project Requirements and Conditions

The following conditions and requirements are necessary to fulfil the development project objectives and scope of delivery. These conditions established at the early stage of the project must be visible and taken into consideration by all Stakeholders. During the development of the first Hydrogen Bus#1 these requirements should be revisited to perfect the outcomes towards the successful goal of demonstrating the Hydrogen Bus#1 and to provide guidelines for the next stage of Hydrogen buses development.

The requirements for the development of the Hydrogen Fuel Cell Electric Buses (FCEBs) should incorporate the following actions and assets:

a) Victorian Government supporting the initial State of Requirements SOR and backing the expected project outcomes in order to be successful in cases investor/s or industry partner/s change the direction of investment.
b) The industry partner/investor/s should provide a facility able to be used for the duration of the development of the first, second and third Hydrogen Fuel Cell Electric Buses (FCEBs). The facility must be appropriate for buses manufacturing. This will be defined at the stage of partners' engagement. If the VHIP program provides full support for the development of Hydrogen buses on a continuous bases, the facility could be a permanent manufacturing site.
c) Budget forecast specified for the project (see section of Cost), is for the development of the Hydrogen Buses #1, #2 and #3, including components, minimum tools, technical consultants, fees for regulation approvals, imports and the minimum team of personnel required for the duration of the project development.
d) The industry partner/ investors must provide a fully operational city bus chassis and body with the primary Identification Plate Approval - IPA approval ready for the second stage of manufacture (SSM). The chassis will count with the body of the bus, brake system and suspension (to be confirmed), steering system, instrument clusters, lighting, and all body functions and control. These technical requirements are subject to the preliminary design of the skeleton of the future Hydrogen buses. The Hydrogen buses development based on the second stage of manufacture (SSM) substantially reduce the cost of regulations on ADR-IPA approval and shorter the time for development. These requirements must be discussed at the early stage of the project. This will impact in the definition of components required to be on board of the bus chassis before the project start.
e) The industry partner/investors should contribute with labour costs beyond the engineering project development for the duration of the project when requires. The labour cost required will be in the form of administrative costs, legal work and contracts, lawyer fees, a number of predefined hours of labour of skilled personnel for dedicated works, supply additional subcontractors for the installation of heavy and special equipment, provision of heavy tools requires by the bus industry and cost of tooling based on industry OH&S, transport or freight of the bus chassis if required. In general all the additional work that is not included in the scope of this Hydrogen buses development project.
f) The consultancy for homologation and ADR regulations is included in the budget of the project proposal. However, it could be extra cost associated with certain unforeseen regulations or new regulations coming inforce, certifications and specialised test leading to regulation acceptance. These extra costs are out of the scope of this project and they should be absorbed by the industry partner/ investors.
g) The documentation and legal establishment of the paperwork which is part of the setup of the development project is out of the budget of this proposal and it needs to be included within the initial setup of the project by the VHIP partner/ investors.

This submission is open to accept different proposals than specified here in the lead to the development of the Hydrogen Fuel Cell Electric Buses (FCEBs) for Victoria.

5.2 Hydrogen Fuel Cell Electric Bus specifications

The proposed project targets the development of Hydrogen Fuel Cell Electric Buses (FCEBs) with the following expected specifications. This is based on experience and existing buses of the public transport. The specifications are subject to adjustment once the expression of interest are submitted.

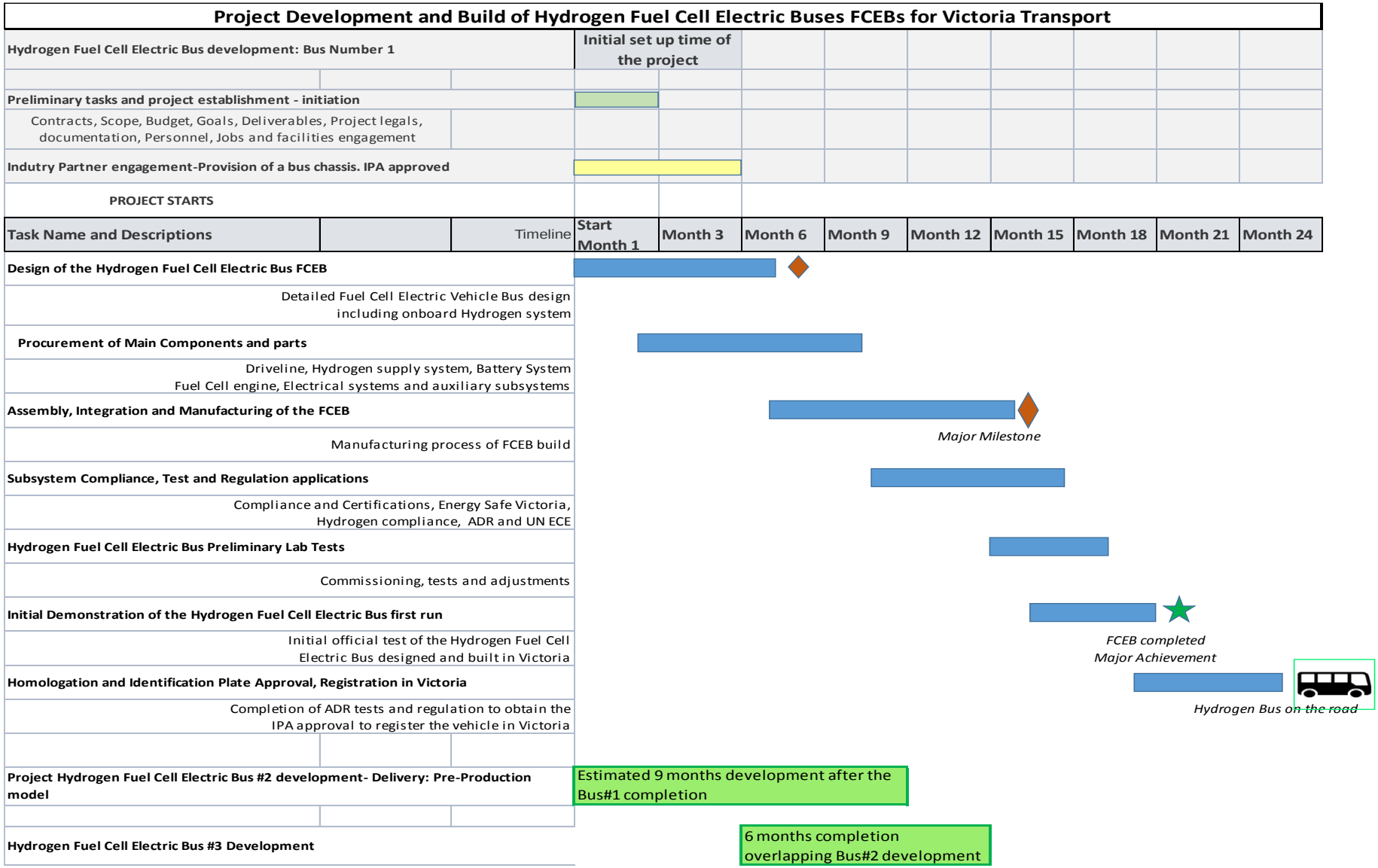
Hydrogen Fuel Cell Electric Bus #1 specifications

Type:	Omnibus category ME as per ADR, M3 as per UN ECE
Size:	City bus 12 or 12.5 m length, 2.5 m wide, height to be defined
Floor:	Low floor
Capacity:	40 to 45 seat, 70 passengers' maximum
Tire size (Standard):	275/70R22.5
Brakes:	Ventilated disk brakes
Drivetrain:	Electrical, 3 phase asynchronous dual motor 120 kW max ea.
Rear Axle:	ZF with air bag suspension.
Rear Axle load:	11000 kg rating
Gross Vehicle Mass, GVM:	Below 18000 kg
Cooling:	Liquid cooling for motor and motor controllers
Torque:	465 Nm per motor max
Output Torque:	2 x 11000 Nm maximum
Operating Voltage DC:	570 - 700 V
Battery Energy:	100 – 150 kWh
Fuel Cell:	50 - 60 kW fuel cell engine expected
Hydrogen tank:	6 m3 initially supplied by Australian company for general use of Hydrogen system. Subsequently will be refuelling tanks.
Speed:	83 km/h maximum @ 0% road grade
Operating Range:	200 – 400 km
Charging mode:	Electrical and Hydrogen charge
Steering:	Hydraulic or electric
HVAC system:	10 kW estimated

Specifications for Hydrogen Bus#2 and Hydrogen Bus#3 are practically the same as the Hydrogen Bus#1, with the exception that the hydrogen tank will the type of pressurised hydrogen tank for 300 bar + above, with a refuelling hydrogen station required. However, in the absence of a suitable hydrogen refuelling stations the Hydrogen buses will be supplied in the same way as the prototype Hydrogen Bus#1.

5.3 Hydrogen Fuel Cell Electric Buses (FCEBs) Project development plan

The following chart is the top level project timing to develop the first 3 Hydrogen Fuel Cell Electric Buses (FCEBs) as specified in the Scope in Section 4


Project Development and Build of Hydrogen Fuel Cell Electric Buses FCEBs for Victoria Transport
Hydrogen Fuel Cell Electric Bus development: Bus Number 1
Initial set up time of the project
Preliminary tasks and project establishment - initiation
Contracts, Scope, Budget, Goals, Deliverables, Project legals, documentation, Personnel, Jobs and facilities engagement
Indutry Partner engagement-Provision of a bus chassis. IPA approved
PROJECT STARTS
Task Name and Descriptions
Timeline
Start Month 1
Month 3
Month 6
Month 9
Month 12
Month 15
Month 18
Month 21
Month 24
Design of the Hydrogen Fuel Cell Electric Bus FCEB
Detailed Fuel Cell Electric Vehicle Bus design including onboard Hydrogen system
Procurement of Main Components and parts
Driveline, Hydrogen supply system, Battery System Fuel Cell engine, Electrical systems and auxiliary subsystems
Assembly, Integration and Manufacturing of the FCEB
Manufacturing process of FCEB build
Major Milestone
Subsystem Compliance, Test and Regulation applications
Compliance and Certifications, Energy Safe Victoria, Hydrogen compliance, ADR and UN ECE
Hydrogen Fuel Cell Electric Bus Preliminary Lab Tests
Commissioning, tests and adjustments
Initial Demonstration of the Hydrogen Fuel Cell Electric Bus first run
Initial official test of the Hydrogen Fuel Cell Electric Bus designed and built in Victoria
FCEB completed
Major Achievement
Homologation and Identification Plate Approval, Registration in Victoria
Completion of ADR tests and regulation to obtain the IPA approval to register the vehicle in Victoria
Hydrogen Bus on the road
Project Hydrogen Fuel Cell Electric Bus #2 development- Delivery: Pre-Production model
Estimated 9 months development after the Bus#1 completion
Hydrogen Fuel Cell Electric Bus #3 Development
6 months completion overlapping Bus#2 development

Analysis of the development project timing plan

- The timing line of the project essentially comprises the engineering activities of OEM engagement, procurement of components, detailed design of the Hydrogen buses, building the vehicles, commissioning, testing, homologation and demonstration.
- It can be seen from the project plan that the completion of the Hydrogen Fuel Cell Electric Bus#1 is about 21-24 months.
- Likewise the main integration of the Hydrogen Bus#2 and Hydrogen Bus#3 will be a continuation task immediately after the completion of the Hydrogen Bus#1. It is indicative that the development of the Hydrogen Bus#2 will take 9 to12 months and the Hydrogen Bus#3 will be ready in 6 months period.

5.3.1 Project Deliverables

Figure 1 summarises the project plan deliverables

Milestone	Deliverable
First 15 months of vehicle development	• Hydrogen Fuel Cell Electric Bus #1 prototype assembled and ready for engineering tests
Month # 21 of the project	• Hydrogen Fuel Cell Electric Bus #1 prototype initial demonstration to stakeholders, investors and partners
Month #24 of the project	• Hydrogen Fuel Cell Electric Bus #1 prototype registered in Victoria and ready for trial runs in a predetermined route. Expected 50 km to 100 km run
Month #25 of the project	• Hydrogen Fuel Cell Electric Bus #2 pre-production vehicle development starts. This development includes improvements and lessons learnt from the Hydrogen Bus#1
Month #34 of the project	• Hydrogen Fuel Cell Electric Bus #2 completed and registered in Victoria. Ready for trials in an established route, preselected for its evaluation
Month #31 to Month #35	• Hydrogen Fuel Cell Electric Bus #3 production vehicle development starts. This development will be shorter than other Hydrogen buses
Month #38 to Month #41	• Hydrogen Fuel Cell Electric Bus #3 production vehicle registered in Victoria, trial starts and eventually put it in operation in an established bus route. The hydrogen fuel supply infrastructure should be developed at this stage and expected at least one supply station in the route of this Hydrogen Bus#3 be available.

Table 1: Project Deliverables

5.4 Cost of development of Hydrogen Fuel Cell Electric Buses

The cost estimated for the project development of the Hydrogen Fuel Cell Electric Buses (FCEBs) is divided in four parts:

5.4.1 Estimated Cost of development of the prototype Hydrogen Fuel Cell Electric Bus one (Hydrogen Bus#1)

Certainly the large part of the cost is associated with the development of the prototype Hydrogen Fuel Cell Electric Bus #1. This Hydrogen Bus#1 will be the base vehicle for the subsequent buses development, perfecting the technology and make them compliant with the local Victorian bus requirements.

The development of this Hydrogen Fuel Cell Electric Bus#1 includes the costs associated to establish part of the initial project setup, leaving the main costs of admin and legal setup to section four.

Table 1 shows the amount in Australian Dollars rounded to describe gross sections of costs. This total cost of Hydrogen Bus#1 is estimated on a 2 year development period.

Type	Description	Cost (A$)	Total Costs (A$)
EV1	Components for the Hydrogen Bus#1	487,100.-	487,100.-
HR1	Personnel, Labour x 2 years	770,000.-	1,540,000.-
T&E1	Tools, equipment, instrument and basic infrastructure required	38,500.-	38,500.-
CON1	Consultant and Subcontractors	45,000.-	45,000.-
REG1	Regulations for homologation	30,000.-	30,000.-
XT1	Contingencies 20% of EV and T&E	105,120.-	105,120.-
Bus#1	**TOTAL Cost**		**2,245,720.-**

Table 2: Cost of development of Hydrogen Fuel Cell Electric Bus #1

5.4.2 Estimated Cost of development of the Hydrogen Bus #2

The second part of the total cost is the development of a pre-production model Hydrogen Fuel Cell Electric Bus #2.

The cost associated with the Hydrogen Bus#2 development involves the same main components cost used in the Hydrogen Bus#1, personnel required is reduced due to the short development time, and regulations expenses are the same cost. There will be saving in tools, computers and software licenses.

The Hydrogen Bus#2 as it is shown in the timing chart has a development period of 9 months, but it could be long 12 months. This is based on the experience acquired during the development of the Hydrogen Bus#1, utilizing the test results and data from the prototype bus.

Type	Description	Cost (A$)	Total Costs (A$)
EV2	Components for the Hydrogen Bus#2	487,100.-	487,100.-
HR2	Personnel, Labour x 9 months	64,167.-	577,500.-
CON2	Consultant and Subcontractors	45,000.-	45,000.-
REG2	Regulations for homologation	30,000.-	30,000.-
Bus#2	**TOTAL Cost**		**1,139,600.-**

Table 3: Cost of development of Hydrogen Fuel Cell Electric Bus #2

5.4.3 Estimated Cost of development of the Hydrogen Bus #3

The third part of the total cost for this project is associated with the development of a production model Hydrogen Bus#3, which is estimated to be carried out in only 6 months.

The Hydrogen Bus#3 would be a production model representation and it will be the Hydrogen Fuel Cell Electric Bus that can be replicated to start continuous production of this vehicle. It is envisaged that this production model Hydrogen Bus#3 subsequently will replace the old ICE buses in operation in Victoria and/or it will be added to the existing buses operation.

Type	Description	Cost (A$)	Total Costs (A$)
EV3	Components for the Hydrogen Bus#2	487,100.-	487,100.-
HR3	Personnel, Labour x 6 months	64,167.-	385,000.-
CON3	Consultant and Subcontractors	45,000.-	45,000.-
REG3	Regulations for homologation	30,000.-	30,000.-
Bus#3	**TOTAL Cost**		**947,100.-**

Table 4: Cost of development of Hydrogen Fuel Cell Electric Bus #3

It is expected that the Hydrogen Bus#3 will provide variants to different passenger capacity and options to fulfil the future demands of hydrogen buses that operators around Australia want to introduce zero emission buses into their fleets. The variants from this Hydrogen Bus#3 should be treated separately on a case by case basis.

5.4.4 Cost of development of three Hydrogen Fuel Cell Electric Buses

The total cost of development project for the proposed three Hydrogen Fuel Cell Electric Buses (FCEBs) specified in this proposal document will be associated exclusively with the cost of development of the individual Hydrogen Fuel Cell Buses, this does not consider the cost of supporting infrastructure described in Table 6:

Type	Description	Total Costs (A$)
Bus#1	Development of Hydrogen Bus#1	2,245,720.-
Bus#2	Development of Hydrogen Bus#2	1,139,600.-
Bus#3	Development of Hydrogen Bus#3	947,100.-
Project	**TOTAL COST OF THE HYDROGEN BUSES DEVELOPMENT PROJECT (rounded)**	**4,350,000.-**

Table 5: Total Cost of the development of three FCEBs

5.4.5 Cost considerations for the project establishment

There is an initial investment during the project establishment stage that includes the manufacturing facility establishment, office facility setup and the process to gather initial resources required. The cost for the project establishment is more or less the type of contribution by the stakeholders or investors in this respect. For instance, it is possible to have an in-kind contribution directly to the project by the investors.

Otherwise, the industry partner could absorb these expenses with the intention to set up their own manufacturing facility for the FCEBs development. This contribution will be evaluate at the beginning of the engagement during the expression of interest.

Other alternative is the direct financial contribution to the project, allowing the project leadership team to manage the expenses associated to the project establishment. At this stage it is uncertain which entity will manage the financial assets and the administration of the project. Certainly I expect that Victorian Government will play an important role in this project administration.

The following resources for the project establishment are required from the initial stage of the project setup. These resources are the supporting units for the launch of the technical development of the Hydrogen Fuel Cell Electric Buses.

Table 6: summarises the required resources and contributions explained, this is not an exhaust list, which will be updated on regular basis to satisfy the needs of the project.

Item	Description	Estimation cost or time	Contribution
1	Vehicle chassis/unfinished body IPA approved	A$ 150K to 200K tbc 2 months estimation	Industry Partner or procurement
2	Engineering and Manufacturing facility. Able to design and manufacture 3 FCEB buses	Established or to be established. Includes tools and equipment	Industry Partner or will be part of the Project engagement
3	Supporting area: finance area, lawyer, contractual documentation, OH&S and initial admin costs	To be determine depending of the contribution type by the stakeholders	Administered by project management
4	Specialist contractors	Estimation of 200 to 500 man hours	In-kind contribution of industry partner or top up the project budget
5	Transport and logistic for demonstration	Hidden cost that requires to be estimated at the time of project establishment	Stakeholders and in partnership with possible demonstrators (VIC transport)
6	Travels if any	Interstate and overseas if required	Stakeholders or top up the project budget

Table 6: Resources required to establish the FCEBs development

5.4.6 Considerations and Cost trending

The individual costs and total cost estimated in this submission includes only the development of three Hydrogen Fuel Cell Electric Buses, named Hydrogen Bus#1, Hydrogen Bus#2 and Hydrogen Bus#3.

Beyond the development of these three FCEBs the prospect of continuous Hydrogen buses manufacturing is enormous. This project is to establish the technology for Victorian public buses running on Hydrogen. This prospect of continuous manufacturing of Hydrogen buses is not covered in this submission, but it will be part of the project scope with the interested stakeholders and investor entities at the time of the establishment and definition of this development project.

In my opinion the development of the subsequent FCEB buses is an extension of this project that could lead to a major interest from a variety of investors.

Other consideration is that the cost for the development of Hydrogen Bus#2, Hydrogen Bus#3 can be considered independent of the manufacturing of Hydrogen Bus#1. This means that once the Hydrogen Bus#1 is completed, the subsequent buses development could be part of a new fresh project.

It can be seen from the summary Tables that the cost of development of the Hydrogen Bus#3 tends to approach to a comparable cost of an ICE bus. This is an important trend and glimpse indicating that the production of Hydrogen Buses in Victoria will be competitive to the existing market of Electric Buses.

In the long term the development cost for production models of Hydrogen Fuel Cell Electric Buses in Victoria will be competitive with the market value and will tend to the cost of components.

Additionally the estimated costs of development of Hydrogen Fuel Cell Electric Buses FCEBs does consider components prices up today in 2020, but many components will be drifting their prices as the technology improves. It is expected that certain components will drop the price in the next 5 to 10 years. Case is the Fuel Cell engines, Hydrogen tanks, battery systems and powerful traction motor systems or electric axles.

6. SAFETY OF THE HYDROGEN FUEL CELL ELECTRIC BUSES

The proposed development of the Hydrogen Fuel Cell Electric Buses is based on the condition that the city bus chassis required must have the primary IPA approved. This means the vehicle chassis is fully compliant with Australian Design Rules before the SSM starts. The ADR covers all safety required by legislation for passenger buses. Among the safety requirements are brakes system, capacity, weight, cabin and driver safety, doors, lighting, steering, suspension, etc.

The Hydrogen Fuel Cell Electric Buses FCEBs will be developed based on the chassis with a primary IPA approved and all additional equipment and components installed on this chassis will be part of the Second Stage of Manufacture SSM-IPA that affect the primary IPA approval.

The Hydrogen system installation and the electrification of the vehicle will have enhanced Safety associated to, this is to comply with the affected ADRs due to SSM and with the international EV regulations. Additionally, the vehicle will count with safety systems that enhance the minimum required Safety by regulations.

Among the Safety of these FCEBs vehicles are:

- Battery System approved for UNECE R100/2 for battery modules
- Vehicle Electro Magnetic Compatibility EMC compliance, UN ECE R10
- Charging system as per AS IEC 61851
- Hydrogen tank and supply system under H2 regulations, components and control. Will be approved by Energy Safe Victoria.
- Fuel Cell engines with international standard approval and Type B appliance approval in Victoria
- Battery Management System BMS managing the charging and conditioning of the battery cells. Informing the control system of faults, failures or out of nominal conditions.

- Expected functional safety products compliant with ISO26262 Functional Safety for road vehicles.
- Hazardous Voltage Interlocking Loops to detect malfunctions in the High voltage system including cables and connectors.
- Low Insulation detection to protect the Hydrogen bus in case the high voltage from battery is electrically short to chassis.
- First respondent, fire brigade mechanism to isolate the energy of the vehicle in case of crash or accident.
- Manual Service Disconnect to isolate the electrical energy from the battery system.
- Double block and bleed valves for the Hydrogen supply lines
- Gas detector system for the Hydrogen gas leak detection.
- Emergency stop system implemented for the Hydrogen buses
- Comprehensive driver warning system from the vehicle control system
- Others to be specified

7. HYDROGEN INFRASTRUCTURE AND REFILLING SYSTEM

The proposed development of Hydrogen Fuel Cell Electric Buses utilizes the existing energy infrastructure system for their operation.

The Hydrogen Fuel Cell Electric Bus#1 and Hydrogen Fuel Cell Electric Bus#2 are expected to run with pre-loaded hydrogen bottles that will be replaced in the vehicle as per usage. Example is that Transport for Brisbane (TfB) runs public transport buses on Compressed Natural Gas (CNG) buses which are preloaded with CNG bottles mounted on the roof of the vehicles.

The Hydrogen Fuel Cell Electric Bus#3 (Hydrogen Bus#2 is to be confirmed) is expected to be finished with a refillable hydrogen tank certified for the road vehicles. This Hydrogen Bus#3 will have the refilling system compatible with the hydrogen refilling station. It is expected that the refilling station infrastructure will be developed at the time the Hydrogen Bus#3 is completed.

The submission project does not include the development, procurement, installation and utilization of the hydrogen refuelling station infrastructure.

A separate project for the establishment of the refuelling station infrastructure must be treated outside of this vehicle's project. The project of refilling station infrastructure will receive inputs by the project management team of this vehicle development project, with recommendations and engagements.

The Hydrogen Fuel Cell Electric Buses (FCEBs) are all expected to be able to charge the traction battery system with an Australian standard charging system, irrespective of the hydrogen content in the vehicle hydrogen tank. In this case the Hydrogen Fuel Cell Electric Buses will have the option to rely only on the energy of the traction battery when the hydrogen run out or in case the hydrogen system is unable to generate electricity.

On the other hand, the Hydrogen Fuel Cell Electric Buses will be able to run for many kilometres using the energy in the traction battery only, until the hydrogen refilling station is reached.

8. RISKS AND CONTINGENCIES

Even hydrogen for transport is a growing opportunity and relatively new, in my opinion the risks associated with this project proposal are minimal. The risks identified are more or less associated with the barriers for hydrogen availability, immature regulations in Australia for hydrogen in transport and the reluctance of investors to fully commit with the development of hydrogen buses in Victoria because it hasn't been done before. In summary the barriers to overcome are

Vehicle manufacturer commitment: the buses manufacturers in Australia are few only. Some of these companies are not high tech developers and none of them are allocating fund for RD&D. They are concentrated for the daily operation of their facility, placing their major efforts in the improvement and manufacturing of the existing products, mainly diesel buses.

To attract their interest it is necessary to offer subsidies and financial support from Victorian Government to those companies, in order to create business opportunities for them and expand their product range, so that they can smoothly enter to utilize the new technology, without interrupting their operations, acquiring skills for their employees and enabling the creation of jobs.

Cost competitiveness: Is an actual fact that the Hydrogen buses are more expensive than existing diesel buses. This is largely driven by the high cost of production and development of the hydrogen vehicles by big corporations imposing substantial margin to the final products, especially if they introduce the fuel cell vehicle first in a particular market niche.

This project proposal to develop the Hydrogen Fuel Cell Electric Buses in Victoria has the main purpose of decarbonise the Victorian transport system. This is an inexpensive solution to develop the Hydrogen buses in Victoria, there are not requirements of overhead expenses similar to those of large corporations, and the cost associated to the development of these three Hydrogen buses is very tight. It can be seen in the cost of development of **$4.35 million** there is no ambitious business opportunity, it is only driven by commitment to develop the first three FCEBs in Victoria.

At the same time, I am expecting the support of the Victoria Government and the commitment of industry partners for the project to be successful.

Hydrogen supply availability: this is not considered a major risk for the success of this project, but it is worth to mention that today there is not Hydrogen supply infrastructure in Victoria.

However, the development of the first 2 Hydrogen buses as it is mentioned before are not dependant of the hydrogen infrastructure availability. At the time the Hydrogen buses are complete, I expect some part of the hydrogen infrastructure will be developed.

9. COMMITMENT

This proposal submission to Victoria Government is a response to the Victorian Hydrogen Investment Program VHIP call for submissions and support to establish the hydrogen as a clean energy fuel. This proposal project has strong commitment to succeed. The author of

this submission is an expert in development of Electric buses, electric trucks and expert in Fuel Cell systems. This proposal is based on existing developments and existing designs of hydrogen buses waiting for the support for implementation. The author owns many Intellectual Properties (IP) for the development of electrical vehicles, therefore there are high chances of success.

The technology proposed here in this development project is enough to provide the first steps to the hydrogen transport system in Victoria.

This technology will be competitive, but in no way preclude or diminishes the options to purchase hydrogen buses from overseas suppliers. However this technology will be designed for Australian conditions and Victorian transport operations. Any hydrogen bus supplier from overseas will be matching this Victorian FCEBs requirements, because they will be tested and commissioned for Victoria state operations.

In the section of my experience and biography, there are extra information about defining electric buses requirements, such as the latest electrification transport system for Brisbane Metro project.

My commitment with Victoria state transport system and Australia is very strong, delivering excellence in Hydrogen buses to our community.

10. FINAL WORDS

This development proposal provides a plan and cost for the development of three FCEBs for Victoria public transport, they are ready of building and demonstration.

This submission paper is not a study or research publication.

For the development of FCEBs it is necessary to count with an extensive experience, high level of expertise and the corresponding funds investment. The technology to be delivered in these FCEBs has a level of maturity with very low uncertainties. Although hydrogen technology is a higher upfront capital cost at present, the Total Cost of Ownership (TCO) compared with diesel buses is forecast to be lower. This is also briefly appreciated in the section of cost that the Hydrogen Bus#3 becomes cost competitive. The TCO in the long run is low and it balances the upfront investment.

I am available any time for discussion, for presentations and meetings to explain in details the benefits to develop the Hydrogen Fuel Cell Electric Buses (FCEBs) in Victoria.

11. VICTORIAN HYDROGEN INVESTMENT PROGRAM

Question from VHIP paper Answered for hydrogen in transport

Summary of questions

These questions take into consideration what we have learnt from the request for industry submissions and the questions raised through the National Hydrogen Strategy Consultations

1. What are the greatest opportunities for investment and employment in hydrogen?

A: This proposal project submission should create greatest opportunities for investment and employment opportunities due to the development of Hydrogen Fuel Cell Electric Buses (FCEBs) in Victoria. Once the hydrogen becomes proved in the transport system in Victoria or Australia, the opportunities for investment from many sectors will be strong and very attractive for developers, heavy vehicles manufacturers and transport operators. This situates Victoria as the centre of hydrogen for transport.

2. What is Victoria's competitive advantage in relation to capitalising on an emerging hydrogen economy?

A: The Victoria's competitive advantage of decarbonisation of the transport system regarding the use of hydrogen as a source of energy for electric vehicles brings great benefits to the environment and opportunities to provide jobs and training to Victorians.
The introduction of Hydrogen Fuel Cell Electric Buses, which is the proposed submission will bring the following benefits:

- Jobs creation about the new technology
- Improvements of the air quality, noise and vibration reduction
- Training and skill program development in educational institutions
- OEM hydrogen system engagement for Victorian conditions
- Vehicles developed locally bring the revenues to the Australian economy
- Hydrogen buses developed locally will be the knowledge used for the future technology improvement
- Hydrogen buses will lead the heavy vehicle hydrogen transport infrastructure development
- Recommendations and inputs to the Australian and international regulations for hydrogen buses and heavy hydrogen vehicles in general.
- Investment opportunities for overseas interested parties in our technology
- Increment competition of hydrogen buses development Australia wide.
- Export opportunities of the Hydrogen Fuel Cell Electric Buses developed in Victoria
- Increased green hydrogen generation to be used locally in Australia

3. What lessons can Victoria learn from the global hydrogen agenda and international experience to date?

A: development of Hydrogen Fuel Cell Electric Buses (FCEBs) is in infancy state and few countries have programs of Hydrogen Buses development. The cost associated to these developments make the vehicles to double or triplicate the cost of a normal ICE diesel bus.
Victoria should learn from the international development of hydrogen buses high cost and slow applications so far. In Victoria and Australia there is sufficient knowledge, resources and skills available to make this proposal a reality and competitive.

4. Geographically, where are the most significant clusters for this investment, employment and production?

   A: Geographically Victoria is well positioned to develop the FCEBs because the expected green Hydrogen production in Victoria will grow exponentially in few years, making the Victoria state a prime place for the technology that utilises the hydrogen. The hydrogen produced in Victoria should be used primarily for cleaning the Victorian greenhouse gas emissions and provides revenues to the Victorian economy.

5. What are the skills and training requirements needed to grow Victoria's hydrogen industry?

   A: The present skills required in Victoria's hydrogen industry are already more or less developed. Example is the expertise of many engineers and scientists that worked for Ceramic Fuel Cells Ltd in Victoria in the past that are waiting for the opportunity to provide their skills to the Victoria's hydrogen industry if the opportunities exist. There is also a young generation of engineers and scientists that are in one way or another involved in the hydrogen technology, either by tertiary education, R&D or being working in connection with hydrogen and they are available.
   With particular interest in the production and development of Hydrogen Fuel Cell Electric Buses (FCEBs) the skills exist. The present submission itself answer this question. The indirect benefit of the project proposed in this submission is the uptake of extensive training on the technology of developing zero emission vehicles and in particular Hydrogen Fuel Cell Electric Buses (FCEBs). The training in hydrogen associated technology will be developed as part of the project programs.
   Example of training in development of electric buses was done by myself at Swinburne University of Technology at the time the Electric Bus E-Bus was developed and the MAI team went through an extensive training about the electric bus E-Bus developed for them. Please also refer to the section "My Experience" for more information on skills and training.

6. What are the challenges to developing a hydrogen economy in Victoria?

   A: The challenges to developing a hydrogen economy in Victoria regarding the development of Hydrogen Fuel Cell Electric Buses (FCEBs) for public transport are related on how to attract funds and investors interested to initiate a hydrogen buses program that is relatively new and uncertain for non-specialist individuals.

   The knowledge today is related to the integration of the technology to achieve the zero emission vehicles. However, this integration of technology for Hydrogen vehicles is considered low impact challenge from my perspective.

7. Who are the critical stakeholders needed to support a Victorian hydrogen economy?

   A: For the transport system zero emission vehicles in particular to develop Hydrogen Fuel Cell Electric Buses (FCEBs) in Victoria, the stakeholders are those that come from the transport sector, such as buses manufacturers, vehicles developers and in

general investors that provide financial contribution to projects like the one is proposed here in this submission.
The prospect of hydrogen economy developing the Hydrogen Fuel Cell Electric Buses (FCEBs) is promising for Victoria. Despite of that, my primary objective is to provide clean transportation system in the near future and the utilization of hydrogen system will enable the public transport system to be sustainable, not limited by the energy range of the vehicles. This will create thousands of job and skills development for the Victorian economy.
From an industry perspective, however, the development of hydrogen FCEBs will need to be incentivised by government policy.

8. What does a supportive regulatory environment for a sustainable hydrogen industry look like?

A: In my opinion there must be a Victorian Government commitment to incentivise the development of the hydrogen FCEBs in Victoria. The incentive will be backed up of policies and regulatory working group administering the overall hydrogen buses program to ultimate replace the fossil fuel vehicles for public transport.
The Victoria Government should develop policies and regulations helping buses operators to introduce clean technology in their fleets.

9. Are there barriers to achieving a social licence for hydrogen to operate? What does the Victorian Government need to consider in addressing these?

A: Certainly there are some barriers to achieve the social licence for Hydrogen Fuel Cell Electric Buses (FCEBs). However, with education programs and demonstration showing that the hydrogen vehicles are not much different, they are safe to operate. Then the public transport system operators will accept the challenge of introducing new technology.
The hydrogen buses will be operating under vehicle regulations, under the existing regulations targeting the safety of ICE buses and regulations that are pertaining to the hydrogen system.
Today there is also improvements of international regulations to target the safety of vehicles using battery system, hydrogen or other sources of energy.

10. What role can hydrogen play in Victoria's energy system into the future? Are there limits to the role hydrogen can play in Victoria's energy mix?

A: Question not directly related to transport system. But this proposal of Hydrogen Fuel Cell Electric Vehicle development does not consider hydrogen mix.

11. What does the Victorian Government need to consider attracting investment in the hydrogen supply chain in Victoria?

A: Hydrogen supply for transport system is important issue to discuss in conjunction with a program for hydrogen buses introduction in to the Victorian transport operation. This topic needs to be discussed extensible. However, this submission document does not elaborate the hydrogen supply and refuelling systems because

the development of the first two Hydrogen Fuel Cell Electric Buses are using prefilled hydrogen bottle system at the first stage. Once the technology is demonstrated the introduction of the hydrogen refuelling tanks will be incorporated.

12. What is the best way for the Victorian Government to support hydrogen R&D, pilot projects and demonstrations? Are there any we should prioritise?

A: The transport system based on hydrogen vehicles is the ultimate vision of people from all sort of life and from many specialists like me. This present paper submission is the basic information to develop Hydrogen Fuel Cell Electric Buses (FCEBs) in Victoria. This proposal includes the hydrogen Research Development and Demonstration (RD&D), pilot hydrogen buses and expert project management of manufacturing hydrogen buses. The present submission targets the public transport system made by buses. However, this proposal can be extendable beyond the public transport and develop hydrogen buses and hydrogen vehicles for other sectors, such as private buses, local school buses, goods vehicles up to certain tonnage.
The Victoria Government is in front of a priority proposal that requires full support and it needs to be prioritised. The sooner the development starts the sooner we will see the zero emission transport benefit for the environment and for the community.

13. What possible uses for hydrogen offer greatest benefit to Victoria?

A: The main benefits for Victoria and Australia with the hydrogen vehicles development in our country, for our conditions and to suit our operational requirements brings enormous benefits to the economy and the environment. The benefits of having zero emission public buses for Victoria and Australia will improve the lifestyle of all Australians.
There are many studies showing that public transport made of clean vehicles will reduce the greenhouse gas emissions in the cities beyond the figures already stipulated (approximately 18%) . On the other hand the extension of the public transport is a need for the cities due to the growth of population. The program of introducing zero emission vehicles is urgent.

14. What is the level of hydrogen transport infrastructure needed in Victoria and where are the priority areas for infrastructure and Victorian Government policy (e.g. procurement)?

A: The hydrogen transport infrastructure is a very important program to develop and discuss extensively with all transport sectors. Victorian Government must set a working group that will organise and facilitate the discussions of the hydrogen transport infrastructure proposals.
The hydrogen transport infrastructure will supply hydrogen to an enormous amount of different vehicles, such as buses, minibuses, passenger cars, motorcycles, trucks and special vehicles. In my opinion is not a simple measure of procurement of technology or systems, it is more about rules and regulations for the technology that suits our needs in Victoria.
The hydrogen transport infrastructure will be defined and segregated by sectors and regions. The Victorian Government should take control of the requirements,

regulations and development of the hydrogen transport infrastructure rather to leave the infrastructure development to the fuel companies.
This proposal of Hydrogen Buses development does not include the proposal and recommendations for the hydrogen transport infrastructure, because the Hydrogen buses in this project proposal are based on hydrogen gas preloaded in tanks/bottles that already Australian gas companies deliver until the hydrogen supply infrastructure for transport is developed.
Equally, at the time when the public transport system will introduce hydrogen buses it will be a set of pilot vehicles for certain time and a refuelling system can be established for these reduced fleet of vehicles in particular routes until the technology is fully adopted and deployed.

15. What are the considerations for business and consumers in purchasing a new type of vehicle, such as hydrogen or battery electric vehicle?

A: Being an expert in electric vehicles and expert in fuel cell system, I can read many opinions about this topic that needs clarification.
The electric vehicles based on purely battery system (BEV) are dependable of the battery energy only. The battery chemistry dictates the capacity of energy density and ultimately the range of a vehicle can have with 1 charge.
The battery vehicles are mainly based on lithium ion batteries with different chemistry around the lithium. The developers of battery cells are constantly improving the technology. There is a high competition in order to develop battery cells with higher energy density. Consequently, the battery systems are extending the range of a vehicle slowly due to new battery cell energy density and dropping the cost too.
Hydrogen vehicles are not better developed than the BEV vehicles today, because the fuel cell systems (mainly PEM fuel cell) are not a technology that is cost effective to implement in a vehicle. On the other hand the fuel cell engines requires certain specialised installation that makes them complex in comparison with purely battery system vehicle.
In my opinion there is not hydrogen vehicle, especially heavy vehicles and buses (which is my expertise) that are running purely with hydrogen. It is a misconception to think that purely hydrogen will move a vehicle in the same way that is doing an ICE engine vehicle. All hydrogen vehicles are electric vehicles and use either battery, supercapacitors or a combination of both. Fuel cell engine generate electricity that it needs to be stored in order to minimize the loses of electricity generation and utilization.
The considerations today for businesses using electric buses reside in their operations, for instant businesses with requirements of operation up to 200 km a day the battery electric vehicle is a cost effective solution, especially if they have the idle spare hours to charge the vehicle during nigh time or at rest.
The hydrogen vehicle will provide extended range per hydrogen tank. Bus operators that required extensive long-haul and many kilometres per day operation the hydrogen vehicle could be a solution. However, in Australia we have no hydrogen fuelling infrastructure today to forecast the range of the hydrogen buses can achieve. This proposal submission estimate the FCEBs can reach 400 km per hydrogen tank. There could be some businesses that invest in a refuelling dedicated system for their own fleet of hydrogen vehicles.

Once the refuelling system infrastructure is deployed the fuel cell vehicles will be much optimal to cover longer ranges.

16. Other than cost and technology barriers, what factors help current and potential users of hydrogen in commercial and industrial settings decide how to procure hydrogen? How could the Victorian Government assist commercial and industrial businesses switch to green hydrogen for chemical feedstock and/or heating?

A: N/A, not transport system related

17. What other issues does the Victorian Government need to consider in developing an Industry Development Plan?

A: As indicated before, Victorian Government should form working groups made of knowledgeable teams covering all different areas of hydrogen development projects These areas are already identified by the VHIP program and the Australian National Hydrogen Strategy, such as Mobility, Heating, Electricity Generation, Feedstock, off-grid, back up generation, storage and transport, export, pipelines, etc.
The Victorian Government has to invite publicly to the experts in Victoria to be part of the working groups in order to initiate the rapid development of technology, systems to utilise the hydrogen for the benefits of Victorian.

12. BIOGRAPHY - MY EXPERIENCE

Arnaldo Sanchez B. Eng.(Electrical), MEng (CIM), MIEAust CPEng

My comprehensive professional experience is over 35 years for different industries, mainly I was part of industries that led me to the green energy development with strong expertise in technology either as a senior engineer, manager or consultant. I have worked for industries in automotive, transport, railway, fuel cells, industrial, research and development.

I am expert in Electric Vehicles design, development, manufacturing, testing, regulations, homologation and consultancy.

Expert in Fuel Cell system design, development, integration with grid connected system, regulations and safety system.

Expert in hydrogen for fuel cell safety system and control system for safe operation of fuel cell system.

Expert in electrical, electronic and control systems.

Expert in vehicle testing and testing systems for automotive, heavy transportation and railway.

My extensive professional history included positions in reputable companies holding high technical rank to develop systems that formed part of the main milestones of the companies. The following companies contributed to my background in hydrogen fuel cell and electric vehicles.

TS Engineering Consulting

Senior engineering consultant for heavy electric vehicles, electric vehicles infrastructure, charging systems, electric vehicles homologation, testing under Australian Design Rules ADR. Electric vehicles international standards and Australian standard applications.

I am the senior consultant and advisor for the Brisbane Metro project managed by Brisbane City Council BCC responsible for writing the technical requirements of the Electric buses that forms the document for tender, reviewing tenderer submissions, analysis of the high power charging infrastructure, definition of layouts for the depot/garage to allow the service, maintenance and to fast and slow charge 60 bi-articulated electric buses. Additionally provide educational presentations to a diverse BCC teams about electric buses safety, on board battery system and EV technology applicable to Brisbane Metro project vehicles.

SEA Electric – Electric Trucks developer

As Engineering Manager at SEA Electric I was responsible for a team of 11 engineers developing electric trucks in Victoria for Australia and international markets. The BEV trucks were well accepted by local government councils because of zero emission transport for truck companies and logistics operators.

Swinburne University of Technology

I was the technical leader of the International Electric bus E-Bus project to design and develop a standard 12.5 m electric bus for Malaysia Automotive Institute MAI.

I’ve led a team of experts to successfully design and build the International Electric bus E-Bus on time and on budget, including the development of the first Rechargeable Energy Storage System RESS for transport in Australia. The submission of the E-Bus to MAI included extensive training to MAI teams as part of the knowledge transfer stage.

General Motor Holden

Among my responsibilities at GM Holden I was in charge of the electric vehicle VOLT technical training, the setup of the maintenance facility for the companies’ fleet electric vehicles that GM Holden introduced in Australia.

The modernization of the engine test lab and wind tunnel was under my technical responsibility during my 11 years tenure at GM Holden.

Ceramic Fuel Cells Ltd/ CSIRO

I was the electrical project leader to develop almost all hydrogen fuel cell system and testing rigs of the company during 10 years tenure. My expertise is to detailed design the fuel cell systems, integration and commissioning.

Ceramic Fuel Cells Ltd and CSIRO fuel cell program was supported by the systems developed in house to investigate, test and evaluate the development of fuel cell technology using hydrogen and natural gas.

During this time I developed more than 40 type of fuel cell systems, highlighting the development of the main milestone of CFCL a fuel cell system of 25 kW energy generation running on hydrogen.

12.1 Relevant projects of Electric vehicles and Hydrogen Fuel Cells

The following examples are brief information on projects and work done in fuel cell and electric vehicles during my professional activity for over 30 years period.

2018- Onwards - TS Engineering Consulting - Electric Vehicle Senior Consultant

Project: Brisbane Metro project – Brisbane City Council
The Brisbane City Council Metro project is a sustainable transport project using high-capacity battery electric buses BEV running along dedicated busways divided in two Metro lines. Metro 1 line and Metro 2 line comprise 18 stations with 5 stations common to both lines. The expected cost of the Brisbane Metro project is fully-funded with a budget of A$944 million with contribution of A$300 million from Australian Federal Budget. The Brisbane Metro project includes the delivery of 60 bi-articulated electric buses, the charging infrastructure system, civil engineering for new and updated busways stations and design and build the new depot and maintenance facility for the high technology electric buses.

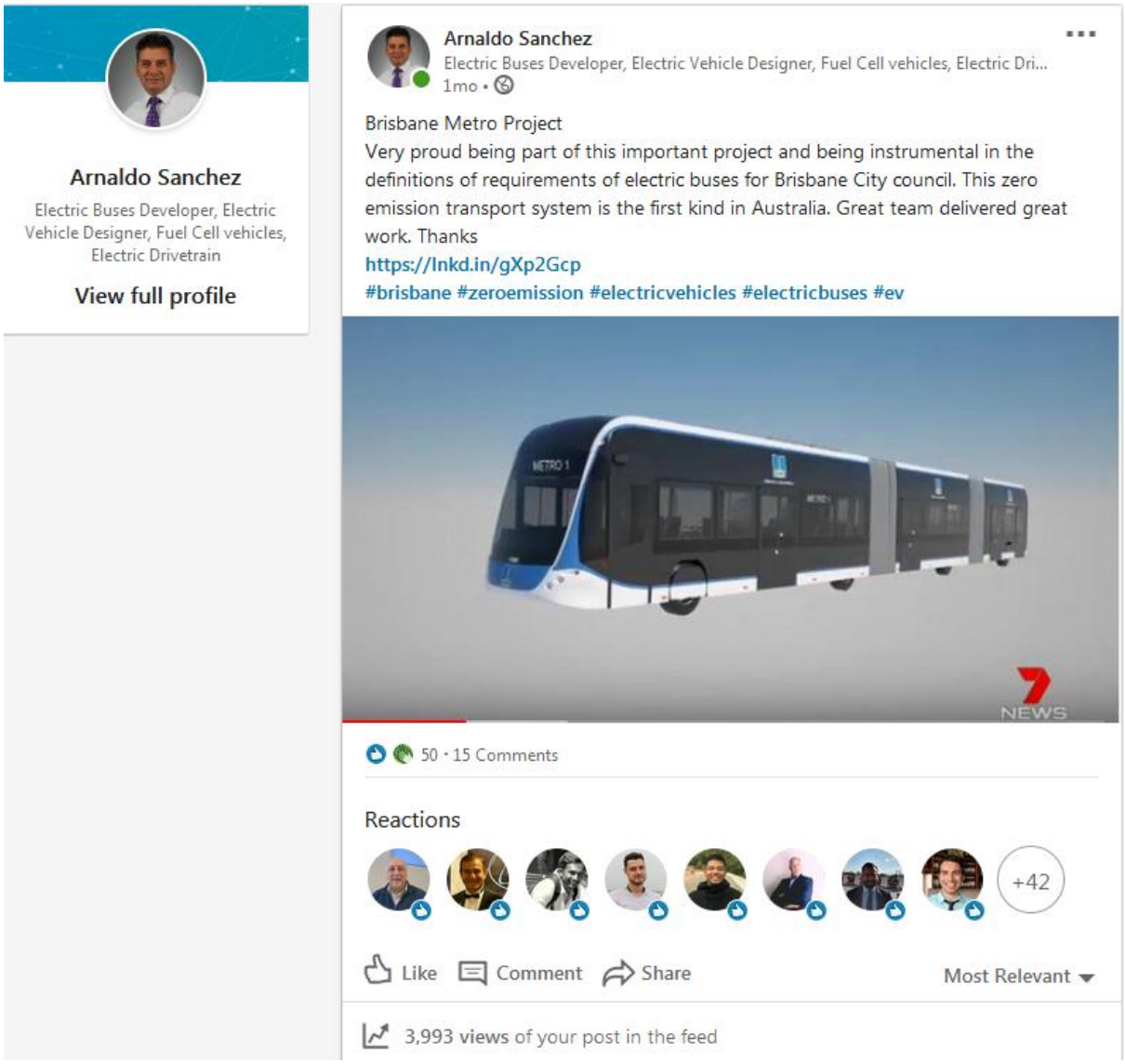
My involvement in this great project is extensive: writing and defining the technical requirements for the battery electric buses, revision of the tenderer's submissions, participate in the interactive technical workshop with the short listed tenderers, revision of the charging infrastructure specifications, verification of proposed BEV energy consumption and simulations, definition of requirements for the new depot and maintenance facility, studies provided to BCC on battery safety, electric vehicle safety and regulations, EV technology, electrical substations requirements, maintenance of electric vehicles and telematics.

Brisbane Metro project links

https://www.brisbane.qld.gov.au/traffic-and-transport/public-transport/brisbane-metro/brisbane-metro-vehicle

https://www.linkedin.com/posts/arnaldo-sanchez-5542b0110_brisbane-zeroemission-electricvehicles-activity-6604687967082676224-QaJu/

https://m.youtube.com/watch?v=2wUZaKkmWgo&feature=youtu.be



2018 SEA Electric – Engineering Manager
Specifically for the design and manufacturing of electric trucks I managed micro projects to:

- Improve the high voltage technology of the electric trucks
- Improves battery modules safety by providing requirements to OEM supplier
- Safety training to the company personnel engineers and technicians in contact with the battery system
- Analysis and test of data from test and customers feedbacks
- Homologation and ADR scrutiny for the electric trucks with consultant

2015-2017 Swinburne University of Technology – Technical Manager

- International Electric Bus E-Bus development project

The project was a collaboration agreement among Malaysia Automotive Institute MAI, Auto CRC Australia and Swinburne University of Technology, it was funded by MAI.

I managed a team of engineers to design, develop and build a standard size city bus of 12.5m. The E-Bus was a battery electric bus BEV, utilising a chassis frame and bus body made in Australia. The E-Bus was built and commissioned in Australia, then shipped it to Malaysia. MAI's used this E-Bus to further develop zero emission buses with their local vehicle manufacturers.

The project of the E-Bus was the first electric bus designed and built in Australia, it was successful project attracting many accolades. The picture on the right below shows the industry partners in Kuala Lumpur welcoming the first electric bus for Malaysia with high expectations, during the knowledge transfer and training process for the MAI teams.

- A second project for the engineering design collaboration to develop an electric bus ZDi of 10 m length belonging to Bustech. This electric bus ZDi was presented in the bus show Melbourne 2015. This was a subproject of the International E-Bus project.

2014 CSIRO – Centre for Hybrid Energy Systems (CHES) in Clayton, Victoria

Project of energy integration in the Centre for Hybrid Energy System (CHES) CSIRO in Clayton. The work aimed to have a system that allow CSIRO demonstrates to stakeholders and visitors multiple options of green energy connectivity, from hydrogen generation, fuel cells electricity generation and exporting to the grid. The CHES is a green energy centre which integrates a variety of hydrogen fuel cells, electrolysers for hydrogen generation, rechargeable energy storage units and solar power generation.

This project automate the electrical energy connectivity, allowing the scientists to evaluate proposed options of green energy. The CHES is an energy centre for simulations, research and development. The CHES centre is a scalable model, able to be replicated as a large green energy system using hydrogen, solar and fuel cells.

2012-2014 GM Holden - Electric Vehicle VOLT training and maintenance facility

One of the important tasks carried out at GM Holden, was the training of technical team in regards of the new electric vehicle technology. Also included the establishment of the training program and the maintenance facility for the EV VOLT when Holden introduced this Extended Range Electric Vehicle EREV in Australia. The maintenance facility was able to support about 40 EREV VOLTs being part of the Holden's first fleet.

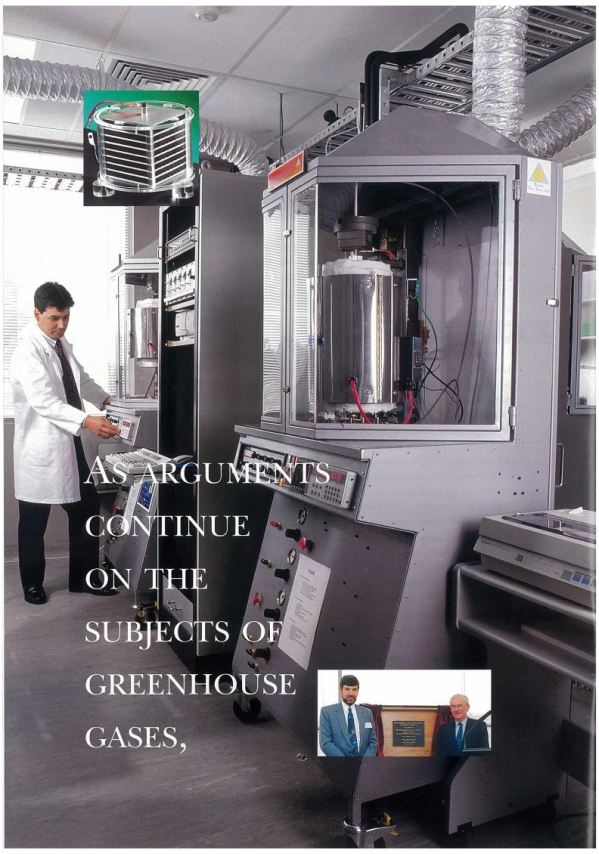
1993-2002 Ceramic Fuel Cell Ltd – CSIRO

Projects of Fuel Cell Systems design, development and building

During 10 years at Ceramic Fuel Cell Ltd CFCL/CSIRO I have developed fuel cell systems and test stations to evaluate SOFC and PEMFC fuel cells, such systems are more than 30 test stations, characterisation rigs and state of concept systems.

Being proud of leading a team of dedicated electrical experts to achieve the main milestone of CFCL, the SOFC fuel cell system Genesys capable to generate 25 kW of electricity and exported to the grid.

At the same level I have designed and developed many Proton-exchange Membrane Fuel Cell PEMFC systems for CSIRO fuel cell program. Almost all these systems are still in use at SCIRO in Clayton, Victoria.



Last but not the least, I have extensive experience in railway and transportation.

I am active presenter speaker of Electric Vehicles at the EV Expo in Melbourne every year.

13. REFERENCES

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[4] Design and development of electric bus XDiE for Malaysia Automotive Institute. A Sanchez 2017

[5] Engineering design of electric show bus ZDi. A Sanchez 2015

[6] Design and Manufacture of an Electric Bus (Draft book). A Sanchez, D Bilston, L de Vries, A Kapoor, H Mazumder, 2017