

# Future Wellington Zero Emissions Transport Fleet in Jeopardy?

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## Summary

This document outlines an urgent impending bump on the road towards a zero-emissions transport fleet and related health issues within Wellington City. In motion charging (IMC) presents Wellington with a unique opportunity to be a world leader in a cost effective zero emissions electric public transport system. Urgent action (preferably by 31/10/17) is required by the incoming government to halt removal of critical sections of trolley overhead and loss of associated substations which could be used to support current zero emission bus operation & light rail in the future.

## Greater Wellington Regional Council (GWRC) Goal

Their stated goal is to move towards modern hybrids, followed by the introduction of 32 battery electric buses. (1) Is this goal the most cost effective or technically feasible for Wellington's hilly terrain? Is it the fastest route to introducing an all-electric fleet? Or is a combination of fully battery and IMC buses more appropriate for use through the constrained Golden Mile and over hilly terrain?

## Worldwide Experience with Battery Buses on Hilly Terrain

### Prague - Czech Republic

#### The Problem

The Prague Transport Company (DPP) has been testing various battery buses since 2010 and by early this year had collected at least 140,000kms of performance data on their latest model. The conclusion reached is...

*"hilly terrain uses up a lot of battery power, and limits the usefulness of electric buses." (2)*

## Prague's Solution

Although Prague has not used trolleys for around 45 years, recently they commenced testing a new type of system that combines the best of battery and trolley buses. The new technology is known as in motion charging (IMC). The bus features high capacity batteries and has poles which automatically wire and de-wire. The trolley overhead only extends 1km over a hilly section of the approximately 10km bus route, along with ability to charge at the terminus.

The new system opened on 15 October 2017, with several additional hilly routes possible depending on the outcome of these tests.

There are various online YouTube video clips providing a good overview of the route topography which appears quite like parts of Wellington or Dunedin. Clips from opening day feature battery electric bus (SO RNS 12), trolley / battery hybrid (SOR TNB 12) and a nostalgic trolley (Tatra T400).  
(3) (4) (5) (6)

## San Francisco

The SFMTA Municipal Transport Agency has also been testing electric battery buses. In September 2017, John Haley Director of SFMTA Transit Operations stated ...

*“it is factually incorrect and irresponsible to suggest that anyone knows that off-wire electric buses are ready to operate in San Francisco.” (7)*

## New Technologies for an Old Work Horse

The ground-breaking technology in Prague's solution is combining high capacity batteries with automatic pole wiring and de-wiring. The batteries charge while the bus is in motion and can also be charged while stationary at a terminus. The length of overhead require will typically vary between 10-50% of the route depending on a range of factors including climate, topography, passenger numbers etc. The batteries differ from those currently used in the Wellington fleet in that they are high capacity batteries designed for everyday use, rather than emergency use.

Together these technologies are known as Trolley / Battery Hybrids and feature In Motion or Dynamic Charging. (8) The label 'Extended Range Trolley Systems' or 'SlideIn' is also sometimes used. IMC (In Motion Charging) will be the term used for the remainder of this document.

Several other cities around the world are now embracing this technology. It can radically transform existing trolley operations too. Dayton, USA has been trialling this system for several years. In October 2017 they have committed to buying a fleet of IMC buses as they have the flexibility to be routed to any area without extension of overhead. They have been unimpressed with hybrids (proposed by NZ Bus) which they previously purchased. (9)

Both Seattle and San Francisco have recently purchased a total of 452 IMC buses, these forming one of the largest procurements of zero emission buses in North America to date. As of August 2017, Kiepe Electric have supplied 580 IMC bus systems now in revenue service, with a further 264 on order. (10) Other companies are also producing IMC buses and / or hardware.

*“For electric buses, IMC is seen as the most economical technology for high capacity lines (frequent service, high capacity vehicles) or lines with a high energy demand. Therefore, IMC is seen as an essential part of an electrification strategy for urban transport.” (11)*

This is likely to be the best option for Wellington with its hilly terrain and high capacity Golden Mile route. As this is a constrained route, shouldn't the most effective solution be employed, rather than displacing passengers with large loads of batteries?

IMC was not considered by GWRC when evaluating different fleet configurations (12). The technology would have been in its infancy when different fleet configurations were evaluated in 2014. As trials of this technology have progressed quickly leading to adoptions of this system, urgent consideration of this configuration should be taken now.

## IMC – Trolley / Battery Bus Combo

As IMC combines the best of traditional trolley and battery bus fleets, it is an exceptional system.

(13) Advantages include: -

- Low noise to foster urban growth and a liveable city
- Zero emissions, except at the generation source.
- Synergies allow for easier introduction of other electrically powered public or private vehicles.
- Synergies drive down prices for all modes of electrically powered vehicles, by leveraging off existing DC substations.
- Buses have a large degree of route flexibility
- Overhead costs can be reduced by up to 90% or more.
- Speed is increased as buses do not need to slow for 'special work' at intersections or curves / roundabouts. These can simply be removed, which also minimises visual pollution.
- Problems with pole de-wiring is significantly reduced and now under automatic or push of the button control.
- Large reduction in number of substations and associated DC cabling required to cover a given route.
- More efficient use of fleet compared to opportunity battery bus systems which require a specific charging time at the end of each run.
- Due to lighter battery requirements, the bus may have more passengers for a given vehicle weight. Opportunity or overnight charging systems require larger and heavier batteries. This is a critical factor for efficient use of the constrained 'Golden Mile'.

## Addressing the Negatives

### Substations & Strategic Value

One argument is that there is a large capital investment required in Wellington substations and associated cabling. Prices have been given from approximately 5 – 50 million, with a lot more detail being apparent at the lower costing. (14) However, what seems to have been ignored by local government is the strategic value of the 15 substations and associated DC cabling. Overseas such an asset could be utilised among light rail, trolley, and public EV charging facilities. So, the cost becomes shared among multiple users and systems.

In a long-term PPP arrangement, the power company could be willing to pay the capital cost, while charging a fixed rate + per unit rate / month. As the life time of electrical distribution equipment tends to be up to 30 – 50 years, the fixed rate per year could be relatively low.

If the trolley system is decommissioned (God forbid!), the power company could potentially sell the substations and associated land. Is the new government going to be happy for the private power company to sell the substations and associated land (especially as these assets may have been 'gifted' in the first place)?

Or would it be better for the incoming and local government to recognise the strategic value of the substations etc. for not only trolleys / IMC, but also light rail, battery bus charging and / or public EV charging facilities in the future? As such, a commitment to trolleys or IMC at this point would be the best way to secure these strategic sites now.

### Inflexible Routes

This criticism is largely gone with IMC as only a portion of the route needs overhead. In the Wellington scenario, perhaps overhead is only required within the downtown area and on hilly sections. Potentially that means the route can be extended or changed more easily than a system using opportunity charging.

In an opportunity charging system, the terminus location is fixed. So, if the route is redesigned and the terminus needs to move, the cost to move equipment and associated power supply could be considerable, not to mention resource consent maybe required.

## Visual Pollution

Vastly reduced as per the reason given above. In addition, generally you can selectively choose to remove overhead from 'sensitive sites'.

## High Overhead Maintenance Costs

With IMC, high overhead maintenance costs are a thing of the past as length and complexity are significantly reduced. Due to increased flexibility, more routes can operate under the same overhead, further reducing the cost per passenger.

## Slow Speed

Traditional trolleys may need to slow when going through intersections, 'special work', roundabouts or corners. The solution with IMC is simply to remove the overhead from the offending section.

## Health Issues

Under the current proposals from 1/11/17, Wellington city will be flooded with diesel buses. Studies into the effects of diesel fumes have concluded they are carcinogenic and can lead to poor health outcomes.

In Wellington we have a very confined Golden Mile corridor which in certain weather conditions leads to a concentration of diesel fumes (even with trolleys in service). From 1/11/17, the concentration of diesel fumes could be expected to rise if this route is dieselised. Furthermore, the Karori, Seatoun and Hataitai bus tunnels will have a higher concentration of diesel buses on a sustained basis.

I did once ask GWRC if a study had been done measuring particulate levels along the Golden Mile. Apparently, a study had never been carried out, although overseas studies suggest levels along such a corridor can be problematic, not to mention the effects of running diesels frequently through unvented tunnels.

Perhaps it would be best to halt the destruction of our current trolley system while a study is carried out into the effects of diesel fumes within the Golden Mile and tunnels. The incoming Government wishes to have better health outcomes, so this would be one way to potentially improve the long-term health of many Wellingtonians.

Although the current plan is to move to battery buses, this does not occur for many years. If our test results are similar to Prague, Wellington could be stuck with emission causing buses on at least some routes for ever. Keeping existing trolley overhead and buses (or retrofitting with IMC) for the meantime would mitigate against this risk in the future.

## Recommendations

1. Use the \$11 million allocated for overhead removal to immediately upgrade a limited number of substations & any essential protection circuitry required for IMC operation along the NZ Bus routes (Karori – Seatoun route at least). The upgrade would include transformers for 600 – 750V DC operation to enable compatibility with potential future light rail operation and to purchase off the shelf IMC bus technology.
2. Instead of fitting Wrightspeed power trains to existing trolley fleet, fit IMC technology. This should be still possible as NZ Bus have not yet accepted Wrightspeed prototypes or converted the fleet. (15)
3. As existing trolleys are retro-fitted with IMC technology begin to use them over at least the Karori – Seatoun route.
4. Additional IMC buses could be introduced if experience demonstrates that this technology is superior in the Wellington context.
5. Depending on outcome of Let's Get Welly Moving study, introduce light rail leveraging off the upgraded substations. This would reduce OPEX for both systems, while potentially substantially reducing CAPEX costs for light rail.

## References

1. **Wellington, Greater.** Wellington Regional Public Transport Plan. [Online] 2014. [Cited: 25 October 2017.] <http://www.gw.govt.nz/assets/Transport/Regional-transport/RPTP/WGNDOCS-1386111-v1-FinalRPTPdocWEBversion.PDF>.
2. **Johnson, Raymond.** Electric Trolleybuses Being Tested in Prosek. *Prague.TV*. [Online] 5 August 2017. [Cited: 25 October 2017.] <https://prague.tv/en/s72/Directory/c207-Travel/n10412-Electric-trolleybuses-being-tested-in-Prosek>.
3. **MhdVideo.** Návrat trolejbusů do Prahy - Prosecká ul. (15.10.2017) - 4K video. *YouTube*. [Online] 15 October 2017. [Cited: 29 October 2017.] <https://www.youtube.com/watch?v=Er7Zc3OmsXE>.
4. **Tichavsky, Jan.** Zahájení zkušebních jízd trolejbusů a elektrobusu v Prosecké ulici v Praze. *YouTube*. [Online] 17 October 2017. [Cited: 27 October 2017.] <https://www.youtube.com/watch?v=0bSX4Gh2Cc8>.
5. **Biron Gaming.** Návrat trolejbusů do pražské MHD | Projížďka v SOR TNB 12 / SOR NS 12 / Tatra T400. *YouTube*. [Online] 15 October 2017. [Cited: 25 October 2017.] <https://www.youtube.com/watch?v=gwiOqyVw2ek>.
6. **Ledovy Kocour.** Autobus/Trolejbus! Návrat trolejbusů do Prahy! *YouTube*. [Online] 15 October 2017. [Cited: 29 October 2017.] <https://www.youtube.com/watch?v=Mt8-KQWlaPI>.
7. **John Haley - Director of SFMTA Transit Operations.** Letters: Focus should be on making Muni service better. *San Francisco Examiner*. [Online] 17 September 2017. [Cited: 28 October 2017.] <http://www.sfexaminer.com/letters-focus-making-muni-service-better/>.
8. **Kiepe Electric.** In Motion Charging (IMC): Vossloh Kiepe Leads Cross Border Project, Setting the Pathway of Battery-Bus-Fleets. *Kiepe Electric*. [Online] July 2016. [Cited: 26 October 2017.] <http://www.kiepe.knorr-bremse.com/news/press-releases/in-motion-charging-imc-vossloh-kiepe-leads-cross-border-project-setting-the-pathway-of-battery-bus-fleets>.
9. **My Dayton Daily News.** RTA to buy 26 NexGen electric trolley buses — at \$1.2 million each. [Online] 19 October 2017. [Cited: 27 October 2017.] <http://www.mydaytondailynews.com/news/local/rta-buy-electric-trolley-buses-million-each/sfKZdDO1p6ijxmleUVBP2J/>.

10. **Electric, Kiepe.** Kiepe Electric to Supply 185 Systems for San Francisco. *Mass Transit*. [Online] 4 August 2017. [Cited: 27 October 2017.]  
[http://www.masstransitmag.com/press\\_release/12357185/imc-electric-buses-on-trend-in-the-usa-kiepe-electric-to-supply-185-systems-for-san-francisco](http://www.masstransitmag.com/press_release/12357185/imc-electric-buses-on-trend-in-the-usa-kiepe-electric-to-supply-185-systems-for-san-francisco).
11. **Fabian Bergk et Al.** Potential of In-Motion Charging Buses for the Electrification of Urban Bus Routes. *ScienPress Ltd*. [Online] 2016. [Cited: 28 October 2017.]  
[http://www.sciencpress.com/Upload/GEO/Vol%206\\_4\\_21.pdf](http://www.sciencpress.com/Upload/GEO/Vol%206_4_21.pdf).
12. **PWC.** Evaluating the Impact of Different Bus Fleet Configurations. *Greater Wellington*. [Online] April 2014. [Cited: 25 October 2017.] <http://www.gw.govt.nz/assets/Transport/Regional-transport/RPTP/GWRC-Bus-Fleet-Configurations-Final-version.pdf>.
13. **Steiner, Daniel.** Trolley Roadmap - Industry Perspective on Ebus Future. *Trolley Project*. [Online] 12 March 2013. [Cited: 25 October 2017.] [http://www.trolley-project.eu/fileadmin/user\\_upload/download/TROLLEY\\_Workshop\\_Brussels/8\\_TROLLEY\\_Roadmap\\_Event\\_Brussels\\_Presentation\\_Steiner\\_TM.pdf](http://www.trolley-project.eu/fileadmin/user_upload/download/TROLLEY_Workshop_Brussels/8_TROLLEY_Roadmap_Event_Brussels_Presentation_Steiner_TM.pdf).
14. **Neilson, Allan.** Independent Technical Analysis of the Wellington Trolleybus Electrical Infrastructure. *Scoop*. [Online] 14 Decemeber 2015. [Cited: 28 October 2017.]  
[http://img.scoop.co.nz/media/pdfs/1512/Wgtn\\_trolley\\_bus\\_electrical\\_infrastructure\\_review\\_A\\_Neilson\\_draft\\_1412...2.pdf](http://img.scoop.co.nz/media/pdfs/1512/Wgtn_trolley_bus_electrical_infrastructure_review_A_Neilson_draft_1412...2.pdf).
15. **Bruce, Paul.** Paul Bruce: Retaining the trolley buses – not too late for a rethink. *Stuff*. [Online] 15 August 2017. [Cited: 29 October 2017.] <https://www.stuff.co.nz/dominion-post/comment/95728286/paul-bruce-retaining-the-trolley-buses--not-too-late-for-a-rethink>.
16. **Johnson, Raymond.** Trolley-bus-starts-testing. *Prague.TV*. [Online] 15 October 2017. [Cited: 25 October 2017.] <https://prague.tv/en/s72/Directory/c207-Travel/n11188-Trolley-bus-starts-testing>.
17. **Transport Company of the Capital City of Prague.** DPP Launched the Trial Operation of an Electric-powered Bus with Dynamic Recharging. [Online] 19 October 2017. [Cited: 15 October 2017.]  
<http://www.dpp.cz/en/dpp-launched-the-trial-operation-of-an-electric-powered-bus-with-dynamic-recharging-return-of-trolleybuses-to-prague-45-years-later/>.
18. **Kiepe Electric.** In Motion Charging (IMC®)-Buses (In Motion Charging). [Online] [Cited: 27 October 2017.] <http://www.kiepe.knorr-bremse.com/electric-buses/trolleybuses>.