North Island Rail Decarbonisation Peer Review Report

Final (amended following release of updated IBC)
May 2024

Disclaimer

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Executive Summary

The ask

WSP have been commissioned by KiwiRail to provide a peer review of the “Report on the Decarbonisation of New Zealand’s Freight Railway” (KiwiRail, May 2023, and updated in May 2024) which sets out the arguments and investment justification for a preferred strategy to decarbonise KiwiRail’s freight operations. The peer review has been done in the context of other KiwiRail studies which are either inputs to the strategy or relate to it in material ways. These are as follows:

- North Island Electrification Study (Beca/Systra, May 2021)
- Wellington Network Capacity Constraints Study (KiwiRail, Mar 2023)
- Waikanae - Otaki - Levin Service Summary Paper (KiwiRail, Dec 2022)

The results of the peer review are presented in this document and include assessment of the individual elements of the preferred strategy as well as identifying recommendations to inform next phases of work.

Unless stated otherwise, references to the “the report” in this document are specifically regarding the “Report on the Decarbonisation of New Zealand’s Freight Railway”. Where commentary on the other reports is provided, these are made with clear reference to the specific report in question.

May 2024

Executive Summary

WSP have been commissioned by KiwiRail to provide a peer review of the “Report on the Decarbonisation of New Zealand’s Freight Railway” (KiwiRail, May 2023 and updated in May 2024) which sets out the arguments and investment justification for a preferred strategy to decarbonise KiwiRail’s freight operations. The report was written in response to New Zealand’s legislated climate change reduction targets. KiwiRail’s report was prepared using the Treasury Indicative Business Case (IBC) framework. A number of operational, technical and financial specialists were used by KiwiRail to prepare the IBC.

The summary of the key decarbonisation IBC recommendations are:

- Extend the existing 25kV Overhead Line Electrification (OLE) network to provide complete coverage of the Auckland – Hamilton –Tauranga and Palmerston North routes and enable operation by existing and new conventional electric locomotives. The target to complete this OLE extension is by 2030.
- Advance and gain experience with battery electric locomotive operations through more detailed feasibility studies and pilot trials, including use of mixed consist operations. This will help prove that battery electric locomotives are viable for helping KiwiRail efficiently decarbonise further from 2030.
- Continue progress to introduce a new build fleet of diesel locomotives of the highest efficiency and performance for non-OLE routes until they are progressively replaced by zero GHG emission locomotive options from the decade starting 2030.
- Advance the above recommendations methodically and, before each level of commitment, be prepared to adjust the methods of decarbonisation should better options become technically and operationally viable.

WSP have concluded that the preferred strategy as argued in the report is sound and creates a robust and defensible platform to decarbonise KiwiRail’s freight operations. The strategy balances the need to take the large decarbonisation wins that are available now, using proven-in-NZ techniques, and acknowledges the decarbonisation opportunities that new technologies may provide in the medium term (noting the speed at which rolling stock propulsion and battery technology is developing in other countries).

Specifically, as KiwiRail is commencing development of a Detailed Business Case (DBC) into extending the existing 25kV OLE and obtaining new electric locomotives, WSP supports KiwiRail’s assessment that there is currently no better decarbonisation options or technology available.

Executive Summary

The main elements of the strategy are discussed on the following pages, but we make the following observations and conclusions on the strategy as a whole:

- The report identifies an approach to decarbonising KiwiRail's freight operations. In the main, this refers almost exclusively to the carbon emissions relating to the operation of its diesel locomotives. While it was not in the scope of the report, there is the opportunity to also reduce emissions relating to KiwiRail's role as a rail infrastructure provider. This opportunity does not detract from the validity of the strategy itself, and it is important to note that other strategies and investments will be required to achieve full decarbonisation.

- A challenge identified in the review of the May 2023 version of the IBC was the use of assumed mode-shift to rail from road in the quantification of decarbonisation benefits. Given the natural carbon advantage rail enjoys over road transport, the activity with the greatest net decarbonisation benefit are investments that create mode shift to rail. However, this has the effect of masking the additional benefits of decarbonising KiwiRail's own operations and confusing the overall narrative. Refinements to the latest version of the IBC (May 2024) have largely addressed this issue and we note the improvements made. However, the Detailed Business Case should take the opportunity to further isolate the costs and benefits of these two separate but related ideas and ensure clarity of investment narrative, beginning with revisiting of the Investment Objectives.

- WSP notes that the report development was guided by the Treasury Indicative Business Case (IBC) framework. It contains the traditional "cases" required in an IBC – i.e. Strategic, Economic, Management, Commercial and Financial. Our view is that the investment logic for decarbonising KiwiRail's freight operations makes good technical sense from the perspective of carbon emission reduction and pragmatic, flexible delivery. It should be noted that WSP were not commissioned to undertake a full IQA process on the report. Further, we were advised by KiwiRail that targeted reviews have already been undertaken by other interested stakeholders. As such, the financial, economic and commercial cases have been taken "as read" and we have not performed a critical, in-depth evaluation of the modelled costs and benefits (including carbon reduction modelling). However, where possible we have made comments on aspects of costs or benefits which we believe are material for future phases of work.

- Noting the above, WSP's view is that the robust and comprehensive work described in the report should be taken as a firm foundation for moving to the next phases of work. We do not recommend retesting or revisiting the core findings of the strategy. We recommend that the next phase of DBC work tests the assumptions, costs, benefits, procurement and delivery strategies to a higher level of detail and certainty, to justify and inform a firm investment decision.

- WSP notes that the time to obtain funding and implement the substantive recommendations in the report will take a number of years. As the first GHG reduction deadline is targeting 2030, work on the DBC and subsequent phases needs to progress rapidly to meet this timeframe. Assuming KiwiRail's decarbonisation plans are implemented as recommended in the report, a significant reduction in GHG emissions should be obtainable from the early 2030s.

Executive Summary
Preferred options / programme elements

Strategic conclusion from decarbonisation report	Commentary
Make existing diesel operations as efficient as possible	Rationalising older, less efficient diesel stock, and extending the South Island (Stadler 'DM') fleet order of modern diesel-electric locomotives to supplement the North Island fleet is a pragmatic and effective way to begin decarbonisation whilst larger initiatives are implemented. Noting that the DM fleet also has the potential for future electric/battery conversion. Continuing use of driver assistance tools to maximise diesel locomotive efficiency is also appropriate.
Extend electrification – AKL-HAM, HAM-TGA .and procure electric locomotives with, as a minimum, first and last mile battery capability	Initial focus on the 'Golden Triangle' (KiwiRail's most highly used freight route) is justified and pragmatic. Extending the electrification on this route delivers the greatest decarbonisation benefits due to current rail customer demand and expected future freight growth (including increasing rail volumes generated by modal shift and intermodal freight hubs). Extending the OLE on this route and obtaining new OLE locomotives facilitates an immediate 40%+ reduction in KiwiRail's total operational carbon emissions. Design and investment considerations will need to include network capacity analysis and an operations plan (ConOps) for freight, passenger and infrastructure to define user needs. Where justified there may be the need to include customer, operational and infrastructure improvements (or future proof for improvements later). Examples include: curve easings to increase line speeds, additional passing loops to increase capacity, making provision for longer trains, and increasing the amount of double track south of Auckland.
Battery electric locomotives trial – shunt and mainline	Undertaking a pilot trial (subject to further feasibility checks) is a sound way to explore a locomotive technology shift without committing to only one technical platform solution. Feasibility work and trials will help gain empirical experience and learning relating to: operating in the NZ context; safety/regulatory matters; battery range/re-charging practicalities; staff change/training experience; battery electric locomotive reliability/maintenance; etc.
Consider future integration of inter-regional passenger services	Extending the OLE creates secondary benefits for improved and extended low or zero GHG emission inter-regional passenger rail. There are currently parallel projects considering regional passenger rail by a number of Regional Councils in the Lower North Island and the Auckland-Waikato-Bay of Plenty areas. Benefits for freight decarbonisation and improving regional passenger rail can potentially be amplified if integration of the two operations are considered at the outset, for example timetabling, network infrastructure, charging facilities.

Executive Summary
Non-preferred options

Strategic conclusion from decarbonisation report	Commentary
Do not pursue hydrogen as an alternative fuel source	Hydrogen supply and transmission infrastructure is not sufficiently developed, available or certain in the short to medium term to effectively decarbonise rail operations in NZ. Hydrogen as an energy source may only become viable under a “NZ Inc” approach, covering multiple industries. Compared to pure electric propulsion for locomotives, it is noted that there are significant energy losses through the process of creating hydrogen to the point of turning a locomotive wheel. While hydrogen is currently not viable, WSP supports KiwiRail’s proposed approach to monitor hydrogen developments and adopt solutions if appropriate.
Do not pursue electrification of the whole network	For lower density lines, subject to completing feasibility checks, these lines can be serviced by battery electric locomotives avoiding the costs of installing OLE and other power infrastructure. It is noted that further detailed operational and technical work may identify other parts of the North Island network where extending the 25kV electrification is beneficial.
Do not pursue transitional fuels – e.g. biofuels for use in existing internal combustion locomotives	There are high uncertainties with establishment of green internal combustion engine fuel types in terms of quantities available and supply chain security. Pursuing alternate green fuel approaches which are currently unavailable is not a compelling approach from both a risk and overall emissions reduction strategy due to: OLE locomotives already being used and proven in NZ and overseas, NZ’s electricity mostly coming from green renewable sources, and the successful emergence of battery electric locomotive technology. WSP agrees wtih KiwiRail’s plan to keep monitoring transitional approaches and consider them if new developments indicate they are viable.

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Executive Summary
Next steps

WSP is aware that funding has been provided and work has started on preparing a DBC, with a series of workstreams identified to support the process. WSP are supportive of the DBC approach as it has been explained to us and we make the following observations and recommendations to inform the finalisation of the DBC planning process.

- The DBC will need an updated Strategic Case to capture the latest legislated / binding GHG emission reduction targets, KiwiRail's corporate alignment, and timing imperatives. A review and update of the Investment Objectives and Investment Logic Mapping as documented in the IBC may be required. The DBC will also need to update/refine the economic, financial and carbon reduction model (developed in the IBC) to inform technical workstreams and satisfy IQA requirements.
- Technical workstreams to support the DBC process should include:
    - Infrastructure requirements to complete 25kV electrification from Pukekohe to Tauranga. These requirements will need to include trackside OLE infrastructure, High Voltage infrastructure (including analysis of feed arrangements and transformer technologies) and other infrastructure improvements if justified (including curve easings, additional duplication work, yards, etc).
    - Specification of new OLE powered locomotives with first and last mile capability and associated procurement strategy.
    - Investigation into feasibility and specification of full battery powered mainline locomotives, with determination of appropriate pilot programme(s).
- An operational workstream should be created to define the ConOps, determining a range of viable freight and passenger scenarios (over time) and requirements to inform technical workstreams.
- The DBC will need to take account of the recently completed 30-year rail plan for Auckland (which contemplates increased freight flow scenarios relating to the Golden Triangle and north of Auckland) plus other related projects and programmes.

Discussion

Discussion – Climate targets

The Decarbonisation Report presents a detailed discussion of KiwiRail's carbon emission sources, their history, and the emission reduction targets that KiwiRail is subject to. When reviewing this the following points were noted:

- The first Investment Objective details the specific emission reduction from motive power of the fleet: i.e. "Reduce rail freight motive power emissions from 122.5 ktCO2-e (2020) to 65 by 2035 (a 47% reduction) and zero by the 2040-2050 decade". It is understood that these target figures were derived from the modelled reductions made possible through planned replacement of the diesel fleet with OLE and battery electric before 2035. Specifying investment objectives in terms of the preferred project benefits is unusual. The Detailed Business Case (DBC) should take the opportunity to recast this particular investment objectives to a more strategic level, to which various business case options can then respond.

- The second Problem Statement (and Investment Objectives 2 and 3) talks to increasing rail's share of the freight task to reduce emissions. The DBC should better define the relative benefits (both separately and in combination) of transport decarbonisation through rail mode shift as distinct from decarbonising the rail mode alone.

- Taken together, the fleet conversion and increasing share of the freight task offer considerable freight emission reductions for Aotearoa New Zealand and are likely to be in broad alignment with the First Emissions Reduction Plan (ERP). Exploring the extent of this contribution to each budget period in the upcoming ERP during the DBC might add further supporting evidence to the case for investment.

- Further to emission reduction requirements of the ERP, KiwiRail understands that the Climate Leaders Coalition (CLC) will require that KiwiRail increases its 2030 reduction target, but it is not detailed how much more this will increase from the current 30% reduction. The CLC requirements are likely to be considerably more than the current 30% and this would be important to understand when reviewing / updating the investment objectives in the DBC. We agree the decarbonisation strategy direction chosen by KiwiRail provides a high degree of certainty in terms of GHG reduction and timing. Furthermore, if targets become more aggressive efforts can be expedited.

Discussion – Climate targets

- It's also worth noting that rail's full decarbonisation (referred to on page 9) also requires addressing embodied emissions from construction, operations and maintenance activities and addressing emissions from wastage. Embodied emissions have been noted in the MCA, and the DBC may offer an opportunity to expand on this.
- Physical impacts from climate change are not considered in the IBC. This is understandable given the investments focus on decarbonisation. It is best practice for a 'transition plan' to consider both emissions mitigation and climate adaptation. This will ensure that investments are more broadly future proofed and resilient. We are aware that KiwiRail has recently completed a "resilience" Programme Business Case which examined the entire network, investigating climate related risks in more detail. Further works on decarbonisation should examine and manage any interdependencies between the two programmes.
- The report mentions external debt financing but there is no mention of sustainable funding and finance sources in section 11.4 Funding Sources. The DBC could explore options for green bonds and sustainability bonds. The DBC should be shaped in a way so that they fit the EU taxonomy for green bonds and Treasury's green bond principles to improve funding and financing opportunities.

Discussion – Fleet Strategy

Overall strategy

General comments

The KiwiRail decarbonisation report provides a clear step wise approach of transitioning the KiwiRail locomotive fleet to meet the GHG targets and is based on a detailed analysis of constraints, options and scenarios. It is aligned with international trends and approach, while also considering the New Zealand specific conditions.

The strategy focuses on where the biggest reductions can be achieved, creating a staged, clear and credible migration plan towards full decarbonisation of the fleet. Comments on the 'three legged approach':

1. Maximising use of a new fleet of modern and efficient diesel locomotives on non-electrified routes, we find is in line with best practice of enabling early considerable decarbonisation gains. Specifically, we endorse the strategy to expand the DM procurement and DFT life extension (and note without comment the more recent decision to also life extend 12 DF locomotive)
2. Use existing and new conventional electric locomotives on electrified lines including electrifying the "Golden Triangle" meaning that up to 50% of KiwiRail's freight operation (by volume carried) is running on electricity generated by renewable resources. Again, this aligns with targeting the main early benefits (the new electric locomotive programme should include provision of 'first and last mile' battery capability to avoid electrifying all roads in the various freight yards)
3. Progressively replacing diesel locomotives with battery electric locomotives on non-electrified and lower density routes in 2030-2040 period. This allows KiwiRail to test in small scale new technology, while monitoring the rapid development in battery technology as it matures for longer distances.

WSP agree that regular monitoring of technological advancements and adjacent infrastructure development will be important to fine tune and optimise implementation.

Discussion – Fleet Strategy

Overall strategy

Recommendations for future DBC work on the locomotive fleet strategy

1. International best practice demonstrates energy reductions of up to 20-25% using modern connected DAS and other energy management technology, such as the Knorr-Bremse "the LEADER", CUBRIS "GreenSpeed" and the Swedish “CATO”. While these technologies cannot be considered an alternative to moving to fully electric fleet operations, they should be considered part of a transition strategy given their relatively low cost and ease of implementation, with legacy benefits for any traction energy source. KiwiRail has been trialling driver advisory systems (DAS) for some time already, so is well placed to further implement DAS technology as part of any future transition.
2. Better understand operational characteristics and constraints for each traction option with a focus on various charging and fuelling options
3. Utilise specific rail timetable modelling (e.g. OpenTrack) to better refine battery operation scenarios
4. Better define the traction performance characteristics between the reference diesel locomotive and electric locomotive.

Discussion – Fleet Strategy

Battery electric

General comments

- The modelled Stadler 'DM' is a reasonable option for comparison
- While we find no reason to question the selection of an X-64 locomotive, further analysis should explore the relative capacity of other options
- The timelines provided for procurement of 12 mainline battery electric (for trial purposes) may be overly optimistic and will need further validation through the DBC process
- Assumptions regarding battery sizing are reasonable, although it depends on whether batteries are high-energy or high-power. LFP (lithium ferro-phosphate) is a good starting point, however battery technology developments should continue to be closely monitored
- The strategy for charging a future battery electric fleet requires further analysis, particularly with respect to the advantages and disadvantages of in-motion-charging (IMC). We note that some existing battery locomotives (e.g. Wabtec and Progress Rail) have no pantograph at all. Decisions taken now around IMC could unintentionally preclude suppliers.

Discussion – Fleet Strategy

Battery electric

Recommendations for future DBC work

- Future work should analyse the further development of battery locomotives, e.g. by BHP and RioTinto in Western Australia to see whether a single loco could be sufficient, with high-energy density battery technologies to keep weight and clearances within limits
- Impact from fast charging on battery life should be investigated with suppliers and further analysed within the context of the NZ rail network
- We also recommend an analysis of fire load and safety, particularly running in tunnels
- We agree with the need for further investigations into the availability of economic charging for battery locomotives as it is the largest uncertainty with battery-electric locomotives
- The trade-off between more locomotives and fewer charging stations needs further studies of particular routes to see if such optimisation is viable
- 12No. mainline battery electric loco procurement (for trial) timelines need validating within a DBC process
- Future DBCs should check the advantages and disadvantages of charging via pantograph (IMC), versus other existing battery locomotives (e.g. Wabtec and Progress Rail) which have no pantograph at all.

Discussion – Fleet Strategy

Hydrogen (and ammonia) propulsion

General

We agree with the analysis of the hydrogen option in the report. Hydrogen is currently not a mature technology for a relatively small New Zealand railway (by international comparison) to justify being at the leading edge of adopting hydrogen propulsion in the near future. It also relies on a complex supply chain requiring a national hydrogen strategy across multiple industries. Further, battery technology reach of up to 800-1000km is sufficient for the main KiwiRail needs on low-density lines and is cheaper and more reliable. Battery technology development promises longer reach and reduced cost in the future.

However, development is rapid also for hydrogen. Under the Biden administration the US government is making big investments into so called Green earth-shots, which are initiatives to promote the reduction of the price of hydrogen at the tail pipe to viable levels. In the UK there is an emerging national strategy for using hydrogen in in e.g. community heating, thus making distributed hydrogen available.

Hence, development should be monitored, as the report also suggests.

Similarly, advancement in ammonia technology to power locomotives should also be monitored, although compared to hydrogen this still in a conceptual stage.

Discussion – Fleet Strategy

Hydrogen (and ammonia) propulsion - Specific comments

Technical challenges and risks

- Low availability of green hydrogen. Many studies assume green (renewables) hydrogen (ignoring its limited availability and higher costs) will be used, whereas higher emissions hydrogen, such as blue (natural gas) or grey (fossil fuels) hydrogen, is more likely to be used.
- It is important to have batteries and hydrogen tanks properly separated and not adjacent to each other due to the risk of fire.
- Hydrogen usage in tunnels poses a significant safety risk. In the case of a collision hydrogen can create extreme heat at high pressure if the gas is ignited at the valve. If hydrogen was adopted all impacted tunnels would need to be fitted with a specialised ventilation system plus additional safety related functions. This is likely to attract significant cost given NZ has numerous tunnels.
- The long fuelling times required with current hydrogen technology poses an operational constraint and potentially decreases productivity of the locomotives.

Commercial challenges

- Maintenance costs are high for hydrogen tanks and fuel cells. They must be sent for maintenance every 3 – 7 years and replaced after about 15 years. Studies and suppliers tend to underestimate these costs.
- It is notable that the €93 million Alstom Coradia iLint hydrogen passenger trains that have been in commercial service in the Lower Saxony region in Germany for a year will be taken out of service. The state-owned transport company LNVG announced at the end of July that it will use only battery electric trains after it determined that they are "cheaper to run" than hydrogen fuel-cell alternatives.
- Cost and space requirements to implement hydrogen refuelling stations (HRS) and adapt existing depots for hydrogen operation are likely to be significant
- Hydrogen volume is a significant problem, for the supply chain and physically carrying the fuel on the train. Higher pressure can partially help solve this challenge, however with existing technology costs are likely to increase significantly.

Discussion – Fleet Strategy

Biofuels

General

Diesel alternatives produced from plant and animal sources generally offer a reduced GHG footprint. These fuels are either blended with conventional diesel or in some cases serve as a 'drop-in' replacement. In general, they exhibit lower energy density and lubricity than conventional diesel fuel while having a higher cold filter plug point (also cloud point) and flash point.

The most common group as mentioned in the report is the biodiesel (Fatty Acid Methyl Esters) that is obtained by the esterification of oil derived from plants or animal. It is used to extend or replace the use of fossil fuel diesel. Renewable Diesel (2nd generation or advanced biofuel) or Hydrotreated Vegetable Oil (HVO), like biodiesel, is produced from plant and animal products, but impurities are removed from the raw materials and the final product is a colourless and odourless fuel with less problems than biodiesel.

The report briefly covers bio-ethanol which is fuel produced from starch and sugar crops via the fermentation process. It is typically used in a blend of unleaded petrol containing up to 10% ethanol, 'E10'. Though it is possible to produce ethanol/diesel blends, they are not commonly available within the New Zealand market.

Biofuel has the advantage that it is financially viable and not a high-risk option, with immediate emission reduction benefits at a low investment cost for the vehicle owner. However, the lack of an established supply chain and therefore commercial supply availability is a key inhibitor.   Further, we agree that rail transport has better options in electrification that other possible biofuel consumers users can not readily access.

We agree with the analysis of the biofuel options in the report. Second generation "drop-in" biofuels are still developing but will likely become mature in the early 2030's, whereas third and fourth generation biofuels are not yet commercially viable.

Discussion – Fleet Strategy
Biofuels

Technical challenges and risks

Low technical risk, however

- Lower specific energy and energy density compared to mineral diesel, resulting in reduced engine power and fuel economy.
- Incompatibility with some elastomers which can result in the swelling and leaking of seals (biodiesel)
- Biodiesel is hygroscopic (absorbs moisture from the atmosphere), the presence of moisture within biodiesel aids microbe contamination. Furthermore, biodiesel is more susceptible to oxidation than mineral diesel as a result of its chemical structure.
- Reduced lubricity with HVO (Hydrotreated Vegetable Oil)
- Energy fuel density – HVO is marketed as a 'drop-in' replacement to diesel, but its density effectively introduces an upper limit to the blending percentage.

To manage these issues without engine modification or significant changes to maintenance regimes, biodiesel is blended with fossil fuel diesel in relatively low concentrations (B20 and below). When a high percentage blend of renewable diesel is used, lubricity additive may be needed in the final blend to protect fuel injection equipment against excess wear.

Commercial/ethical challenges

- More maintenance is required with any ICE, and so far biofuels cause more residual clogging
- As a relatively new fuel source, the rate of adoption is limited by supply volume and associated higher costs. Higher adoption can be seen in markets where the use of diesel is curtailed. There is currently no renewable diesel production occurring within New Zealand at a commercial scale
- Bio fuels are also criticised for their potential to impact on food supply and deforestation

Discussion – Electrification

An important conclusion from the report is the extension of the 25kV electrification from Hamilton to Auckland and Tauranga to Hamilton. The report sources details of the scope and cost of this infrastructure primarily from the North Island Electrification Study (Beca/Systra, May 2021). The discussion in this section focuses on the details contained in this report as the scope, methodology and costs are material to the IBC. However, it should be noted that the Beca/Systra report is CAPEX only, and whole-of-life costs for business case purposes were estimated separately (by the Decarbonisation report project team).

The discussion below is broken into general comments followed by specific commentary of the trackside scope (OLE and signalling) and then HV scope.

General comments

- The review included assessment of the 2021 Beca/Systra report and appendices (12 No.) but was limited to assessment of key scope and cost assumptions. The Beca/Systra report was seen as competent and complete for the stated task.
- WSP "took as read" the calculations contained in the estimating sheets or the quantitative risk register, including the route clearance analysis (e.g. bridge modifications) which is an important cost driver. For the avoidance of doubt, WSP have not conducted a peer review of the Beca/Systra cost estimate.
- It is noted that the Decarbonisation report extrapolates costs from the Beca/Systra report to come to high level estimates for those line sections (e.g. South Island) not included in the Beca/Systra report. While such extrapolation comes with obvious risk, the approach is seen as appropriate for the task, and we do not see that it was material to the conclusion ultimately drawn that electrification of the entire KiwiRail network is not justifiable.
- From a whole-of-life perspective, some of the OLE network maintenance OPEX costs were derived by taking data from Japan Railways and scaling it, due to the relative light duty and recent mothballing of the existing North Island OLE. Developing validated OPEX models in the NZ context should be a focus area in future business cases.

Discussion – Electrification

General comments (continued)

Two major themes emerged from the review of the electrification scope and cost:

1. Cost escalation has been significant in recent years (noting that the Beca/Systra report was completed in 2021) and represents a risk to ongoing investment justification. This applies to all elements of the electrification infrastructure – OLE, signalling and HV supply / switching. It should be noted that the QRA used in the Beca/Systra report makes genuine allowance for escalation (including COVID-19 cost surges), but the probability weighting applied ultimately does not reflect the experienced reality of the last two-three years.
2. The HV solution estimate in the 2021 Beca/Systra report generally assumes more traditional forms of HV supply and transformer technology – e.g. 110 or 220kV supply from Transpower and some form of auto-transformer system, with acknowledgment that Static Frequency Converter (SFC) technology may be required depending on the load and supply risks identified (and in one location allowed for in the base scope). SFCs are noted in the report as being expensive and generally to be avoided if possible. However, in the intervening years KiwiRail has invested for the first time in SFC technology, with the first two systems currently in detailed design, for commissioning in 2025 at Glen Eden in Auckland's west. Notably, the Glen Eden SFCs are being connected to a 33kV Vector site, not a Transpower substation as had been assumed through earlier investigations. SFC technology has advanced in recent years and KiwiRail, through the recently completed 30-year rail plan, have assumed they will become the dominant technology choice in the Auckland rail network over the next 30 years.

Discussion – Electrification

Trackside scope

Overhead Line Equipment (OLE)

- As noted, costs are the primary area of concern (mostly infrastructure) although rolling stock assumptions / costs also need updating given pace of change and emergent strategy – e.g. longer trains up to 1500m.
- The cost estimates for OLE (and associated infrastructure) should be treated as out of date given the market cost increases that have occurred in the intervening years (the Beca/Systra report was completed in early 2021). In the next phase of DBC work there should be focus on determining an OLE design and construction methodology that is fit for purpose, exploring innovations for cost effectiveness and taking lessons from recent OLE projects in New Zealand (e.g. various WMUP projects in Wellington and CRL / P2P in Auckland) as well as overseas (e.g. large mainline electrification programmes in the UK). Key cost risks to mitigate are:
    - Lack of efficiency working around live traffic
    - Scope creep – e.g. rebuilding large portions of track formation to resolve legacy drainage issues or manage constraints for OLE foundations etc.
    - Procurement methodology in a constrained New Zealand market noting a lack of OLE design and construction capability
- Lack of historical OLE maintenance records (particularly for NIMT, but also a challenge for AKL and WLG metros) were noted as being a challenge in the IBC for producing robust OPEX figures. For future DBC phases additional work will be required to develop a defensible estimating approach that is NZ specific.
- The Beca/Systra report assumes that there is no material change to the existing alignment between Auckland and Hamilton, and Hamilton and Tauranga. This assumption will need to be tested in future DBC stages to account for other infrastructure improvements (e.g. passing loops and bypasses) needed to support service level improvements in freight and passenger services. An important consideration for next phases of work will be clearly identifying those projects which are fundamentally required to enable electrification versus those projects for which allowance should be made (or simply noted).

Discussion – Electrification

Trackside scope

Signalling

- The Siemens cost estimate (Appendix B of the Beca/Systra report) was reviewed, and it is noted that the estimation methodology was high level – i.e. three estimation methodologies were presented in increasing order of accuracy with the least accurate methodology (Method A) used. Greater detail will likely be required in future detailed business case work.
- Several items of signalling scope were also explicitly excluded (e.g. KiwiRail and other stakeholder costs) and the Beca/Systra cost estimate filled these gaps in their estimate. These other costs will also need further review in subsequent phases.
- The signalling scope has been assumed as being traditional – i.e. replacement of the existing coloured light signalling and old interlockings with new immunised equipment and Westrace interlockings. This is pragmatic, but further examination of signalling solutions should be investigated. In particular, in light of potential ETCS Level 2 investment for Wellington and Auckland (in similar sorts of timeframes to this project), there could be an argument to make that an essentially (physical) signal free deployment of ETCS Level 2 could be a more cost-effective way to simultaneously deal with optimising the signalling and providing electrical immunisation. This should be investigated in the next phase of work but acknowledging the risks around timing and the potential for this project to become a “first mover” on ETCS Level 2.
- For future stages of work KiwiRail may also want to encourage a broader market response for the eventual physical works and as such should consider its use of suppliers to provide estimates.

Discussion – Electrification

High Voltage scope

The costs associated with comparing connection options i.e. Transpower (lower voltage = cheaper), autotransformers adding costs and SFCs need further review in the DBC. The view of the peer review team is that much depends on the required amount of civil work (clearances in tunnels, under bridges etc). The use of network-wide costing averages is reasonable if whole network electrification is considered, however if individual lines are considered - using a network average might be misleading (in one or the other direction). Other minor observations from the peer review of the Beca/Systra report include:

- The QR Tilt Train is Hitachi, not Bombardier and is not 8MW (closer to 3MW). However, 8MW is a sensible rating for this speed.
- It is not recommended to place traction assets in the utility area as there is no control (tap/impedance of 25kV transformer, or SFC characteristics). It is recommended that the demarcation point be at the HV circuit breaker of the transformer/SFC.
- It should not be assumed that passenger services require less power than freight service. As an example, some modern EMU consists in Europe have more MW than a freight loco (even two freight locos in some cases).
- No property costs for off-corridor power assets were included in the cost estimates. While these are unlikely to be significant in the scheme of the whole project they will need to be identified and costed in future DBC phases.

Discussion – Electrification

High Voltage scope

As previously noted, SFC technology is now the assumed technology choice for required power enhancements to the Auckland metro over the next 30 years. For future business case phases for this project, SFC technology should be assessed at the same level of detail as other HV technology options. Some specific comments on SFC technology are below to support this view:

- The upstream HV network may not be needed to be upgraded if SFC technology is used, which are suitable on weak grids and supply voltages as low as 22kV. As an example of the benefits possible, the proposed mega substations assumed to be required in the Beca/Systra report (Appendix C) could potentially be avoided.
- SFC technology is advancing - 110kV and 33kV are now in scope.
- If the Transpower supply fails, the SFC can still provide reactive power support to the railway without 3AC grid.
- Re-generative power from braking trains can be blocked with a SFC to be prioritised to trains, and if there are no trains power can be exported back to the grid.
- Catenary losses are reduced with SFCs, lowering OPEX electricity costs.
- Multi-source SFC feeders may reduce the need for 25kV substations.

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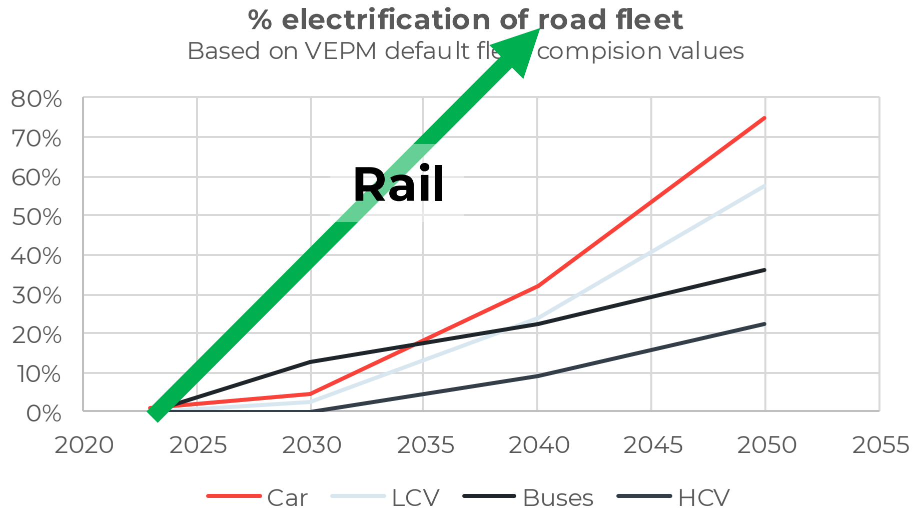
Discussion –Business Case

Decarbonisation of the competitive modes:

- A potential risk to the programme is that road-freight decarbonisation occurs at a faster rate than assumed in the IBC, while unlikely, it would result in the decarbonisation benefits of shifting from road to rail being less than claimed.
- On the other hand, the assumptions appear to be consistent with the rate of HVC electrification in other sources (e.g. NZTA VEPM). The relative rate of decarbonisation of road freight vs. rail freight could provide strong justification for the programme (note that the private car fleet is expected to move to electrification at a significantly faster rate than the heavy vehicle fleet).
- The figure to right shows rates of road fleet electrification extracted from VEPM fleet composition values, with the assumed rate of electrification in the IBC.

- Electrification of the heavy commercial vehicle fleet is slow – giving freight a potentially strong advantage (planned to be fully electrified by 2040)



Discussion – Business Case

Mode shift potential:

- All freight growth scenarios, including BAU represent substantial increases in freight demand over the next 1–2 decades. The BAU scenario for example represents ~20% increase in rail mode share between 2020 – 2035 (from 12.5% today to 15.2% in 2035).
- This mode shift will be induced by a variety of policy shifts, demand and stakeholder interventions. It will likely be a combination of being driven by external factors or *induced* by enhancements to KiwiRail freight services:
    - improved performance (planned/efficient maintenance, optimised timings, capacity)
    - better multi-modal connections
    - access to new customers/markets
    - greater separation of passenger and freight to increase capacity efficiency and increase reliability (reducing cross-mode delays) by operational means and new infrastructure
    - analysis of critical infrastructure (high failure rate equipment with great impact on system reliability in high traffic density sections of the network)

  Such enhancements may require further infrastructure investment, which should form part of the overall Rail Network Investment Plan.
- It is important to understand how the assumed level of mode shift is captured to ensure a robust case for investment, particularly as these appear to represent a large majority of the quantified benefits.
- As noted elsewhere, in the DBC, it will be important to create the distinction between the decarbonisation benefits attributable to mode shift (i.e. decarbonisation to New Zealand's overall transport task) and decarbonisation of KiwiRail's operations.

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Discussion – Business Case

Freight forecast volumes:

- A key input to the IBC is the freight demand forecasts. Four growth scenarios (BAU, A, B1, D) have been considered, which are consistent with those used for the Auckland Rail Programme Business Case.
- The case for investment has been made on the lowest growth (BAU) scenario. This is considered a conservative approach, and it is noted that other work (e.g. the Auckland Rail PBC) has used B1 as a base case demand scenario.
- Sensitivities on higher growth outcomes have been considered, which is important given these depend on many factors beyond KiwiRail control. However additional OLE and network capacity investment would likely be required to support these scenarios (e.g. the network will require scaling up around existing investments when running more and/or longer trains) which does not appear to have been considered.

Discussion – Business Case

Passenger Rail Considerations

- The IBC refers almost exclusively to the carbon emissions relating to the operation of its diesel locomotives. While the majority of decarbonisation benefits are likely to come from freight operations, the interaction of passenger and freight services on the network may make the required infrastructure solutions more intensive. For example:
  - Hamilton to Auckland: Passenger services between Auckland and Hamilton operate amongst freight traffic on a primarily double track corridor. As freight and passenger volumes increase, this will place restrictions on passenger service average speeds. To achieve faster journey times, additional track infrastructure may be required to allow passenger services to pass slower freight services. For example - a recent IBC for future Hamilton to Auckland faster-rail services investigated options for building by-passes around specific areas of the NIMT (indicative timing: late 2030s-early 2040s).
  - Tauranga to Auckland: Future passenger services between Auckland and Tauranga would operate amongst freight traffic on a primarily single-track corridor with passing loops. A passenger service along this corridor would likely require significant infrastructure improvements to be viable (additional loops or fully double tracked sections). Timing is uncertain, however late 2030s would seem realistic.
- Care should be taken early in the programme to ensure that all potential demands for network capacity are documented (e.g. freight, inter-regional passenger, tourists, maintenance access, etc.) and that any infrastructure development and design integrates pragmatic future proofing.

Phasing Implications

- It is noted that electrification of NIMT and the ECMT are proposed to be programmed almost fully in parallel, with only a year of lag between completion of NIMT in 2028 vs. ECMT in 2029.
- If this phasing becomes staggered (e.g. due to funding constraints) this may create a scenario where MetroPort services have rakes exchanged between Electric and Diesel locos at Hamilton. This would add significant complexity to the network operations and negate long term benefits. Future DBCs should explore phasing options and implications.

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Discussion – Business Case

Operational and Infrastructure Considerations

- The mode shift assumptions of the IBC are expected to result in a significant increase in rail volumes, particularly under higher growth scenarios. For example, under Scenario A, total freight volumes between Tauranga and Auckland (MetroPort) are expected to double by 2032. To accommodate this growth, additional infrastructure and operational / timetable changes may be required that have not been factored into the IBC. For example:
  - Accommodating longer freight trains: The AR PBC has assumed that longer freight trains (up to 1500m) will be introduced onto the MetroPort line in the next 10-20 years. This will require lengthening of sidings, loops and other track and signalling adjustments. The highest potential for long train lengths is on the MP line, between Hamilton and Tauranga where the highest growth occurs.
  - Requirement for double tracking of the Whangamirino : It seems likely that the existing single track bottleneck at this area of the NIMT will constrain capacity as train volumes grow. This is an environmentally sensitive area with high significance to local Iwi which may result in higher complexity.
- In the next phase, work should be undertaken to *develop a workable, attractive timetable and infrastructure concept along with a supporting Concept of Operations and Maintenance, as a basis for subsequent detailed analysis*. This will allow for a robust assessment of programme costs and benefits.

Discussion – Business Case

Discount rates

- In future business case work it is possible that recommended Treasury discount rates could change, in line with persistently higher global interest rates.
- Guidance from Treasury has remained unchanged since 2020 at 5% for infrastructure projects, and the IBC work has, as appropriate, used this figure in the base case economic analysis.
- As noted in a recent article by New Zealand Infrastructure Commission Te Waihanga, a better estimate of the actual discount rate in 2024 would be something closer to 7%, which is even higher than the 6% used as the high-range sensitivity test in the IBC.
- If published discount rates were to change to a level close to 7% this would have a material impact on calculated benefit-cost ratios – i.e. greater benefits relative to costs would need to be found to maintain the same BCR.
- Future business case teams should remain alert to this possibility.

Analysis and brief conclusions of other reports

North Island Electrification Study and Appendices (BECA 2021) - Summary

The North Island Electrification Study (The Study) focuses on estimating the costs associated with electrifying specific route segments of the North Island rail network.

- The Study includes the development of the national High Voltage grid for power supply to the railway and upgrades to existing signalling systems to prevent electrical interference.
- The scope of the study covers four distinct North Island route segments: Te Rapa to Pukekohe, Hamilton to Mt Maunganui, Waikanae to Palmerston North, and Upper Hutt to Masterton.
- The Study aims to support or inform a future business case for investment options related to electrification.
- The Study Appendices include a report on the initial approximate cost estimation for resignalling the areas where future electrification is proposed.
- The Study Appendices provide detailed information on the signalling requirements and cost estimates for the electrification of specific route segments in the North Island rail network.

Analysis and brief conclusions of other reports

North Island Electrification Study and Appendices (BECA 2021) - Conclusions

- The Study assumes the existing corridor land, track capacity and depot facilities are sufficient and correctly sized, equipped and located. This approach is appropriate for the purposes and scope of the report at the time, however the peripheral network and service aspects will need to be defined and specified in the DBC phase.
- GWRC's more recent LNIRIM strategy and technology aspirations supersede many of the stated assumptions i.e. online charging, train configurations – which will need updating in subsequent DBCs
- Developments in traction power / OLE assumptions and costing in NZ (especially relating to SFC technology) need updating.
- The Study deliberately excludes consideration of operational expenditure which will need investigation in subsequent studies.
- Te Huia assumptions will need revalidating against current plans and business cases including Te Huia assumptions in the Auckland Rail PBC 30 year rail plan.
- Freight timetables in the study need proper development and testing against realistic future freight operations assumptions. This should include future locomotive specifications, train consist length and power weight calculations, and network power modelling.

Analysis and brief conclusions of other reports

Wellington Network Capacity Constraints Study - Summary

The report on the Wellington Network Capacity Constraints Study provides an assessment of the existing infrastructure and timetables in the Wellington rail network, identifying constraints and proposing recommendations for improvement.

- The study highlights that passenger and freight growth on the network is limited by the current infrastructure and operational timetables.
- Infrastructure changes are necessary to alleviate these constraints and enable higher frequency timetables to be implemented.
- KiwiRail, as the asset owner, has evaluated the required capacity based on the Wellington Rail Plan's future timetables and has identified network constraints that could hinder achieving the desired capacity without intervention.

Analysis and brief conclusions of other reports

Wellington Network Capacity Constraints Study - Conclusions

- The key driver of this report is capacity rather than electrification, therefore it is to be expected that there are no recommendations or key findings relating to further electrification on the Lower North Island Network.
- This Study has very little impact on any initial North Island Electrification programme
- Removing network constraints to lift capacity for passenger and freight services in the Wellington region is a higher priority than further electrification of the Wellington Electrified Area.

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Analysis and brief conclusions of other reports

Waikanae Otaki Levin (WOL) - Summary

The report on the Waikanae - Otaki - Levin Service Summary Paper provides a summary of the work conducted by KiwiRail in assessing the infrastructure requirements for extending a commuter train service north from Waikanae to Otaki or Levin.

- The purpose of the study was to assess the infrastructure needed for a 'WOL' shuttle service to improve commuter connectivity in these growing areas.
- KiwiRail considered factors such as rail infrastructure requirements, electrification options, fleet capacity, and strategic alignment with other service initiatives.
- The report provides a conceptual overview of the infrastructure scope and approximate costs, without justifying the service itself.

Analysis and brief conclusions of other reports

Waikanae Otaki Levin (WOL) - Conclusions

- OLE options require significant investment and would need to support a coordinated delivery of strategic outcomes beyond just WOL services to be justified. A combined justification might include:
  - WOL train operation (not justified due to future LNIRIM services and increased frequency)
  - LNIRIM train operation (OLE not needed due to proposed LNIRIM battery capability)
  - Electric freight operations over the full length of the North Island Main Trunk (OLE likely not needed due to potential for new locomotive battery capability)
- If OLE was justified, extending the 25kV AC supply south from Palmerston North is preferred over extending the 1600V DC supply north from Waikanae
- Duplication of track, level crossing upgrades, signalling and platform works is the priority for improving capacity of passenger services beyond Waikanae.
- Very little impact on the wider North Island Electrification programme furthermore, removing network constraints to lift capacity for passenger and freight services in the Wellington region is a higher priority than further electrification of the Wellington Electrified Area.

Report Contributors

Insert sub-title and/or speakers here

Contributors

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