



23 November 2012

Queensland Competition Authority
GPO Box 2257
BRISBANE
Queensland 4001

By email: rail@qca.org.au

Dear Sir/Madam

SUBJECT: QR Network Draft Amending Access Undertaking (DAAU) for Electric Traction Services – Request for Further Comment on Draft Decision

Electro Motive Diesel (EMD) and Downer Rail have reviewed QR Network's DAAU, the draft decision of the Queensland Competition Authority (QCA) and the commentary submitted by the various interested parties affected by the DAAU.

We would like to confirm that we support the QCA draft decision and, in response to the QCA's request for further comments of 8 October 2012, wish to submit the following commentary.

Shorter Headways

Diesel electric locomotive powered coal trains will have greater capability for reducing headways compared to electric locomotive powered trains. With electric controlled pneumatic (ECP) braking available now on the QR Network, train headways can be reduced due to the shorter stopping distances. Advanced signaling systems now available in the market can further reduce train separation. ECP and advanced signaling systems can be applied to both electric and diesel electric powered trains however the number of electric powered trains on the network will be limited by the power available from the supply system and configuration of electrical sections of the supply infrastructure. Our view is that diesel electric powered trains provide significantly higher flexibility and potential for increasing capacity on the existing network with minimal increased infrastructure costs. The costs of implementing technologies such as ECP and advanced signaling systems would need to be applied irrespective of locomotive technology, however diesel electric powered trains would not require the additional electric supply infrastructure that electric powered trains would need to realize this increased network capacity.

Relative Performance of Electric versus Diesel Traction



A number of recent submissions highlighted the higher power and thus theoretically faster run times of electric locomotives compared to diesel electric locomotives. These submissions however do not factor in maximum speed limitations on the QR Network. The latest technology electric locomotives have larger wheels and traction motors increasing unsprung mass and resultant P2 forces compared to current diesel electric locomotives. We understand that electric locomotives are limited to a maximum speed of 80kph in the loaded and unloaded direction. With their lower unsprung mass and P2 forces, diesel electric locomotives can operate up to 100kph in the unloaded direction. For this reason the overall cycle time for diesel electric powered trains is comparable to current electric locomotive powered trains.

Downer Rail provided trip time analysis in their submission of 10 May to the QCA. This analysis suggests the trip cycle time difference between three electric locomotives and 102 coal wagons and four diesel electric locomotives and 100 wagons is only approximately 5 minutes (over a total journey time of approximately 10.5 hours).

Also, Downer Rail/EMD is developing a new narrow gauge diesel electric locomotive capable of producing 4,500 BHP which represents a 36% increase in power compared to existing diesel electric locomotives on the QR Network. These new diesel electric locomotives will be capable of hauling longer trains with similar cycle times and in some cases, three of these locomotives will be able to haul the same load as four existing diesel electric locomotives with similar cycle times. Our analysis shows that these new diesel electric locomotives can provide similar haulage performance as current electric locomotives and, with the lower unsprung mass and P2 forces, can achieve overall similar cycle times to the electric locomotives.

Cycle Time

It is accepted that diesel electric locomotives require regular refueling however as shown in the Downer Rail submission of 10 May, with modern refueling systems this refueling time can be reduced to approximately 5 minutes. While fuelling dwell time may be higher due to operational factors, such factors can be minimized with relatively minimal cost to reduce the overall impact. For example, both diesel electric and electric locomotives require regular provisioning, inspections, crew changes etc and fuelling can be performed concurrently with such activities to reduce net impact of fuelling dwell time.

It should also be noted that fuel consumption and fuel tank capacity on the diesel electric locomotive are such that, in many cases, this refueling is required only every second trip, thus halving the fuelling dwell time on a per-cycle basis.

When factoring in the simulation calculations which show overall running time for diesel electric trains to be within a few minutes of electric trains, we believe there is little discernible difference in overall cycle time between electric and diesel electric powered trains with similar loads.



Other factors such as loading and unloading time, waiting at passing loops, waiting for train paths etc provide much greater opportunity for improvement in overall cycle time compared to electric versus diesel electric traction.

Competition in the Locomotive Supply Market

Both diesel and electric locomotive suppliers must tailor their locomotive designs to meet QR Network access requirements. These design requirements do impact on development costs and thus barriers to entry for new suppliers. However, in the case of diesel electric locomotives, there is far greater opportunity for such development costs to be amortised over a greater worldwide market potential for similar products. There are many rail networks throughout the world including Asia, Africa and South America where diesel electric locomotives designed for the QR Network could be applied with minimal modification. While similar heavy haul electrified rail networks do exist (for example South Africa), the worldwide market potential for electric locomotives designed to QR Network requirements is significantly lower.

Evidence of the relatively highly competitive market in diesel electric locomotives designed to QR Network requirements can be seen today with two alternative narrow gauge diesel electric locomotive products currently under construction that could operate on the QR Network in addition to the existing diesel electric locomotive and the new 4,500BHP model locomotive being developed by Downer Rail and EMD.

This competition is already driving substantial reduction in the capital cost of diesel electric locomotives and it is our belief that further reductions in diesel locomotive pricing will occur in the near future as this competition grows.

Whilst we agree there are a numerous locomotive manufacturers capable of supplying electric locomotives for operation on the QR Network, our view is that the barriers to entry for new electric locomotive suppliers is higher due to the QR Network specific design requirements for electric locomotives and the lower worldwide demand for heavy haul electric locomotives with similar design requirements. This is supported by the fact that there has been only one supplier of new electric locomotives for Queensland operation in the past 15 years and, to our knowledge, there are no immediate plans for alternative electric locomotive products to be introduced on to the QR Network today.

Capital Costs

It is widely accepted that the capital cost of diesel locomotives today is significantly lower than electric locomotives. Submissions to the QCA have highlighted this, showing electric locomotives to be approximately 30% higher cost. However submissions to the QCA have assumed more diesel electric locomotives would be required to achieve a similar haulage task. Our position is that our new diesel locomotive will be able to haul a similar load with the

same quantity of locomotives as in the electric locomotive case. For this reason, a valid comparison of capital costs should not factor in higher quantities of diesel electric locomotives.

Also, whilst commercially sensitive information cannot be provided in this open forum, it is widely accepted that capital costs of diesel electric locomotives has reduced substantially in the past year as a result of supply chain and production innovations.

Maintenance Costs

Electric locomotives do require similar levels of maintenance and overhaul, with the exception of the engine. For example, electric motors, bogies and traction motors, miscellaneous equipment on both electric and diesel electric locomotives are fundamentally the same and require similar levels of maintenance and overhaul. The key difference is the engine and associated ancillary equipment.

The whole of life maintenance cost describes the costs associated with operating locomotives over the course of their asset life, excluding energy costs but including scheduled and unscheduled maintenance, rotables, labour and major equipment overhauls. Based on a variety of data sources and industry knowledge, typical benchmarking values for diesel and electric locomotive whole of life maintenance costs are presented in Figure 1. Our analysis suggests electric locomotives are approximately 30% cheaper to maintain on a locomotive – to – locomotive comparison basis, which is broadly consistent with submissions to the QCAⁱ.

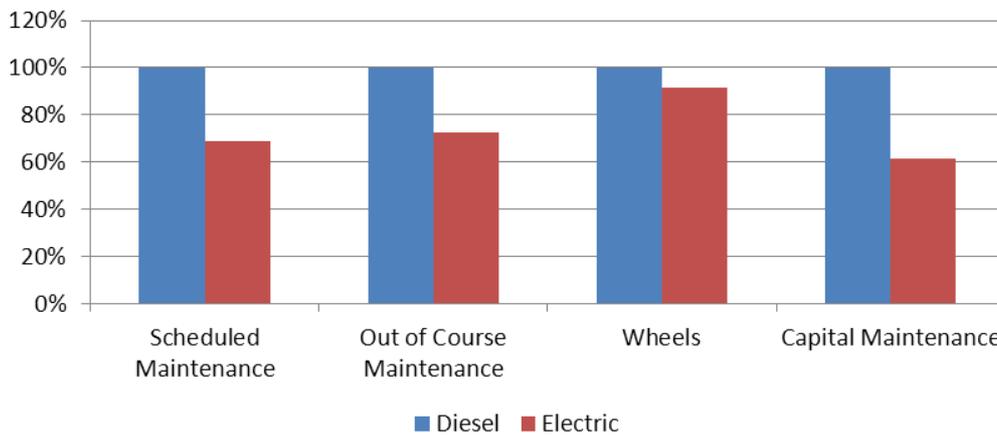


Figure 1: Whole of life maintenance benchmarks.

Scheduled maintenance costs for diesel locomotives are higher than for electric locomotives due to additional costs for items such as lubrication oil, oil analysis, coolant, oil and fuel filter changes. By comparison, some components specific to electric locomotives, such as the transformer and pantograph, do not incur similarly substantial maintenance costs.



Wheel maintenance costs for electric locomotives may be lower than for diesel locomotives. Firstly, the ability to configure the locomotive with a Bo'Bo'Bo configuration allows for better radial alignment of wheels in curves, reducing flange wear; secondly, ~6% larger wheel diameters can be expected to have an approximately linear effect on wheel life.

The out of course maintenance costs for diesel locomotives are higher than for electric locomotives due to out of course maintenance related to the diesel engine.

Similarly, capital maintenance costs for diesel locomotives are higher than for electric locomotives due to the need for engine overhauls which electric locomotives do not require. Additional systems on electric locomotives such as pantographs do not have the same scale of capital maintenance cost.

While we agree that overall maintenance costs for diesel electric locomotives is higher than for electric locomotives, our view is that this difference is not as great as indicated in recent submissions to the QCA. Such submissions suggested diesel electric maintenance costs to be double that of electric locomotives however these calculations assumed higher quantity of diesel electric locomotives for the same haulage task as electric locomotives. As discussed above, our new diesel electric locomotive can achieve similar haulage tasks and cycle times as existing electric locomotives so such analysis should assume similar quantities of locomotives in both cases.

Also, when comparing maintenance costs of electric versus diesels electric traction power, electrical infrastructure maintenance costs should be considered. Typical annual electrical infrastructure maintenance costs vary between 1% and 3% of the capital cost of the installationⁱⁱ. This is consistent with data provided in some submissions to the QCA which showed annual maintenance costs over 3% of the capital cost. When factoring in the maintenance cost of electrical infrastructure, electric locomotive maintenance costs are estimated to be three times higher than diesel electric locomotive maintenance. For example, referencing the submission to the QCA by Toshiba on 25 September 2012ⁱ:

Electrical Infrastructure Maintenance Costs:	\$1,126M over 30 years
Electric Locomotive Maintenance Costs:	\$390M over 30 years
Total:	\$1,516M over 30 years

Diesel Electric Locomotive Maintenance Costs: (assuming same number of locomotives)	\$556M over 30 years
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Comparative Efficiency of Diesel and Electric Traction

The 'total efficiency' of a locomotive reflects the efficiency of energy conversion processes which occur from the point the energy source (i.e diesel, coal, natural gas, etc) is initially consumed to the point at which some useful work (i.e traction) is done.

It is noted that submissions to the QCA have suggested that the transport, refining and storage of diesel should be included in the total efficiency. Such an approach makes a number of assumptions regarding the processes, efficiencies and energy sources involved in the production and transport of diesel fuel while not accounting for the considerable energy required to extract coal for the production of electricity.

Based on the ‘total efficiency’ as defined above, there is no material difference between the total efficiency of diesel locomotives and electric locomotives, as illustrated in Figure 2. The efficiency of a diesel engine was estimated on the basis of typical diesel fuel consumption values and an engine load profile applicable to Queensland. The efficiency of the traction system was estimated based on traction curve data for a relevant diesel locomotive. The energy required to move the diesel fuel, as a portion of empty and loaded consists, was estimated based on the assumption that energy expended on loaded consists accounts for 70% of all energy consumption. This estimate was conservative in that only the fully provisioned condition was assessed and found that no more than 0.6% of the energy output of a diesel locomotive would be consumed in carrying diesel fuel in a typical Blackwater consist.

The efficiency of the electric locomotive was assessed by assuming that the energy would be supplied by a coal fired power station with an efficiency of between 38% and 40%. Losses in the 132kV power distribution network and 25kV electrification network were estimated based on data from the UK which indicate total transmission losses are likely to be in the range of 4.5% to 7.9%. The onboard efficiency of the electric locomotive was assessed using typical values for subsystem efficiencies.

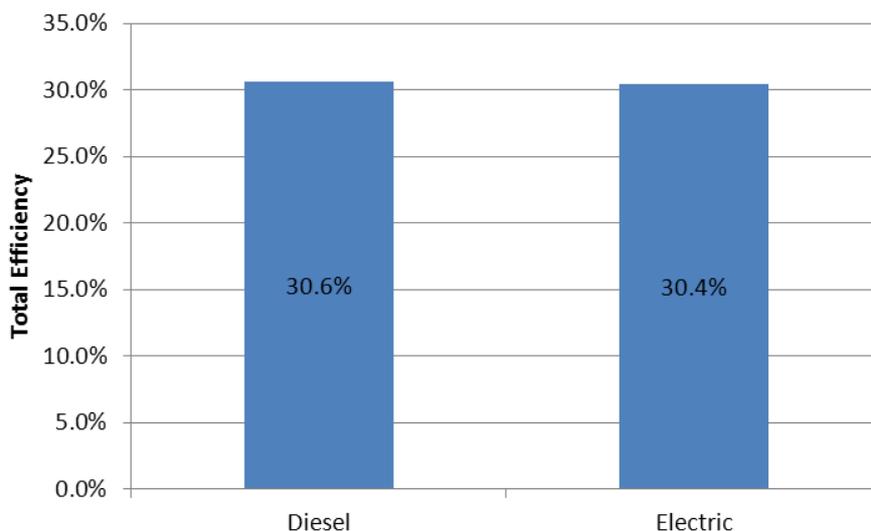


Figure 2: Total Efficiency of Diesel and Electric Locomotives.



While electric locomotives can gain efficiency improvements through the use of regenerative braking, such improvements are usually only realised if there is another electric train on the same section of track, which is under power, and which is able to consume the energy being dissipated by the braking train. Submissions to the QCA discuss the advantages of electric traction due to regeneration of power from train braking back into the electrical supply infrastructure. However, in reality, such regeneration is limited and we would suggest further investigation into actual achieved regeneration power on the QR Network is investigated.

One reason that diesel locomotives have traditionally been less efficient than electric locomotives is due to excessive time spent idling. Automatic Engine Start-Stop (AESS) technology shuts down the engine when given idling conditions are met. The EMD AESS system reduces unnecessary idling time by more than 50%ⁱⁱⁱ. The implementation of this technology needs to be considered when comparing the efficiency of diesel and electric locomotives.

The implementation of trip optimisation systems to assist drivers in achieving a ‘golden run’ can assist drivers in reducing fuel consumption. However, for electric locomotives, the energy reduction gains achieved may be offset by reduced potential for regenerative braking.

LNG Locomotive Technology

As stated in the Downer Rail submission of 20 September 2012, EMD is developing LNG engine technology for future locomotive applications. This development is being conducted with EMD’s parent company Caterpillar Inc., as part of a larger development project for Caterpillar off-road vehicles, including mining trucks. The LNG locomotive will be capable of substituting 95% of the diesel fuel intake with LNG with no impact on locomotive performance.

Estimates suggest that, at today’s pricing, fuel costs for the LNG locomotive will be approximately 50% that of a 100% diesel fuelled locomotive. Figure 3 is provided by the Bureau of Resources and Energy Economics and presents a comparison of predicted energy costs for oil (diesel), electricity and natural gas. This forecasts the movements expected in energy price inputs compared to 2008-09 prices, discounted to 2008-09 dollars. This figure supports the view that LNG fuel pricing will continue to be significantly lower than diesel costs in the foreseeable future.

It is accepted that the LNG locomotive will have an impact on locomotive capital pricing, fuelling infrastructure costs and a minor loss in haulage capacity (due to the need for a LNG tender car). Such costs however are minor compared to the overall fuel cost savings over the life of the locomotive. It should also be noted that mining customers are interested in LNG powered mining trucks and that fuelling infrastructure for LNG locomotives could be amortised with similar infrastructure for mining trucks.

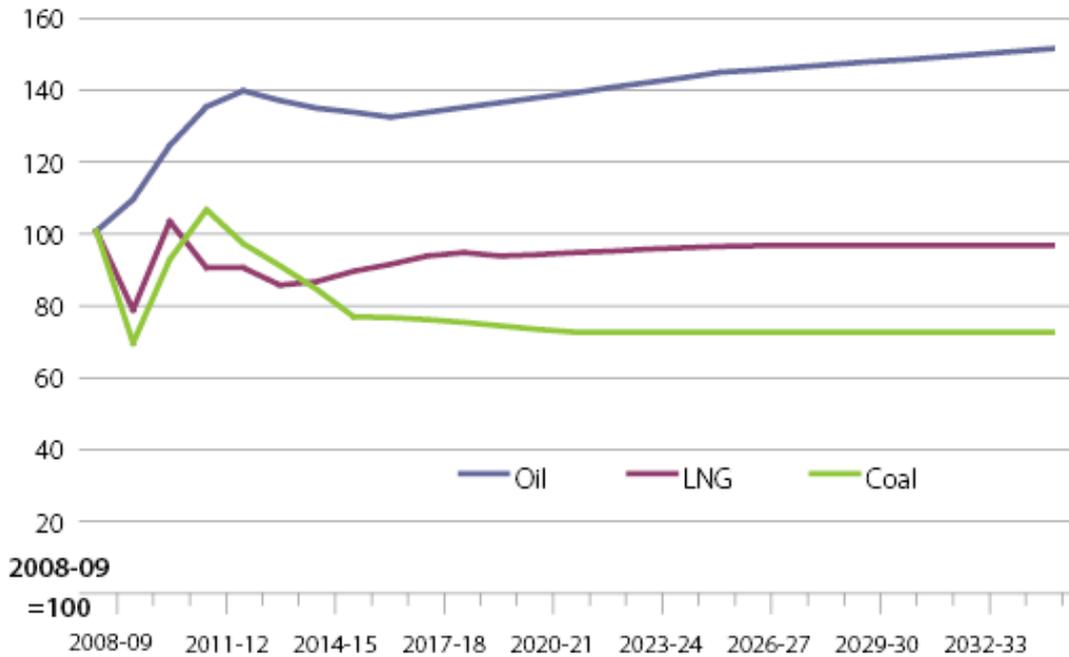


Figure 3: Index of world real energy prices, 2008–09 dollars^{iv}

Carbon Footprint of Diesel and Electric Traction

Diesel locomotives have a lower carbon footprint (intensity) than electric locomotives in Queensland. The carbon intensity of a locomotive is dependent on the ultimate energy source as well as the total efficiency of the locomotive. Coal is an inherently more carbon intensive fuel than other fossil fuels, such as diesel or natural gas^v. The carbon intensities of diesel fuel and coal fired electricity generation, along with the efficiencies of diesel and electric locomotives, were used to compare the carbon intensity of electric and diesel locomotives. The results are presented in Figure 4.

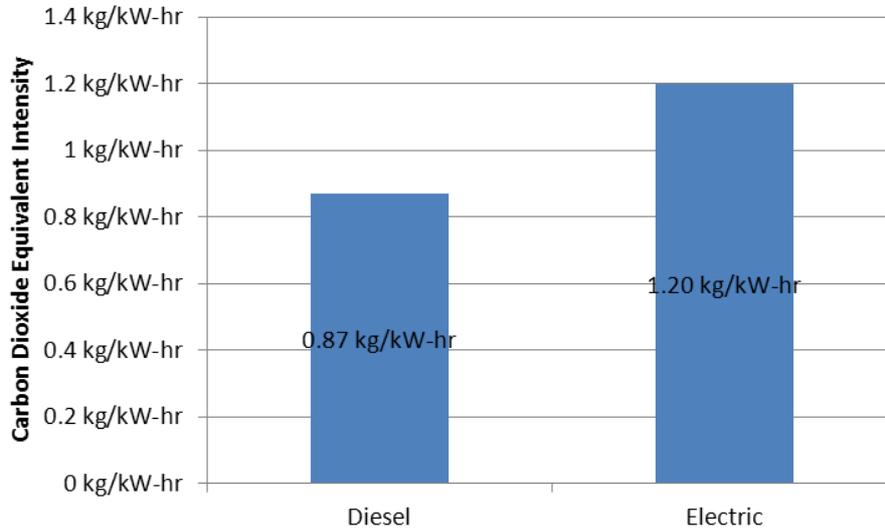


Figure 4: CO₂-e intensity of Diesel and Electric Locomotives.

LNG is less carbon intensive than diesel fuel^v and has the potential to reduce carbon emissions further again compared to diesel technology. There are also a number of other emerging or future technologies which have the potential to substantially reduce the carbon intensity of locomotives. Biofuels are entering wide-spread use and next generation fuel sources are being developed which do not impact food stocks^{vi}. EMD supports the use of biofuels on its locomotives and has announced that 5% biodiesel products can be used on its locomotives with no impact on performance or maintenance costs. EMD is also actively working with customers on fuel products with up to 20% biofuels.

Carbon Tax

With the lower carbon intensity of diesel and LNG compared to coal, the impact of carbon tax should also be considered. A treasury forecast for carbon price is presented in Figure 5, suggesting carbon tax will have an increasing impact on operational costs for rail operators in the future. Any consideration of total cost of ownership should factor in the lower potential carbon tax impacts of diesel and LNG compared to coal generated electricity supply.

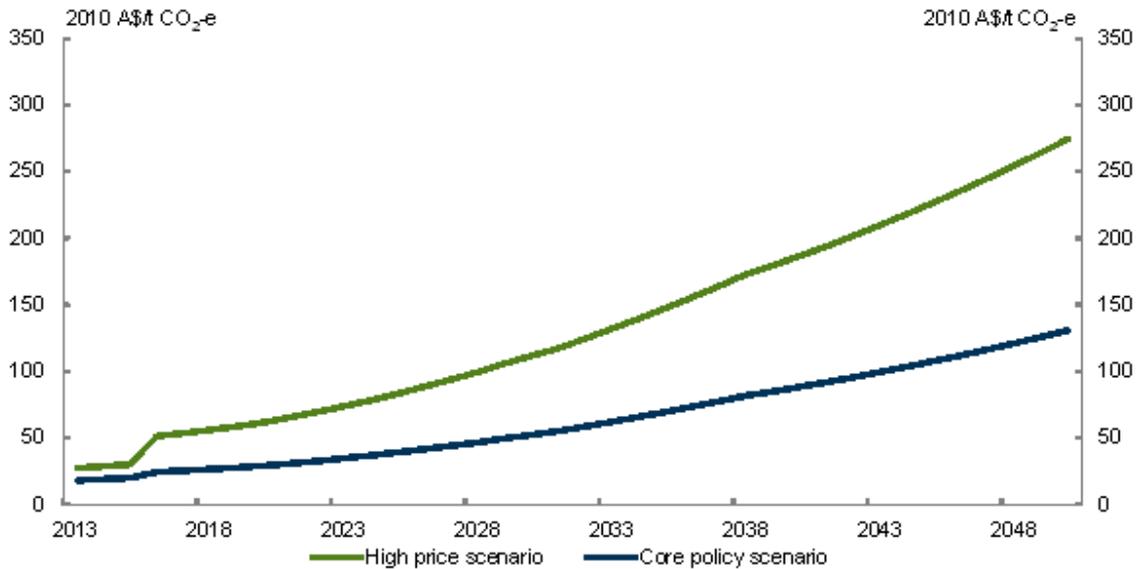


Figure 5: Carbon price forecast^{vii}.

Summary

Downer Rail and EMD believe the diesel electric locomotives provide more flexibility and potential for reducing headways with lower infrastructure costs compared to electric locomotives. We are developing a new narrow gauge locomotive with 36% more power compared to the current diesel electric locomotive. This new locomotive will be capable of hauling similar loads to the existing electric locomotives with the same number of locomotives. Simulations show overall cycle time of the diesel electric powered trains to be similar to that of electric locomotive powered trains.

We agree that the electric locomotive market is competitive however question whether the electric locomotive market in Queensland is as competitive as the diesel electric locomotive market as evidenced by the new narrow gauge diesel electric locomotives being introduced into this market now and the lack of comparable alternative electric locomotives being introduced on to the QR Network.

Downer Rail and EMD agree that maintenance costs for electric locomotives are generally lower than that for diesel electric locomotives. However, when considering the additional maintenance costs of the electrical infrastructure, the total maintenance costs for electric locomotives and infrastructure are approximately three times that of diesel electric locomotive maintenance.

Previous submissions to the QCA had suggested electric powered locomotives to be more efficient than diesel electric locomotives. However, when considering the efficiency of coal

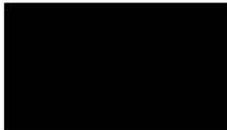


powered generation and losses in transmission, our view is that the overall efficiency of electric and diesel electric traction is similar.

EMD is developing LNG powered diesel electric locomotives which have the potential to drastically reduce fuel costs for operators. While fuelling infrastructure and locomotive capital costs would need to be considered, such costs would be low compared to the large net reduction in total cost of ownership of such locomotives.

Data provided in this submission shows carbon intensity of coal to be substantially higher than diesel. Carbon intensity of LNG is also lower than diesel. The impact of lower carbon emissions and lower carbon tax of the diesel and potential LNG locomotives is a significant factor in total cost of ownership.

Regards



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Matthew Dunwoodie
Area Sales Director
Electro Motive Diesel

References:

ⁱ Toshiba submission 25 September 2012

ⁱⁱ Baumgartner, J P; 2001; *Prices and Costs in the Railway Sector*; Laboratoire d'Intermodalité des Transports et de Planification, École Polytechnique Fédérale de Lausanne, Losanne

ⁱⁱⁱ <http://www.emdiesels.com/emdweb/products/pdf/AESS.pdf>

^{iv} Bureau of Resources and Energy Economics, Australian Energy Projections to 2034-35, 2011. <http://bree.gov.au/documents/publications/aep/Australian-Energy-Projections-report.pdf>

^v http://www.engineeringtoolbox.com/co2-emission-fuels-d_1085.html

^{vi} <http://www.biofuelstp.eu/fuelproduction.html>

^{vii} The Treasury, Strong Growth, Low Pollution: Modelling a Carbon Price, 2011, Chapter 5. <http://archive.treasury.gov.au/carbonpricemodelling/content/report/09chapter5.asp>