Downer

Connecting rail's next opportunity

Practical pathways to lower emissions in passenger and freight rail

Prepared for the PTAANZ Global Transport Leaders' Summit



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PUBLIC TRANSPORT ASSOCIATION AUSTRALIA NEW ZEALAND


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Executive Summary

Rail can provide lower operational emissions than some road transport alternatives, moving passengers and freight efficiently across cities, regions and supply chains. However, achieving further emissions reductions will require continued evolution across the sector.

Operators must consider how to reduce emissions across rollingstock, infrastructure and operations while maintaining the reliability, productivity and asset performance on which rail networks depend.

As Sydney marks a century of rail electrification, the milestone provides a timely reminder of the sector's experience in adapting how rail is powered, and an opportunity to consider what the next phase of that transition could look like.

For operators, that next phase must be technically achievable and commercially viable. Battery, electrification, hybrid solutions and alternative fuels may all have a role, but their suitability will depend on the operating task, existing assets and infrastructure, network requirements and asset life.

No single decarbonisation pathway suits every rail application. For many operators, the transition will be staged: optimise existing assets, use planned modernisation to prepare for future needs, and trial emerging technologies where the operating case is strongest.

Decarbonising rail also extends beyond rollingstock. Infrastructure, energy supply, charging or fuelling requirements, maintenance and operations form part of an interconnected system. The transition also needs to maintain the safe, reliable services that passengers, freight customers and communities depend on.

The challenge is to turn these considerations into a practical transition pathway that starts with the operating task, makes the most of existing assets and infrastructure, and creates options for new technologies as they become viable.

> "The opportunity for rail is not to pursue one technology, but to build a practical pathway to lower emissions. Downer is committed to working with operators and industry to make the most of today's assets, prepare for what comes next and introduce new technologies where they can deliver real value. Taking a whole-system approach can help move the transition forward while maintaining the reliability and productivity that passengers, freight customers and communities depend on."

David Rees , EGM Corporate Development & Origination, Rail and Transit Systems



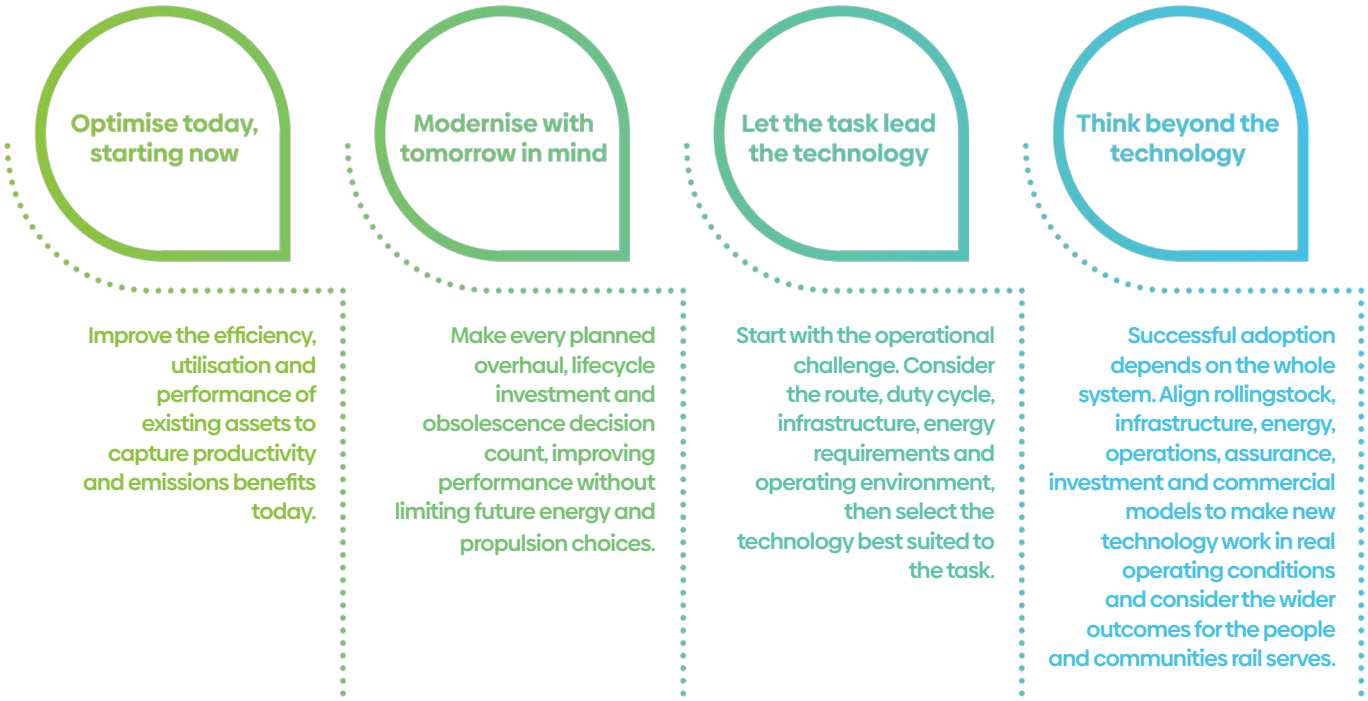
How should rail operators approach decarbonisation?

Passenger and freight rail will not follow the same path to decarbonisation. Passenger networks must consider service requirements and existing electrification, while freight applications range from shunting and short-haul movements to long-distance and heavy-haul operations.

In both cases, the starting point is the same: understand the operating task before selecting the technology.

Operators, technology providers, infrastructure owners, governments, financiers and energy providers all influence what can be delivered. Progress depends on aligning these elements around a practical pathway for change.

Four principles can shape that pathway:



The transition to zero-emission buses offers a useful lesson for rail: changing the vehicle is only one part of the transition. Fleet electrification requires vehicle and route requirements to be considered alongside charging demand, depot operations, grid capacity, site constraints and transition sequencing. Experience from Downer's work in this transition highlights the value of considering these elements together early. For rail, the same whole-system thinking can help operators understand what is needed beyond the rollingstock itself.



How can existing rail fleets reduce emissions today?

The transition does not always need to begin with new technology. For many operators, the first opportunity is to improve the performance of assets and networks already in service.

Better planning, reduced idling, driver support and improvements in asset performance can reduce energy consumption while supporting productivity and reliability. Better asset information can also help identify where further value can be realised and where investment is better directed towards modernisation or new technology.

Asset management therefore becomes part of the decarbonisation pathway. Understanding asset condition, utilisation, performance and remaining life can support better-informed whole-of-life investment decisions.

How can rail modernisation prepare fleets for future propulsion technologies?

Optimising existing assets is one part of the pathway. The next is to use planned modernisation to improve performance without unnecessarily constraining future energy and propulsion options.

Rail assets are typically managed through planned overhauls, lifecycle investment and obsolescence-driven upgrades. These interventions can also create opportunities to prepare assets for future change, particularly where fleet replacement is neither operationally nor commercially appropriate.

The principle is to separate the elements of the locomotive that should endure from those we know will evolve. Future energy requirements can therefore be considered alongside immediate asset needs. For example, traction and electrical architecture can be assessed during planned upgrades with future energy options in mind.

The objective is not to predict which technology will prevail, but to make informed investment decisions that preserve the ability to adapt.

Power technology will evolve. The locomotive should be ready to evolve with it.

Enduring locomotive platform – designed for the rail asset life

- Vehicle structure and cabs
- Bogies and wheelsets
- Braking and safety systems
- Traction motors
- Traction and auxiliary architecture
- Train control and communications

Power systems – design to change over time

- Diesel or renewable-fuel generation
- Onboard batteries
- Future higher capacity battery systems
- Battery or energy tenders
- Wayside charging
- Pantograph and in-motion supply
- Energy-management software


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Passenger rail: design around the journey

For passenger rail, the transition starts with the service requirement, the passengers it serves and the network available to support it. Where electrification ends, the engineering question is how to extend lower-emission operation without necessarily extending fixed infrastructure across the entire route.

Battery-enabled rollingstock provides one potential pathway for partially electrified networks. A train can draw power from the overhead network where it exists, operate on onboard battery power beyond the electrified section and recharge when it returns to the electrified network.

Downer has modelled various rollingstock configurations around this type of operating requirement. Route characteristics, duty cycle, the extent of existing electrification, energy demand and charging strategy determine what is technically practical.

> "The opportunity in passenger rail is not simply to change how we power trains. It is to design the rollingstock, energy and infrastructure around the journey we need to deliver, using what already exists while creating the flexibility to adopt what comes next."



Todd Garvey
Director, Passenger

Rollingstock, energy supply, timetable, route and charging strategy therefore become parts of the same design problem.

In the passenger scenario explored, onboard energy storage is sized for operation beyond the electrified network and the return journey. This allows the train to recharge from existing overhead infrastructure rather than requiring dedicated charging infrastructure at the end of the non-electrified route.

The emissions performance of battery-electric rail depends partly on the electricity used to charge the train. Battery operation can provide an alternative to onboard diesel operation, but the electricity supplying the network remains part of the whole-system emissions equation.

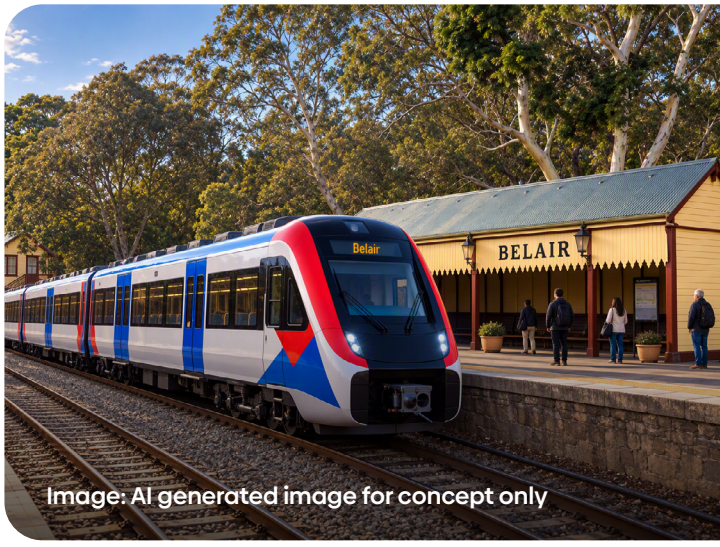


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Freight: match the technology to the task

Battery-electric locomotives are most likely to suit Australian freight applications where the duty cycle, route and charging requirements are clearly defined, including selected shunting, port-shuttle and short-haul operations.

Long-distance and heavy-haul freight present different energy, infrastructure and operational requirements and may require different solutions. Technology selection should therefore start with the operating task rather than a preferred propulsion technology.

The key variables include route, duty cycle, fleet requirements, available energy, charging infrastructure, network interfaces and operating model. A solution suited to a defined shunting or port-shuttle duty cycle may not meet the requirements of long-distance or heavy-haul operations, making technology selection an application-specific engineering decision.

International developments are

> Freight decarbonisation won't be achieved by forcing one technology across every operation. It's about how we manage the entire system: the assets, the infrastructure, the technology, and the operating environment, and build a pathway that delivers emissions benefits without compromising the productivity and reliability our freight networks depend on. We don't need perfect certainty to start the transition. What we need is a practical pathway, strong partnerships and the willingness to start solving the system together.

Troy Sparkman
EGM Freight & Motive Systems,



accelerating the range of battery and energy solutions available to rail. For Australia, the opportunity is to draw on proven global technology while applying the engineering, assurance and integration required for local distances, operating environments and network requirements.

Our recent visit to InnoTrans provided valuable insight into this evolving market. Battery-electric and bi-mode locomotives are continuing to emerge, with a small number of battery-electric prototypes on display and manufacturers signalling a broader range of alternative-traction products towards 2030.

For Australian freight, this reinforces the need to match the technology to the task. For shunting, port-shuttle and selected short-haul applications, defined duty cycles may create an opportunity for battery-electric traction. Downer is developing battery-electric solutions for these applications, providing an opportunity to apply the technology to defined freight tasks in Australian operating conditions.

Case Study:

Battery-electric locomotives

Battery-electric technology is emerging as a potential option for defined freight application specific freight applications. Shunting, port-shuttle and short-haul operations provide defined duty cycles where the technology can be matched to the task. Downer is developing a battery-electric locomotive solution with these applications in mind.

For Australian freight, the engineering challenge extends beyond the locomotive. Successful operation also depends on charging infrastructure, energy supply, network interfaces, standards and the operating model.

This means energy and charging infrastructure cannot be treated as a downstream consideration. They need to be considered alongside the rollingstock from the outset, particularly where connection and infrastructure requirements may influence the timing and viability of deployment.

In Australia's multi-operator rail environment, Downer's work is considering the locomotive and enabling charging infrastructure together, alongside the stakeholder and interface requirements needed to support their introduction into operation.

Commercial models also need to evolve alongside the technology. Deployment may require different approaches to funding and delivering rollingstock, energy infrastructure and lifecycle support, particularly where enabling infrastructure is shared across multiple stakeholders.

Proof matters. Operating trials provide the evidence operators need to assess energy consumption, infrastructure requirements, performance and whole-of-life economics. Real operating data can help operators understand performance, energy

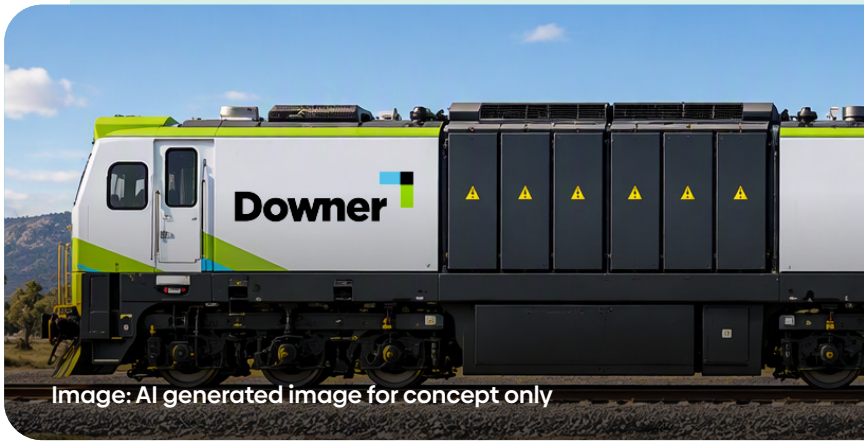


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How can diesel locomotives reduce fuel use and emissions today?



The transition to lower emissions is not limited to new propulsion technologies. For diesel freight fleets, there are opportunities to reduce fuel consumption, emissions and non-productive engine hours from assets already in service.

Reducing unnecessary idling is one example. ZTR SmartStart automatically shuts down and restarts the locomotive engine when operating conditions permit, reducing non-productive fuel consumption, emissions and engine hours while maintaining locomotive readiness.

Technology creates the capability, but locomotive condition, configuration, maintenance and operating practices influence how much value is ultimately captured. Reducing unnecessary idling can also reduce avoidable engine noise where freight operations interact with employees and surrounding communities.

Operating data can help identify where technical capability is not translating into operational benefit. Understanding the causes of unrealised shutdown opportunities allows operators to focus on the conditions preventing available benefits from being captured.

For fleets facing ageing control systems or limited diagnostics, ZTR NexSys provides a modular control architecture incorporating onboard diagnostics, automatic engine stop-start capability, equipment protection, battery-charging control and optional remote monitoring.

Together, idle-reduction technology, operational optimisation and control-system modernisation demonstrate how a staged approach can work in practice: capture measurable benefits from the fleet operating today, use data to identify further opportunities, and use planned modernisation to prepare ageing assets for future requirements.

Operating challenge

Aging assets, higher costs, limited visibility.

- Higher operating costs
- More emissions
- Greater maintenance needs
- Increased risk of in-service failure

SmartStart - immediate efficiency

Automatic engine stop/start intelligent and safe.

- Reduce idle time
- Lower fuel use
- Lower emissions
- Lower engine hours

Case Study:

Downer SmartStart Trial with an Australian Fleet Operator

Decarbonising freight is not only about introducing new propulsion technologies. There are also opportunities to reduce fuel consumption and emissions from diesel locomotives already operating on Australian rail networks.

Downer is trialling ZTR SmartStart technology with an Australian fleet operator to explore these opportunities. SmartStart automatically shuts down and restarts locomotive engines when operating conditions permit, reducing unnecessary idling while maintaining locomotive readiness.

An assessment of six Q Class locomotives from 1 to 30 June 2026 demonstrated the potential impact:

- 305 hours of SmartStart engine shutdown
- 3,580 litres of realised fuel savings
- 9.6 tonnes of avoided carbon emissions
- 16,009 litres of further identified fuel-saving opportunity

Importantly, the assessment also identified opportunities to capture greater value from the technology. The difference between realised and identified fuel savings was linked principally to system overrides and water-temperature conditions that prevented available shutdowns.

The trial demonstrated that addressing these operating conditions could increase SmartStart shutdown time and unlock further fuel and emissions savings across the fleet.



The transition does not always start with replacing the asset. It can start by understanding how the asset is performing today, capturing the benefits already available and using that knowledge to inform what comes next.

System conditions Determine value

Real-world factors influence the outcome

- System availability
- Configuration
- Overrides
- Locomotive condition
- Operating practices

NexSys - broader modernisation

A modular control platform for a smarter, more capable locomotive.

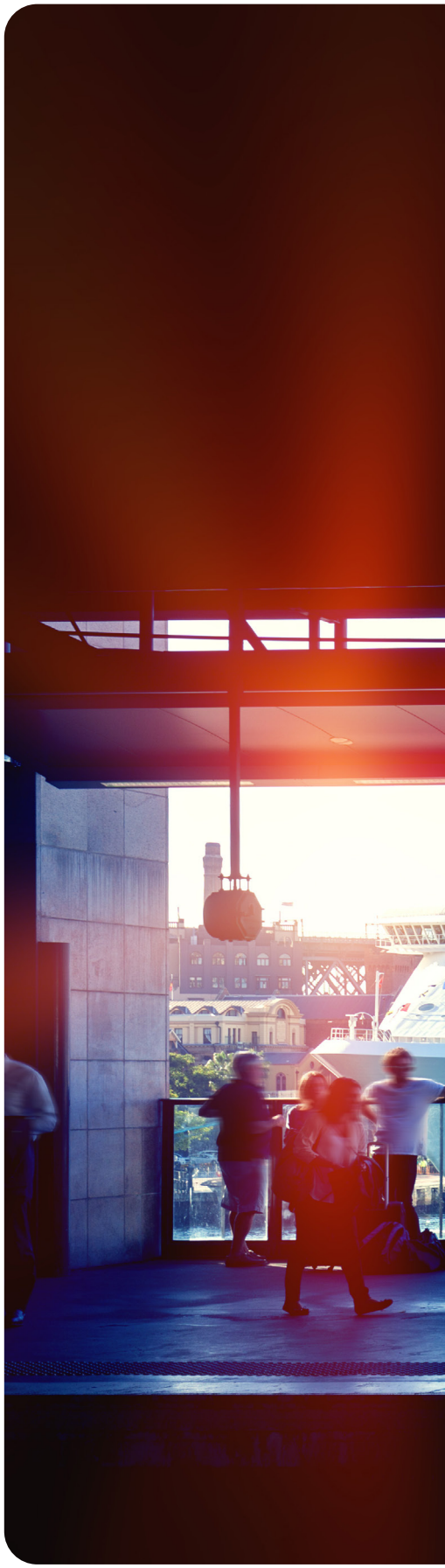
- Modular locomotive control
- Onboard HMI diagnostics
- Remote connectivity
- Equipment protection
- Integrated SmartStart

Downer + ZTR pathway

Local expertise. End to end support. Scalable across your fleet.

- Local engineering
- Integration
- Installation support
- Maintenance support
- Phased fleet scale up

What does a practical rail decarbonisation pathway look like?



Operators do not need perfect certainty to begin the transition. They need practical pathways grounded in the operating task, supported by evidence and capable of evolving as technology changes.

Passenger and freight rail will follow different pathways. Route, duty cycle, existing infrastructure, energy requirements and asset lifecycle will shape what is technically achievable and commercially viable. Technology is an enabler of the transition, not its starting point.

Evidence matters. Technologies need to be proven against real operating requirements, while operational data can show where technical capability is translating into measurable benefit and where further optimisation is needed.

The next phase of rail decarbonisation will require decisions that balance emissions reduction with reliability, productivity and whole-of-life value. It will also require collaboration across operators, technology providers, infrastructure owners, energy providers, government and industry where requirements extend beyond the control of any one organisation. Ultimately, those decisions must support a rail system that continues to move passengers and freight reliably while delivering better outcomes for the customers, employees and communities it serves.

For rail operators, the pathway forward is to make the most of existing fleets and infrastructure, use planned modernisation to prepare assets for future requirements, and introduce new technologies where the route, duty cycle and operating environment support a clear technical and commercial case.



Downer

There is no single pathway to lower-emission rail. Progress will come from sharing experience, testing new approaches and building the evidence needed to make informed decisions.

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