Vale’s journey to Green Energy Vehicle

Vale Energy Transition Metals

Vale North Atlantic Operations

North Atlantic Operates 7 Mines, 3 Mills, 1 Smelter and 5 Refineries in Canada, UK and Japan

What’s our journey …

2030 Vision for Green Energy Vehicles underground

2030 VISION

"To successfully implement *low carbon mining vehicles* that **reduce GHG emissions** and **improve health and safety in the workplace,** driven by **challenging mine conditions at depth** and corporate sustainability goals which **prioritize environmental stewardship and zero harm operations.**"

SUSTAINABLE

Initiatives are in-line with Vale's targets of a 33% reduction in GHG emissions by 2030, and net-zero by 2050

HEALTH-FOCUSED

Air quality and ventilation is improved in underground operations to better working conditions

RESULTS-DRIVEN

With innovative technologies, GEVs meet or exceed diesel equivalents in performance. Enabling mining at Depth

VALE

A multi-step process underway to guide BEVs future adoption

Establish current and forward-looking view for Battery equipment and charging technologies.

Enter the market and gain experience.
Demo 1st electric equipment prior to broader testing.

Test equipment, charging designs and fleet philosophies. Obtain performance at Vale's operation and measure the benefits.

Establish guideline for green field and brownfield operation related to BEVs selection and design for implementation.

Embed BEV into future projects and Life of Mine plans and start full scale execution.

Vehicles Purchase History and Timeline

That's the new 2-yard **electric scooptram,** now in operation at Creighton mine. A new concept in load-haul-dump operation, the unit is operating in a cut-and-fill stoping complex on the 6600 level.

1976

Tethered 2-yard electric LHD at Creighton Mine (6600 Level)

Vehicles Purchase History and Timeline

1996

Kiruna Trolley electric truck haulage initiated at Coleman

Vehicles Purchase History and Timeline

2017

1st battery electric LHD underground at Ontario Operations (Coleman)

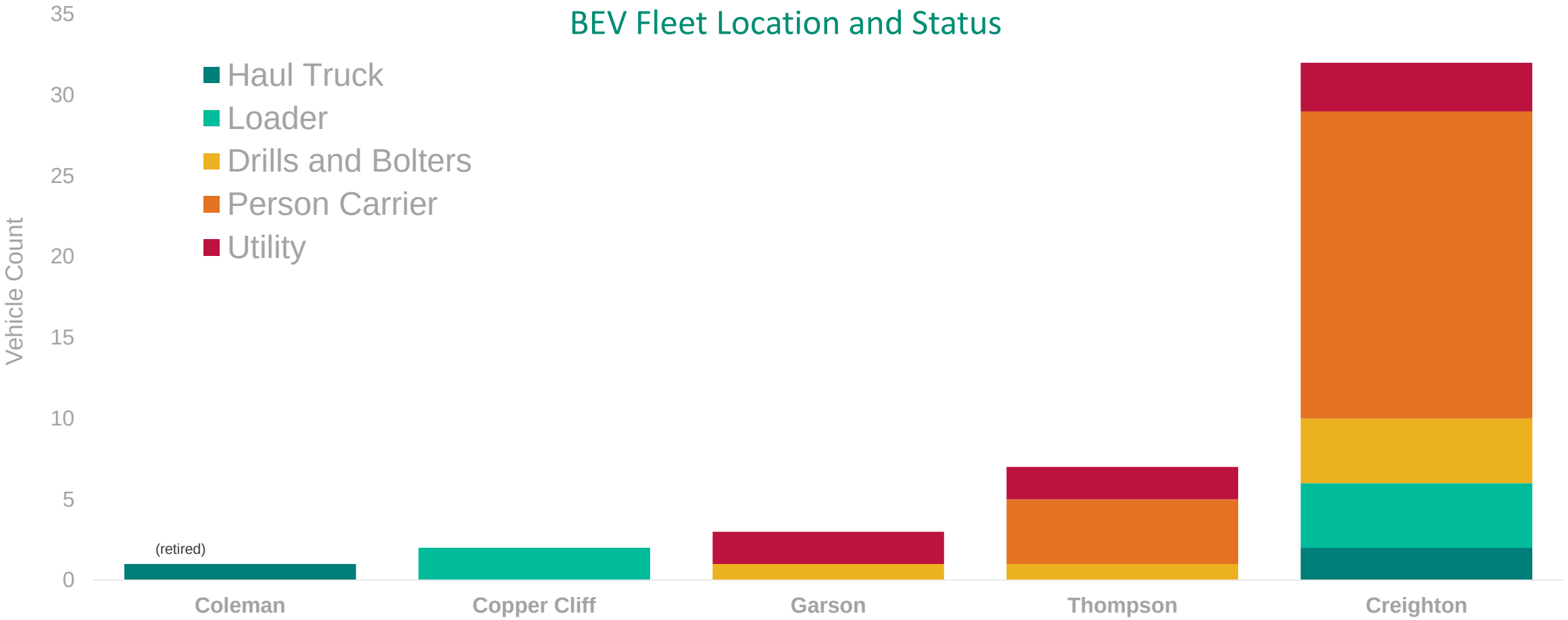
Vehicles Purchase History and Timeline

2023

Vale is currently trialing ~50 BEV’s within North Atlantic Base Metal mines

Leveraging the investment made is top of mind. Operational feedback, vehicle data and telemetry, environmental monitoring and vehicle performance are key indicators that are determining the future viability of these technologies.

North Atlantic U/G BEV Portfolio



Vale’s Green Energy Vehicle Playbook

Green Energy Vehicle Playbook

2016

Scout

Establish current and forward-looking view for Battery equipment and charging technologies.

2018

Demo

Enter the market and gain experience.
Demo 1st electric equipment prior to broader testing.

2019- 2023

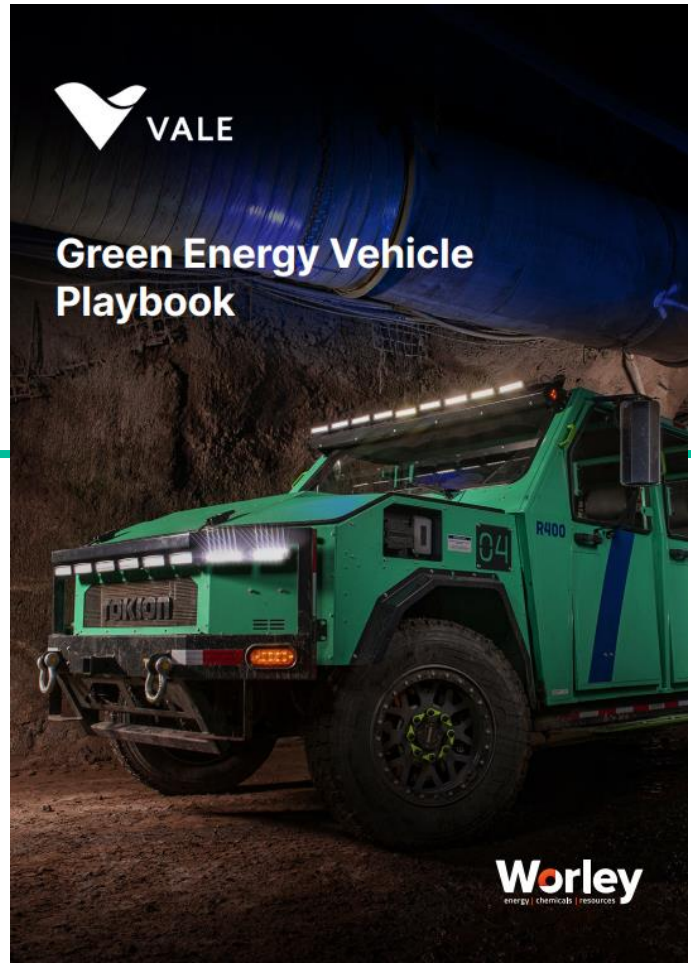
Pilot

Test equipment, charging designs and fleet philosophies. Obtain performance at Vale's operation and measure the benefits.

2023

Assess and consolidate

Establish guideline for green field and brownfield operation related to BEVs selection and design for implementation.



Green Energy Vehicle Playbook

Intent

Assess and consolidate: Enabler of Vale's GEV vision and guideline for future greenfield and brownfield electric vehicle investment decisions.

Content

- *Trial and study review*
- *BEV technology scan*
- *Mine design guidelines*
- *BEV equipment data and specs*
- *Business recommendations*
- *Operational readiness*

Next Steps

Continued stakeholder engagement, mine data review and market scan to further evolve dimensions such as Ops Readiness, trade-offs, support for technology validation & development, and budget planning & investment.

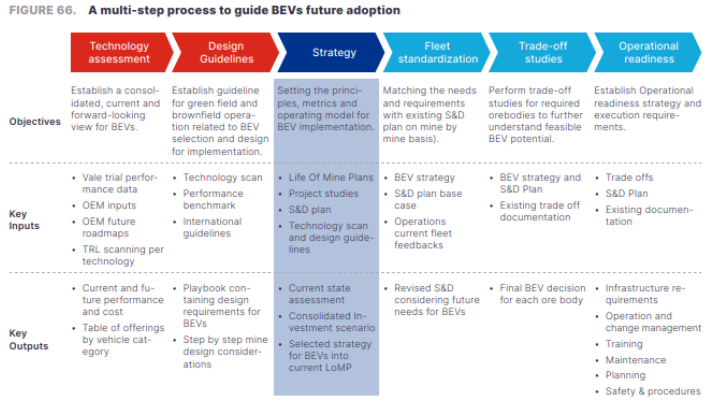


FIGURE 66. **A multi-step process to guide BEVs future adoption**

	Technology assessment	Design Guidelines	Strategy	Fleet standardization	Trade-off studies	Operational readiness
Objectives	Establish a consolidated, current and forward-looking view for BEVs.	Establish guideline for green field and brownfield operation related to BEV selection and design for implementation.	Setting the principles, metrics and operating model for BEV implementation	Matching the needs and requirements with existing S&D plan on mine by mine basis).	Perform trade-off studies for required orebodies to further understand feasible BEV potential.	Establish Operational readiness strategy and execution requirements.
Key Inputs	• Vale trial performance data • OEM inputs • OEM future roadmaps • TRL scanning per technology	• Technology scan • Performance benchmark • International guidelines	• Life Of Mine Plans • Project studies • S&D plan • Technology scan and design guidelines	• BEV strategy • S&D plan base case • Operations current fleet feedbacks	• BEV strategy and S&D Plan • Existing trade off documentation	• Trade offs • S&D Plan • Existing documentation
Key Outputs	• Current and future performance and cost • Table of offerings by vehicle category	• Playbook containing design requirements for BEVs • Step by step mine design considerations	• Current state assessment • Consolidated Investment scenario • Selected strategy for BEVs into current LoMP	• Revised S&D considering future needs for BEVs	• Final BEV decision for each ore body	• Infrastructure requirements • Operation and change management • Training • Maintenance • Planning • Safety & procedures

Green Energy Vehicle Playbook

Who Can Use It?

- **Internal Departments**
  Mine planning, NAPG and studies, mobile, procurement etc.
- **External Collaboration Groups**
  Engineering firms, OEMs.
- **Business and Operations**
  Leadership and management, as well as site-level leadership.

How Can It Be Used?

- **Stop and Assess**
  First alignment tool for ever-evolving BEV technology. Past, present, & future.
- **Education**
  Intended to educate its reader and drive further thought.
- **Cooperation**
  Not intended to be a final version, but a starting point to be continually expanded upon with all partners involved.

What Makes It Different?

- **Vale's Approach**
  Adapted to suit Vale's mine design process and considerations.
- **Technical Review**
  Tailored approach to consolidating and reviewing site-specific and vehicle performance data.
- **Guidance**
  Considers LoMP and provides guidance on next steps and where to focus efforts.

A collaborative effort to provide a starting point for education, guidance, and future work…

Few Lesson Learned along the way …

Lesson Learned (1/2)

Economics

Increased Capex per unit and infrastructure cost

Increased Opex with BaaS vs fuel

→ Wholistic business case is required

Savings can be made on Ventilation requirement (40% to 60% in greenfield) or allowing access to constrained OBs

→ Look at both saving ventilation cost or increasing mining intensity

Performance

Higher Performance is observed with higher torque in muck pile and speed for trucking

→ Not one solution works for all

Improved working conditions & morale
(Cooler air temperatures, Less noise, Cleaner air, Improved vehicle performance, Effective working hours per shift)

→ Consider Electrification as part of your transformation journey

Lesson Learned (2/2)

Technology

Technology is rapidly evolving with new generation of equipment and chemistry	Work closely with OEMs as partners, build platform for ease of transformation
Knowledge is limited inside and outside the company	Build flexibility into design

Operational Readiness

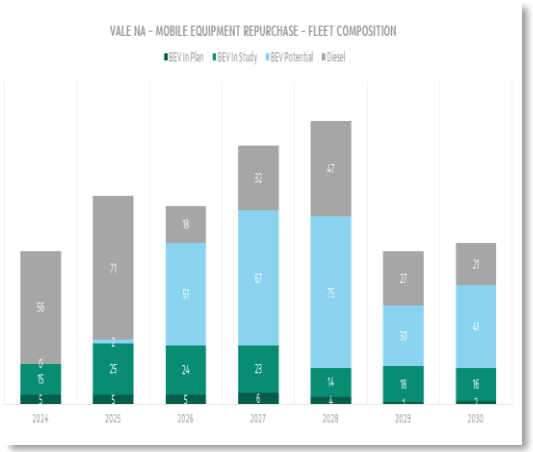
Training operational and maintenance personal is critical for success	Advance strategical planning
Safety is a key concern for many	Build your own internal specifications, education, safety protocols, training, mock-up

Where are we going next?

There is still tremendous work to embed BEV equipment within our mines

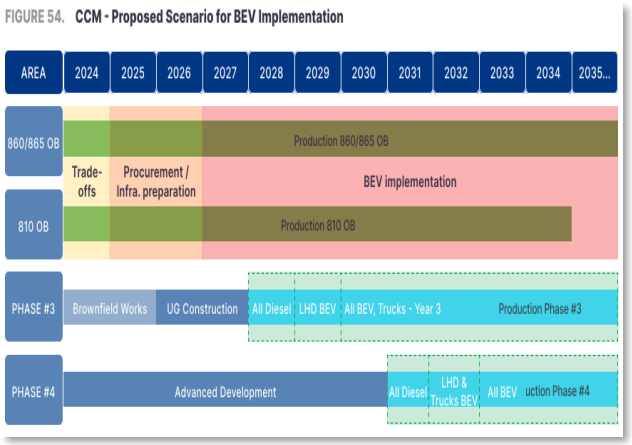
Execute current plan

Implement where we know there is Value



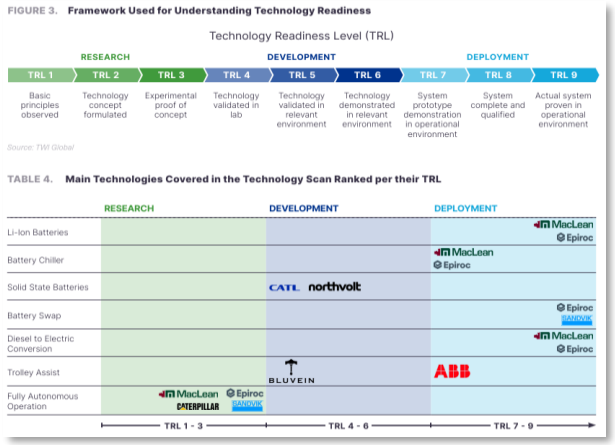
Assess the remaining uncertainty

Trade-offs Perform remaining Trade-off studies where path is unclear



Develop Technology

Continue to work on Technology development to offset current shortcomings
(Dynamic charging, range anxiety e.g)



Many questions are still to be answered…

Technology Risk

- **Technology development**
  Wait for the next generation or implement now?
- **Charging Strategy**
- **Adjacent Technologies**
  How do EV's align with automation?

Implementation risk

- **Power Grid:**
  Can we handle the draw for a full fleet? How to manage charging sequence as a new constraints for operations?
- **Change Management:**
  How do we ensure success at the operation? Slow or fast implementation?
- **Operational Benefit**
  Will we realize the savings we expect?

Market and supply

- **Market Supply**
  Does it align with our needs ?
- **Sustainability**
  Manufacturing location and its carbon footprint?

And Many others…


VALE