Environmental Impacts: A Comparative Study on Noise and Air Quality in Diesel and EV Mobile Equipment

WSN Presentation

Feb 15, 2024

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INTRODUCTION

- *Why will the Maple Leaf's win the Stanley Cup this year ?*

Because Montreal will let them !

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MacLean Underground Test Facility – Sudbury, Ontario

MacLean
Performance. Reliability. Innovation.

MacLean Test Vehicles used

EV Cassette Truck CS3-086
134 kwh Battery Pack c/w 189 kw electric motor.
Empty Load 42,800lbs.
Fully Loaded 56,4000lbs.

Diesel Water Truck WC-010 150kW
Engine c/w150l diesel tank
Empty Load 43,900 lbs.
Fully Loaded 54,400 lbs.

INTRODUCTION

MacLean Engineering started our journey in 2015 with our first steps into the design of BEV mobile units for the underground mining sector. The goal back then was to develop a design that would replace the need for diesel propulsion engines underground. This transition away from diesel propulsion at the time was in its very infancy and a commercially successful product was in no way a guaranteed outcome. As our design started to mature and gained viability based on testing and verification of the initial three prototypes, we started to develop a list of benefits or assumed benefits that we felt would aid in the adoption of EV equipment for our customers as listed below;

1/. Elimination of exhaust gases and DPM.

2/. Reduced ventilation and associated costs.

3/. Noise Reduction.

4/. Reduction of Parts and maintenance/servicing hours compared to diesel engine/exhaust and air intake components.

5/. Cooler running units.

6/. Elimination of “hot” surface areas on mobile equipment.

OBJECTIVES

With the introduction of any new technology there are lots of challenges that need to addressed by proof-of-concept testing and validation while the expectations of the benefits of EV adoption would be many and in line with most of if not all our assumptions. To address the initial assumptions, we tested at many sites in conjunction with our customers. Range and performance testing confirmed many of our original assumptions. These results have been previously shared on many occasions and below is a link to some additional third-party testing for performance results.

CanmetMINING diesel and BEV field test series: MacLean Engineering diesel and battery electric cassette truck: CIM Journal: Vol 0, No 0 (tandfonline.com)

So, the emphasis on today's presentation will focus on three areas of EV versus diesel testing.

1/. Respirable Dust.

2/. Noise.

3/. Elemental Carbon.

1/.Respirable Dust

This topic of respirable dust is referring to the disturbance caused by the porting of the exhaust stream that can contribute to dust generation in a U/G environment.

The force of the exhaust expulsion can cause a dust on the ground or sidewalls to be “kicked up” and that can introduce issues with air quality and visibility.

The introduction of BEV equipment in the U/G environment eliminates this issue, but during this test no appreciable respirable dust was observed by the diesel unit.

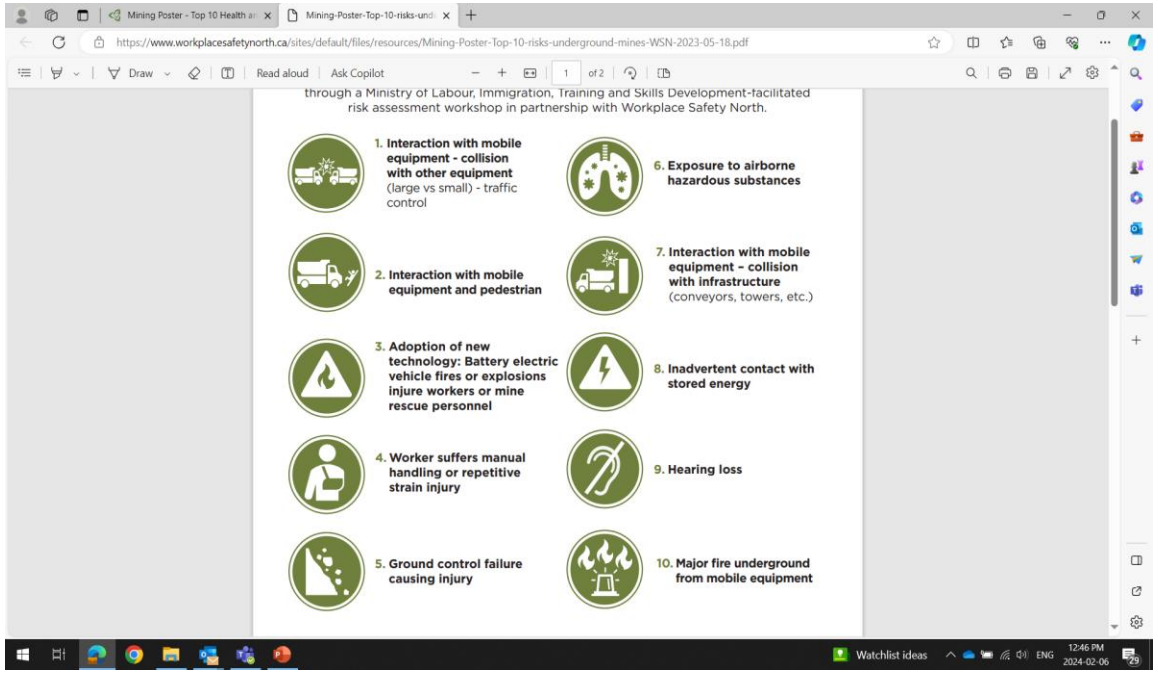
This could be explained by several factors;

- Ground water was coming through the rock resulting in wet , humid conditions.
- The sidewalls had no accumulated dust.
- Ramp was well graded and wet.

2/.Noise

This topic of noise in the workplace is a well- documented issue so any improvements are a welcome result. The introduction of BEV in the U/G environment is seen as an area of strength, anyone that has used a diesel vehicle and the same or equivalent EV unit can notice a reduction of noise in both the surface and u/g environment, so here is a case of we think it is better but after this testing we can say with a high degree of confidence we know it is better.

[Occupational disease risks in key industries: Protecting workers' health | Workplace Safety North]



2/.Noise

The testing method looked at several conditions that included the following;

A/. BEV Full Load vs. Empty Load (20kcfm) in four locations.

B/. BEV Full Load (20kcfm)vs. Full Load (10kcfm) in four locations.

C/. BEV Full Load (20kcfm) vs Diesel Full Load (20 kcfm) in four locations

D/. BEV Empty Load vs Diesel Empty Load (20kcfm) in four locations.

E/. Diesel Full Load vs Diesel Empty Load (20kcfm) in four locations.

The results of the different testing conditions can be seen on the following slides except for Test E which can be seen below.

Test			
E	Avg. diesel Full Load 20 (kcfm) dB	Avg. diesel Empty Load 20 (kcfm) dB	Diff. dB
	88.29	84.86	-3.43

2/.Noise

The testing method looked at several conditions that included the following;

A/. BEV Full Load vs. Empty Load (20kcfm) in four locations.

B/. BEV Full Load (20kcfm)vs. Full Load (10kcfm) in four locations.

test			
A	Average BEV Full Load 20 (kcfm) dB	Average BEV empty Load (20 kcfm) dB	Diff. dB
	83.25	82.68	0.57
B	Average BEV Full Load 20 (kcfm) dB	Average BEV Full Load 10 (kcfm) dB	Diff Db
	83.25	83	0.25

2/.Noise

The testing method looked at several conditions that included the following;

C/. BEV Full Load (20kcfm) vs Diesel Full Load (20 kcfm) in four locations.

D/. BEV Empty Load vs Diesel Empty Load (20kcfm) in four locations.

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Test			
C	Avg. BEV Full Load 20 (kcfm) dB	Avg. diesel Full Load 20 (kcfm) dB	Diff. dB
	81.875	88.275	6.4
D	Avg. BEV Empty Load 20 (kcfm) dB	Avg. diesel Empty Load 20 (kcfm) dB	Diff. dB
	81.75	85.17	3.42

2/.Noise

The final testing was based on both vehicle being tested while idle and performing different actions.

F/. Equipment noise exposure BEV vs Diesel.

The following testing was conducted on the units in four locations while in the following modes;

- Idle.
- Idle and Steering + brake Mode.
- Brake Testing.

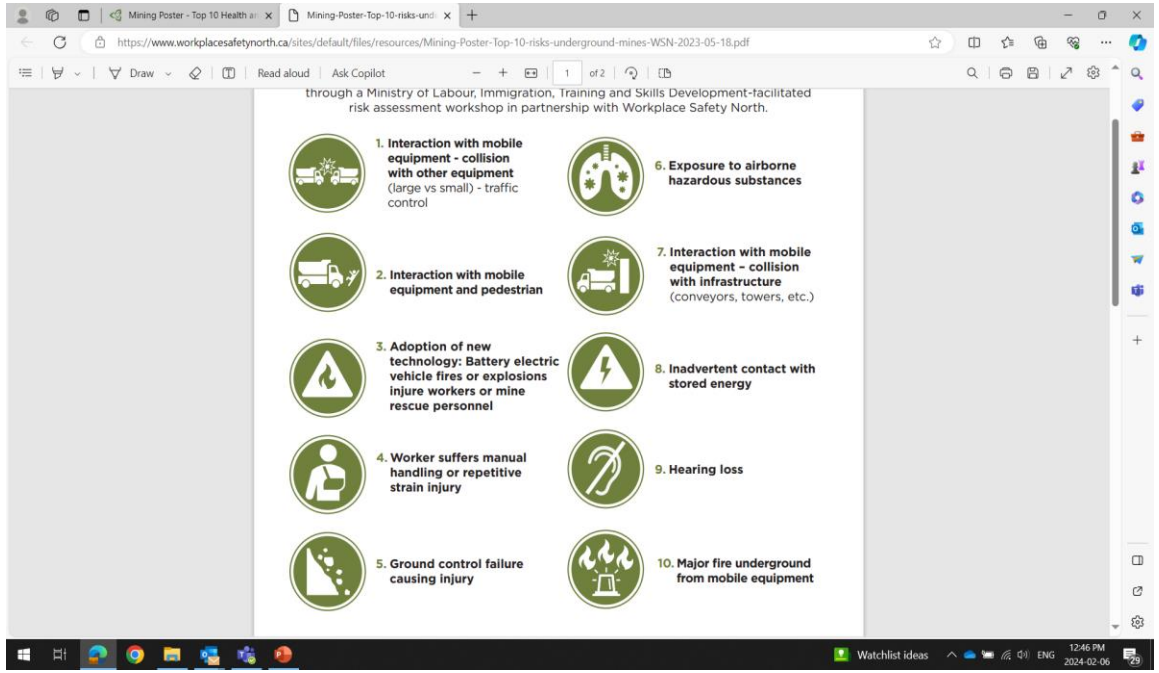
Test			
F	Avg BEV dB	Average Diesel dB	Diff Db
Idle	76.4	93.9	17.5
Idle, steering + Brake	80	94.9	14.9
Brake Test	78.5	104.3	25.8

3/. Elemental Carbon

This topic of diesel emissions in the underground mining sector has been discussed, identified for some time and one of the acknowledged benefits is the elimination of diesel exhaust emissions.

The following slides will show the results of various

Tests that were undertaken.



3/. Elemental Carbon

This topic of diesel emissions in the underground mining sector has been discussed, identified for some time and one of the acknowledged benefits is the elimination of diesel exhaust emissions.

The following slides will show the results of three (3) separate tests that were undertaken at 4 different locations in the mine and are shown below as an average.

1/. Elemental Carbon.

Test #1	Elemental Carbon mg/m3		
	Avg. Full Load mg/m3	Avg.Empty Load mg/m3	Diff
Diesel Full Load vs Diesel Empty Load (20kcfm)	0.033	0.02	0.013
BEV Full Load vs Diesel Full Load (20kcfm)	0.0012	0.03	0.0288
BEV Empty Load vs Diesel empty Load (20kcfm)	0.00115	0.02	0.0188

3/. Carbon Monoxide (CO)

During the 9 days of testing at the site no measurable carbon monoxide was observed. Measurement range was 0-2000 ppm.

3/. Nitrogen Dioxide (NO2)

The measurement range was 0-50ppm.

3/. Nitrogen Dioxide (NO2)

Test	Nitrogen Dioxide (NO2) ppm		
	Avg. Full Load. ppm	Avg. Empty Load ppm	Diff
BEV Full Load vs Empty Load (20 kcfm)	0.25	0.012	0.238
BEV Full Load vs Empty Load (10 kcfm)	0.025	0.024	0.001
	Avg. Full Load . ppm	Avg. Full Load ppm	
BEV Full Load vs Diesel Full Load (20kcfm)	0.025	0.53	0.505
	Avg. Empty Load ppm	Avg. Empty Load ppm	
BEV Empty Load vs Diesel empty Load (20kcfm)	0.012	0.515	0.503
	Avg. Full Load ppm	Avg. Empty Load ppm	
Diesel Full Load vs Diesel Empty Load (20kcfm)	0.53	0.515	0.015

3/. Nitrogen Monoxide (NO)

The measurement range was 0-200ppm.

3/. Nitrogen Monoxide (NO)

Test	Nitrogen Monoxide (NO) ppm		
	Avg. Full Load . ppm	Avg. Empty Load ppm	Diff
BEV Full Load vs Empty Load (20 kcfm)	No measurable Levels	No measurable Levels	
BEV Full Load vs Empty Load (10 kcfm)	No measurable Levels	No measurable Levels	
	Avg. Full Load . ppm	Avg. Full Load ppm	
BEV Full Load vs Diesel Full Load (20kcfm)	0	0.845	0.845
	Avg. Empty Load ppm	Avg. Empty Load ppm	
BEV Empty Load vs Diesel empty Load (20kcfm)	0	0.53	0.53
	Avg. Full Load ppm	Avg. Empty Load ppm	
Diesel Full Load vs Diesel Empty Load (20kcfm)	0.832	0.53	0.302

4/. Next Steps

With this testing completed part of our takeaway was that the EV units produced desirable results when compared to an equivalent diesel unit.

The test we conducted were on MacLean units , while not identical were as comparable as possible they were also based on a standard commercial product using standard components that would normally be found on commercially available equipment. We also tested just one of our lines that was our Utility Vehicle product, the results do not reflect all the products produced by Macleans.

The test site while not an operating mine was close as we could replicate to a u/g operation, granted there was not huge volumes of equipment operating and the site is not deep in comparison to operating mines we feel that these results are a good baseline and reasonably indicative of operating conditions.

Testing will continue as data and customer requests develop and as the EV adoption continues to gain traction.

4/. Next Steps

The aspect of noise generation has led us to introduce a new enclosed cab, the GR5, this cab is now available and is offered on both diesel and EV units.

Our previous enclosed cab was essentially designed based on diesel operated vehicles and one of the primary features was to protect the operator from noise coming from the engine and associated components, as this source is no longer an issue with EV units the new design focused on several new areas, better ergonomics, better visibility and site lines while not forgetting about protection from noise.

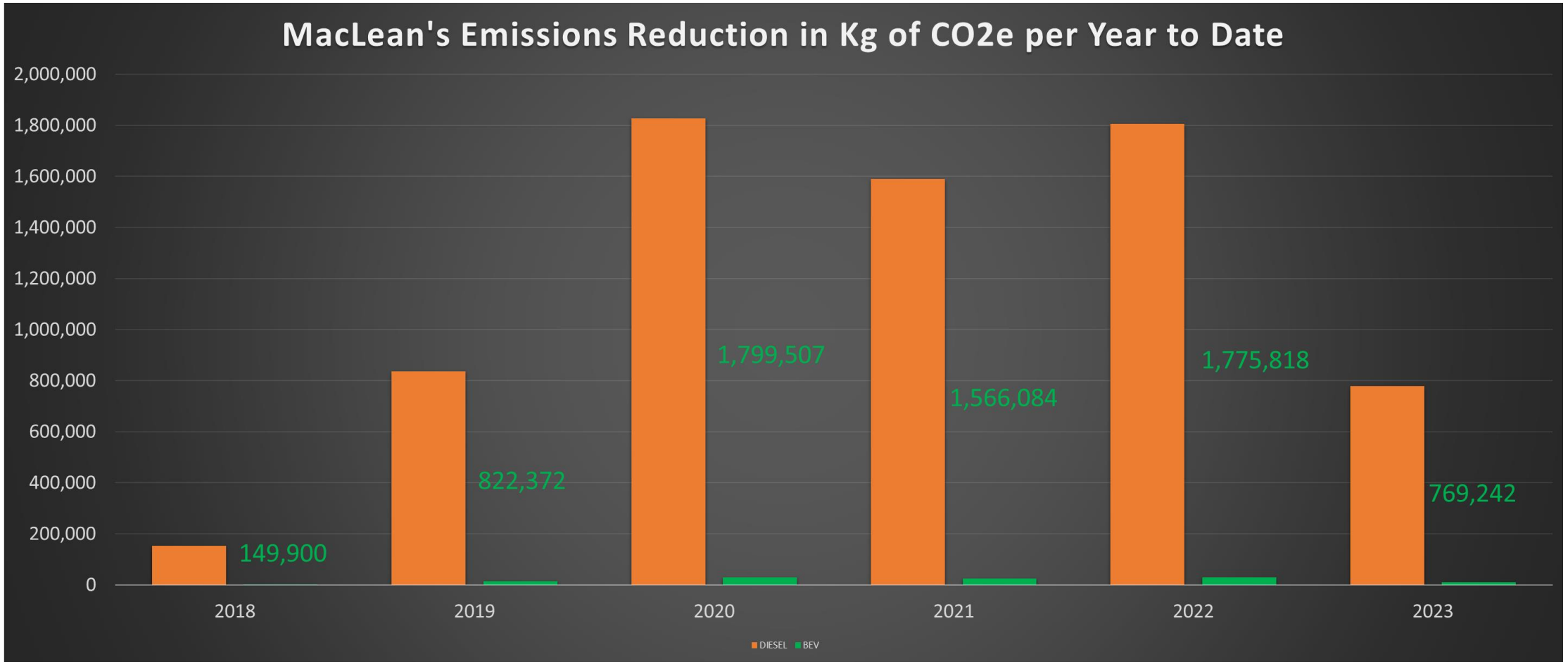
We are constantly looking at noise reduction even on EV units by investigating the use of intermittent pumps and motors as opposed to constant service, this will also lessen the draw on the batteries.

So, by advancing our EV design and understanding the diesel units better, we can continue to provide a better solution for both.

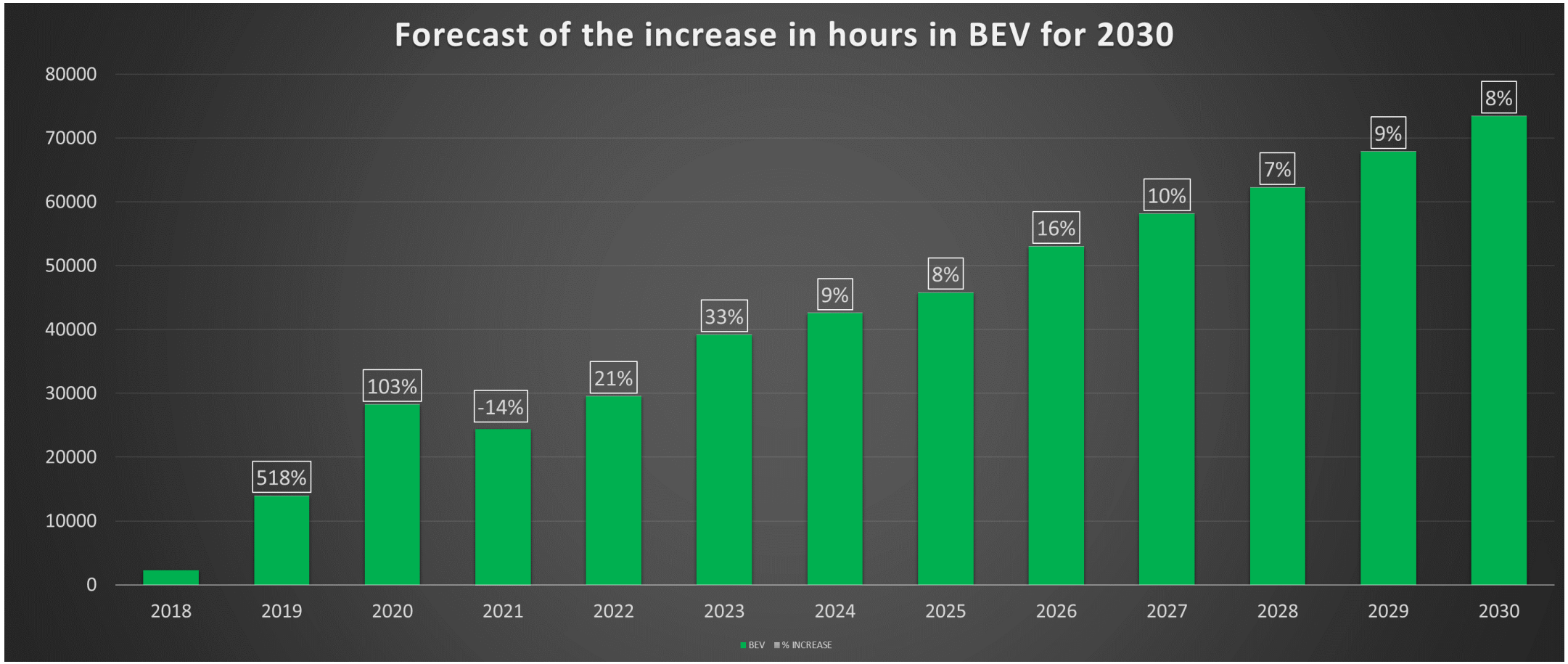
Test , test and more testing and with our U/G facility we can continue to share what we are finding.

The next two slides were produced at about the same time as the EV vs diesel testing above took place and indicates what we forecast in total annual EV hours and emissions reductions.

CO2e reductions.



EV Fleet operational hour trends.



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5. Conclusions

5/. Summary and Conclusions.

1/. The results for respirable dust at first glance would appear to indicate that this can be dismissed, however our takeaway is that a well managed and conditioned ramp system will reduce or eliminate any negative effects of exhaust porting.

2/. The over all noise reduction by adopting EV units is significant in both idle and moving conditions. The testing was done on one unit, this result multiplied by the adoption of a complete fleet will certainly be a beneficial outcome and provide for a better working environment.

3/. The results of the air quality testing also show that the EV units have eliminated this issue associated with diesel emissions. This development also has significant benefits for a better working environment.

While this test was limited in scope, time and resources it does provide us with baseline data for future innovation, it does show that EV adoption can be seen as a first step to improving the workplace for existing workers, making a strong statement to new miners entering the work force, as well as providing a positive net benefit in terms of our Carbon Footprint.

MacLean

THANK YOU / MERCI / GRACIAS

Q&A + Contact Info

Please do reach out for any questions, requests for documentation or discussions on how this could work for your project/operation.

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