

# BEV FLEET MAINTENANCE AND RELIABILITY

HALEY BLINN & SAKETH ADIRAJU

CIM MEMO - 2023



# CURRENT OFFERING

## BATTERY ELECTRIC LOADERS AND TRUCKS



### LH518iB

Dimension (L-W-H) 11.8 x 2.9 x 2.6 m

Capacity 18 000 kg

Bucket range 6.3 - 8.6 m<sup>3</sup>

Weight (operating) 52 000 kg

Power, continuous 540 kW

Speed (loaded, 0%) 27.5 km/h



### TH550B

Dimension (L-W-H) 11.1 x 3.3 x 2.9 m

Capacity 50 000 kg

Dump box 28 m<sup>3</sup>

Weight (operating) 49 600 kg

Power, continuous 540 kW

Speed (loaded, 0%) 37 km/h



### TH665B

Dimension (L-W-H) 11.6 x 3.5 x 3.6 m

Capacity 65 000 kg

Dump box 40 m<sup>3</sup>

Weight (operating) 56 400 kg

Power, continuous 540 kW

Speed (loaded, 0%) 33 km/h

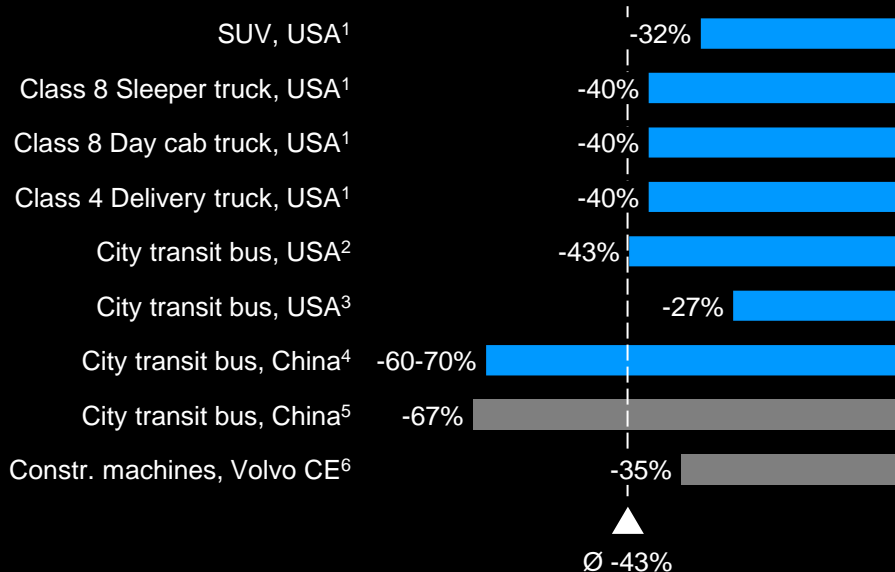
# ECONOMICS & OPERATING COSTS

~40% REDUCTION VS DIESEL TO BE EXPECTED



## BEV REPAIR & MAINTENANCE BENEFIT BENCHMARKS

% reduction in lifecycle repair & maintenance cost vs. diesel equivalent



## FACTORS DRIVING THE BENEFITS

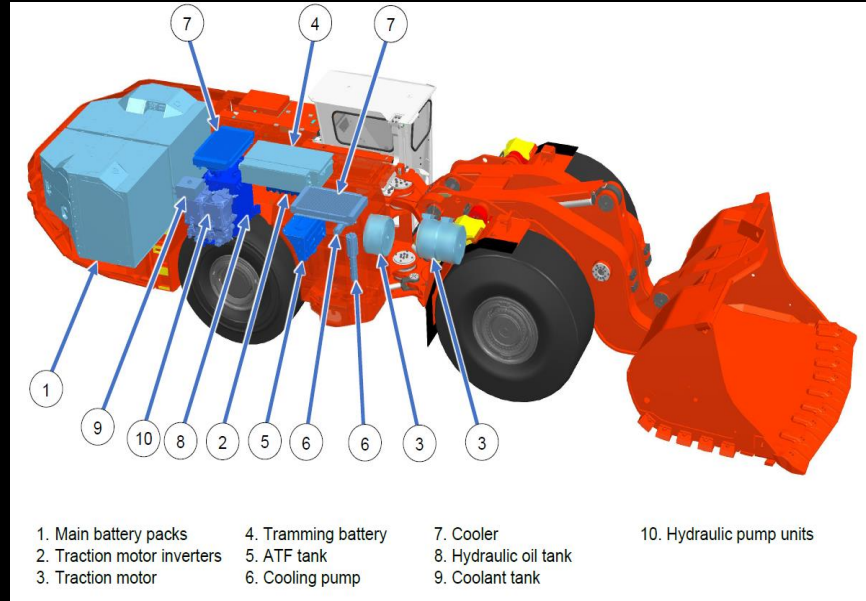
As mentioned in benchmark sources

- Less maintenance labor and downtime due to lack of
  - Transmission
  - Exhaust systems
  - Fuel systems
  - Spark plugs
  - Oxygen sensors
  - Fuel, engine air and oil filters
- Reduced wear and consumables use
  - Less brake pad wear due to regenerative braking
  - 60-80% lower overall fluids consumption<sup>7</sup>

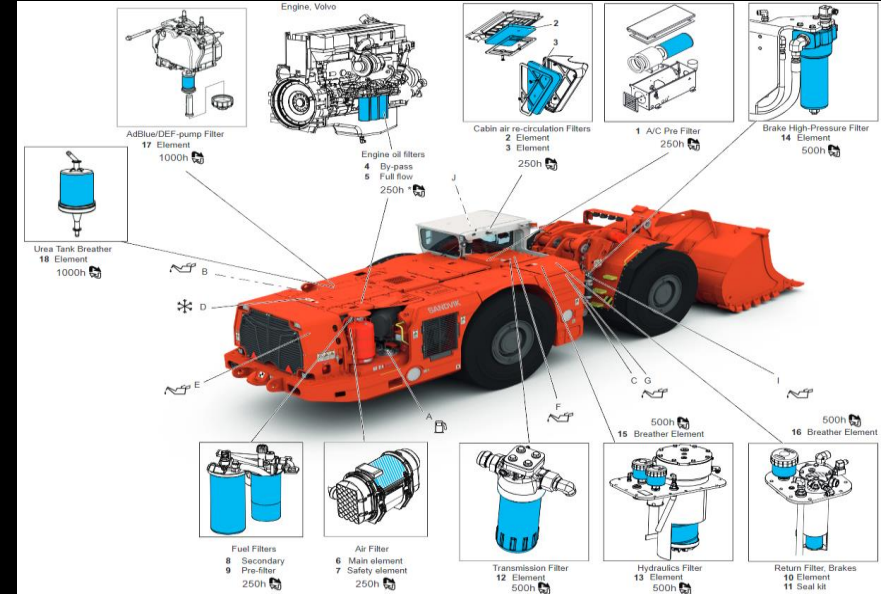


# DESIGN

## LH518B



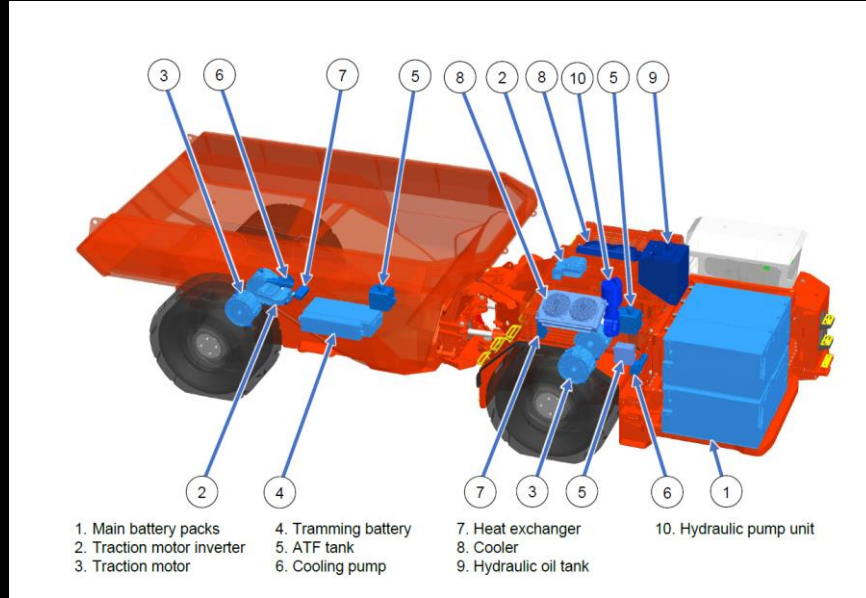
## LH517



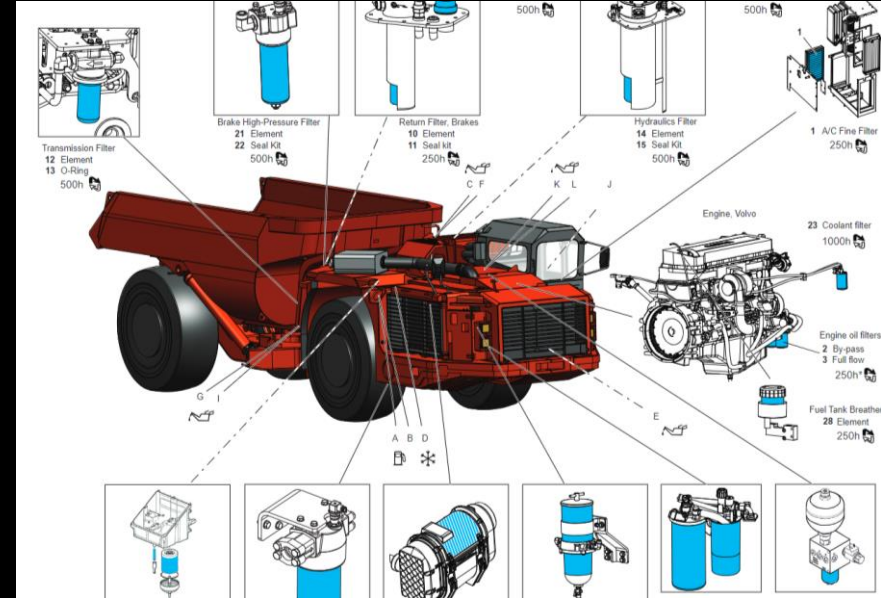


# DESIGN

## TH50B








## TH551



# DESIGN

## BEV VS. DIESEL MACHINE DIFFERENCES



DIESEL MACHINE	BATTERY-ELECTRIC MACHINE (Generation 3)	
<p>MAJOR COMPONENTS AND PARTS</p> <ul style="list-style-type: none"> <li>• Diesel engine</li> <li>• Air intake &amp; exhaust</li> <li>• Torque Converter</li> <li>• Transmission</li> <li>• Axles</li> <li>• Differentials</li> <li>• Brakes</li> <li>• Hydraulic pumps</li> <li>• Hydraulic cylinders</li> <li>• Filters (fuel, air, oil)</li> </ul>	<p><b>REMOVED</b></p> 	<ul style="list-style-type: none"> <li>• Diesel engine</li> <li>• Air intake and exhaust</li> <li>• Torque Converter</li> <li>• Transmission</li> <li>• Axles (T)</li> <li>• Fuel tank</li> </ul> 
	<p><b>ADDED</b></p> 	<ul style="list-style-type: none"> <li>• Battery lift rack</li> <li>• Batteries</li> <li>• Traction motors</li> <li>• Hydraulic pump motors</li> <li>• Inverters</li> <li>• Wheel end reducers (T)</li> <li>• Drop box (L)</li> </ul> 
	<p><b>CHANGED</b></p> 	<ul style="list-style-type: none"> <li>• <b>Brake assembly:</b> regenerative braking, significantly less use, no midlife rebuild</li> <li>• <b>Filters:</b> no fuel or air filters, lower fluid flow from on-demand hydraulics</li> <li>• <b>Hydraulics:</b> less pump wear due to speeds on-demand rather than by engine speed</li> </ul>

## LIFECYCLE IMPACT

**30-40% lower operating cost**  
(excluding fuel and batteries)



**~50% fewer maintenance procedures / year**

(T) = Trucks, (L) = Loaders



# DESIGN

## MAJOR COMPONENT INDICATIVE LIFE HOURS



### DIESEL MACHINE

#### MAJOR COMPONENTS

- Diesel engine – 15,000hrs
- Air intake & exhaust – 6,000 hours
- Torque Converter – 10,000 hours
- Transmission – 10,000 hours
- Axles – 15,000 hours
- Differentials – 10,000 hours
- Brakes – 7,000 hours
- Hydraulic pumps – 6,000 hours
- Hydraulic cylinders – 6,000 hours

### BEV

#### MAJOR COMPONENTS

- Electric drive motors – 40,000hrs
- Inverters & HV components – 40,000 hours
- ATF Cooling motors – 30,000 hours
- Pumps & Cylinders – 7,000 hours
- Brakes: 15,000 hours or more

### LIFECYCLE IMPACT

**30-40% lower  
operating cost**  
(excluding fuel and batteries)



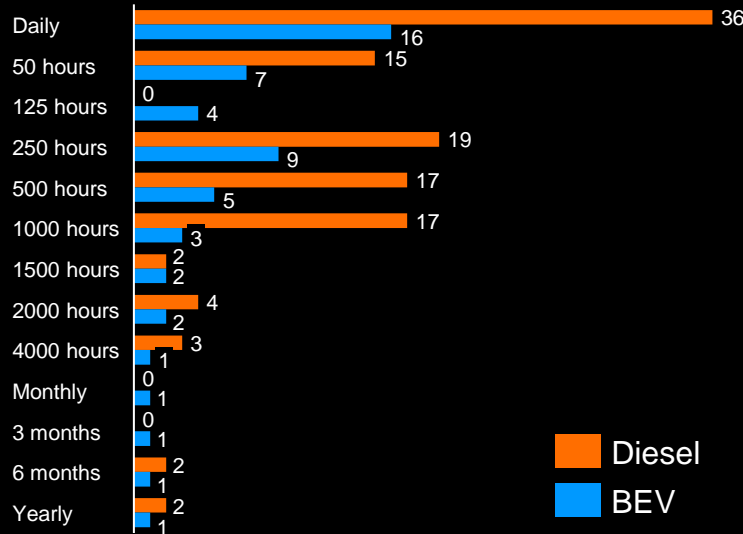
**~50% fewer  
maintenance  
procedures / year**

# ECONOMICS & OPERATING COSTS

## PLANNED MAINTENANCE TASKS COMPARISON

7.2.5 Every 1000 hours		Diesel hours	1000 HOURS	Notes
Maintenance procedure	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	See the instructions for reading maintenance cards.
Perform the maintenance procedures of all relevant shorter intervals at the same time.	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>FRAME STRUCTURES</b>				
Change the fuel cap breather element	<input type="checkbox"/>	239	<input type="checkbox"/>	
<b>POWERPACK</b>				
Visually check the exhaust gas purifier	<input type="checkbox"/>	271	<input type="checkbox"/>	
Inspect the check valve in the scavenge line	<input type="checkbox"/>	272	<input type="checkbox"/>	
Inspect the cooling system	<input type="checkbox"/>	273	<input type="checkbox"/>	
Change SCR pump filter element	<input type="checkbox"/>	276	<input type="checkbox"/>	
<b>POWERTRAIN</b>				
Change the transmission oil and of filter elements	<input type="checkbox"/>	305	<input type="checkbox"/>	
Change the gearbox oil	<input type="checkbox"/>	310	<input type="checkbox"/>	
Change the oil in the planetary hubs and differentials	<input type="checkbox"/>	315	<input type="checkbox"/>	
Check the tightness of axle fastening nuts	<input type="checkbox"/>	317	<input type="checkbox"/>	
<b>HYDRAULICS</b>				
Change the brake hydraulic oil	<input type="checkbox"/>	346	<input type="checkbox"/>	
Test the pilot system hydraulic pressure	<input type="checkbox"/>	348	<input type="checkbox"/>	
Test the steering system hydraulic pressure	<input type="checkbox"/>	350	<input type="checkbox"/>	
Test the box hydraulic pressure	<input type="checkbox"/>	351	<input type="checkbox"/>	
Test the ejector box hydraulic pressure (option)	<input type="checkbox"/>	352	<input type="checkbox"/>	
Check the suspension system pressure	<input type="checkbox"/>	353	<input type="checkbox"/>	
Check the precharge pressure of the brake system pressure accumulators	<input type="checkbox"/>	355	<input type="checkbox"/>	

### # OF ROUTINE MAINTENANCE PROCEDURES



**-55%**  
Yearly maintenance procedures with BEV

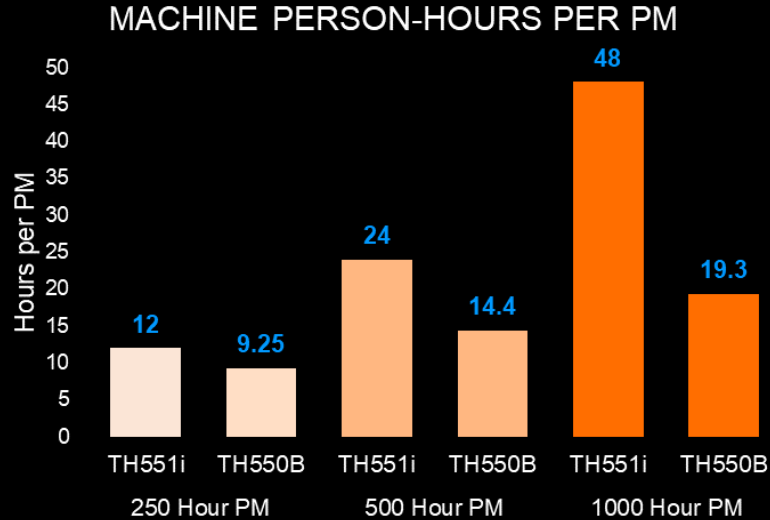
7.2.5 Every 1000 hours		Operation hours - 1000 HOURS	Notes
Maintenance procedure	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	See the instructions for reading maintenance cards.
Perform the maintenance procedures of all relevant shorter intervals at the same time.	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
<b>POWERTRAIN</b>			
Change the planetary hubs oil	<input type="checkbox"/>	192	<input type="checkbox"/>
<b>HYDRAULICS</b>			
Check the main hydraulic pump pressure	<input type="checkbox"/>	205	<input type="checkbox"/>

\* 50-ton diesel vs. 50-ton battery electric truck



# ECONOMICS & OPERATING COSTS

## MAINTENANCE HOURS COMPARISON

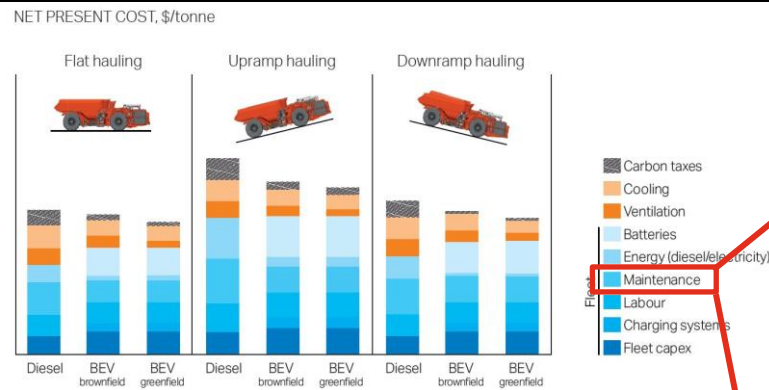
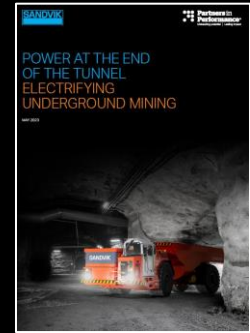


- BEV takes 40-75% of Diesel PM hours
- More uptime and reliable components has led to customer site(s) seeing 92% fleet availability

\*TH551i data reflects Sandvik global average, TH550B data taken from customer study

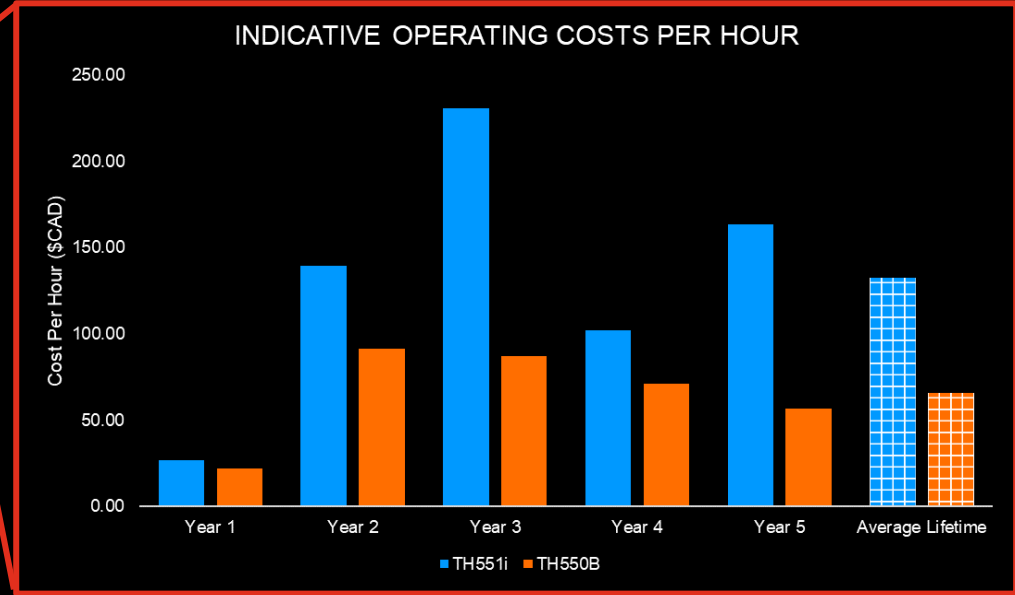
# ECONOMICS & OPERATING COSTS

## BEV TOTAL COST OF OWNERSHIP AT PARITY WITH DIESEL



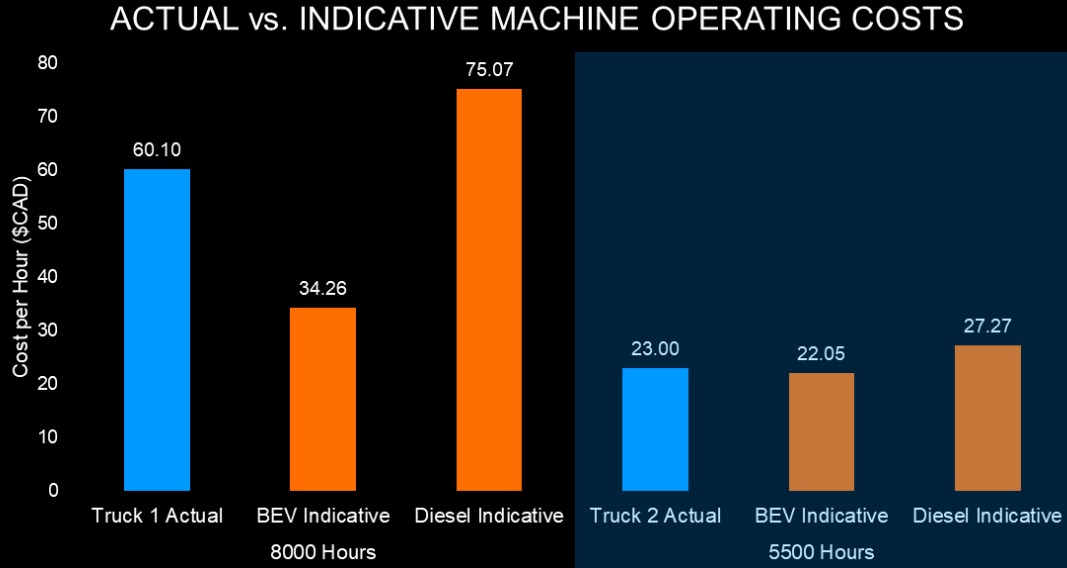
\*Assuming 30,000 hour life  
 \*\*Without fuel/energy costs

Maintenance OPEX accounts for 20-25% of TCO of fleet depending on haulage scenario, reduction of 40% on BEV machine maintenance OPEX can result in ~8-10% in fleet total TCO savings



# ECONOMICS & OPERATING COSTS

## ACTUAL BEV MACHINE OPERATING COSTS VS. INDICATIVE



- Two trucks from same site, BEV truck 1 (8000 hours) landing higher than indicative expectations
  - Customer's first BEV unit, technician & operator learning curve
  - Truck 1 was 3rd truck ever built
- Truck 1 still falling under diesel indicative costs
- Truck 2 (5500 hours) falling in-line with indicative expectations
- Monitoring continuously



# FLEET LABOUR

## 7 – 10 MACHINES, BATTERIES AND CHARGING SYSTEMS



4 MECHANICS



4 ELECTRICIANS



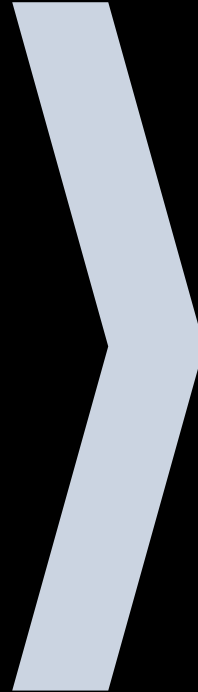
1-2 JUNIOR ELECTRICIANS



1 WAREHOUSE WORKER



1 MANAGER



11 – 12 people team

7 – 10 machines

1.1 – 1.7 persons per machine

# BATTERY DESIGN



## 1. CELL

Chemical energy storage element with safe chemistry and built-in protections



## 2. MODULE

Low voltage for safe service and simple replacement



## 3. PACK

Battery Management System, fusing & disconnects, cooling infrastructure



## 4. CAGE

Robust mechanical protection, mobility and swap-ability



## 5. CHARGING SYSTEM

Modular, stackable, variable voltage input

# BATTERY CHARGE AND SWAP BAY

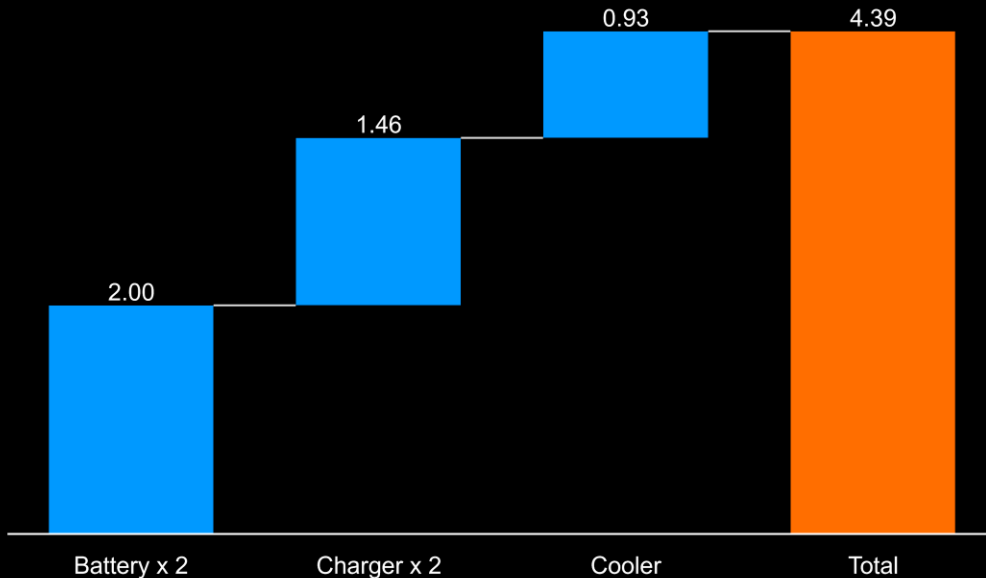


Typical design, many alternative layouts possible  
Sandvik experts will consult in bay design and tooling



# BATTERY, CHARGER & COOLER MAINTENANCE

## MAINTENANCE PARTS COSTS, \$CAD / HOUR

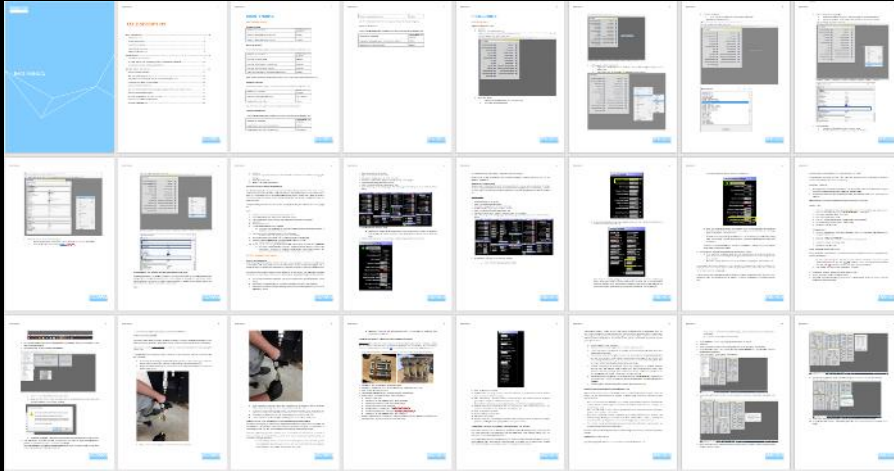


- Does not include battery rental rate (or capital ownership) costs
- Expected cost for all required maintenance parts 4-5 CAD/hr for one machine with 2x batteries and a full charging system
- Annual maintenance kits available
- Can be covered by a separate parts supply agreement with Sandvik

# BATTERY, CHARGER & COOLER MAINTENANCE

## ROUTINE MAINTENANCE

### BAAS MAINTENANCE MANUAL



Battery maintenance amounts to ~5-10hrs per month per battery and ~5hrs per charging system

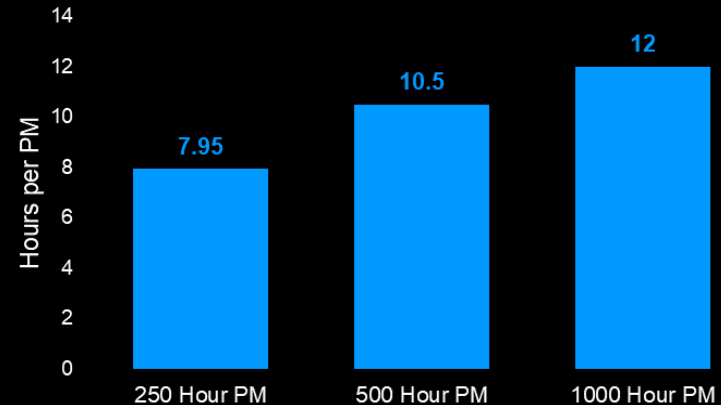
- Varies based on use of batteries
- Battery capacity testing & balance
- Annual seals & washers change
- Charger air filter replacement
- Charging system inspections

# BATTERY, CHARGER & COOLER MAINTENANCE

## SITE EXAMPLE – AVAILABILITY AND LABOUR



COLLECTIVE BATTERIES, CHARGERS,  
COOLER PM TIME



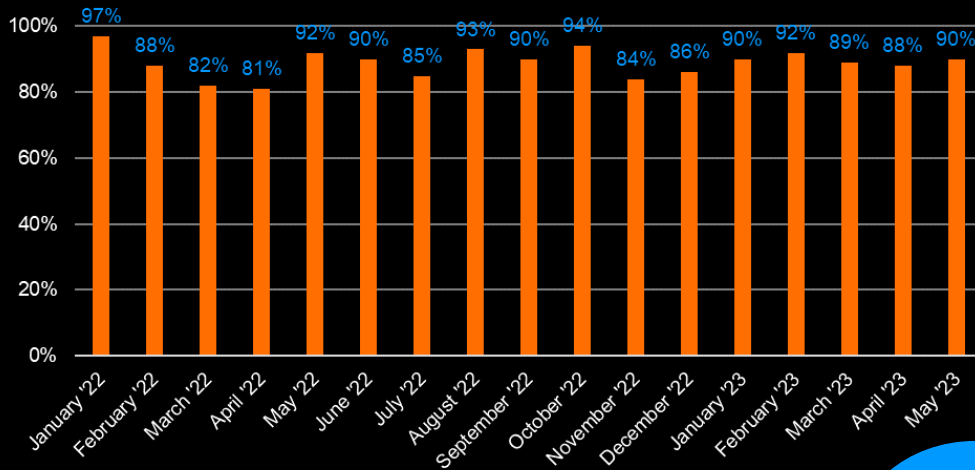
\*Machine PM hours



# BATTERY, CHARGER & COOLER MAINTENANCE

## SITE EXAMPLE – AVAILABILITY AND LABOUR

BATTERY AVAILABILITY 2022-2023



\*19 battery cage fleet

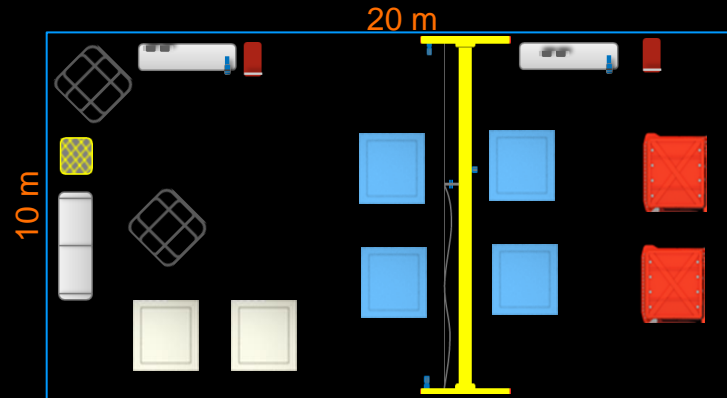
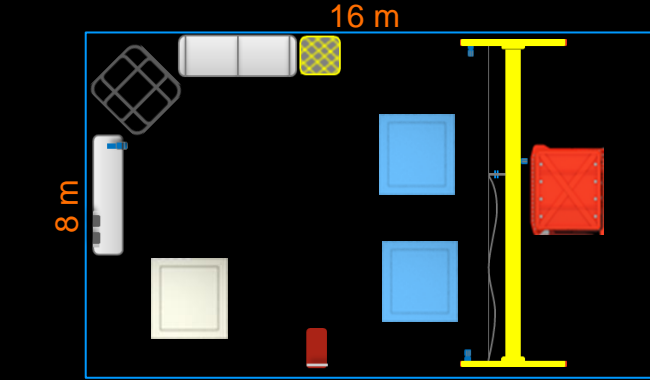
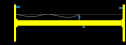
88.8%  
Average



# BATTERY SERVICE BAY

## TWO RECOMMENDED OPTIONS FOR SERVICE BAY WITH OVERHEAD CRANE

- Battery Cage
- Charger / Cooling Cube
- 10T+ Overhead crane
- Sling cabinet
- Battery Pack Stand
- Parts Cabinet
- Workbench
- Hydraulic work table
- Module Charger
- Battery Pack



# MAINTENANCE PHILOSOPHY

## BEV ECOSYSTEM REQUIRES ALL STAKEHOLDER BUY-IN FOR SUCCESS

- The BEV ecosystem requires a strong network of systems, procedures, cross-department communication, planning & scheduling practices to maximize success
- Although less overall maintenance per unit, increased asset-base requires more complex planning & scheduling
- Several assets need to be functioning in order to support the machine

