

# GE Mining

## Battery LHD Equipment



## Agenda

- Challenges with underground mining
- Alternate Propulsion Systems
- Advantages of Battery Propulsion
- Simulations
- Productivity vs Diesel Counterparts
- Value Story



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## Industry challenges...drivers for battery equipment

### UG Mining's Major Challenges

#### Mining Trends

- **UG Output** predicted to grow to 40% of total output by 2030 (Currently Surface/UG @ 80:20)
- **Deeper** ore bodies with lower average ore grade

#### Productivity

- **\$/ton** is the primary driving factor
- High cost of **Ventilation**
- **Heat** from diesel engine (hot gases and engine parts) particularly problematic in deep mines
- **Uncertain Diesel costs**

#### Eco/ Sustainability

- **Emissions** continue to become more stringent
- **Noise and vibration** due to operating diesel equipment
- **Safety**

### Similar transformation in other industries

#### Mining

1960                      1990                      2005                      2015

#### ...Locomotive and Surface



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## Alternative Propulsion Systems

Customer CTQs	Weighting	Diesel	Tethered Electric	Battery Electric: Exchange	Battery Electric: Fixed	Parallel Hybrid: Diesel-Battery	Parallel Plug-in Hybrid: Diesel-Battery	Series Plug-in Hybrid: Diesel-Battery	Series Hybrid: Diesel-Battery	CNG/LNG ICE	H2 Fuel Cell
Safety	10	0	0	0	0	0	0	0	0	-5	-5
Operating Range	5	0	1	-2	-2	1	1	1	1	-1	-1
Availability	5	0	1	2	-5	-1	-1	-1	-1	0	-2
Emissions (DPM, CO, CO2, ...)	10	0	5	5	5	1	2	2	1	2	5
First Cost	5	0	-1	-3	-2	-1	-2	-2	-2	-1	-4
Vehicle Maneuverability	5	0	-5	0	0	0	0	0	0	0	0
Product Differentiation/Impact	10	0	0	2	2	1	1	1	1	1	2
Customer(Mine) Acceptance	10	0	2	-1	-1	1	-1	-1	-1	-5	-5
Reliability	5	0	-1	1	1	-2	-1	0	-1	0	-3
Maintenance	5	0	-1	1	1	-1	-1	-1	-1	0	-1
Fuel Cost	5	0	5	5	5	1	2	2	1	1	-5
<b>Total</b>		<b>0</b>	<b>6</b>	<b>10</b>	<b>4</b>	<b>0</b>	<b>0</b>	<b>1</b>	<b>-2</b>	<b>-9</b>	<b>-22</b>

- battery exchange is the best choice
- fixed batteries render the LHD unusable during charge
- series and parallel hybrids add complexity while still relying on diesel fuel
- CNG is a gaseous fuel that requires safe handling. Low energy density fuel means larger volume fuel tanks
- H2 fuel cell adds cost, reliability issues and safety surrounding hydrogen gas storage and distribution



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## GE BLHD Advantages



**Safety**



Lower **emission, noise & vibration** as compared to diesel equipment.

**Ventilation**



Reduced **ventilation and refrigeration** costs

**Reliability & Maintenance**



Less **wearable parts, reduced fuel and maintenance** costs

**Performance**



Increased **power/torque** through entire battery charge cycle

**Eco-Friendly**



Zero tail pipe **emissions & lower noise** ... improved human safety

Battery powered equipment is a **safer, cleaner, and more efficient** alternative to diesel.



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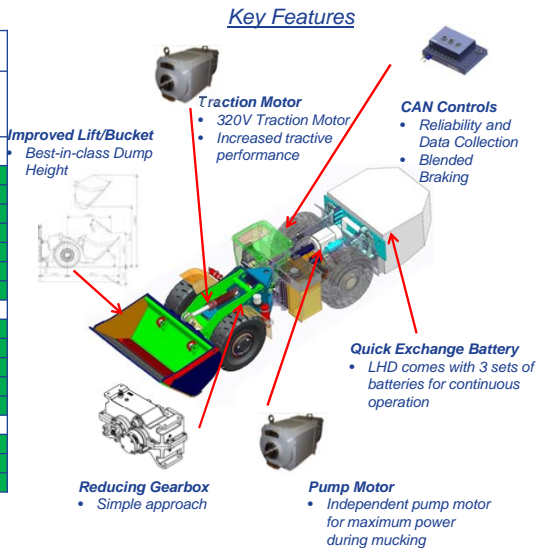
## Battery Powered 7T LHD: Performance



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## 7T Battery LHD Performance

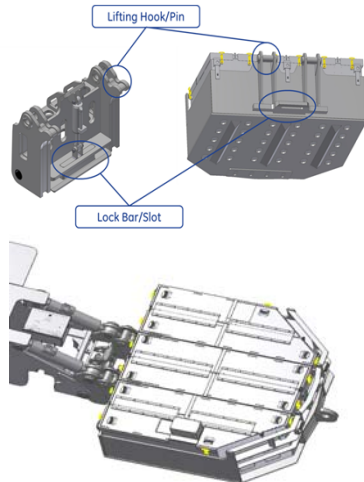
Customer Key-Performance-Indicators (KPIs) 7t Hardrock LHD				
		Diesel (Best on KPI from four OEMs)	GE POC LHD	GE 7T LHD
<b>Performance</b>				
Tram Capacity	T	6.8	4.9	6.8
Max Speed	km/h	24	7	19
Bucket Size	M³	3.1	2.3	3.1
Cycle Time	sec	11-15	13	11.8
Width w/bucket	mm	2236	2520	2197
Dump Height	mm	3210	2200	3234
Cab Height	mm	2120	1826	2120
<b>Op Ex</b>				
Availability	%	90-96%	93-97%	93-97%
Maint. Downtime	%	8% <sup>5</sup>	2%	2%
Energy Cost	\$/yr.	\$86	\$13	\$13
Ventilation	\$/yr	\$100	\$85	\$85
Vehicle Life	yr	4-7	6-7	6-7
<b>Environmental</b>				
Diesel Particulate		T3→ T4 NA	0	0
Emissions		T3→ T4 NA	0	0
Waste Heating	%	60-99%	10-15%	10-15%



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Best-in-Class LHD with best financial payback for the customer

## Quick exchange allows for continuous operation



### Features:

- Quick exchange System
- Change outs under 15 min.

### Benefits:

- No downtime for charging battery (continuous operation)
- No need for any infrastructure such as cranes



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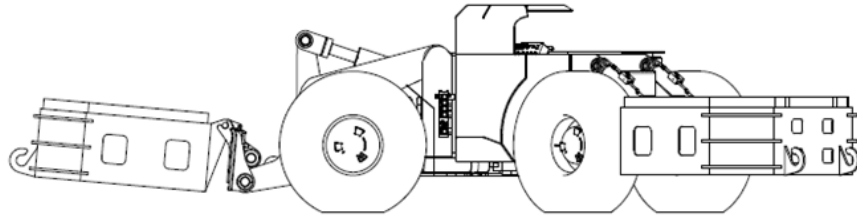
## Battery carried by quick detach system

### Features:

- Allows the operator to quickly disconnect the bucket from the LHD

### Benefits:

- The quick disconnect makes it easy to connect any other attachment to the LHD including the battery pack for moving around the mine site as needed



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## Battery exchange possible close to work area



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# GE Battery



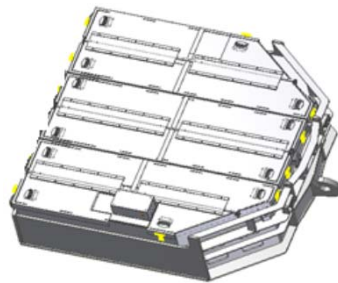
## 2 Battery Options

### PbA

- low cost
- mature / proven in coal industry
- ~8hr charge time
- battery cool down required → 3 trays recommended
- lower energy density
- minimal ventilation required at charging station (hydrogen)
- sensitivity to ambient temperature

### Li-ion (family):

- high energy density
- >2x life relative to PbA
- high power capability
- fast charge rate capability
- rapidly improving technology
- lower sensitivity to ambient temperature
- thermal runaway risk / cell-level BMS protection



# Simulations




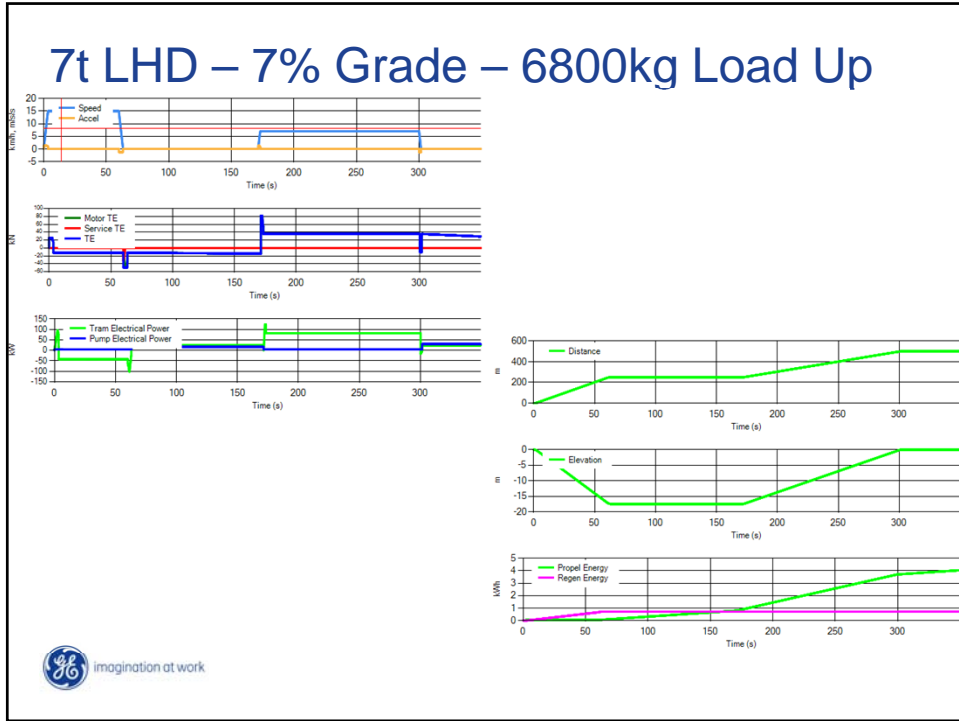
## 7t LHD – 7% Grade – 6800kg Load Up

Vehicle Summary			
	Per Cycle	Repeated Cycle and Utilization	
Time	349.40	29,000.20	s
Distance	500.26	41,521.18	m
Energy	4.47	371.05	kWh
Cycles		83.00	

Production			
	Per Duty Cycle	Repeated Duty Cycle	
Production Rate	70.14		t/hr
Total Production	6.81	564.99	t
Cycles		83.00	





### 7t LHD – 7% Grade – 6800kg Load Down

#### Vehicle Summary

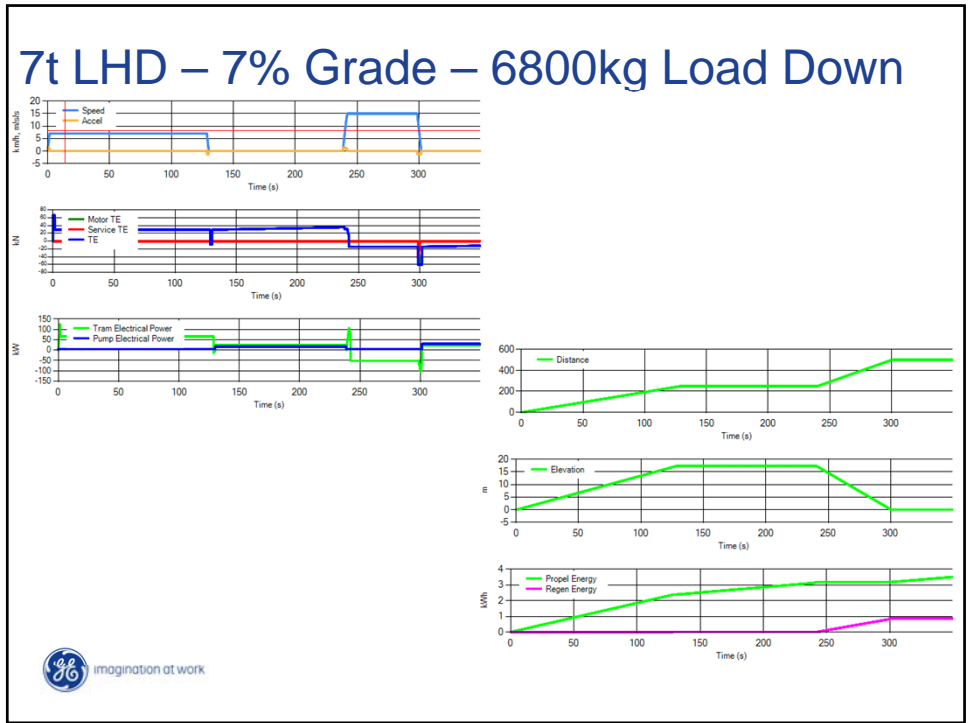
	Per Cycle	Repeated Cycle and Utilization	
Time	349.40	29,000.20	s
Distance	500.35	41,528.83	m
Energy	3.79	314.51	kWh
Cycles		83.00	

#### Production

	Per Duty Cycle	Repeated Duty Cycle	
Production Rate	70.14		t/hr
Total Production	6.81	564.99	t
Cycles		83.00	

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### 7t LHD – 0% Grade – 6800kg Load

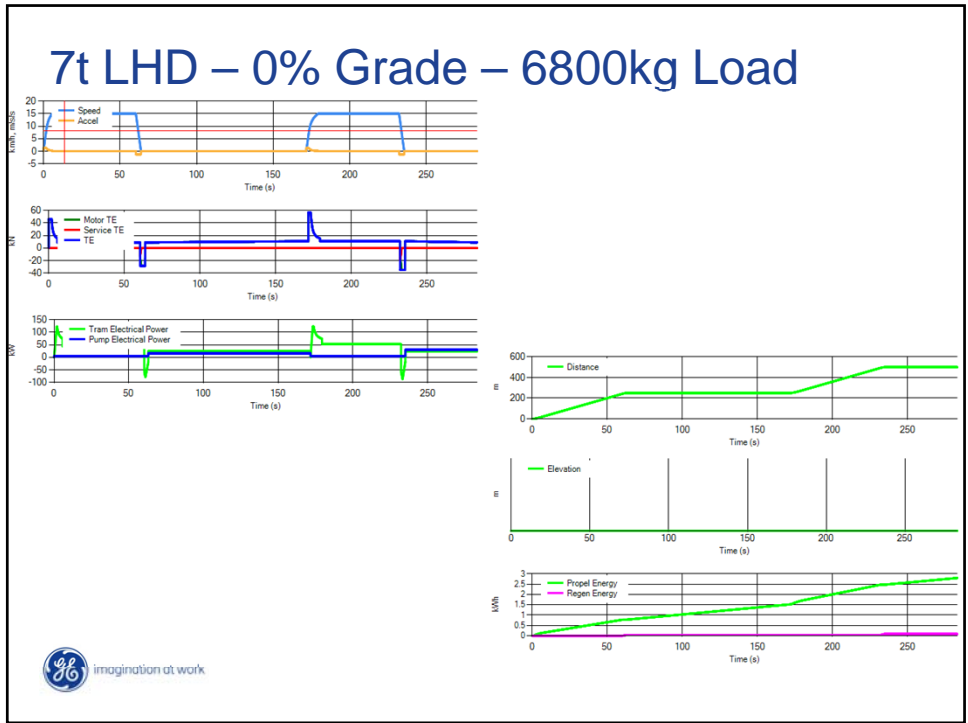
#### Vehicle Summary

	Per Cycle	Repeated Cycle and Utilization	
Time	283.15	28,881.30	s
Distance	500.47	51,047.58	m
Energy	3.76	383.84	kWh
Cycles		102.00	

#### Production

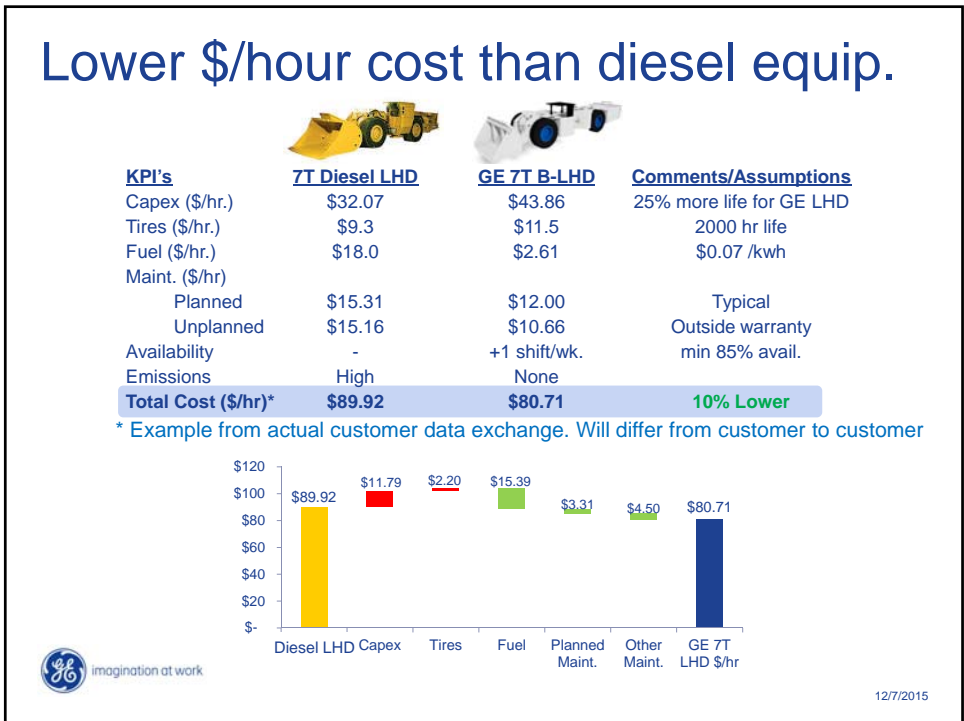
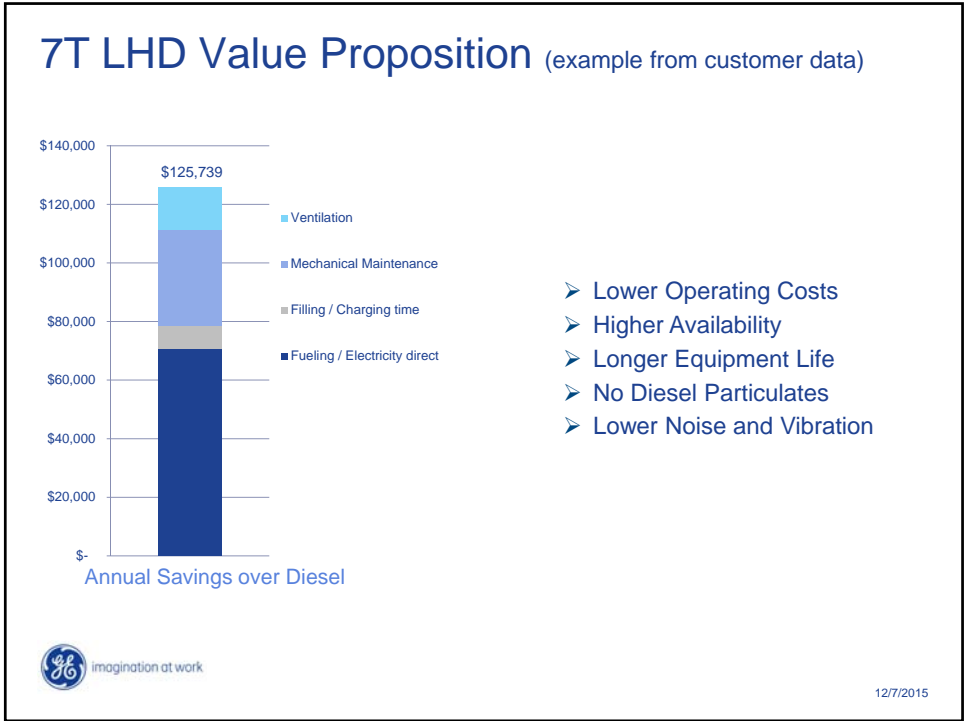
	Per Duty Cycle	Repeated Duty Cycle	
Production Rate	86.55		t/hr
Total Production	6.81	694.32	t
Cycles		102.00	

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## Battery Powered 7T LHD: Value

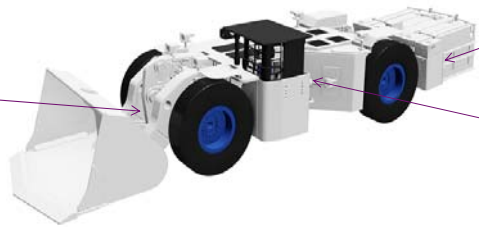
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# Best in Class

25% Improved life

Upgraded Lift arm design



No Engine PbA battery

Upgraded articulation design

50-75% lower maintenance



## Competitive Diesel LHD

Daily (20 min.)  
Weekly (10.5 hrs.)  
6 months @ 2000 hrs. (21 hrs.)

**Total PM hours per year = 700 hrs.**



## GE 7T (projected)

Daily (20 min.)  
Weekly (1 hr.)  
Monthly @ 400 hrs. (1.5 hrs.)  
3 Months @ 1200 hrs. (2.5 hrs.)  
Annual @ 4800 hrs. (4 hrs.)  
**Total PM hours per year = 197 hrs.**

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