



Minecat UT150-eMV

“Review of a Battery Electric U/G Mining Vehicle”



Oct 7, 2015



Agenda

- Who we are
- UT Vehicle Platform description
- Why electrify?
- UT150-eMV Electric Drivetrain Description
- Strategy and Challenges
- Units in the field

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Who we are

- Industrial Fabrication Inc.: Canadian owned, new 37000 ft² facility
- Over 450 Minecats working around the world
- Capacity of 12 units per month



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UT Platform Description

- Purpose built for U/G mining
- Industrial axles with SAHR brakes
- UT150-eMV has the same chassis and body as our popular UT99 utility truck
- High payload from 900kg up to 2700kg, and 5900Kg (13000lb) GVWR



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UT Platform Description




- Heavy gauge ROPS/FOPS level 2 certified cab
- 118 UT99's in service
- Many configurations already built as diesel units: Mechanics vehicles, crane trucks, aerial booms, scissor trucks, flatbeds, personnel carriers for up to 10 people
- Industrial Fabrication began looking at electric drive trains in 2005, but the technology was not ready
- 2011 – eMV project inception




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Why Electrify?



- Health and Safety - diesel exhaust
- Reduction of ventilation requirements and costs
- Reduction in energy requirements and fuel savings
- Reduction in maintenance costs



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Electrification for Health and Safety

- Diesel engine exhaust listed as a Group 1 carcinogen in 2012.
- Reduced vibration and noise = operator comfort and reduced stress

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Electrification = Ventilation Cost Reduction

- Ventilation cost is large
- CFM per HP - mandated
- Less diesel = reduction in costly ventilation
- Battery electric drivetrain by itself causes no requirement for ventilation
- Reduction in heat generation, due to the efficiency of EV vs. diesel



Cost
Down


| | Horsepower | CFM per HP | CFM | Cost per CFM | 1 year cost | 5 year Cost |
|--------------------|------------|------------|-------|--------------|-------------|-------------|
| | | | | \$ | \$ | \$ |
| UT99 Diesel | 100 | 100 | 10000 | 4.50 | 45,000.00 | 225,000.00 |
| | | | | \$ | \$ | \$ |
| Land Cruiser | 134 | 100 | 13400 | 4.50 | 60,300.00 | 301,500.00 |
| UT150-eMV electric | 200 | 0 | n/a | - | - | - |


Electrification = Energy Cost Reduction



- Efficiency of a diesel engine is 30-40% at best, vs 90%+ with our PMAC motor
- Projected \$10000-\$13000 annual savings per vehicle based on 99 hp

| Average Liters/Day | Days | \$/litre | 1 year cost | 5 year Cost |
|--------------------|------|----------|--------------|--------------|
| 19.96 | 360 | 1.40 | \$ 10,059.84 | \$ 50,299.20 |
| 19.96 | 360 | 1.75 | \$ 12,574.80 | \$ 62,874.00 |
| 19.96 | 360 | 2.00 | \$ 14,371.20 | \$ 71,856.00 |




| Pack Size (kWh) | Days | cost per kWh | 1 year cost | 5 year Cost |
|-----------------|------|--------------|-------------|-------------|
| 26 | 360 | 0.05 | \$ 468.00 | \$ 2,340.00 |
| 26 | 360 | 0.10 | \$ 936.00 | \$ 4,680.00 |
| 26 | 360 | 0.15 | \$ 1,404.00 | \$ 7,020.00 |




Electrification = Maintenance Savings

- 77% reduction in part numbers
- 1000 fewer parts
- 30% reduction in maintenance costs.
- \$5/hr savings vs our own diesel unit, Real world data and customer testimonials





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UT150-eMV – Electric Drivetrain Details


Motor design

- Unique drivetrain = Demanding parameters
- Liquid cooled internal permanent magnet AC motor
- Light and powerful, 52kg 150 kW
- This motor type has the highest efficiency over a broad range of RPM



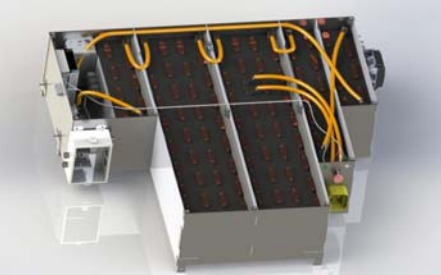


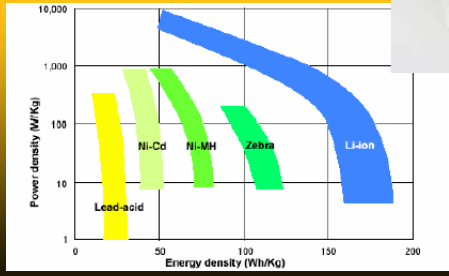
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UT150-eMV – Electric Drivetrain Details

- Battery chemistry
 - Li-Ion dominates BEV market
 - Safe stable chemistry with good power and energy density
 - Projected 50% price reduction by 2020








UT150-eMV – Electric Drivetrain Details

- Minecat inverter programming, and customizable user interface
- Charger
 - 220V, 208V, 600V
 - Onboard, allowing multiple inexpensive charge points throughout the mine









UT150-eMV – Specifications

- Range
 - 50km ramp travel
 - 80km flat terrain
- Charge Time
 - 3.75 - 4 hrs for full charge with standard production pack
 - "Opportunity" charging 35% in 1 hr
 - Li-Ion battery, 10 yrs, 3000 full DOD cycles
- Cost Impact
 - 30-40% premium on capital cost of unit, vs diesel unit




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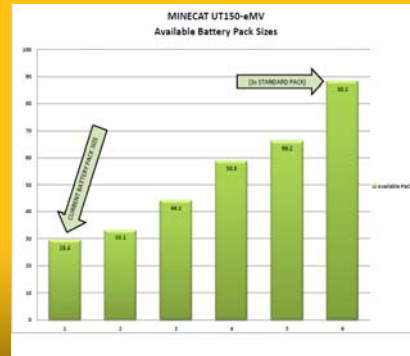


UT150-eMV – Challenges & Development

- Regenerative braking
 - Drive cycle unique to mining: 100% charge on surface, then go downramp
 - 100% S.O.C. = no regen available
- Charge limit levels
 - Limit the amount of charge to enable the maximum regen required
 - Application specific, to account for the maximum regen possible

In Development

- Configurable battery pack sizes available, up to 88 kW/h
- Alternate chemistry – Battery is the “fuel tank”
- Automatic device to allow motor braking without regen if needed (100% charged)



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UT150-eMV – Field unit Details

- Three UT150-eMV units in the field
- Glencore Fraser Mine, Goldcorp Musselwhite Mine, Vale Creighton Mine
- 32 months in service underground, collectively
- 10000+km underground
- No mechanical failures



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Thank you!

