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Electromobility Solutions for Modern Haul Trucks

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Phoenix, Arizona USA

usa.siemens.com/mining

Introduction

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What is Electromobility?

Electromobility is a general term for the development of electric-powered drivetrains designed to shift vehicle design away from the use of fossil fuels and carbon gas emissions.

- Hybrid Electric Vehicles (Internal Combustion Engine (ICE) and batteries w/ Electric motor)
- Plug-in Electric Vehicles (HEV that can be externally charged)
- Battery Electric Vehicles (all electric vehicle that can be externally charged)

Electric Drive Technology and Charging Solutions for Mobility.

Mechanical Vehicle (MV)
w/ On-board Diesel Engine

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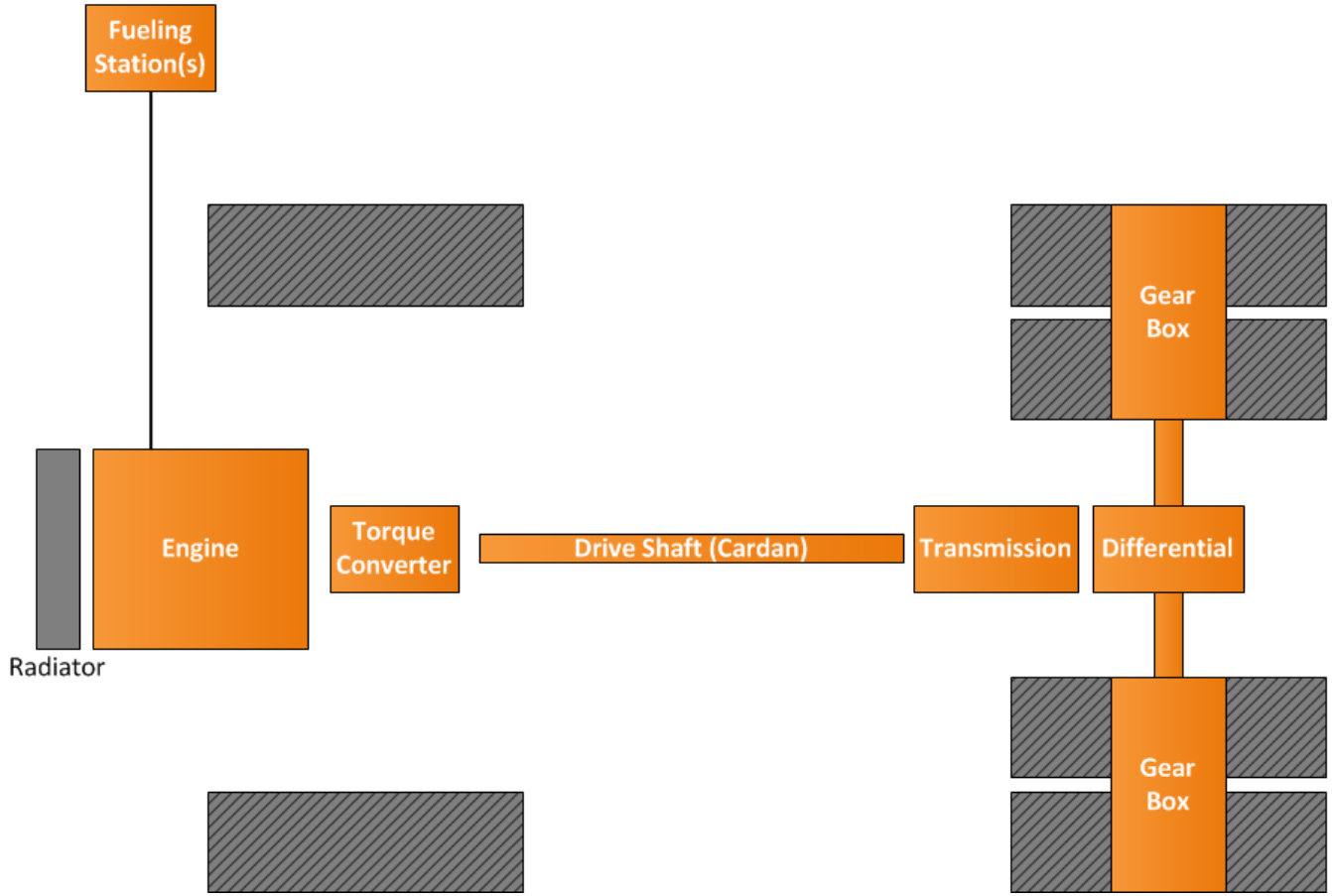

Traditional Powertrain

Main Components:
- Diesel Engine
- Torque Converter
- Drive Shaft (Cardan)
- Transmission
- Differential
- Gearbox

Disadvantages:
- Low efficiency
- High maintenance costs

Electric Vehicle (EV)
w/ On-board Diesel Engine

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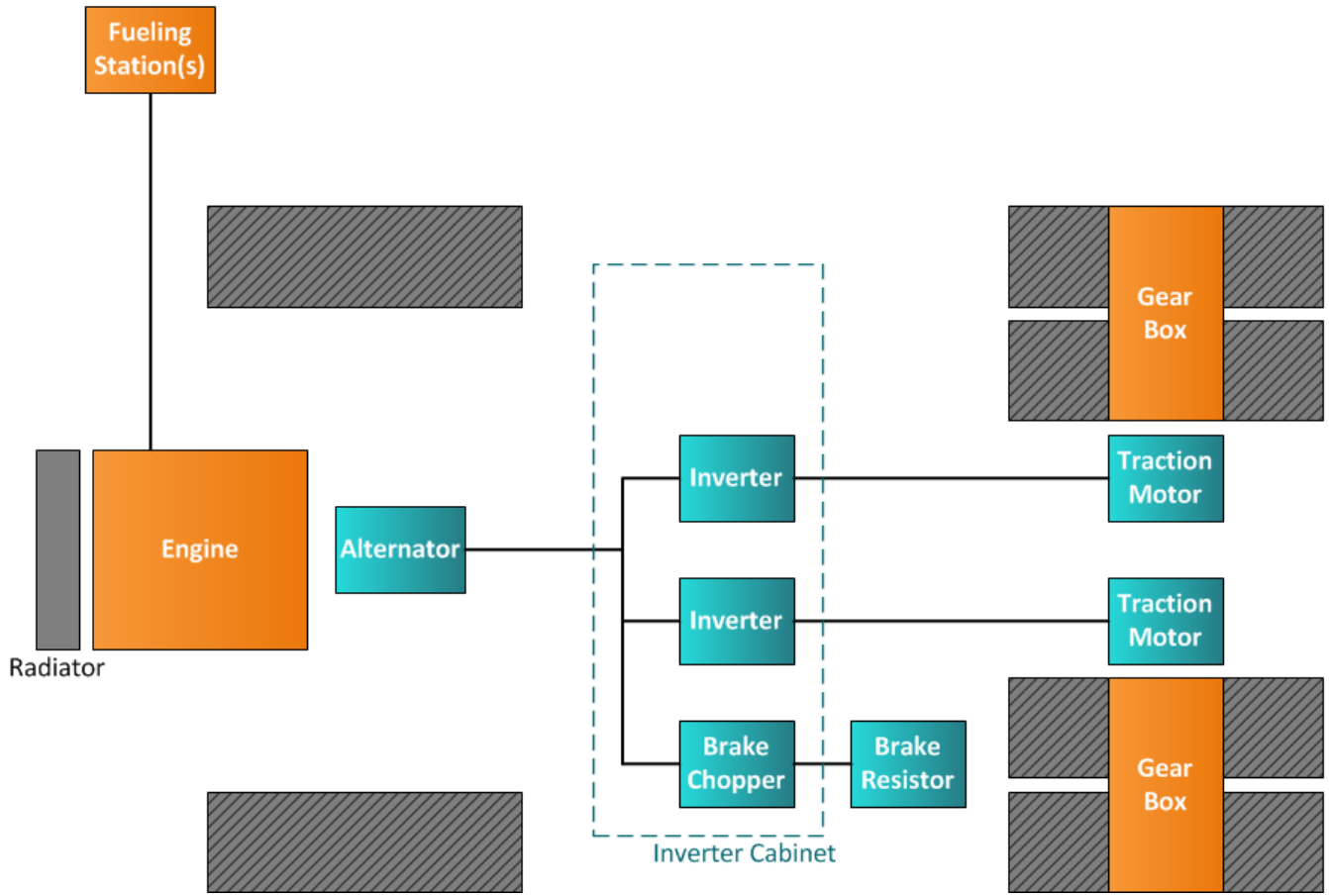

Electrical Drivetrain replaces Mechanical Drivetrain, keeps the diesel engine

Main Components:
- Diesel engine
- Alternator w/ Rectifier
- Inverters
- Traction motors
- Braking chopper/Grid resistor

Benefits
- Higher efficiency
- Electrical braking
- Lower maintenance costs

Electric Vehicle (EV)
w/ On-board Diesel Engine and Off-board Trolley Assist

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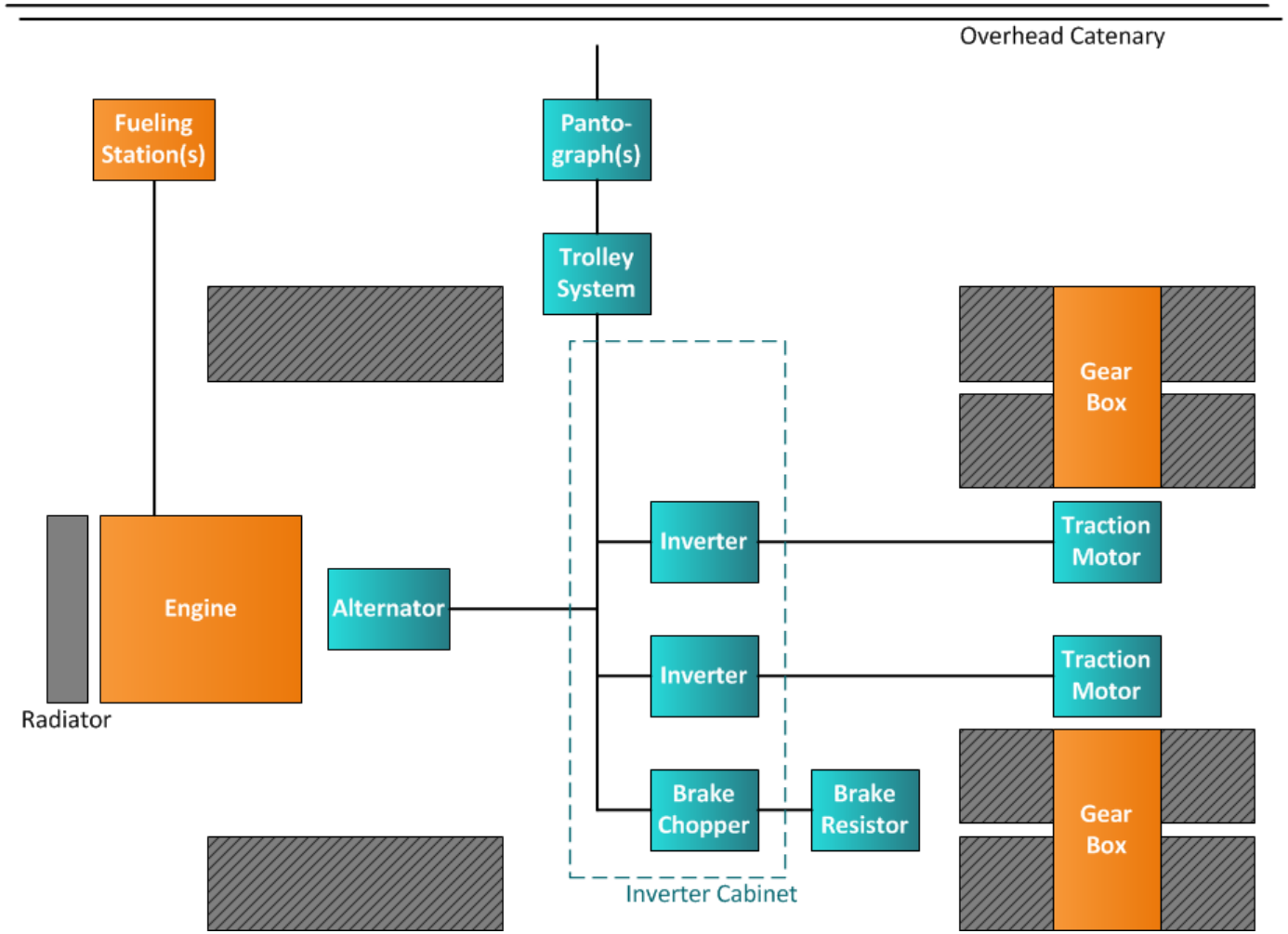


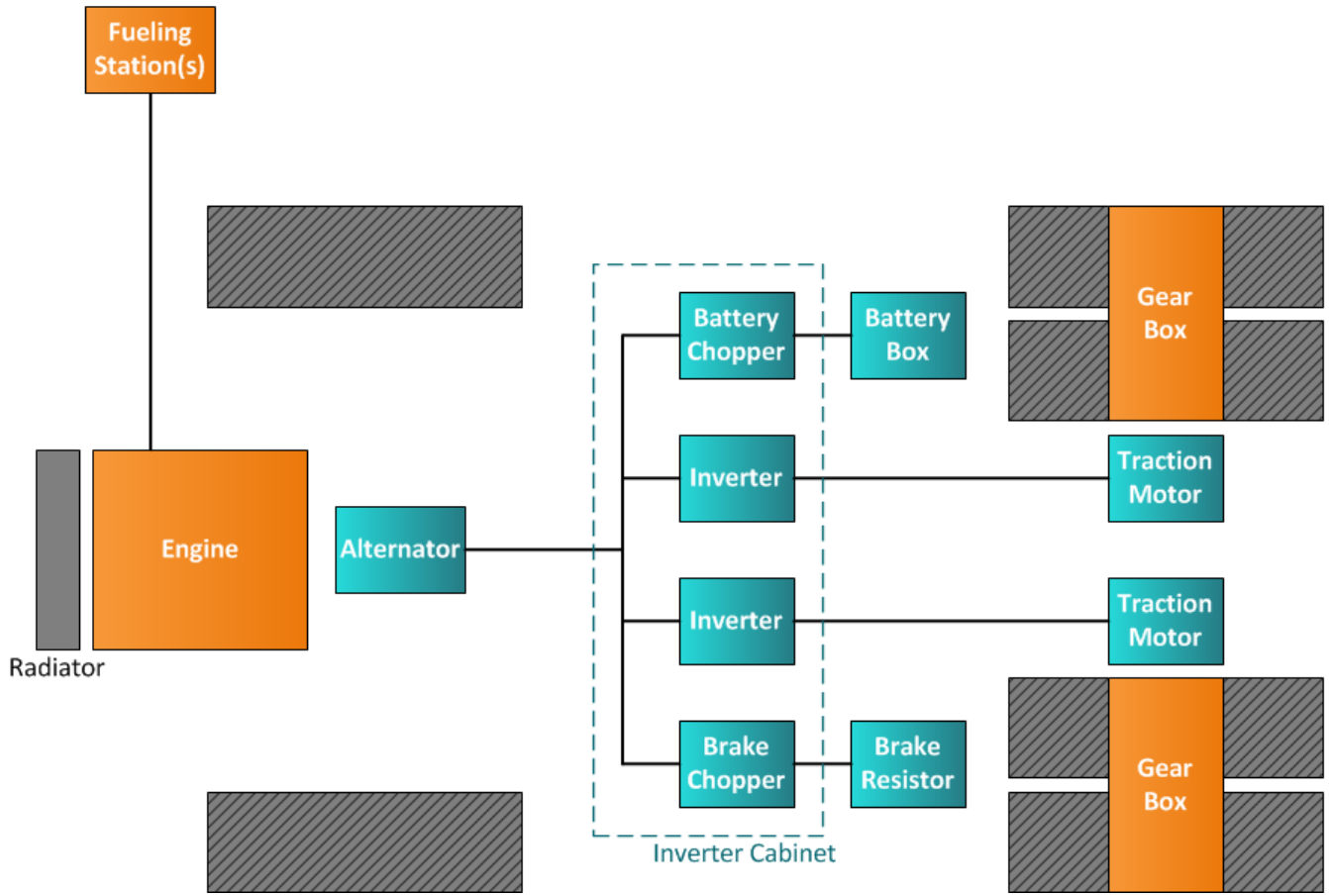
Off-board Trolley Assist adds additional parallel electric power source

Main Components
- Off-board Trolley Infrastructure
- On-board Pantographs
- On-board Trolley box

Benefits:
- Increased Productivity
- Decreased fuel consumption
- Higher efficiency

Due to cost of Infrastructure, mostly suitable for deep mines

Hybrid Electric Vehicle (HEV)
w/ On-board Diesel Engine and On-board Batteries



On-board Batteries provide additional parallel electric power source, energy storage

Main Components:
- Battery chopper
- Battery box
- Energy Management System

Benefits:
- Increased Productivity (speed boost)
- Increased Efficiency (regeneration)
- Reduce/eliminate braking resistors
- No off-board infrastructure required

Charge/discharge imbalance

Battery Electric Vehicle (BEV)
w/ On-board Batteries & Off-board Charging Stations

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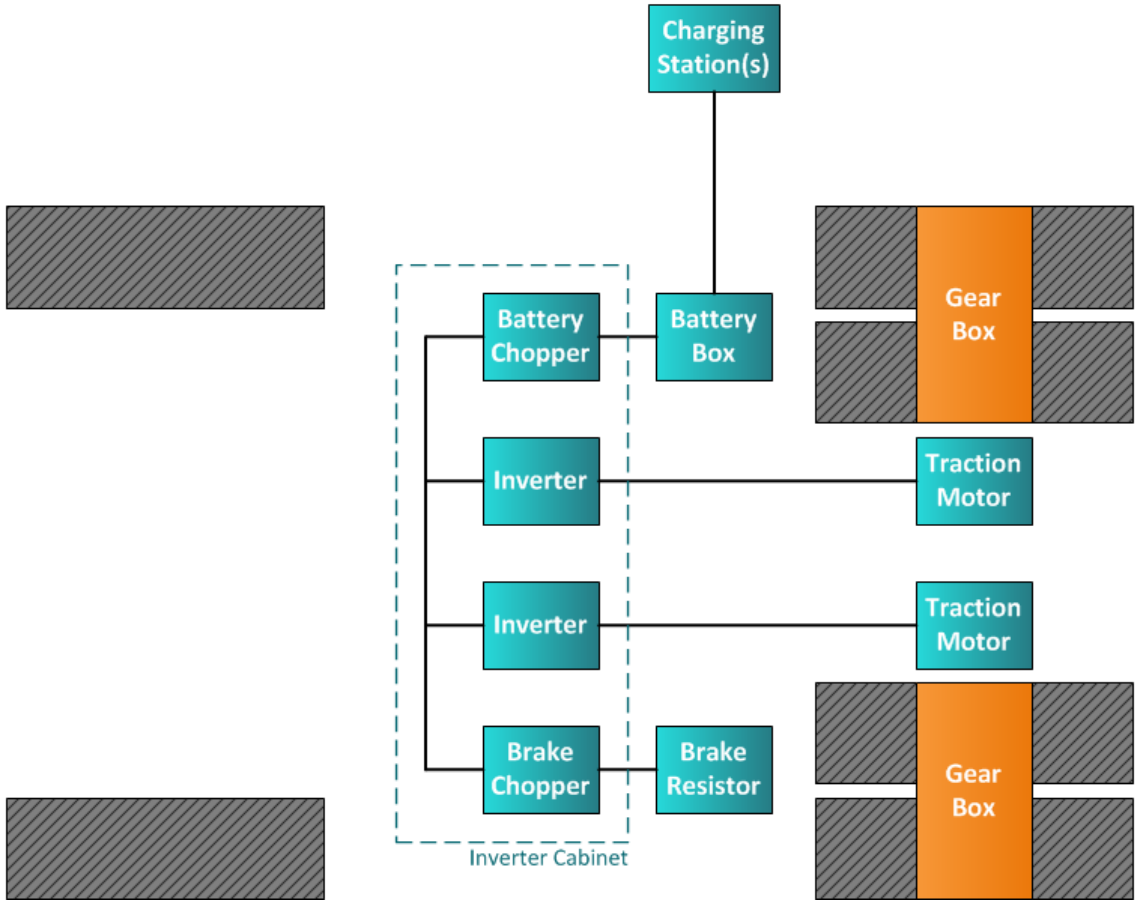

Elimination of the diesel engine, fuel tank, utilize On-board batteries and Off-board charging stations.

Main Components:
- Off-board charging stations

Benefits:
- Reduced Operating costs (no fuel)
- Reduced Maintenance costs

Requires massive batteries and charging stations throughout the mine.
Charging affects availability /production.

Game changer … LTO batteries

Battery Electric Vehicle (BEV)
w/ On-board Batteries & Off-board Trolley Assist

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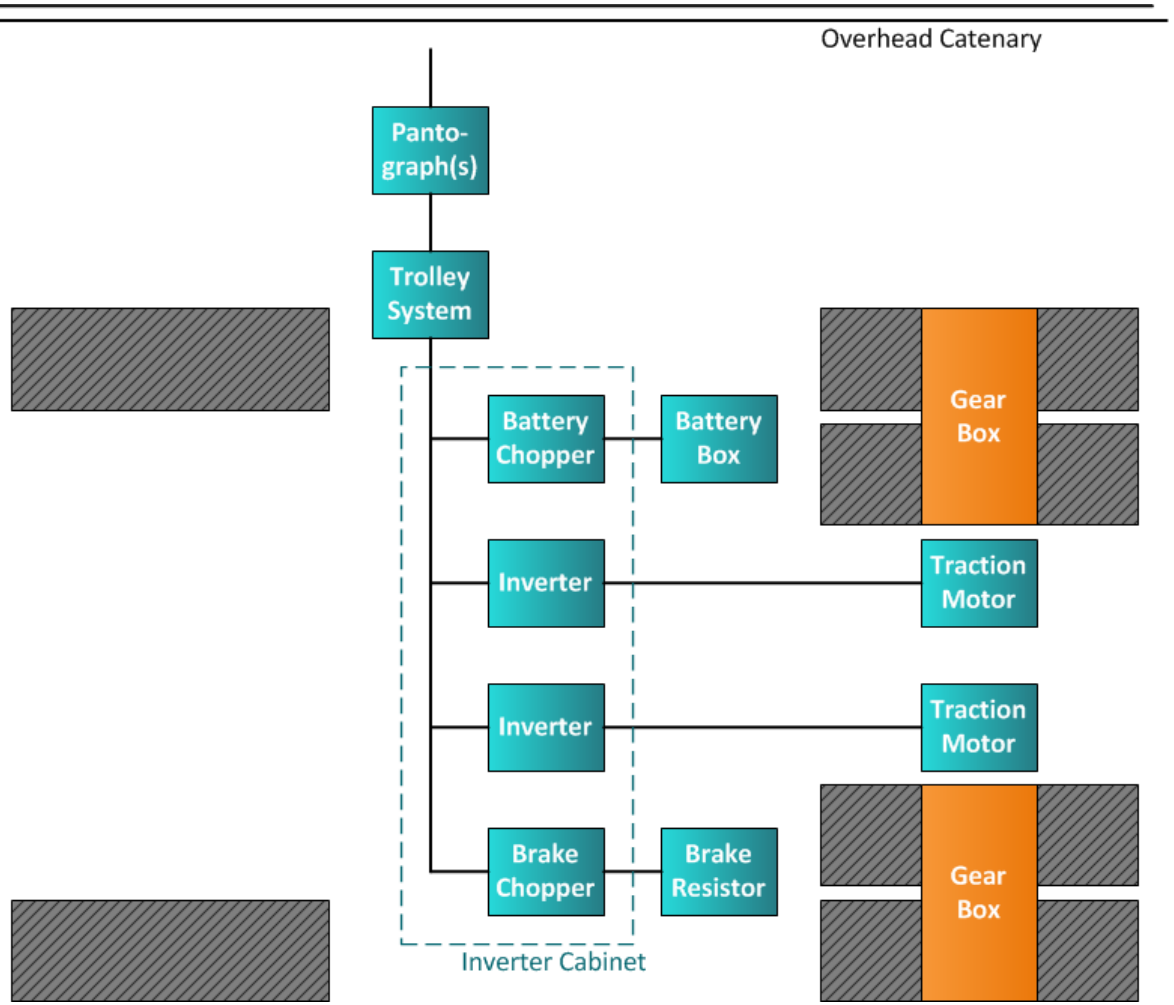

Elimination of the diesel engine, Off-board Trolley system with minimized On-board Battery system.

Main Components:
Trolley System
Battery System

Benefits:
- Decreased Operating Costs (no fuel)
- Decreased Maintenance Costs
- Increased productivity
- Increased efficiency

“Killer-app” for Trolley … BEV, now suitable for nearly all mines.

Conclusion

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What is Electromobility?

Electric Drive Technology and Charging solutions for Mobility.

Benefits:
- Higher Productivity
- Higher Efficiency
- Lower Operating Costs
- Lower Maintenance Costs
- Less Carbon Gas Emissions
- Less Noise

The future of mobility is electric.

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"Ingenuity" stands for **innovation**, **engineering** and **genius**. For us, it also includes **unity**: We are united in our efforts, and we are committed to partnering with our customers.

"For life" relates to our role in society: to make real what matters.

"Ingenuity for life" is therefore our unrelenting drive and promise to create **value** for **customers**, **employees** and **society**.

Thank you for your Attention.

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