Ventilation Tradeoff Study Considering Switch to Battery Electric Vehicles (BEV)

Nathan Wineinger
Consultant (Mine Ventilation), SRK Mine Ventilation Services
Clovis, California, USA

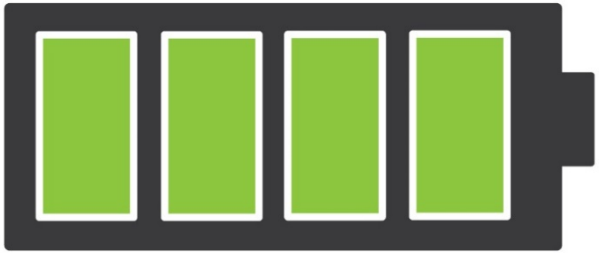
srk consulting

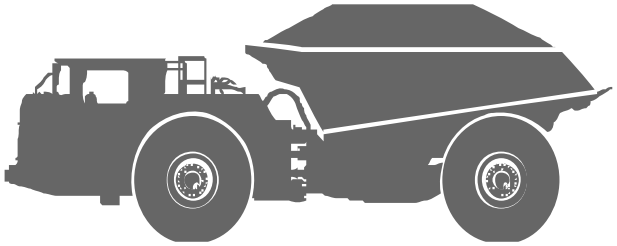
Introduction

- BEV study completed for a new mine in Colombia
- In response to a Feasibility Study - Scoping Study
- High ventilation power demands
- Replace diesel trucks and loaders with BEV equivalents

Key Assumptions and Design Considerations

- BEV substitutions only considered for LHDs and Haul Trucks
- 0.06 m3/s per kW – Colombian Regulations 0.09 - 0.13 m3/s per kW
  - Variance sought for this.
  - Airflow requirements for secondary and maintenance equipment considered.
- 60-tonne diesel trucks and 18-tonne diesel LHDs used in original diesel study.
  - BEV equipment of that size do not yet exist – Assumed they would.





Assumptions and Considerations cont.

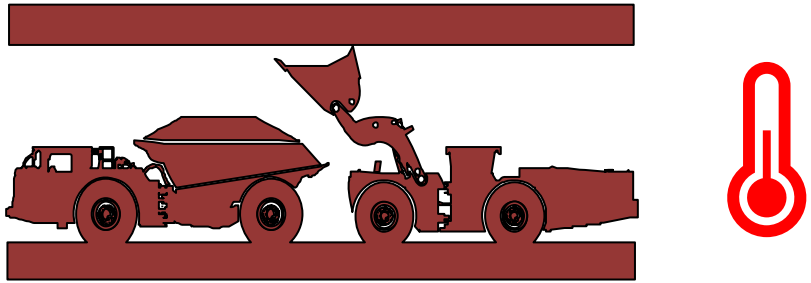
- Potential equip. fires not considered at this stage
  - Lower airflow in mine → more significant fire effects
  - High concentrations of HF gas released

Assumptions and Considerations cont.

- Traffic patterns and mine development schedule assumed not to change
  - Type of BEV chosen can affect mine layout
  - Regenerative braking
  - Strategic locations of charging stations
  - Scoping Level study
- Secondary ventilation – auxiliary fans and headings
  - Unchanged from diesel study – maintain blast clearing times

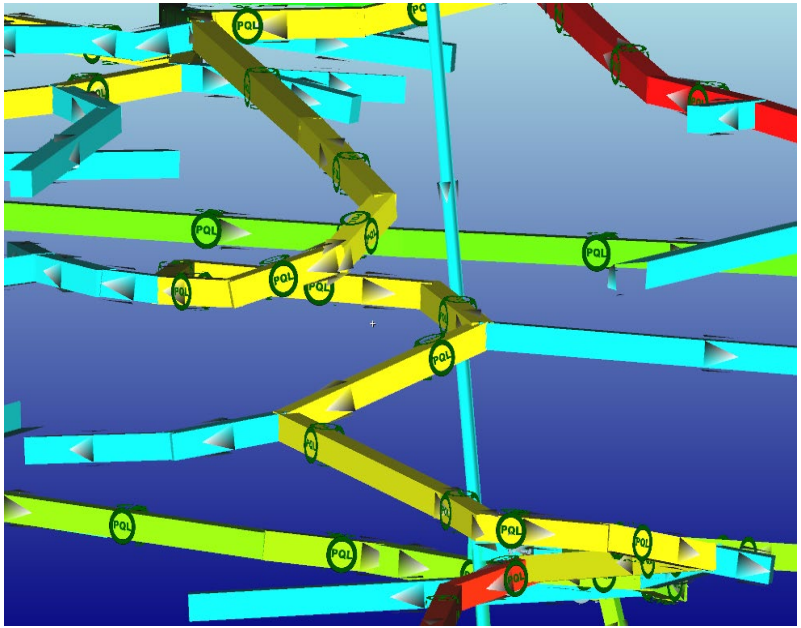
Heat Generation Calculations

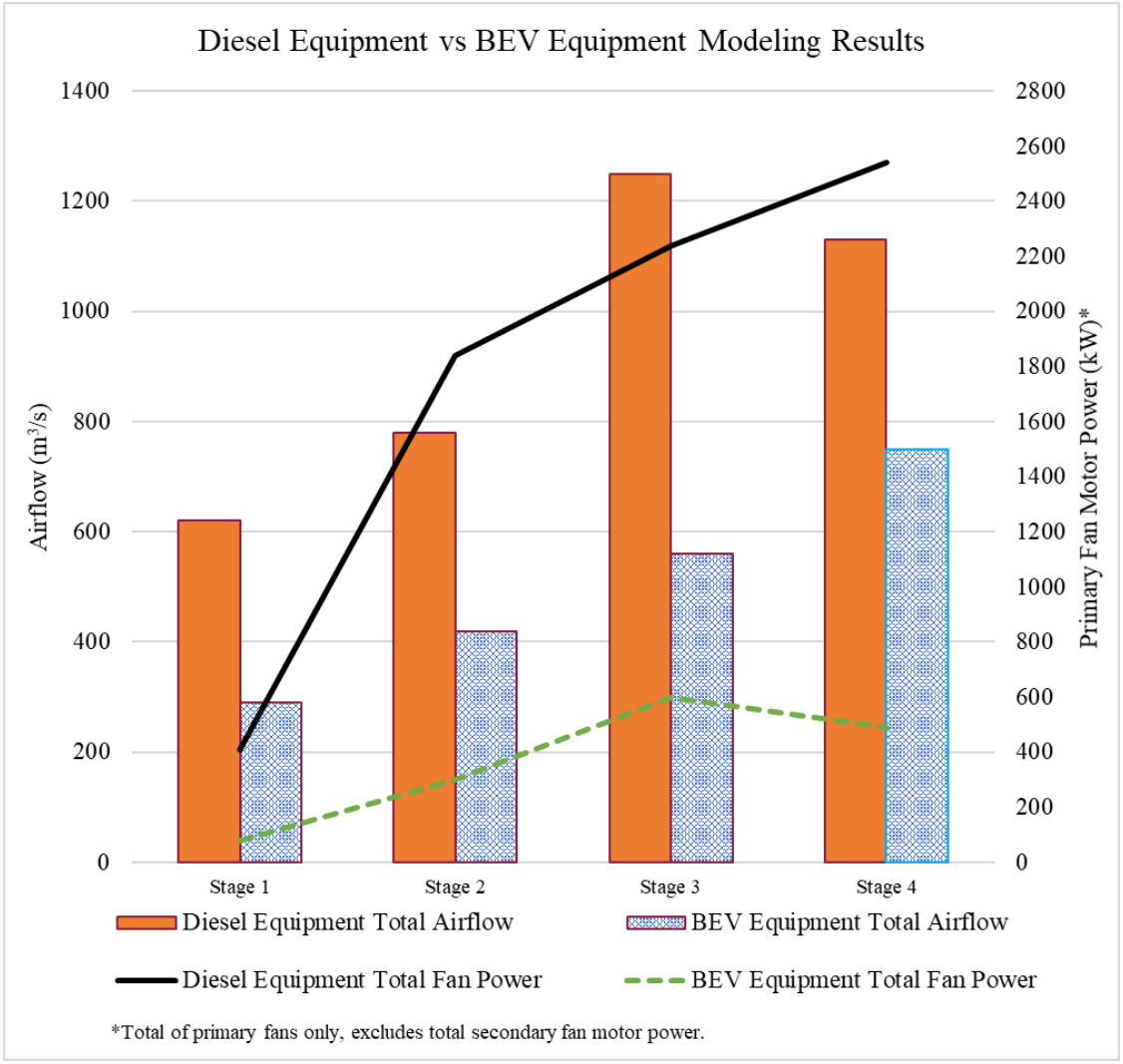
- Diesel Study – High heat generation – large number of equip.
- BEV study – Trucks/LHDs 1/3 of the heat of diesel equivalent.
- Assume larger not yet existing BEV equip – scale similarly
- Add in extra heat for secondary equipment -50% Truck/LHD heat of diesel models
- Additional secondary equipment not modeled – intermittent operation



Calculations and Results

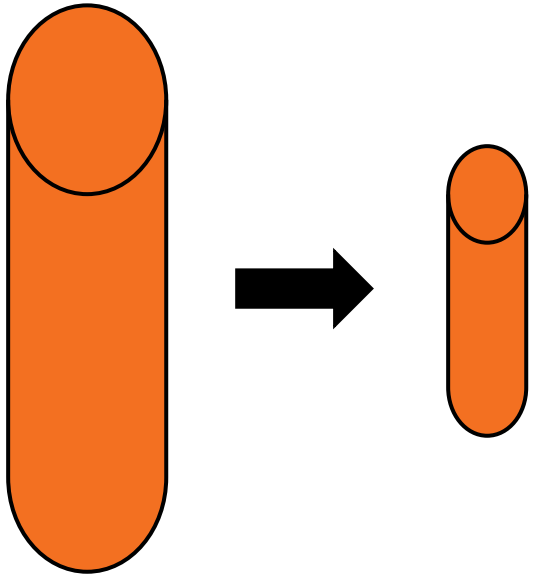
- Four Ventilation modeling stages developed based on original study.
- Original infrastructure left as is since equipment sizes assumed to be similar
- Airflow requirements primarily based on ventilating secondary equipment
- Results show reduction in required airflow of 50% with 80% reduction in power.




Diesel Equipment vs BEV Equipment Modeling Results
1400
1200
1000
800
600
400
200
0
Airflow (m³/s)
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Primary Fan Motor Power (kW)*
Stage 1
Stage 2
Stage 3
Stage 4
Diesel Equipment Total Airflow
BEV Equipment Total Airflow
Diesel Equipment Total Fan Power
BEV Equipment Total Fan Power
*Total of primary fans only, excludes total secondary fan motor power.

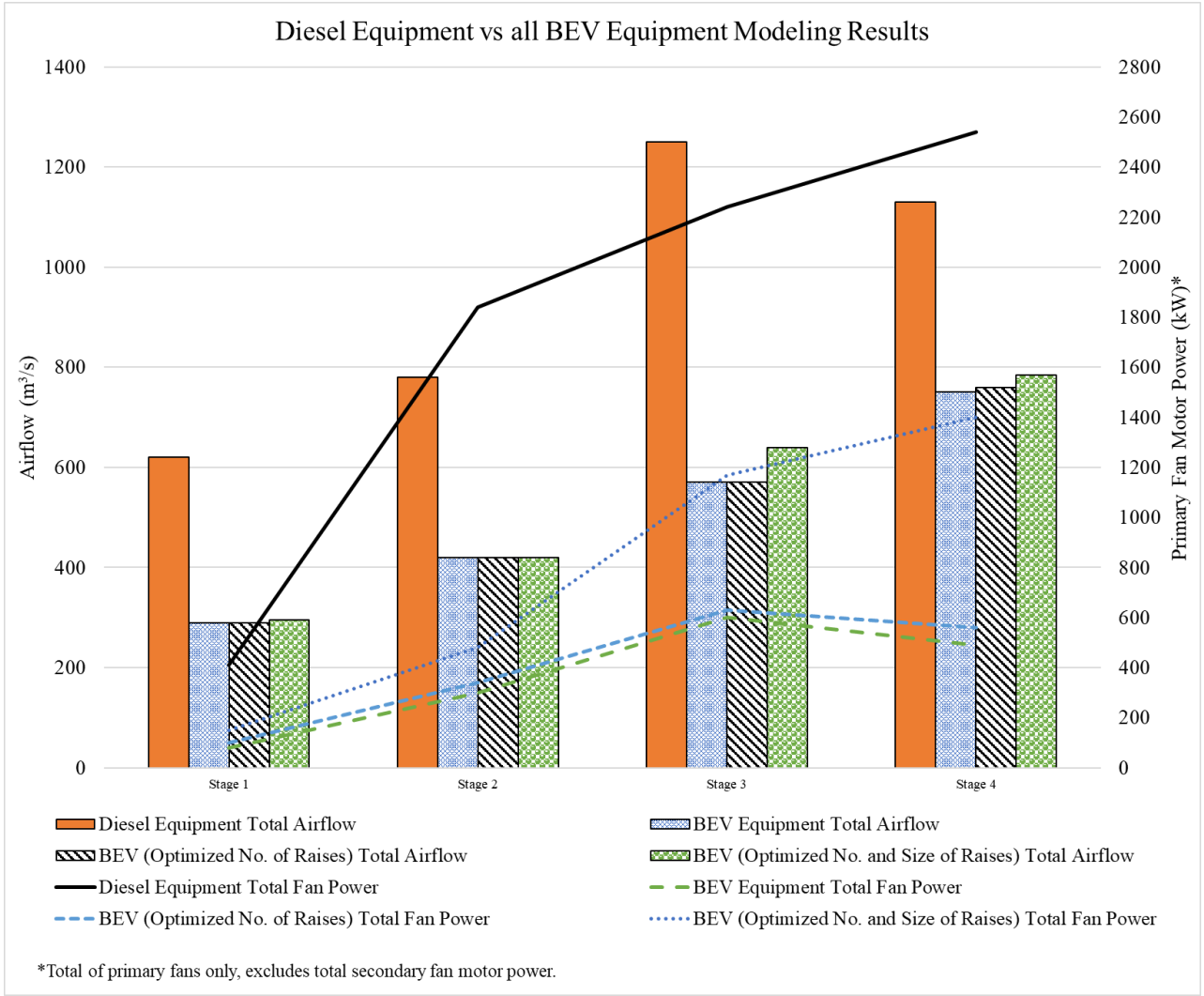
Additional modeling stages

- With significant reduction in airflow – reduce mine infrastructure
  - Ramp, level, and drift changes based on equipment envelops (not changed)
  - Number of raises could be reduced
  - Size of remaining raises could be reduced



Raises Infrastructure Savings

Model Description	Total Raise Volume Saved (m^3)
Original BEV equip./Diesel equip. study	--
BEV equip., optimized size of raises	10,000
BEV equip., optimized number and size of raises	110,000



*Total of primary fans only, excludes total secondary fan motor power.

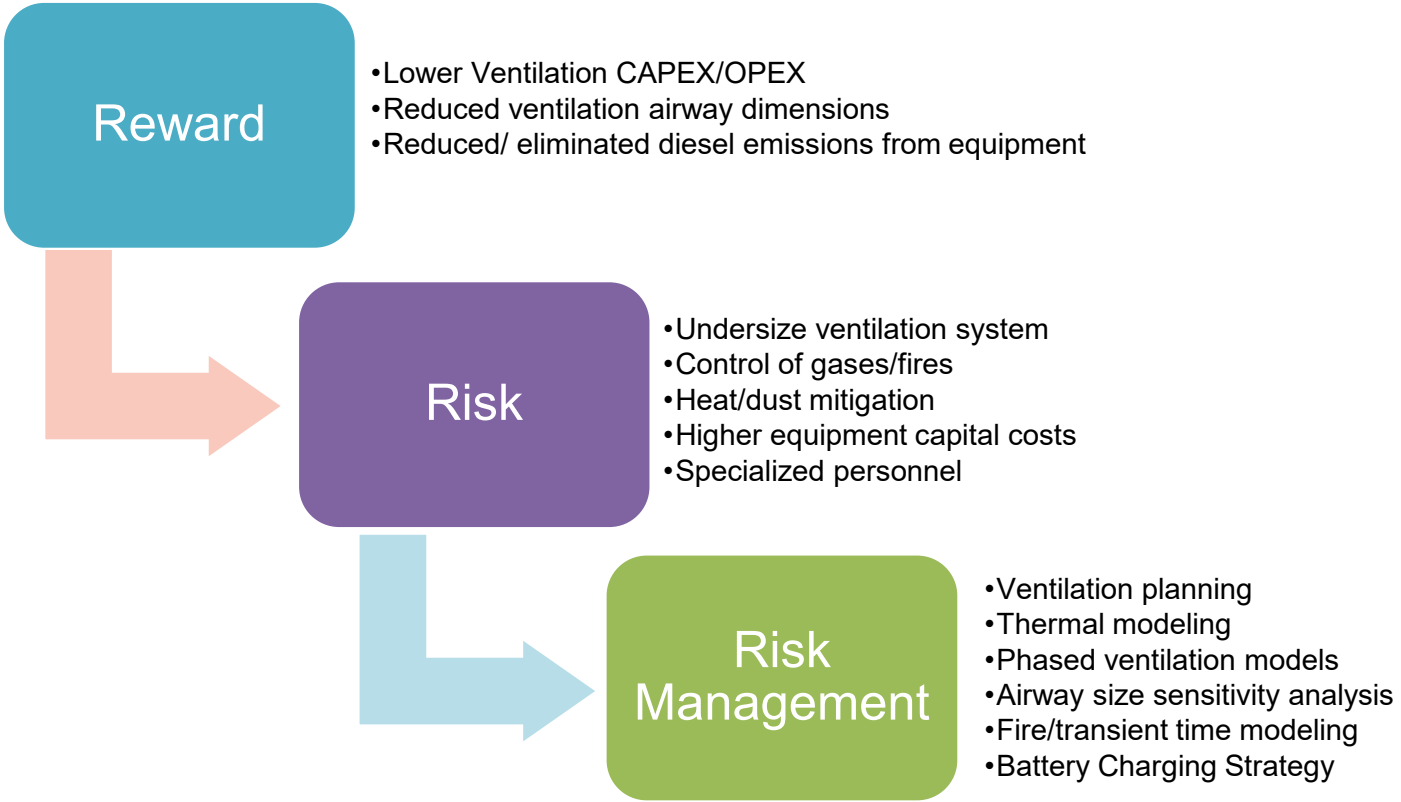
Discussion of Results

- Potential for significant ventilation power cost savings
- Potential for significant reduction in size/# of raises
  - Caution – ventilation should drive production not limit it.
  - If BEV is chosen to size raises, then diesel chosen later – Undersized!
- Reduced power for ventilation, but increased power for BEVs
- Do mines have the available electrical capacity?
- Power grid strategy needs to be considered to avoid spikes in usage

Discussion of Results cont.

- Diesel vs BEV new capital costs – BEVs cost 125% of Diesel equivalent
- Specialized mechanics, electricians, other technical staff different than needed for an all-diesel fleet.
- If battery swap-out chosen, how many swaps per shift?
  - Function of shift length, elevation changes, haul distances, etc.
- Limited data available (maintenance, longevity, reliability, dependability, etc)

Conclusions



Questions?

Nathan Wineinger
Consultant
Mine Ventilation Services,
a business unit of SRK Consulting, (U.S.), Inc.
+1 (559) 452 0182
nwineinger@srk.com

srk consulting