



The Problem

Heavy equipment used in construction and mining runs on diesel fuel. Diesel is produced from petroleum and contributes to the enhanced greenhouse effect by adding carbon to the atmosphere. Combustion of diesel fuel also produces particles and gases that are Class 1 carcinogens.¹ Diesel emissions can cause short term irritation and nausea, and have been linked to long term cancer and heart problems. These problems are magnified in areas with poor airflow, such as underground mines and tunnels.



Diesel haul trucks are vital to the mining industry but have hazardous emissions.

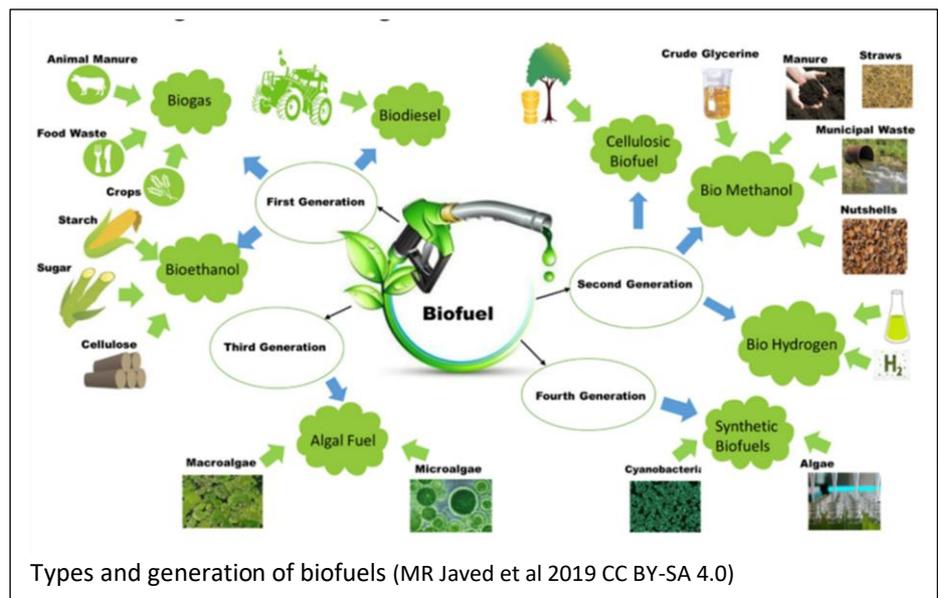
The first preference in eliminating the health problems associated with diesel is to use alternate energy sources.² Other practices such as keeping engines tuned, using better airflow and eliminating unnecessary stops³ can lower diesel use and therefore emissions. Personal protective gear is the least effective health response to diesel emissions.

Alternative Fuel Options

Biofuels⁴

Conventional biofuels include ethanol (mixed with petrol for E10 fuel) and biodiesel (made from oils and fats). Biofuels produce fewer toxic emissions than traditional petroleum-based fuels. Because these are made from recent plant and animal sources, burning of biofuels does not result in the release of carbon that has been sequestered (locked up) for a long time to the atmosphere. Instead, carbon is cycled through the biosphere and atmosphere. Conventional biofuels are made with material that might also be used for human and animal food. Unfortunately, biofuels are not entirely compatible with existing fuel infrastructure.

Advanced biofuels are produced from waste residues that cannot be used to feed humans or animals. They are compatible with existing fuel infrastructure and can be easily implemented. However, producing and using advanced biofuels in Australia will require \$25 - \$30 billion investment in production facilities and at least 20 years to become cost competitive with petroleum fuels.





Natural Gas⁵

Liquefied Natural Gas (LNG) can be mixed with diesel. Natural gas has more efficient combustion, so greenhouse gas reductions of 25% can be gained in cases where engines burn 95% LNG in 5% diesel. Use of LNG saves money on fuel costs and less harmful particulate matter is produced. However, refuelling and distribution systems need to be created at a large scale. LNG comes from fossil fuel sources, so its use continues to add long sequestered carbon to the atmosphere.

Hydrogen⁶

Hydrogen fuel cells are a promising technology for the future of heavy equipment. The first hydrogen-powered excavator was built in 2020 and other heavy equipment is being developed. The main benefit of hydrogen fuel is that the only emissions are heat and water vapour. This means a healthier working environment. At present, most hydrogen is produced from natural gas. Use of natural gas in hydrogen production leads to the addition of long sequestered carbon to the atmosphere. 'Green' hydrogen can be produced through the electrolysis of water using renewable energy sources to power the process. Investment in green hydrogen is gaining pace with major investments from the Australian government and private companies.⁷

Battery Electric Vehicles

Battery electric vehicles are widely available for passenger cars, but their implementation in heavy equipment has been slower. Caterpillar Inc. unveiled an electric excavator in 2019.⁸ A major drawback to this equipment was that it required overnight charging after 5 – 7 hours of use. Volvo has successfully tested electric excavators and loaders.⁹ In addition to producing no emissions, battery-powered equipment is much quieter than diesel machines. Lower noise increased site safety as it was easier for workers to communicate. Solar arrays can be used to charge the batteries, thus avoiding any addition of carbon to the atmosphere.

The Future is Now at Gold Fields' St Ives Gold Mine¹⁰



Battery electric underground haul truck (L) and loader (R) being trialed at St Ives Gold Mine. (photos courtesy of Gold Fields)

Battery electric underground mining equipment is being trialed at Gold Fields' St Ives Gold Mine, south of Kalgoorlie. Underground mines are a priority for electric vehicle implementation because of limited airflow and issues with heat buildup. The lack of emissions and heat from electric equipment has major benefits from an occupational health and safety standpoint.



Replacing diesel trucks with battery electric ones will avoid 940 tonnes of CO₂ production and save approximately 346 000 litres of diesel for each truck on a yearly basis. Sandvik electric trucks have a battery swapping system to avoid down time for recharging. Trucks continue to operate while the alternate battery pack recharges. The total carbon footprint of the vehicles will depend upon the supply of electricity for charging. [Renewable energy grids](#) like that at Gold Fields' Agnew Gold Mine can supply most of the power needed for a mine site at present, with further innovations set to make mines carbon neutral.

Questions

1. Identify at least three environmental and health problems caused by diesel fuel emissions. _

2. Complete the table below, using information from the reading.

Fuel Type	Advantages	Disadvantages
Diesel		
Biofuel		
Natural Gas		
Hydrogen		
Battery Electric		



3. Gold Fields has both open cut and underground mining operations. Why have they introduced the first electric trucks in underground mines? _____

4. What advance in battery power has made the Sandvik trucks more user-friendly than the early Caterpillar excavator? How does this help companies using the machines? _____

5. Both hydrogen and battery electric equipment are seen as future power sources for heavy equipment. Which do you think will be more widely used? Justify your choice. _____

Extension

The Australian parliamentary inquiry into impacts on health of air quality¹⁰ found that off-road diesel vehicles, like mine site heavy machinery, produced as much particulate matter as all on-road vehicles – appx 13 500 tonnes in 2008. There are no regulations or standards limiting emissions. Health benefits of introducing standards similar to those in the USA were estimated at \$2.5 - \$4.6 billion by 2030.

Resourced by





1. Use the information from the reading and the parliamentary inquiry to propose a transition to low or no emissions off-road equipment. In your proposal, explain why the federal and state governments should offer incentives for making this transition and suggest infrastructure investments that could accelerate the process.
2. You are buying equipment for a new mine site that will feature both open cut and underground operations. What factors will be most important in your heavy equipment choices? Create a presentation to persuade investors that your approach is a wise one. (Remember that companies are trying to achieve net zero emissions by 2050, in keeping with the Paris agreement.)

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