



Electrification of Mining Mobile Fleets and Machinery: The Role of Optimal Systematic Design

Dr Hossein Ranjbar
The University of Adelaide





1. Introduction





Background and Motivations

- 1** Australian mining industry consumes about 14% of the total energy usage in the country
- 2** Mining industry is the second largest contributor to carbon emissions in Australia
- 3** The fastest growing sector in GHG emissions for the past 30 years
- 4** About 30-50% of diesel fuel used at mine sites is for transportation;
15-30% of operating cost for material handling, heating, ventilation & processing
- 5** A report by McKinsey & Company: approximately 56% of emissions from diesel usage in an open-pit iron ore mine in Australia result from hauling.



Background and Motivations

1 Improve Mining Economics

- Reduction in Operating Energy Costs
- Reduction of Operating Maintenance Costs
- Reduction in Capital and Operating Ventilation Costs
- Reduction in Total Operational Expenditure (OPEX)
- Pathways to Mining Vehicle Optimisation and Automation
- Improvements in Lower Grade Ore Extraction Economics

1

2

2 GHG Emissions Reduction from Mining

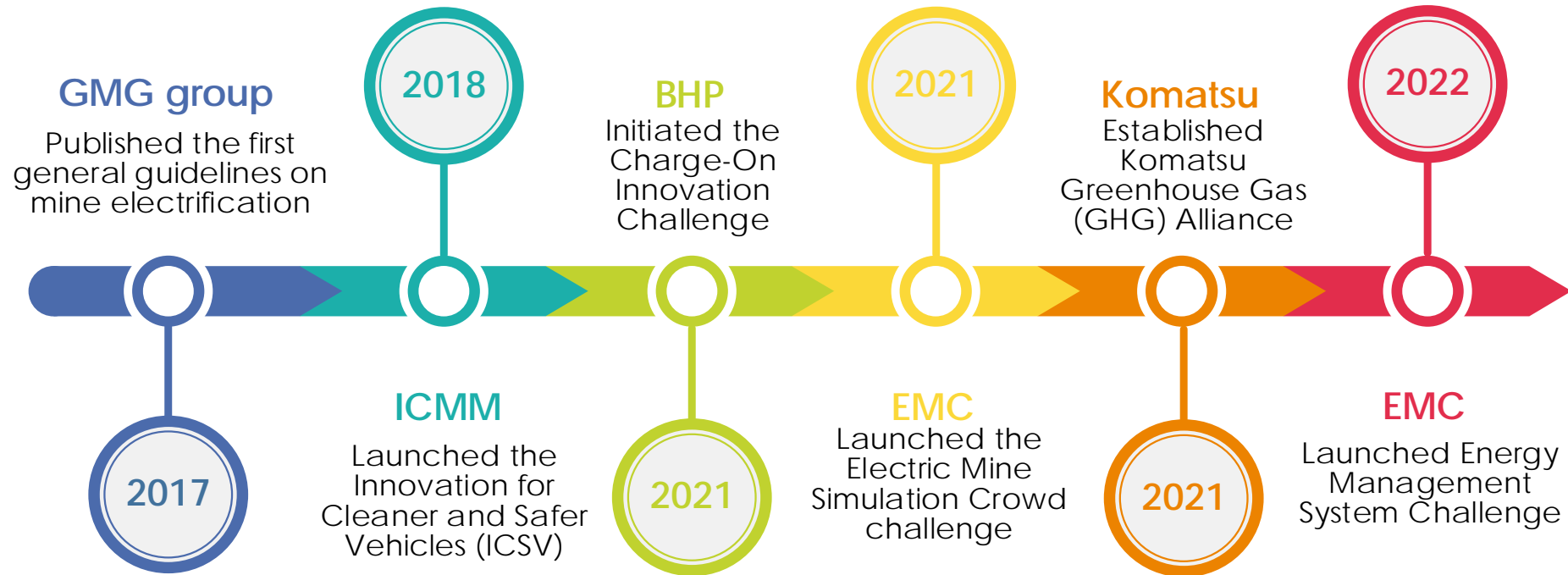
- Greenhouse Gas Emission Targets
- Stakeholder Interests
- Society

3

3 Improve Mining Worker Safety



Background and Motivations



The most recent efforts initiated by the mining industry for mining electrification.



About MOVE project

PROJECT TITLE

Assessment, design and operation of battery-supported electric mining vehicles and machinery

ULTIMATE GOAL

To provide the Australian mining industry with the tools and information needed to help transition their operations to using battery-supported electric vehicles and associated stationary machinery

2 CASE STUDIES

- Leinster Underground Mine, WA (BHP)
- Nova Operation, WA (IGO)



Department of Natural Resources, Mines and Energy





About MOVE project

1

ENERGY
system study
and data
collection

2

DEVELOPMENT
of tools for EV
fleets and
associated
infrastructure

3

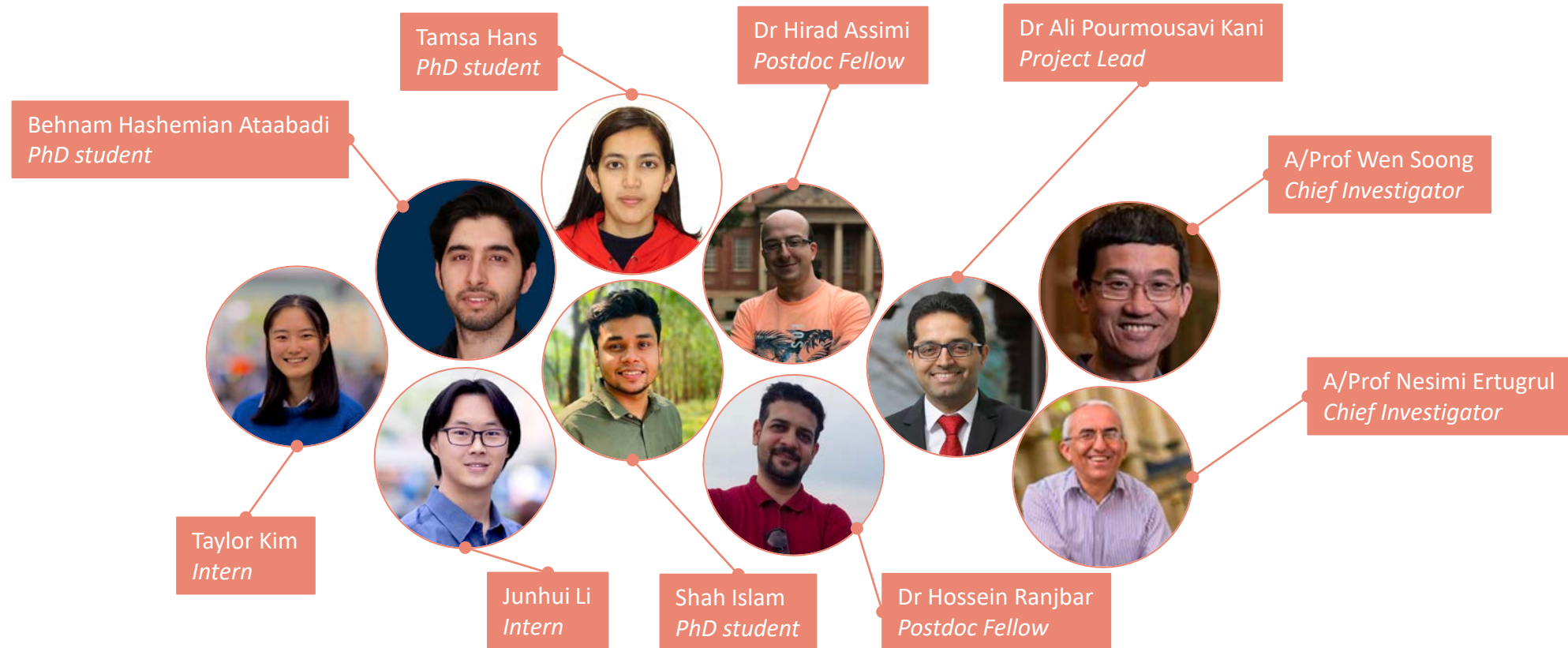
DEVELOPMENT of
the toolkit to
design backbone
energy
infrastructure

4

IDENTIFYING
Electric mine
required skills
and producing
training materials



Our Team



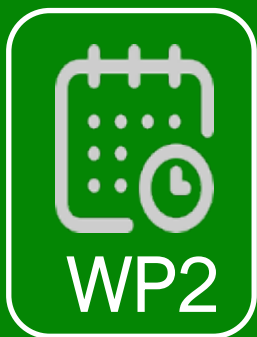
A team of 3 academic staff members, 2 postdocs, 3 PhD students and 2 undergrad interns

School of Electrical & Mechanical Engineering
The University of Adelaide





2. Underground Mining Truck Electrification



DEVELOPMENT of software, tools and frameworks for the management of mine site EV fleets and associated infrastructure

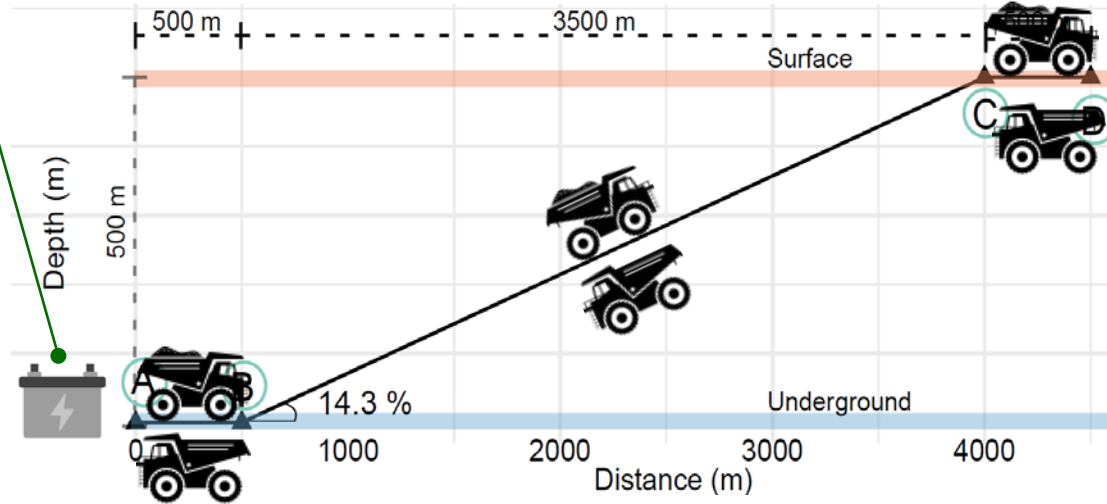




Problem Statement

Charging Technology:

- Rated voltage, power, & energy of the charging technologies
- Location of charging, swapping stations or trolley-assist charging



Electric Truck:

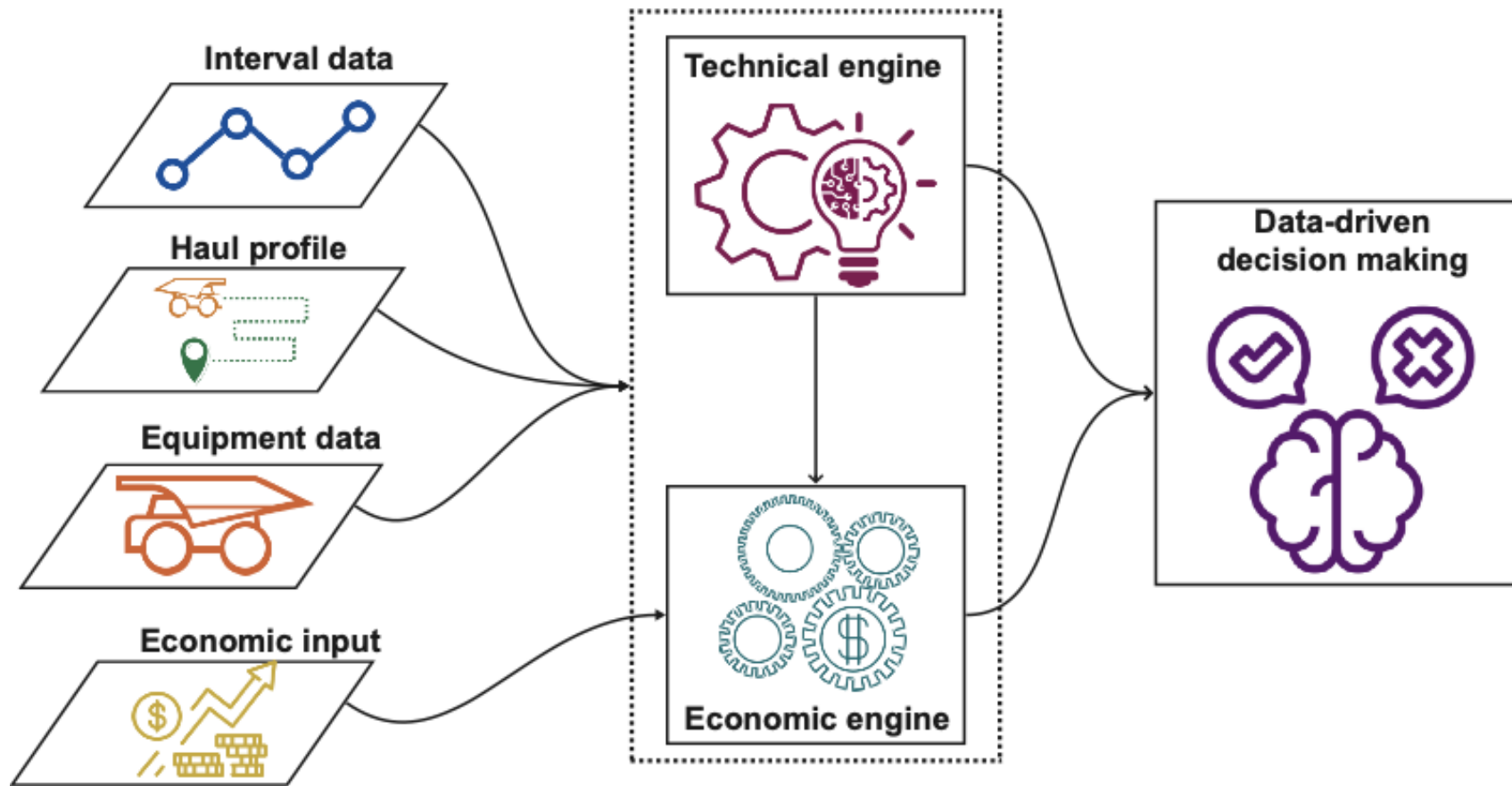
- Power and energy requirements
- Regenerative braking
- Battery onboard the truck

Operational Parameters:

- Battery recharging frequency
- impact of onboard battery size and charging frequency on productivity
- Truck's speed to achieve best cost vs productivity solution
- onboard battery replacement due to degradation

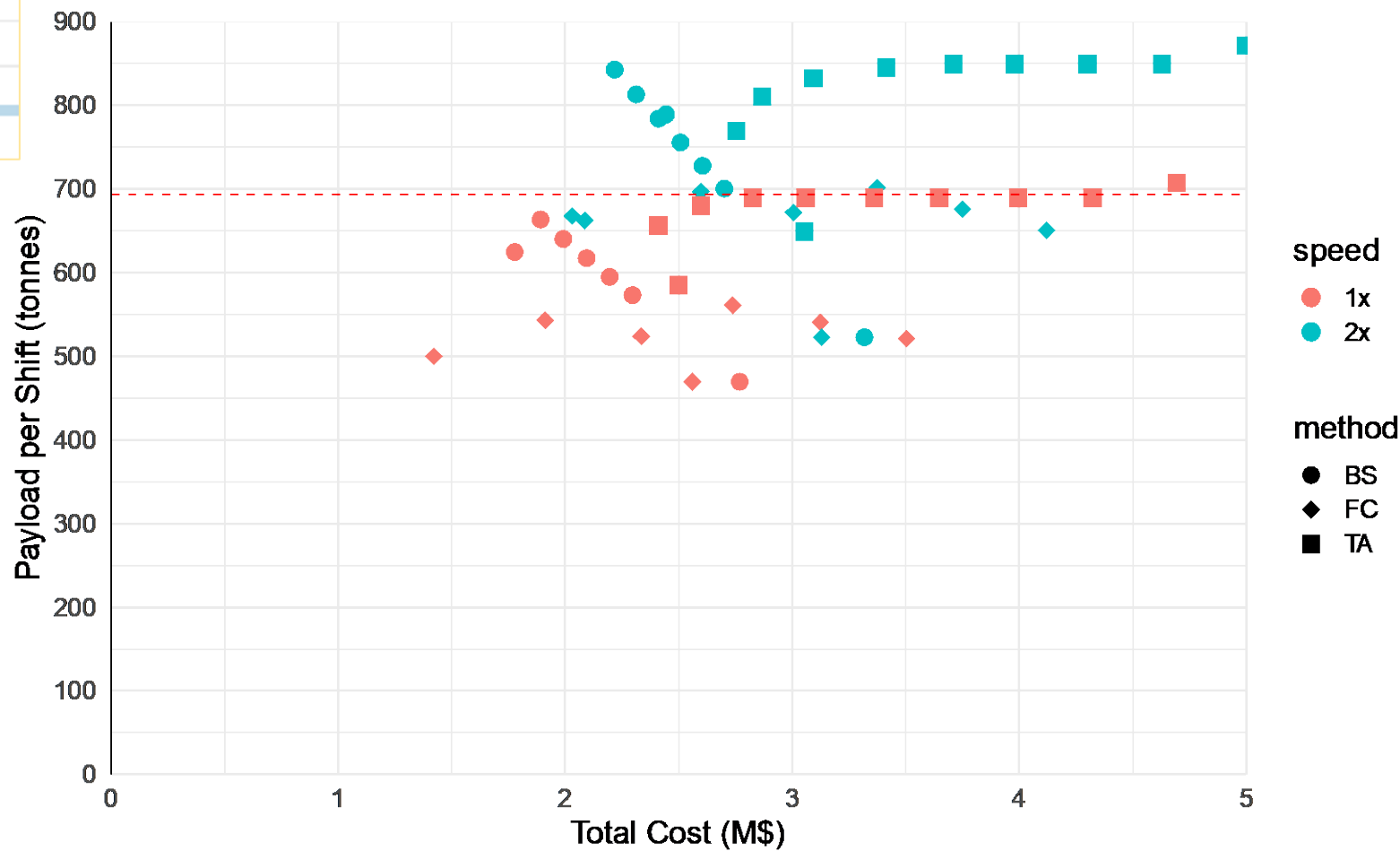
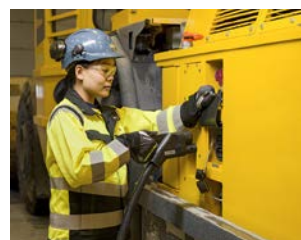
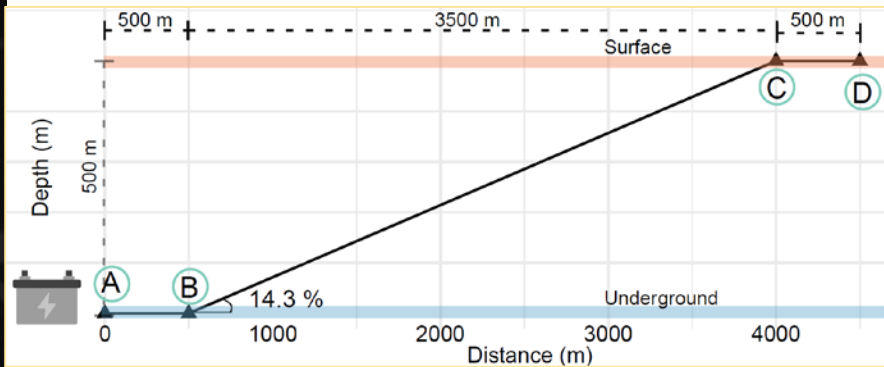


Charging Infrastructure Design Framework



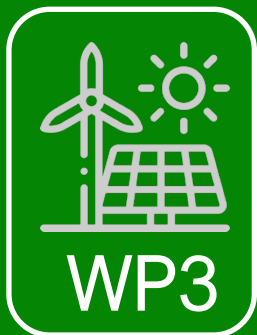


Simulation Results: Cost vs. Productivity Trade-Offs





3. Backbone Energy Infrastructure Design



DEVELOPMENT of the
toolkit to design the
backbone energy
infrastructure





Problem Statement

Grid Connectivity:

- Grid connection/wholesale electricity market nearby?
- Grid upgrade, network charges

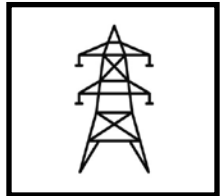
RES Potentials:

- Wind power assessment at the site
- Solar power potential at the site

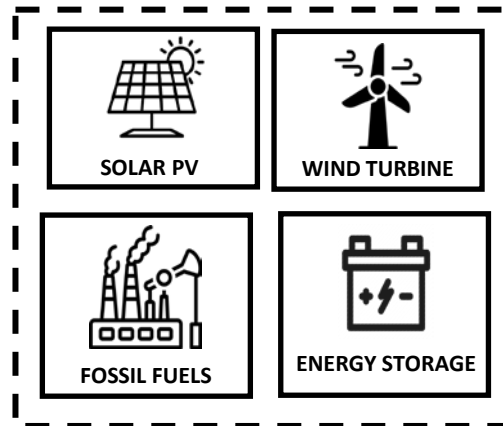
Mining Electricity Load:

- Load change due to the adoption of electric trucks and machinery?
- Load flexibility and V2G capability?

GRID



MICROGRID SYSTEM



MINING INDUSTRY

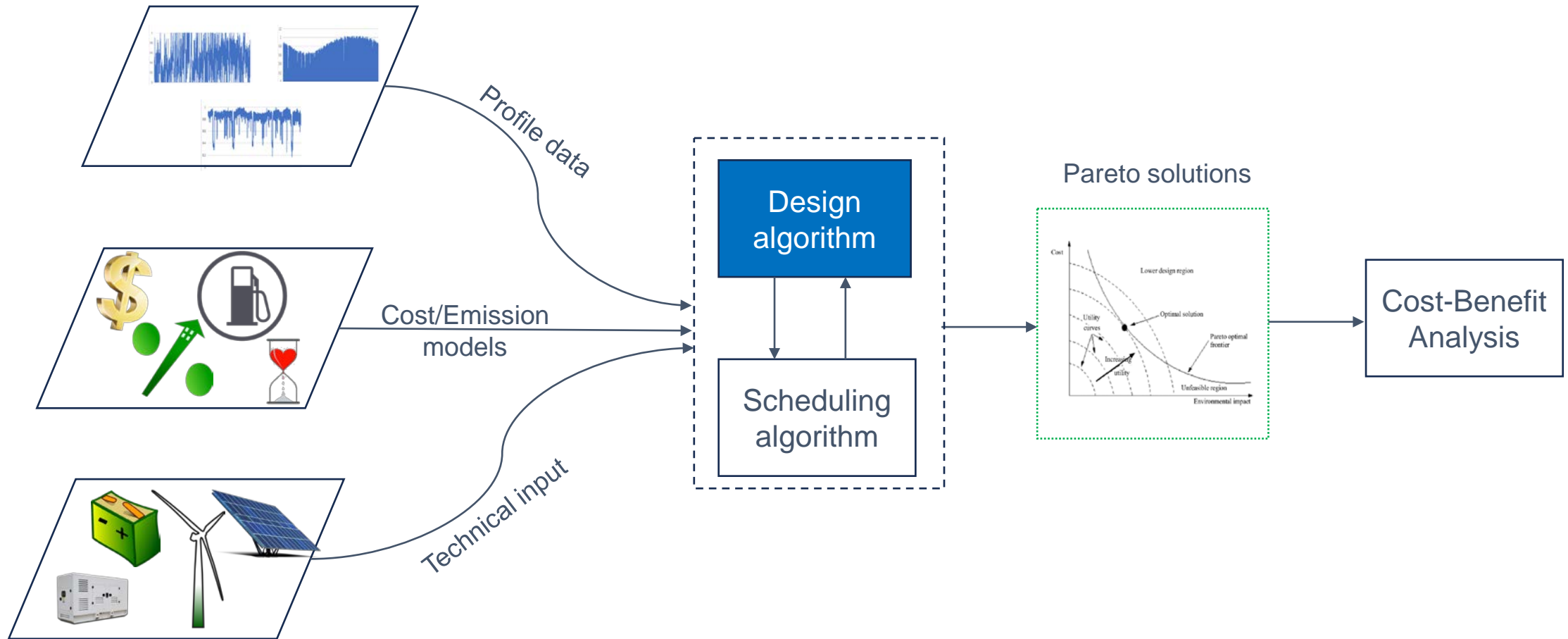


Technology Selection and Sizing:

- Optimum capacity of microgrid components to minimize the cost and emissions?
- Trade-offs between costs and emissions?

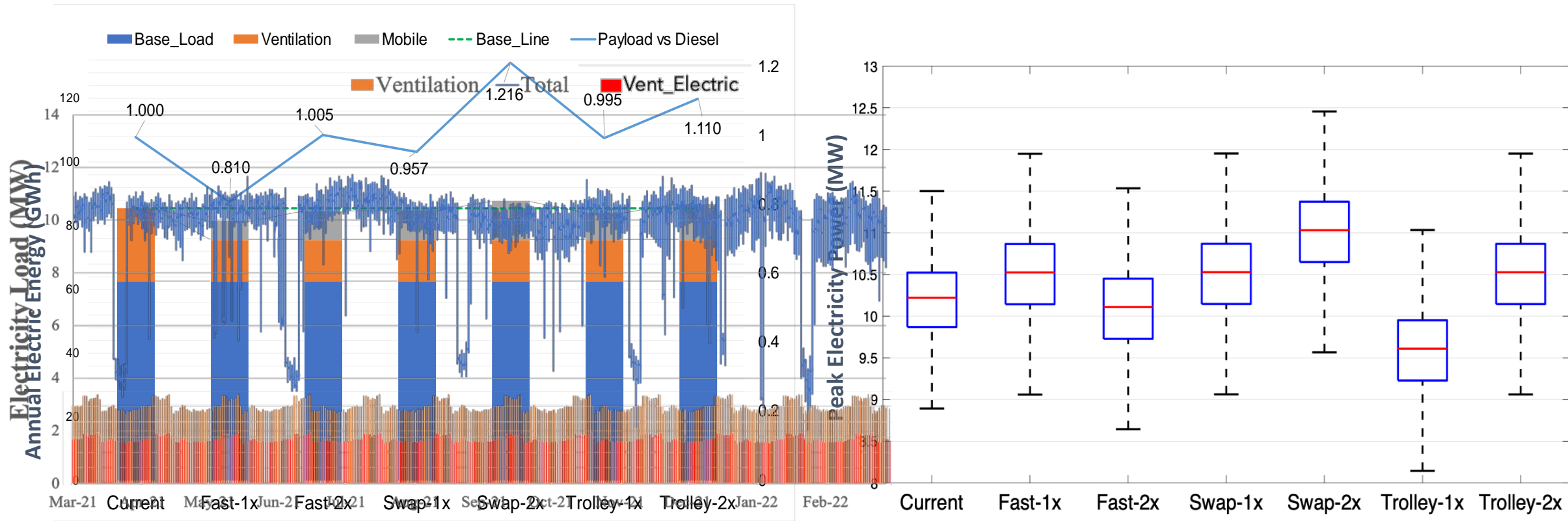


Backbone Energy Infrastructure Design Framework





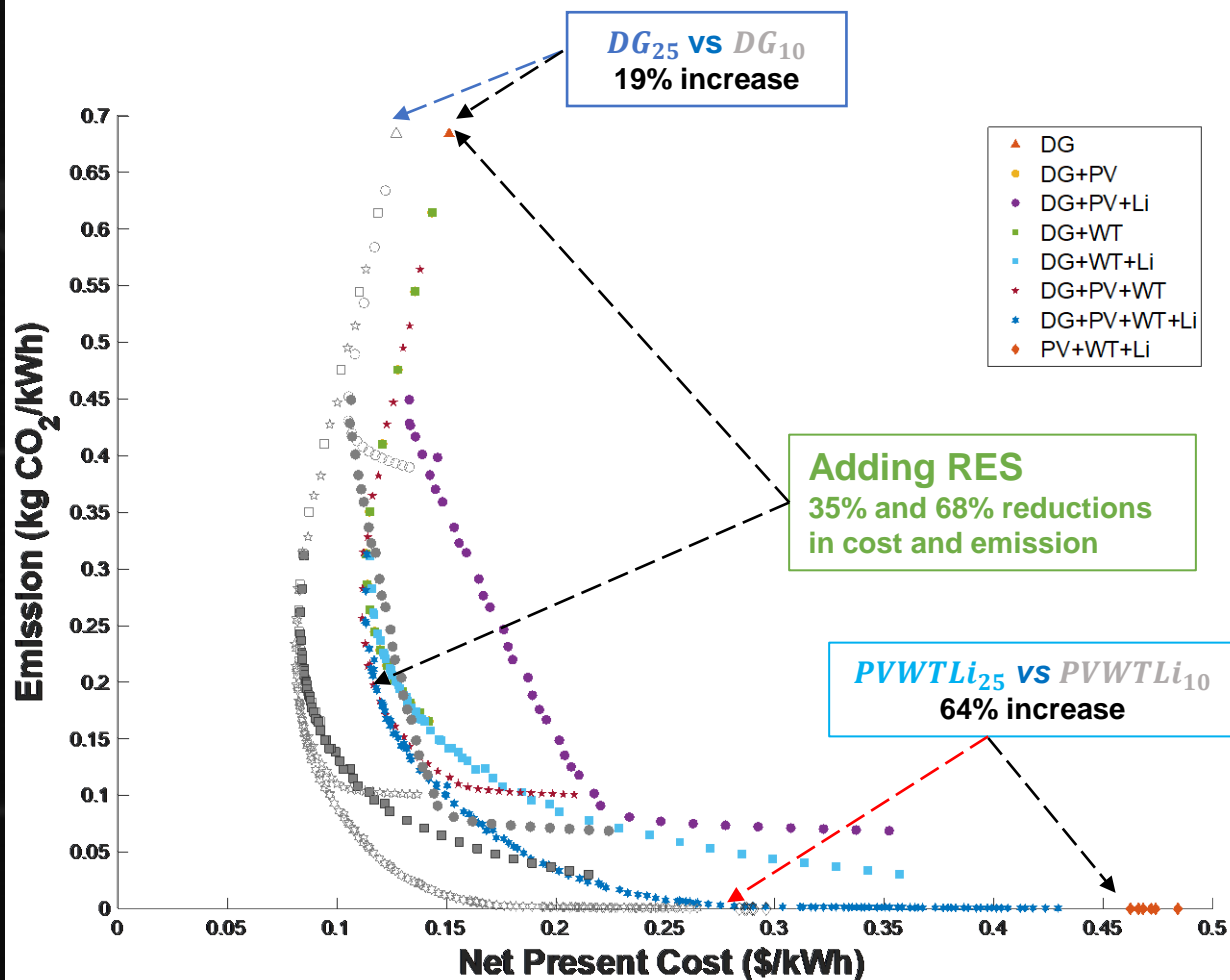
Electricity Demand Analysis



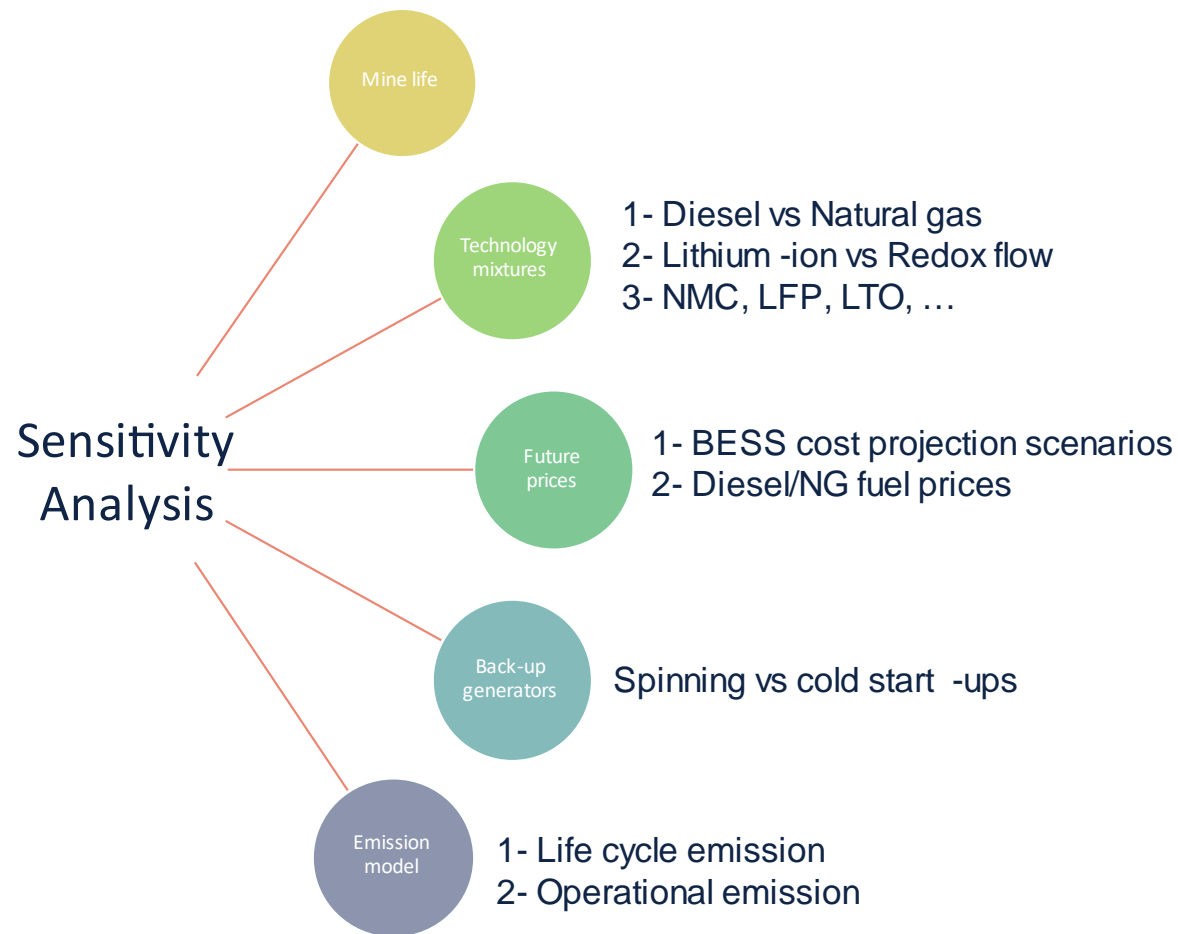
Energy and peak demand for different charging technology of a typical electrified mine



Simulation Results



Trade-off between net present cost and emission for different energy technology and mine life (colored points: 10 yrs, grey/white: 25 yrs)





4. Project Progress





Project Progress

IGO Data Discussion Report – Nova Operation

Mine Operational Vehicle Electrification (MOVE) Project

Project Details
Project Title: Assessment, design and operation of battery-supported electric mining vehicles and machinery
Project Lead: Dr. Ali Pourmousavi Kani
Prepared by: Hiral Asami, Wen Song, Ali Pourmousavi Kani, Bryan Foley
Contributing Organisations: University of Adelaide, IGO Limited
Date: July 2022
Version: 1.0

make history.

BHP Data Discussion Report – Nickel West, Leinster

Mine Operational Vehicle Electrification (MOVE) Project

Project Details
Project Title: Assessment, design and operation of battery-supported electric mining vehicles and machinery
Project Lead: Dr. Ali Pourmousavi Kani
Prepared by: Hiral Asami, Wen Song, Ali Pourmousavi Kani, Bryan Foley
Contributing Organisations: University of Adelaide, BHP
Date: October 2022
Version: 1.0

make history.

D9A – Data requirement for electrifying mobile mining fleet in underground mines

Mine Operational Vehicle Electrification (MOVE) Project

Project Details
Project Title: Assessment, design and operation of battery-supported electric mining vehicles and machinery
Project Lead: Dr. Ali Pourmousavi Kani
Prepared by: Wen Song, Hiral Asami, Behnam Harshehman-Ashtabadi, Shah Islam, Ali Pourmousavi Kani
Contributing Organisations: University of Adelaide, BHP, IGO
Date: June 7, 2022
Version: 1.0

make history.

D9B – Electrified Machinery Assessment Report

Mine Operational Vehicle Electrification (MOVE) Project

Project Details
Project Title: Assessment, design and operation of battery-supported electric mining vehicles and machinery
Project Lead: Dr. Ali Pourmousavi Kani
Prepared by: Ali Pourmousavi Kani, Hiral Asami, Behnam Harshehman-Ashtabadi, Wen Song, Hassan Farjani, Shah Islam
Contributing Organisations: University of Adelaide, BHP, IGO
Date: August 2, 2022
Version: 1.0

make history.

D10 – Algorithms for spatial and temporal demand profile estimation of the electrified fleet

Mine Operational Vehicle Electrification (MOVE) Project

Project Details
Project Title: Assessment, design and operation of battery-supported electric mining vehicles and machinery
Project Lead: Dr. Ali Pourmousavi Kani
Prepared by: Ali Pourmousavi Kani, Hiral Asami, Behnam Harshehman-Ashtabadi, Teresa Hens
Contributing Organisations: University of Adelaide, BHP, IGO
Date: June 7, 2022
Version: 1.0

make history.

D15 – Review on power system and electrified machinery sensors and communication network design guidelines, with specific results for two case studies

Mine Operational Vehicle Electrification (MOVE) Project

Project Details
Project Title: Assessment, design and operation of battery-supported electric mining vehicles and machinery
Project Lead: Dr. Ali Pourmousavi Kani
Prepared by: Hassan Farjani, Hiral Asami, Behnam Harshehman-Ashtabadi
Contributing Organisations: University of Adelaide, BHP, IGO
Date: June 8, 2022
Version: 1.0

make history.

D11 – Design of Charging Infrastructure and Onboard Batteries for BHP Leinster and IGO Nova

Mine Operational Vehicle Electrification (MOVE) Project

Project Details
Project Title: Assessment, design and operation of battery-supported electric mining vehicles and machinery
Project Lead: Dr. Ali Pourmousavi Kani
Prepared by: Ali Pourmousavi Kani, Hiral Asami, Behnam Harshehman-Ashtabadi, Teresa Hens
Contributing Organisations: University of Adelaide, BHP, IGO
Date: November 7, 2022
Version: 1.0

make history.

D16 – Mine electrification power system infrastructure design guidelines with specific results for two case studies

Mine Operational Vehicle Electrification (MOVE) Project

Project Details
Project Title: Assessment, design and operation of battery-supported electric mining vehicles and machinery
Project Lead: Dr. Ali Pourmousavi Kani
Prepared by: Hassan Farjani, Hiral Asami, Ali Pourmousavi Kani, Wen Song
Contributing Organisations: University of Adelaide, BHP, IGO
Date: November 7, 2022
Version: 1.0

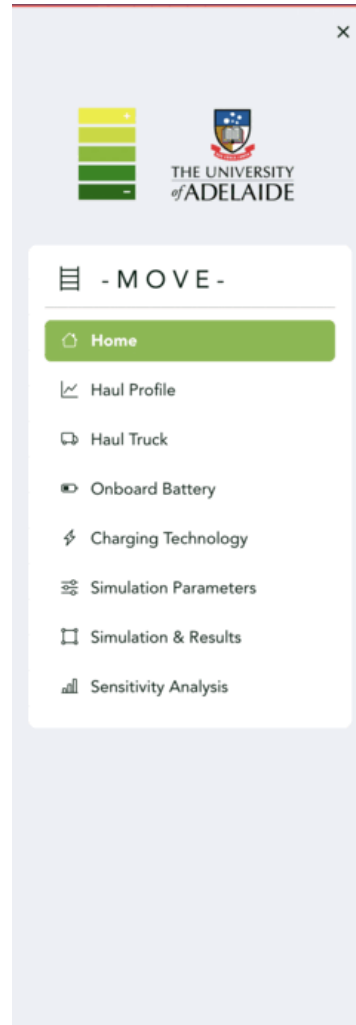
make history.



Project Progress

Graphic User Interface

Charging infrastructure design and onboard battery sizing



Home

Mine Operational Vehicle Electrification (MOVE) Project GUI Tool

Welcome to the graphical user interface (GUI) tool for the algorithms developed in the Mine Operational Vehicle Electrification (MOVE) project.

Overview

The MOVE GUI tool provides a user-friendly interface to interact with the algorithms developed in the MOVE project. It allows you to input various parameters, view design solutions in different formats such as figures and tables, and perform functions like saving, importing, and exporting parameters and results. The tool is designed with flexibility in mind, enabling easy integration of additional items in the future.

Functionality

The GUI tool offers the following key functionalities:

- Algorithm Parameter Inputs:** Easily input all the required parameters for the algorithms with intuitive input elements specific to each parameter.
- Design Solution Visualization:** Visualize the design solutions generated by the algorithms using interactive figures and tables.
- Detailed Reports Generation:** Generate comprehensive and detailed reports containing simulation results and analysis.
- Data Management:** Save, import, and export algorithm parameters and simulation results for easy collaboration and analysis.

Simulation and Analysis



THE UNIVERSITY
of ADELAIDE



Project Progress



Provisional Patent Application

Charging infrastructure sizing, technology selection and onboard battery sizing for electric haul trucks in underground mining application

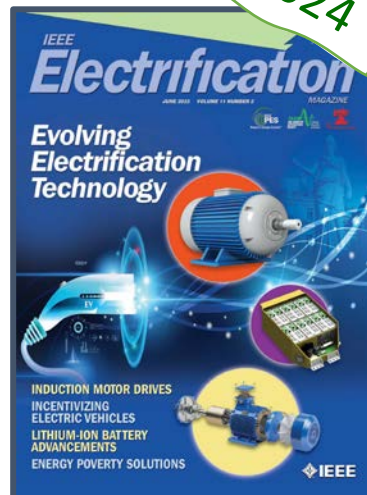


Landscape Report

Provides insight into the current status of mine vehicle electrification in Australia.



2024



IEEE Electrification Magazine

Towards Underground Mobile Fleet Electrification
Three Essential Steps to Make a Real Change

Industrial IoT in Mine Electrification:
Necessity or Luxury?



Our Service

We offer four primary services that can assist your site towards the net zero transition:

ELECTRIFICATION ASSESSMENT

We will work with you to identify the potential to electrify your specific site using extensive data analysis to deliver your custom roadmap for action.

MOBILE FLEET

Armed with this information we can help guide you through the selection of appropriate technology, considering the optimal size of charging mechanism and onboard battery systems to meet your needs.

1

2

3

4

FLEET MANAGEMENT SYSTEM

We can develop and customise software tools to help you manage your site's electric vehicle fleets and associated infrastructure.

ENERGY INFRASTRUCTURE DESIGN

We can also design your optimal energy infrastructure to ensure that EV fleet and electric machinery operates efficiently and reliably.

Q&A

“FROM UNDERSTANDING THE EXACT INVENTORY REQUIRED, TO CALCULATING THE COSTS OF IMPLEMENTATION, OUR TOOLS WILL HELP SUPPORT MINING COMPANIES TO MAKE A SUCCESSFUL TRANSITION TO BEVS.” — Dr Ali Pourmousavi Kani

Contact us

E: a.pourm@adelaide.edu.au

P: 0413 740 277

Scan
for
more

