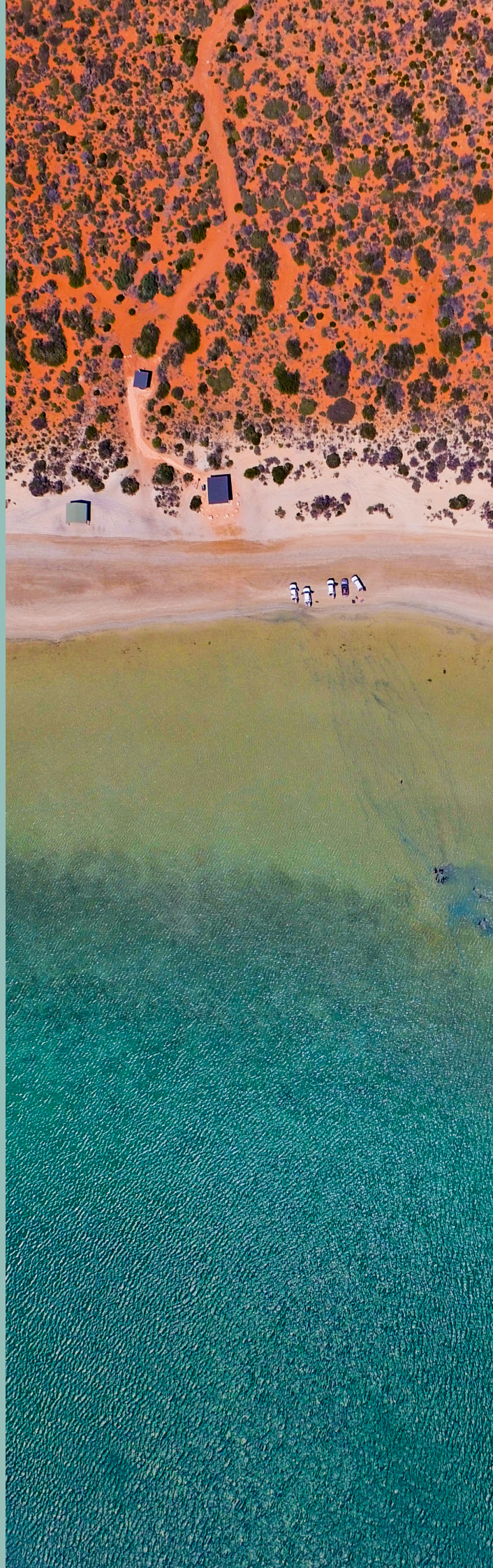


# CoRE LEARNING FOUNDATION GAMIFYING EARTH SCIENCE

Old as Dirt -  
'Modern Mine'

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CREATED BY  
CoRE Learning Foundation



# Modern Mine - Overview

CoRE's Old as Dirt is a compilation of games, which are aligned to the Year 8 ACARA Curriculum. Modern Mine is Game 6 of the compilation, but is not restricted to this year level.

Modern Mine, can be utilised as a digital textbook. The game addresses:

- The digital, decarbonisation and diversification of the mining landscape for the 21st century
- In the Age of Digital Disruption, improved environmental and social governance is described through ten different conversations. Each of these conversations can be separately undertaken and they are decided by student vote.
- The ten different conversations describe the mine site transformation exploring sensors, safety, water use, remote operations and electrification of vehicles.
- The ten conversations are led by an NPC (non-playing character) who describes futuristic career(s) associated with the different stages of mine site transformation processes. (The names of these careers are very broad, that is because through the digital age new careers are being made and not yet available.

The game was designed to highlight how the future mine in a digital and decarbonised world will operate. STEM skills, careers are at the core to these games as they hone in the importance of 'human energy' and the diversity of capabilities required to effectively operate these high tech mine sites of the future. Remote operations and electrification will enable more excellent safety for the Human Energy required to operate these mines. These mines will be deeper and more isolated than current locations due to advancements in technical capability. The Smart Mine of 2040 and beyond will have a diverse STEAM workforce, diversification being key to running the 'Big Data' necessary for 'clean, green, safe and efficient operations.

The careers are broadly described as their interdisciplinary STEAM nature means they have not yet been described or designed.



# Modern Mine - Conversations

Modern Mine - Comprises Ten Conversations and Ten Futuristic Careers describing the infrastructure, energy and digital capabilities of The Smart Mine 2040.

Conversation	Description	Career
1	Sustaining 2040	Smart Mine Specialist
2	Moving Forward and Gaining Momentum	Future Planner
3	Mine Concept 2040	Technology Specialist
4	Transformers 2040	Future Technologist
5	Mine Design 2040	Smart Mine Designer
6	Water - The Earth's universal Solvent	Environmental Officer
7	A Waterless Mine	Research Scientist
8	Energy - The ability to do work!	Electrical Engineer
9	Shining Through and Moving Air	Power Engineer
10	Energising Mine +2040	Power Researcher

# Modern Mine - Game Structure and Operations

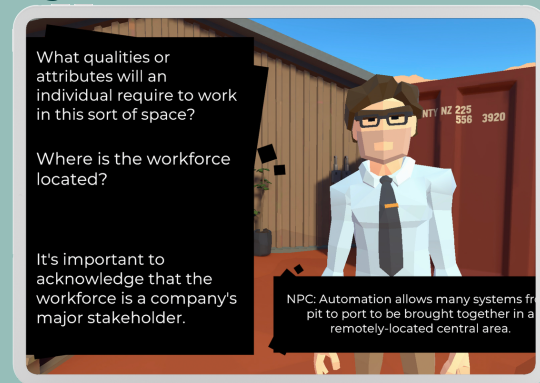
The students select the direction of the conversation (between conversations 1 - 10). Figure 1. It is the opening page of the conversation.

Figure 1



Once a conversation has been selected, a series of questions will present (Figure 2)

Figure 2



The NPCs represent the careers and provide oversight of the selected Topic. Figure 3.

Figure 3



One of the answers (Figure 4) is presented to continue with this conversation. During this process, a series of questions related to the topic are asked and the NPC (the Future Planner) is responsible for the answer.

Figure 4





# Modern Mine - Conversation Structure Tree

This section describes how to read the dialogue in the appendices. The Appendices are attached to demonstrate the content involved in each of the ten conversations. The NPC is the career person who is answering the questions. As the students select the direction of the conversation, they choose the appropriate questions relevant to and extend the topic (A, B or C) of the conversation.

Greeting (Describes the career)	Hub A (Identifies the conversations purpose)	Hub B (Describes the conversations objective)	This is the opening and defines the conversation
Topic A	Topic B	Topic C	Students choose which topic/pathway to choose

For each topic (A, B, C), there are:

- Students (computer students) ask two preferred or favoured questions (the real students select these options) and two favour or favoured answers from the NPC (Career Character).
- One unfavoured or negative question asked by the students (computer students) (which the real students can select) is answered by the NPC in a positive tone, i.e. turning a negative into a positive. This section aims to dilute and refute misconceptions, particularly those associated with environmental and social governance.

For the above two dot points, this process is coded into the game, the students choose the options. Analysis of the appendices will highlight the content addressed and its sequential nature across Topics A, B and C and between conversations one to ten

# The Smart Mine Specialist



Students have voted for the conversation with The SMART Mine Specialist

## Greeting

Let's about about what a mine might look like in 2040 - the future!

## Hub 1

What aspects of the mine of 2040 do you want to talk about?

## Hub 2

Let's chat about the mine of 2040... what do you think?

Students have vote to decide the topic

## Topic A

Why talk about a future mine?

## Topic B

What are the driving factors in future changes to mining?

## Topic C

How can mining be a better partner with the community and others?

## Smart Mine Specialist A Response

Our world is moving towards a sustainable future and we need to use resources more responsibly. It's important to talk about the future and plan for it.

## Smart Mine Specialist B Response

Technology and other disruptive influences are evolving very fast and we need to be part of that evolution.

## Smart Mine Specialist C Response

The future mine will still require humans and we need to work harder to build a skilled future minerals workforce.

## AQ1

How are we going to be more sustainable ?

## AQ2

What are the new energy technologies of the future?

## AQ3

What is the biggest priority of a smart mine in 2040?

## Smart Mine Specialist Ans-A1

We are looking at a decarbonised world where our footprint is reduced through innovative technology and using different minerals.

## Smart Mine Specialist Ans-A2

Many of the most exciting innovations depend on critical metals which we need to mine and produce in a more sustainable way.

## Smart Mine Specialist Ans-A3

We need to reimagine mining with a continued focus on improving people's lives while being more sustainable.

## For Topics B & C

BQ1-3 and CQ1-3 together with Smart Mine Specialist Ans-B1-3 and Smart Mine Specialist Ans-C1-3 are repeated in the same format.

# Appendix 1 - Modern Mine Conversation 1

## Sustaining 2040 - Smart Mine Specialist

### Greeting

Let's talk about what a mine might look like in 2040 - the future!

### Hub 1

What aspects of the mine of 2040 do you want to talk about?

### Hub 2

Let's chat about the mine of 2040... what do you think?

### Topic A

Why talk about a future mine?

### Smart Mine Specialist A-Response

Our world is moving towards a sustainable future and we need to use resources more responsibly. It's important to talk about the future and plan for it.

### AQ1

How are we going to be more sustainable?

### Smart Mine Specialist Ans-A1

We are looking at a decarbonised world where our footprint is reduced through innovative technology and different minerals.

### AQ2

What are the new energy technologies of the future?

### Smart Mine Specialist Ans-A2

Many of the most exciting innovations depend on critical metals, which we must mine and produce more sustainably.

### AQ3

What is the biggest priority of a smart mine in 2040?

### Smart Mine Specialist Ans-A3

We need to reimagine mining with a continued focus on improving people's lives while being more sustainable.



# Appendix 1 - Modern Mine Conversation 1

## Sustaining 2040 - Smart Mine Specialist

### Greeting

Let's talk about what a mine might look like in 2040 - the future!

### Hub 1

What aspects of the mine of 2040 do you want to talk about?

### Hub 2

Let's chat about the mine of 2040... what do you think?

### Topic B

What are the driving factors in future changes to mining?

### Smart Mine Specialist B-Response

Technology and other disruptive influences are evolving very fast and we need to be part of that evolution.

### BQ1

What are some of these technologies?

### Smart Mine Specialist Ans-B1

Blockchain is one such technology to reduce costs and improve efficiency.

### BQ2

What is another potential change?

### Smart Mine Specialist Ans-B2

Big data drives improved decision making in mining by reducing surprises and mapping what's on the ground more accurately.

### BQ3

How does one of these technologies work?

### Smart Mine Specialist Ans-B3

3D printing technologies could make new parts for machines to make maintenance more efficient and reduce costs.

# Appendix 1 - Modern Mine Conversation 1

## Sustaining 2040 - Smart Mine Specialist

### Greeting

Let's talk about what a mine might look like in 2040 - the future!

### Hub 1

What aspects of the mine of 2040 do you want to talk about?

### Hub 2

Let's chat about the mine of 2040... what do you think?

### Topic C

How can mining be a better partner with the community and others?

### Smart Mine Specialist C-Response

The future mine will still require humans and we need to work harder to build a skilled future minerals workforce.

### CQ1

Will there be career opportunities for me in the future mine?

### Smart Mine Specialist Ans-C1

Educating and upskilling yourself in digital technologies, automation, communication, and people skills will position you well for future mining opportunities.

### CQ2

How do mining companies work with the community?

### Smart Mine Specialist Ans-C2

Mining companies build trust with stakeholders by listening to their needs and concerns and acting to implement their commitments.

### CQ3

What is an example of positive stakeholder engagement?

### Smart Mine Specialist Ans-C3

Mining companies work with customers to provide minerals for a new electric car or work with the community to make land available after mining ends.

# Appendix 2 - Modern Mine Conversation 2

## Moving Forward & Gaining Momentum - Future Planner

### Greeting

The world of mining needs to be more efficient, more sustainable and safer.

### Hub 1

People matter!  
Let's chat about the challenges we need to address.

### Hub 2

What are the critical areas and their impacts?

### Topic A

What are the main areas of concern around people?

### Future Planner A-Response

Challenges include recruiting skilled people, safety, securing reliable and low-cost energy with reduced emissions and decreasing ore grades.

### AQ1

It sounds like there is a lot to do here, but that people are the leading change-makers...

### Future Planner Ans-A1

Above all, we need a collaborative, diverse and skilled workforce to address these issues and innovate to develop a better workplace.

### AQ2

So, upskilling people to work with digitisation and automation is a critical enabler of an effective and efficient mine?

### Future Planner Ans-A2

The future mine will use data to make the right decisions through accurately measuring emissions and sensors that detect breakdown and track energy use.

### AQ3

So it's not just about the people currently working now? It's the future workforce?

### Future Planner Ans-C3

As a future leader, you will need to have new or different skills to support an operating model where we have the best people doing the right things.



# Appendix 2 - Modern Mine Conversation 2

## Moving Forward & Gaining Momentum - Future Planner

### Greeting

The world of mining needs to be more efficient, more sustainable and safer.

### Hub 1

People matter!  
Let's chat about the challenges we need to address.

### Hub 2

What are the critical areas and their impacts?

### Topic B

It sounds like our society depends on these critical metals to support and improve our lifestyles through the 21st century...

### Future Planner B-Response

The obtain these metals we need to go deeper while mining more sustainably.

### BQ1

So we have to innovate to make our mines more sustainable, safer, more energy-efficient and more environmentally friendly?

### Future Planner Ans-B1

The future mines will be an "extended operator workplace" to centralise and distribute data across the minerals value chain.

### BQ2

So mines will need to work with the local communities, governments and others to support regional development and growth?

### Future Planner Ans-B2

A healthy mine environment is one with safe and happy workers who adopt innovation and look to the future.

### BQ3

Is it a big ask for mining to be a key enabler of the future society while being more sustainable and providing future career opportunities?

### Future Planner Ans-B3

New tunnelling technologies will use automation to seek and mine the critical metals we need for a more sustainable future. This might be complex, but it's certainly achievable!

# Appendix 2 - Modern Mine Conversation 2

## Moving Forward & Gaining Momentum - Future Planner

### Greeting

The world of mining needs to be more efficient, more sustainable and safer.

### Hub 1

People matter! Let's chat about the challenges we need to address.

### Hub 2

What are the critical areas and their impacts?

### Topic C

Sounds like partnerships are key to mining?

### Future Planner C-Response

Yep! To achieve a sustainable, safe and profitable mining operation, companies need partners with diverse skill sets to solve problems, decarbonise, digitise, and diversify.

### CQ1

It's not just about mining critical metals - the industry will need reliable long-term customers and strong marketing.

### Future Planner Ans-C1

Different areas need to work together for a common goal: mining more sustainably to support the future growth of renewable energies and technologies.

### CQ2

Effective partnerships can help a mining company improve its use of technology for safer workplaces.

### Future Planner Ans-C2

Integrating safer technologies and work practices encourages everyone to contribute to a zero harm culture.

### CQ3

A partnership based on social and environmental principles promotes more sustainable mining and using minerals for a decarbonised future.

### Future Planner Ans-C3

Working with partnership peers will provide new ideas and better support for improved environmental, social and sustainable practices now and into the future.

# Appendix 3 - Modern Mine Conversation 3

## Mine Concept 2040 - Technology Specialist

### Greeting

Future mining will aim to reduce its environmental impact through more efficient processes and innovation.

### Hub 1

Automation and electrification mean that mines can go deeper or into hotter or colder environments.

### Hub 2

Big data can help in mapping and identifying ore bodies more precisely which means mining can be more targeted with reduced waste.

### Topic A

What does this type of mining look like?

### Technology Specialist A-Response

Companies operate over a large area with small working pits or underground mines within that footprint and a central zone for operations, processing and maintenance.

### AQ1

How will trucks and equipment get fixed?

### Technology Specialist Ans-A1

Maintenance will change with the introduction of equipment sensors and increased automation.

### AQ2

Why would smaller trucks be favoured over more giant trucks?

### Technology Specialist Ans-A2

Smaller trucks will use batteries and electric motors and travel over a larger area.

### AQ3

If new mines are going to be in more remote, hotter and colder areas, where do they get their power from?

### Technology Specialist Ans-A3

Energy microgrids will power individual sites.



# Appendix 3 - Modern Mine Conversation 3

## Mine Concept 2040 - Technology Specialist

### Greeting

Future mining will aim to reduce its environmental impact through more efficient processes and innovation.

### Hub 1

Automation and electrification mean that mines can go deeper or into hotter or colder environments.

### Hub 2

Big data can help in mapping and identifying ore bodies more precisely which means mining can be more targeted with reduced waste.

### Topic B

Is automation the answer to extracting more ore from areas which previously were not profitable?

### Technology Specialist B-Response

Future mines are likely to use a mix of smaller electric trucks, mobile and fixed plant based on demand and data.

### BQ1

Why are smaller trucks better?

### Technology Specialist Ans-B1

Smaller trucks move more efficiently and use less energy for the same output.

### BQ2

What is another advantage of a smaller truck?

### Technology Specialist Ans-B2

Smaller trucks will be easier to fix and may be able to travel over a greater area.

### BQ3

How are these trucks operated?

### Technology Specialist Ans-B3

An operator has a computer console and can operate multiple trucks at once.

# Appendix 3 - Modern Mine Conversation 3

## Mine Concept 2040 - Technology Specialist

### Greeting

Future mining will aim to reduce its environmental impact through more efficient processes and innovation.

### Hub 1

Automation and electrification mean that mines can go deeper or into hotter or colder environments.

### Hub 2

Big data can help in mapping and identifying ore bodies more precisely which means mining can be more targeted with reduced waste.

### Topic C

Is the smart mine of the future about connecting innovative technology and people?

### Technology Specialist C-Response

Technology makes new mines more productive and sustainable because of innovation, automation and data which will help people work together to make decisions.

### CQ1

How is this data collected?

### Technology Specialist Ans-C1

There are sensors everywhere around the new mine, measuring all data types.

### CQ2

What is done with this data?

### Technology Specialist Ans-C2

The data is collected and put through algorithms to come up with answers, scenarios and questions.

### CQ3

How is this data presented?

### Technology Specialist Ans-C3

The data is presented on screens, often as 3D visualisations to help operators make quick responses in real-time.

# Appendix 4 - Modern Mine Conversation

## Transformers 2040 - Future Technologist

### Greeting

Rapid advances in technology can ensure effective integration into mine operations to support safety and sustainability.

### Hub 1

Automation allows many systems from pit to port to be brought together in a remotely-located central area.

### Hub 2

Teams of people are working together in this area to make decisions and provide solutions.

### Topic A

What qualities or attributes will an individual require to work in this sort of space?

### Future Technologist A-Response

Our workforce needs to have confident and curious individuals who can listen to others and communicate.

### AQ1

Do they need to be team players?

### Future Technologists Ans-A1

Most definitely, for our operating centres, people need to learn and share their knowledge with their peers to make informed decisions.

### AQ2

What are some of the technical skills they require?

### Future Technologist Ans-A2

It is a bit like game playing; instead, you are dealing with real-time data and need to understand sequencing and logic and the know-how to interpret data, including images, numbers, and words.

### AQ3

Is report writing a part of their job?

### Future Technologist Ans-A3

This is a critical skill - you are accountable for your work and need to report on what you have achieved or innovated.



# Appendix 4 - Modern Mine Conversation

## Transformers 2040 - Future Technologist

### Greeting

Rapid advances in technology can ensure effective integration into mine operations to support safety and sustainability.

### Hub 1

Automation allows many systems from pit to port to be brought together in a remotely-located central area.

### Hub 2

Teams of people are working together in this area to make decisions and provide solutions.

### Topic B

Where is the workforce located?

### Future Technologist B-Response

Mining companies have remote operating centers in capital cities or large regional centers which govern site operations.

### BQ1

Do people have the option to work from the city or a large regional town instead of a remote location?

### Future Technologist Ans-B1

Yes, depending on their current or future job. It's essential to have choices that support your personal and professional life, which will likely change throughout your life.

### BQ2

What are remote operations centres?

### Future Technologist Ans-B2

Remote Operations Centres (ROCs) are the control hub of the mine operations and maybe several thousand kilometres away from the mine.

### BQ3

Do you work nightshift as part of your roster at remote operating centres?

### Future Technologist Ans-B3

Yes, you do. Even working in a remote operations centre, you might work nightshift on your roster, depending upon your role.

# Appendix 4 - Modern Mine Conversation

## Transformers 2040 - Future Technologist

### Greeting

Rapid advances in technology can ensure effective integration into mine operations to support safety and sustainability.

### Hub 1

Automation allows many systems from pit to port to be brought together in a remotely-located central area.

### Hub 2

Teams of people are working together in this area to make decisions and provide solutions.

### Topic C

It's important to acknowledge that the workforce is a company's major stakeholder.

### Future Technologist C-Response

Human energy powers every mining company and everyone is different with a mix of skills and ideas.

### CQ1

Why does it matter to have different skills?

### Future Technologist Ans-C1

There are different sections to the mine value chain, each requiring a range of specialist knowledge and skills.

### CQ2

What are the main types of skills needed by mining companies of the future?

### Future Technologist Ans-C2

Teams of confident individuals who think outside the box, problem-solve, are creative, and can innovate will drive positive change and growth.

### CQ3

Is human energy an essential component of mine operations?

### Future Technologist Ans-C3

People are the heartbeat of mine operations and the brains behind the technology, decisions and outputs.

# Appendix 5 - Modern Mine Conversation 5

## Mine Design 2040 - Smart Mine Designer

### Greeting

We are about to design the 2040 Smart Mine..

### Topic A

Is water required in mining?

### Smart Mine Designer A-Response

Water is essential in mining and processing operations - without it, you can't have a mine.

### Hub 1

What are the critical physical enablers to make this happen?

### Hub 2

How is this industry going to attract a skilled talent pool of enthusiastic and creative individuals?

### AQ1

Where does the water come from?

### Smart Mine Designer Ans-A1

Most mining operations are remote and rely on groundwater for their operations.

### AQ2

What is it used for?

### Smart Mine Designer Ans-A2

In an open-pit mine, it is used to water haul roads to reduce dust and extract metal from rock in processing.

### AQ3

What happens to it during mining and processing - does it get recycled?

### Smart Mine Specialist Ans-A3

Yes, mines do recycle their water through their processing plant. Some water goes back into the aquifer or is used for agricultural purposes.

# Appendix 5 - Modern Mine Conversation 5

## Mine Design 2040 - Smart Mine Designer

### Greeting

We are about to design the 2040 Smart Mine..

### Hub 1

What are the critical physical enablers to make this happen?

### Hub 2

How is this industry going to attract a skilled talent pool of enthusiastic and creative individuals?

### Topic B

What types of energy are needed to run a future mine?

### Smart Mine Designer B-Response

Decarbonisation means mines are reducing their emissions, including by combining current fuels with green energy sources.

### BQ1

What is LNG?

### Smart Mine Designer Ans-B1

LNG is liquefied natural gas and can provide large amounts of energy to run a mine, including its operating and processing plants.

### BQ2

What types of green energies are being used or considered for mine use?

### Smart Mine Designer Ans-B2

Solar panels, wind turbines, and batteries to replace diesel are being used as mines undergo an energy transition.

### BQ3

Why is decarbonisation so important?

### Smart Mine Designer Ans-B3

Atmospheric pollution from carbon dioxide emissions means mining companies need to take action through innovative technologies for a better environment.

# Appendix 5 - Modern Mine Conversation 5

## Mine Design 2040 - Smart Mine Designer

### Greeting

We are about to design the 2040 Smart Mine..

### Topic C

We need critical metals and mining for future growth and a better quality of life. How can this need be balanced with the industry's social license to operate?

### Hub 1

What are the critical physical enablers to make this happen?

### Smart Mine Designer C-Response

Our values and mission will support improvements over time in safety, environmental performance, community engagement and First Nations partnerships.

### Hub 2

How is this industry going to attract a skilled talent pool of enthusiastic and creative individuals?

### CQ1

How does the general public receive this information?

### Smart Mine Designer Ans-C1

A company's brand and values can be promoted transparently through social media or directly through advertising.

### CQ2

How does the general public learn more the use of metals in future and green technologies?

### Smart Mine Designer Ans-C2

Consumers want to know more about how products such as electric cars and wind turbines are made, so it's essential for mining companies and their customers to work together.

### CQ3

How does new talent know where and how to join the industry?

### Smart Mine Designer Ans-C3

Through partners, advertising and promoting tell the whole story about supporting future growth and development while mining more sustainably.



# Appendix 6 - Modern Mine Conversation 6

## Water - The Earth's universal Solvent - Environmental Officer

### Greeting

Water is essential to mine operations.

### Hub 1

Water can be difficult to source for remote mine sites and in some cases there can be too much water!

### Hub 2

Water has to be used responsibly and sustainably.

### Topic A

How is water effectively used at mine sites?

### Environment Officer

#### A-Response

There are many ways that water is used and treated on mine sites to support operations and safety in a sustainable way.

### AQ1

Is this water from recyclable or drinkable sources?

### Environmental Officer Ans-A1

Water used on mine sites may not fit human or animal consumption and can come from desalination or greywater reservoirs with treatment before use.

### AQ2

How much water is used in ore processing?

### Environmental Officer Ans-A2

Specific chemicals are added to ore during processing to ensure minimal water use and maximum metal recovery from rock.

### AQ3

When crushing and sorting rock into ore, what processes minimise water use?

### Environmental Officer Ans-A3

New technology uses drying, and chemical techniques, with the water recycled during the extractive process.

# Appendix 6 - Modern Mine Conversation 6

## Water - The Earth's universal Solvent - Environmental Officer

### Greeting

Water is essential to mine operations.

### Hub 1

Water can be difficult to source for remote mine sites and in some cases there can be too much water!

### Hub 2

Water has to be used responsibly and sustainably.

### Topic B

How is mine water treated to improve environmental sustainability?

### Environment Officer

#### B-Response

This is a critical area where mines adopt the latest innovations to improve the sustainability of water use.

### BQ1

How does water recycling protect the environment?

### Environmental Officer Ans-B1

Contaminants are removed from the water on the mine site through various processes. The clean water is reinjected into the water table at some mine sites.

### BQ2

What are the typical contaminants within mine water?

### Environmental Officer Ans-B2

Contaminants may include metals, mining chemical residue, salts and suspended solids.

### BQ3

What is a process used to make the water clean again?

### Environmental Officer Ans-B3

Several systems can be used to do this, including reverse osmosis.

# Appendix 6 - Modern Mine Conversation 6

## Water - The Earth's universal Solvent - Environmental Officer

### Greeting

Water is essential to mine operations.

### Hub 1

Water can be difficult to source for remote mine sites and in some cases there can be too much water!

### Hub 2

Water has to be used responsibly and sustainably.

### Topic C

Are the water resources managed by mining, provided to local communities or used to support environmental flows?

### Environment Officer C-Response

Before mining commences, the mining company has to show how natural water resources will be maintained and rehabilitated for environmental and community use.

### CQ1

What happens to the water which is extracted from the mine?

### Environmental Officer Ans-C1

The water is returned to nearby river systems or reinjected into the aquifer to maintain groundwater levels and support local environmental values.

### CQ2

Is this water just from dewatering, treated water or both?

### Environmental Officer Ans-C2

Dewatered water may be reinjected into aquifers if the quality is similar to the aquifer water. If not, it may have to be treated prior to reinjection.

### CQ3

How can tourism be integrated into the mine water cycle after mining?

### Environmental Officer Ans-C3

The local community and economy can be supported by converting old mine pits into recreational lakes or using the water for agriculture. The natural water table is reestablished, and new ecosystems develop.

# Appendix 7 - Modern Mine Conversation 7

## A Waterless Mine - Research Scientist

### Greeting

Have you ever heard of a waterless mine?

### Hub 1

While it might sound like science fiction, it may become a reality sooner than you think!

### Hub 2

Waterless mines would be part of increased sustainability across mining which preserves precious resources like water.

### Topic A

What technology will be used for this amazing innovation?

### Research Scientist A-Response

A waterless mine will reduce the amount of fresh water used for mining and mineral processing. Simple as that!

### AQ1

What are the techniques used to achieve a decrease in freshwater use?

### Research Scientist Ans-A1

Recycling water is the first step. Once it's through the circuit, impurities will be removed before the water begins its next step through the sequence.

### AQ2

How is the water cycle applicable to this process?

### Research Scientist Ans-A2

Evaporation rates can be decreased by using a closed-loop circuit which is monitored to identify any leaks.

### AQ3

Is it possible to have no water at all in the processing plant?

### Research Scientist Ans-A3

Research companies are looking at ore processing using alternative technologies, including better identifying ore location in the rock.

# Appendix 7 - Modern Mine Conversation 7

## A Waterless Mine - Research Scientist

### Greeting

Hi folks! I'm an exploration geologist. We've just received some exciting airborne electromagnetic 3D models showing three conductive bodies located about 300 metres below the ground. We need to do some surface sampling to see if there is a correlation between what we see at surface and what the deep sensing results are showing us!

### Hub 1

What sort of techniques do you think we could use to back up the geophysical evidence?

### Hub 2

Any other thoughts on techniques that are going to help us hone in on a prospective ore body?

### Topic B

Waterless mines will maximise ore output while reducing environmental impact.

### Research Scientist

#### B-Response

Sensors in the mine plant will deliver accurate real-time data to monitor water flows and improve the process to make water savings.

### BQ1

How will this system be managed?

### Research Scientist Ans-B1

The monitors will accurately and automatically register real-time data and provide a 3D visual representation to show how water flows through the system.

### BQ2

How will data monitoring improve the process and decrease water use by the mine?

### Research Scientist Ans-B2

Companies are also researching how tailings dams could be eliminated.

### BQ3

What are the main changes which will occur?

### Research Scientist Ans-B3

Removal of tailings dams would be a significant change that would involve selective mining to reduce waste, staging the reprocessing of tailings and developing dry tailings.



# Appendix 7 - Modern Mine Conversation 7

## A Waterless Mine - Research Scientist

### Greeting

Hi folks! I'm an exploration geologist. We've just received some exciting airborne electromagnetic 3D models showing three conductive bodies located about 300 metres below the ground. We need to do some surface sampling to see if there is a correlation between what we see at surface and what the deep sensing results are showing us!

### Hub 1

What sort of techniques do you think we could use to back up the geophysical evidence?

### Hub 2

Any other thoughts on techniques that are going to help us hone in on a prospective ore body?

### Topic C

How would a mine implement waterless mine technology?

### Research Scientist C-Response

Mining companies work with government agencies to get a better understanding of how the water cycle interacts between the mining process and the environment.

### CQ1

Measuring scientific data in real-time and using it to improve the environment sounds really exciting!

### Research Scientist Ans-C1

This intensive system uses satellite data and fibre optics to measure water flows through the journey from the mill to tailings and back into the mill.

### CQ2

What might this data show, and how will it improve mine operations?

### Research Scientist Ans-C2

Understanding where water is in the system, what it's doing and how it's flowing supports mine efficiency.

### CQ3

Are government agencies such as CSIRO and Geoscience Australia important stakeholders?

### Research Scientist Ans-C3

Partnerships between mining companies and government research agencies help share information for conservation and better environmental outcomes.

# Appendix 8 - Modern Mine Conversation 8

Energy the Ability to do Work! - Electrical Engineer

## Greeting

Along with human energy, energy resources are critical to mine function and operation.

## Hub 1

Energy means the ability to do work! What do you think?

## Hub 2

Green energy solutions such as solar, wind and hybrid systems are fundamental to the Smart Mine of 2040. What do you think?

## Topic A

Can you tell me how much energy is used by a mine and to process metals?

## Electrical Engineer A-Response

Mining uses around 12 per cent of Australia's electricity to extract and process minerals.

## AQ1

What are the main sources of energy used in mines today?

## Electrical Engineer Ans-A1

Australian mining uses a lot of electricity and diesel for its energy. So using less energy in mining will positively impact the environment.

## AQ2

What does this include? What's the breakdown of different sources of energy?

## Electrical Engineer Ans-A2

41% of the energy is diesel, 33% LNG, 22% grid electricity, and the remainder is a combination of renewables, biofuel and coal.

## AQ3

When did the transition to renewables on mine sites begin?

## Electrical Engineer Ans-A3

About ten years ago. Since that time, many companies have introduced renewable energy sources such as solar panels and wind turbines.

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## Topic B

Moving towards a decarbonised world...how are mining companies going to continue this transition?

## Electrical Engineer

### B-Response

The smart mine of 2040 will see a shift towards microgrids and greater use of renewables which will decrease energy costs and carbon emissions.

## BQ1

What is a microgrid?

### Electrical Engineer Ans-B1

A microgrid is an independent and automated energy source for a specific operation to provide the mine with its energy needs.

## BQ2

What are the key features of a microgrid?

### Electrical Engineer Ans-B2

The microgrid comprises several energy sources, including renewables, connection to the electrical grid, and battery storage.

## BQ3

How do microgrids operate?

### Electrical Engineer Ans-B3

Microgrids have much technology to manage batteries and generators and coordinate different power sources to deliver energy to the mine operation.

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## Topic C

What are the energy sources of the future? Renewables, I assume?

## Electrical Engineer

### C-Response

As technology improves, so does the efficiency, effectiveness and reliability of renewable energy sources. So yeah, renewables mostly along with new technologies like small modular nuclear reactors.

## CQ1

Why is LNG still incorporated in the microgrid system?

## Engineer Ans-C1

LNG is the cleanest of fossil fuels, and as the transition to renewables takes place, it can ensure a mine can keep operating.

## CQ2

Is the use of diesel energy being decreased?

## Electrical Engineer Ans-C2

Very much so! It has decreased from 49% to 41% in the last decade.

## CQ3

Are mines heading to a fully electric system?

## Electrical Engineer Ans-C3

Decarbonised mines of the future will have different electrical generation and storage systems which may also serve adjacent towns and communities, including after mining is finished.

# Appendix 9 - Modern Mine Conversation 9

## Shining Through and Moving Air - Power Engineer

### Greeting

Solar photovoltaic and wind turbines are mature technologies which have been used for electrical generation at mine sites over the last decade.

### Hub 1

Both solar and wind technologies have helped to reduce dependence on diesel power generation. Let's talk about it!

### Hub 2

Both solar and wind are great. What do you think?

### Topic A

What are the advantages of solar power, specifically here in Australia?

### Power Engineer A-Response

Australia has so much sun, so it makes sense to include this form of energy at a mine site - or anywhere!

### AQ1

So solar power is very effective for a mine site?

### Power Engineer Ans-A1

In Australia, we benefit from accurate and reliable sun data to support and improve the operation of a solar panel system.

### AQ2

Is solar energy expensive to capture?

### Power Engineer Ans-A2

Solar power has come a long way over the last 15 years. Manufacturing and installation costs have decreased by 80% during this period.

### AQ3

How long does it take for a mine site to plan and build a solar farm?

### Power Engineer Ans-A3

Environmental and planning approvals usually take less than 12 months - which is pretty quick in the scheme!

# Appendix 9 - Modern Mine Conversation 9

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### Topic B

I'm curious about wind turbines. What are the challenges and the benefits?

### Power Engineer B-Response

Wind turbines tend to be placed in coastal areas where wind energy is most reliable. They work well when there's a lot of wind!

### BQ1

Is wind a reliable energy source in the desert or other remote inland areas?

### Power Engineer Ans-B1

The efficiency of wind technologies has improved by 50% in the last 15 years - so it's really reliable wherever it goes.

### BQ2

Has technology allowed us to improve the effectiveness of wind, including away from the coast?

### Power Engineer Ans-B2

Satellite data has enabled wind patterns to be more accurately estimated and predicted for inland regions so that wind turbines can be installed with more confidence in the desert.

### BQ3

What is one advantage of wind over solar energy?

### Power Engineer Ans-B3

Sunlight availability is daytime only, compared to the wind, which can blow around the clock. This can make a huge difference in a windy area.



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### Topic C

Can solar and wind be combined to work together in some sort of hybrid operation?

### Power Engineer

#### C-Response

As the world decarbonises, a hybrid system supported by diesel and LNG power generation as backup makes a lot of sense.

### CQ1

Can you describe this hybrid system and its benefits?

### Power Engineer Ans-C1

Renewable is supported by integrating diesel and/or LNG power generation as backup when the sun doesn't shine or the wind doesn't blow.

### CQ2

Can a hybrid system mean that renewables can be used more effectively?

### Power Engineer Ans-C2

Yes, and battery storage is becoming more efficient and more common on mine sites to store excess renewable energy for later use.

### CQ3

What are the long term benefits of such a system?

### Power Engineer Ans-C3

Budgeting and planning for renewables or hybrid systems need to follow mine life, including life cycle costs such as relocation, disposal or recycling as part of the circular economy.

# Appendix 10 - Modern Mine Conversation 10

## Energising Mine +2040 - Power Researcher

### Greeting

Hey there! Let's chat about how our mines are using different sources of power. It's really exciting!

### Hub 1

New energy technologies have all sorts of benefits, and can continue to serve local communities even after the mine has closed. What do you think?

### Hub 2

Electrification and automation are important to improve the environment while improving safety. What do you think?

### Topic A

For the mine of 2040 and beyond, how will the transition from old technologies to new improve safety and reduce emissions?

### Power Researcher A-Response

One of the biggest challenges is moving from mines which operate largely on diesel to the introduction of electric vehicles.

### AQ1

Electric trucks - how do they work?

### Power Researcher Ans-A1

The current generation of electric trucks has been designed to charge directly from existing electrical grids, making them easier to roll out.

### AQ2

How are electric vehicles charged at mine sites?

### Power Researcher Ans-A2

These electric vehicles have an onboard charging feature, which works on the standard electrical system and allows for future innovation.

### AQ3

Are electric trucks safer?

### Power Researcher Ans-A3

Electric trucks don't produce particulates which are a byproduct of diesel combustion. This reduces the costs of underground mine ventilation while making it much safer for people who work there!

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### Topic B

How will future mines reduce energy use and increase energy efficiency?

### Power Researcher B-Response

Digitisation and automation map and monitor energy flows to ensure effectiveness and efficiency using multiple sensors and advanced analytics!

### BQ1

What will be monitored and how? What are we analysing?

### Power Researcher Ans-B1

To give one example, the vehicle speed can be monitored. This is constant in an automated truck, reducing fuel use and increasing efficiency.

### BQ2

What will the analytics let us do? Are batteries involved?

### Power Researcher Ans-B2

Combining renewable energy with battery storage can measure how it's used to inform energy predictions and costs. This is the advantage of using a digitised system!

### BQ3

How will excess power generated through renewables be used effectively to benefit adjacent communities?

### Power Researcher Ans-B3

Stored excess energy can be delivered into the grid during high demand periods to help nearby communities meet their needs.

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### Topic C

What are the considerations for the local communities once the mine has closed?

### Power Engineer C-Response

One consideration is that mining companies can leave behind a clean energy source for the community after mining ends.

### CQ1

How's that work for really, really remote communities?

### Power Researcher Ans-C1

Most remote communities suffer from unreliable power sources and frequent outages, so alternative and more reliable power sources greatly benefit.

### CQ2

Is this sort of energy supply reliable?

### Power Researcher Ans-C2

Big batteries can improve power supply reliability by storing excess energy for backup when renewable energy might not be available in periods of high demand.

### CQ3

What happens when a mine closes?

### Power Researcher Ans-C3

One possibility is that a renewable energy source established by the mine during operations can remain available for the community, including other local industries, after mining ends.