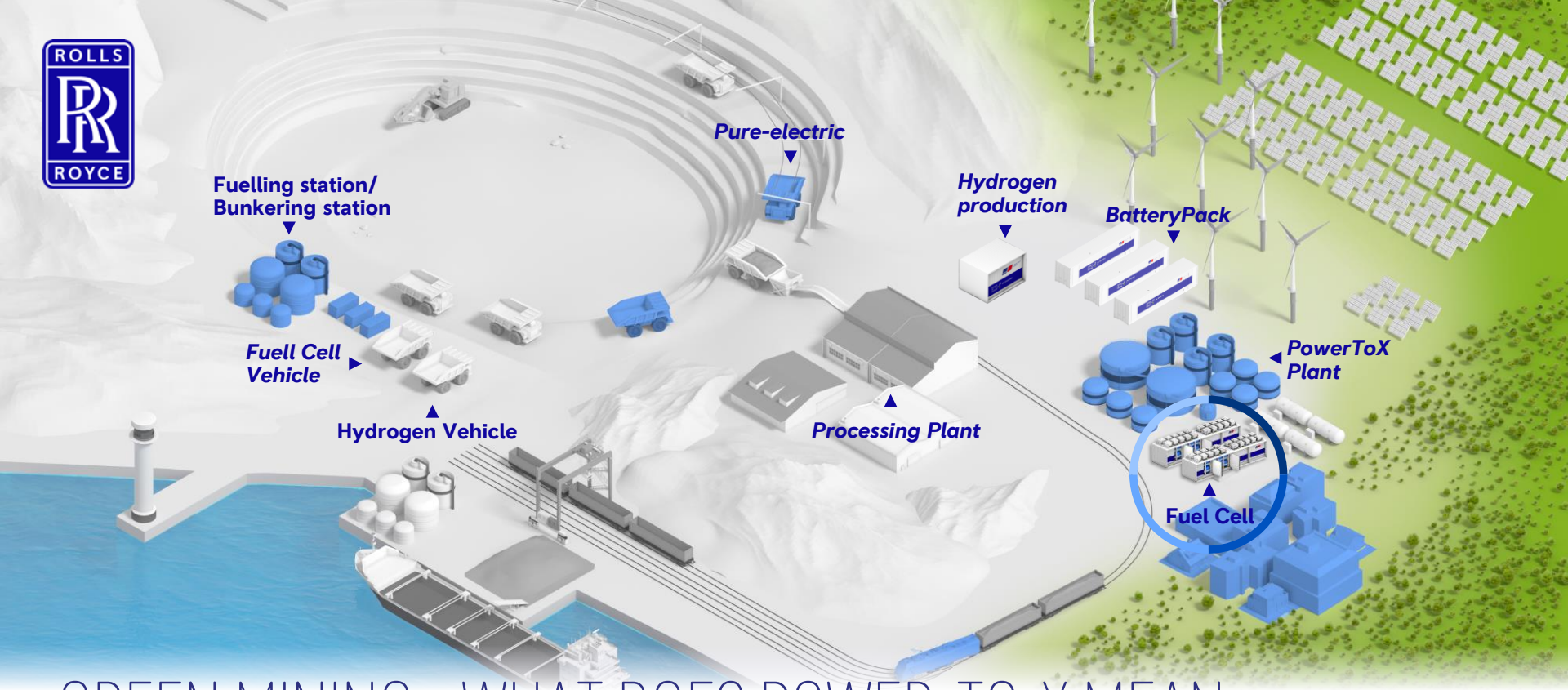


GREEN MINING - WHAT DOES POWER-TO-X MEAN

mtu virtual German-Australian Mining Delegation

November 11, 2021

Session Agenda

01 **Climate Targets & Mining Energy Transition**

02 **Green Mining - The role of technology & fuels**

03 **Power-to-X Ecosystem**

04 **Technology Options for Mining Propulsion**

A Rolls-Royce solution

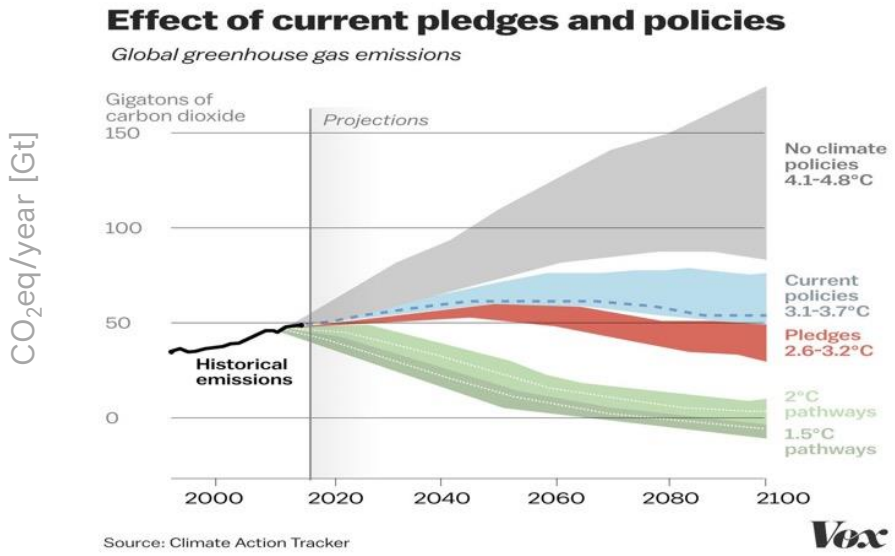
01

Climate Targets & Mining Energy Transition

Climate Targets & Mining Energy Transition

There is only a limited GHG Budget to limit Global Warming:

1.5º C Target = 420 Gt CO_2eq / 2º C Target = 1170 Gt CO_2eq GHG Budget*



Company	2030 Goal	Net Zero
BHP	-30%	2050
RioTinto	-30%	2050
VALE	-33%	2050
ANGLO AMERICAN	-30%	2040
GLENCORE	-40%*	2050
Newmont	-30%	2050
Fortescue	-15%	tbd
FMG	-100%	2030

* 2035

*2018 IPCC, 1.5 ºC Special Report

Sources: https://www.pik-potsdam.de/paris-reality-check/

https://www.nytimes.com/interactive/2018/08/01/magazine/climate-change-losing-earth.html

02

Green Mining
The role of technology & fuels

Solutions for a Greener Tomorrow

Rolls-Royce Green- & High-Tech-Program

A Rolls-Royce solution

Technology Options for carbon neutral propulsion

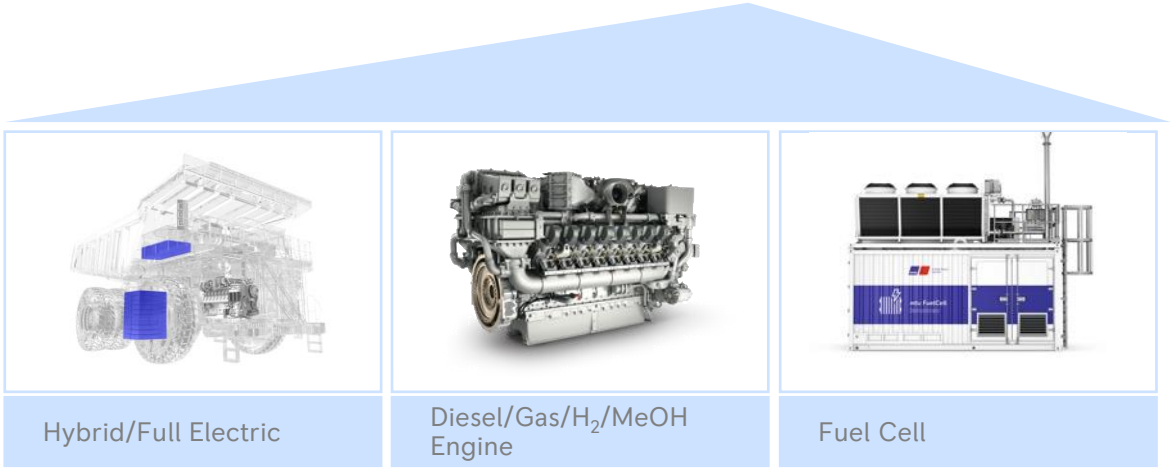
Climate neutrality is determined by the energy source

Closed Carbon Cycle or Carbon free

Biogenic / Direct Air Capture CO_2

CO2

Energy Source → **Energy Carrier** → Energy Conversion → Propulsion



Hybrid/Full Electric

Diesel/Gas/H_2/MeOH Engine

Fuel Cell

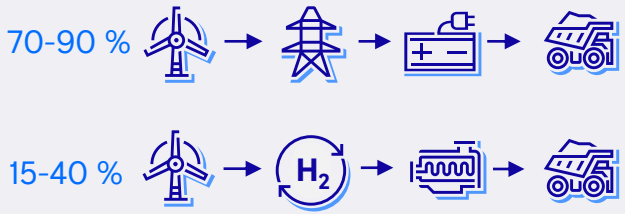
High power applications can hardly be electrified

Who will need alternativer climate neutral fuels ?

Alternative fuels are crucial to reach long-term CO_2-reduction targets in all applications

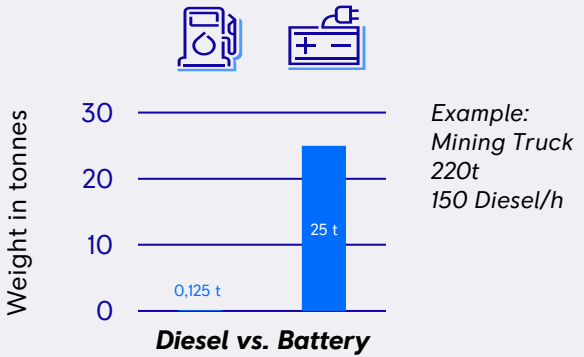
Electrification will increase driven by efficiency

Efficiency well-to-wheel



PtX requires 2-5x more renewable energy

Electrification is technically limited by weight and space of the battery



Example:
Mining Truck
220t
150 Diesel/h

Who will need e-Fuels to reduce GHG-emissions:

High Power Applications

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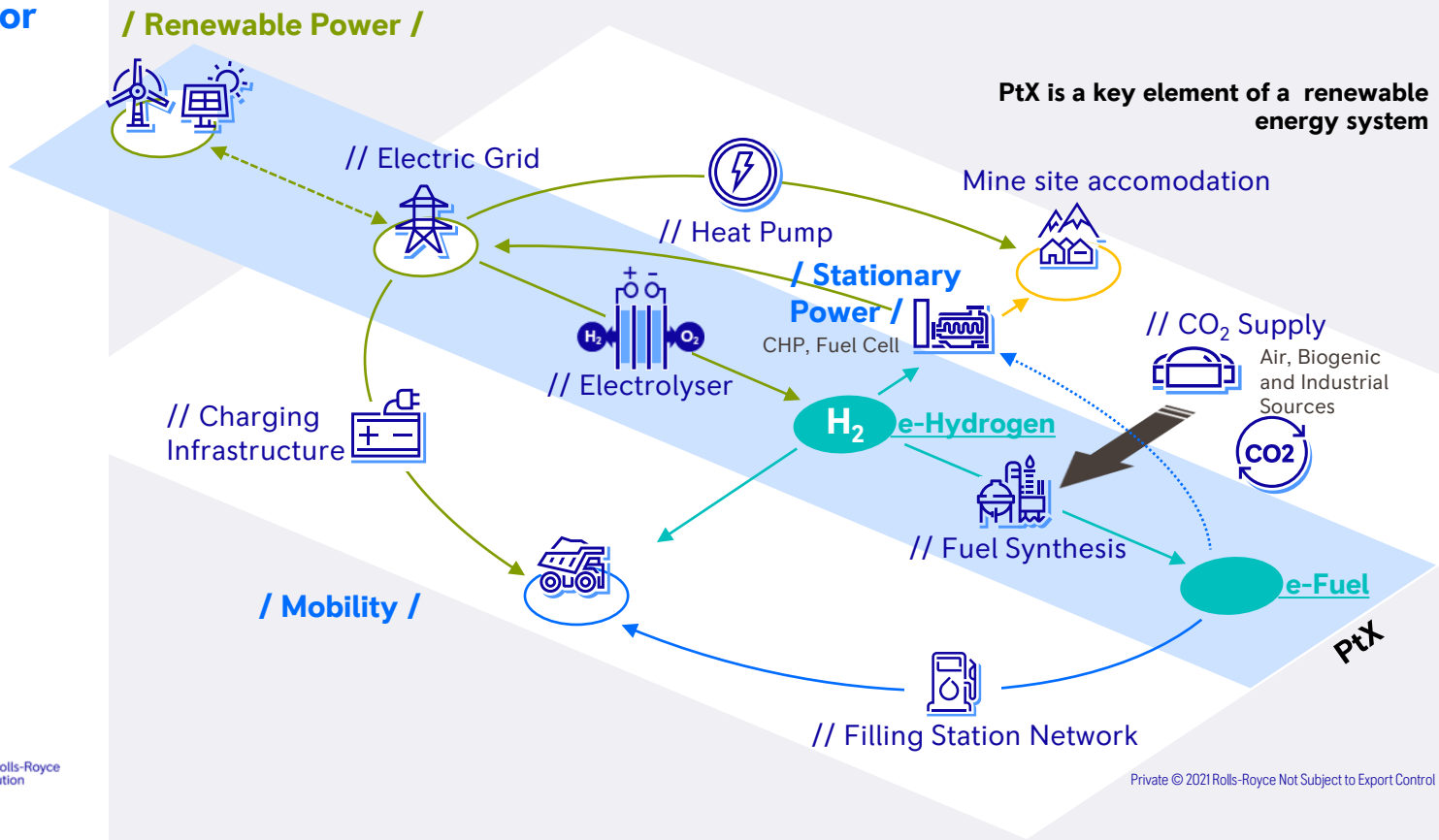
03

Power-to-X Ecosystem

PtX – Access to „Green & CO_2 Neutral“ Fuel utilizing renewable electricity

PtX Ecosystem for Sectorcoupling



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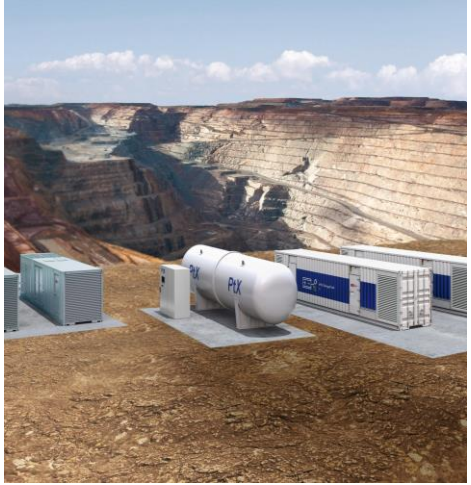
Value Proposition Power-to-X for mining companies

- **Use existing infrastructure** for Mining fleets
- **Use renewable energy sources** for emission-free production = “Green” Hydrogen



- **“Green” Hydrogen** is the **central ingredient** for all PtX fuels
- **Reduce GHG-emissions for „hard-to-electrify“** applications (especially long-haul trucks, aviation, marine, rail, C&I)

- Enable **global renewable energy trade** (Germany currently imports 70 %!)
- **By 2030**, production of PtX fuels is **forecasted to be cost-neutral** with bio fuels in favorable locations

04 Technology Options for Mining Propulsion

Green- and Hightech Technology Options for Mining Propulsion

Alternative Fuels will lead to alternative propulsion concepts

Fuel Cell

- *Zero emissions*
- *Low noise and vibration*
- *High electrical efficiency*

Hybrid Propulsion

- *CO_2 reduction*
- *NOx/PM Emission reduction*

Full Electric

- *Zero emissions*
- *Low noise and vibration*
- *High electrical efficiency*

eMethanol Engine

- *CO2 neutral alternative to diesel and natural gas*
- *Potential energy carrier for future global energy trade*

eMeOH

eDiesel/eSNG -Engine

- *Drop-in solution for fleet decarbonization*
- *Highest energy density of all e-fuels*

eDiesel eCH4

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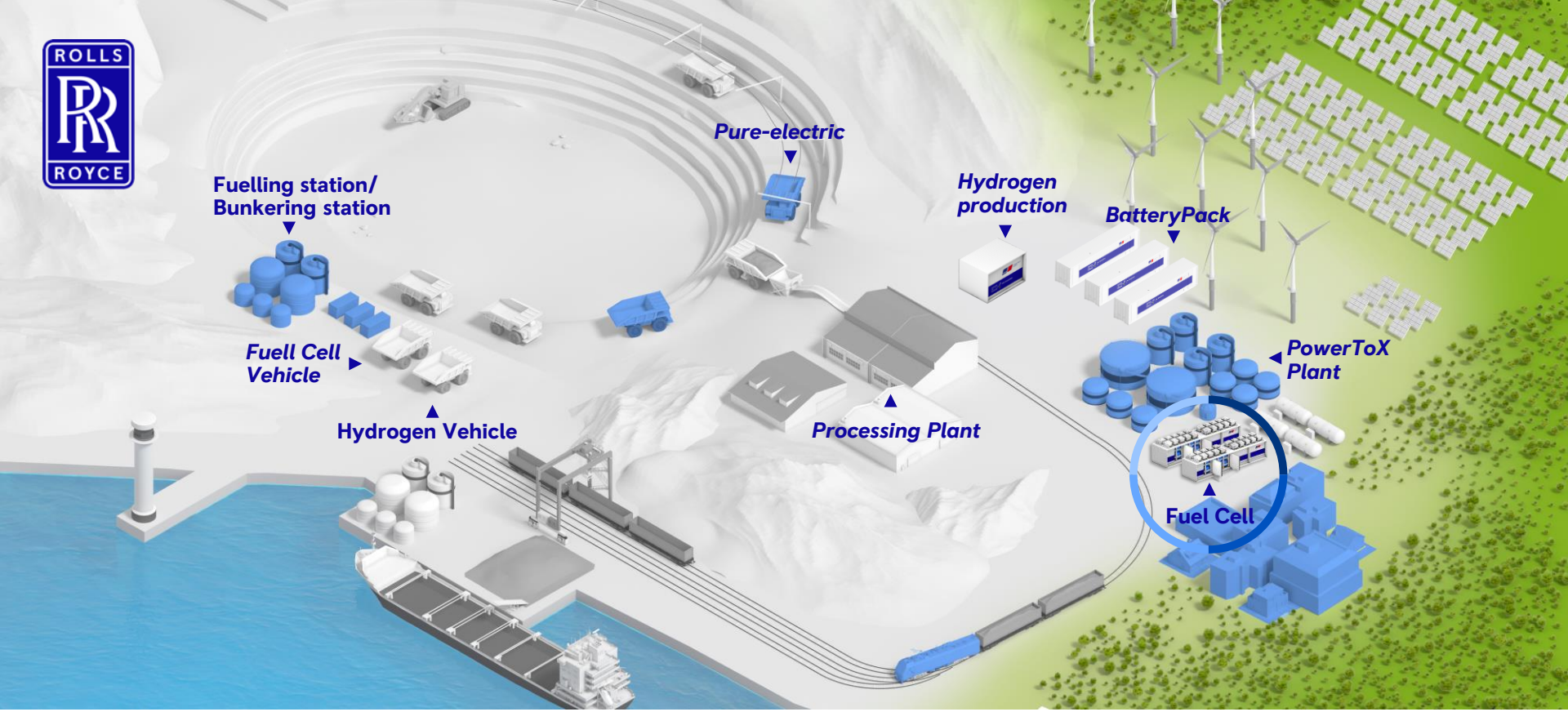

Green- and Hightech for Mining Infrastructure

Alternative Fuels will lead to alternative concepts for mines

- Propulsion technology acts as enabler for climate neutral fuels and lever for efficiency.
- Mining requires (liquid) fuels due to the energy density.

- Fuel origin/energy source is the key for climate neutrality.
- Electrification of fuels addresses also existing fleets and allows to use existing infrastructure and worldwide energy harvesting and transportation.

- e-Fuels will become competitive with bio-Fuels.
- The market uptake of e-Fuels will require a suitable regulatory framework.
- Multiple propulsion concepts for e-Fuels will co-exist in future.

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Thank you very much for your attention.

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