



# Energy Efficiency in Mining Machinery

**APEC Workshop, 2025/12/3-4**

**Cleaner and More Efficient Operation of Fossil Energy Industry**

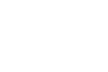
**Hisashi Asada  
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Komatsu Ltd.**

# Komatsu Mining Product Offerings

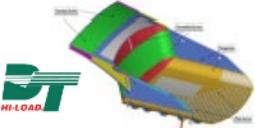


## Surface

## Underground

- |   |   |   |   |  |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|--|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Bull dozer  | Motor grader  | Dump truck  | Hydraulic Excavator   | Mech. Wheel Loader   | Elec. Wheel Loader  | Rope Shovel   | Drill   | Drag line   | Continuous Miner  | Truck   | Roof Support  | Road header   | Sheerer   | Load Haul Dump  |

# Komatsu Mining Offerings – Products & Processes

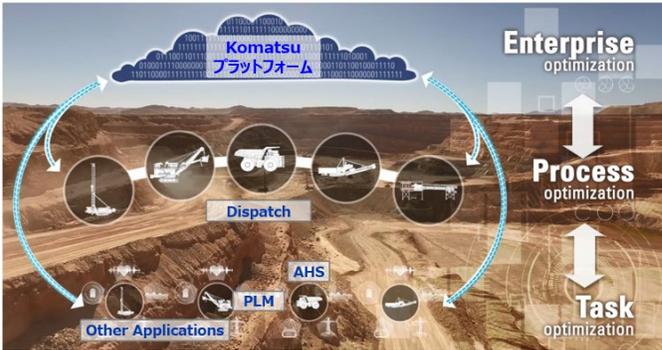
	Surface Mining			Underground Mining		
				Hard Rock (UGHR)		Soft Rock (UGSR)
<b>Products</b>						
	Haul trucks	Hydraulic shovels and excavators	Dozers	Trucks	Loaders	Longwall systems
						
	Motor graders	Electric mining shovels	Draglines	Rock drills & bolters	Load haul dumps	Room and pillar systems
						
	Electric and Mechanical drive wheel loaders	Rotary blasthole drills	Track blasthole drills	Hydraulic drifters	Mechanical cutter	Entry development systems
						
		CPAs		Tunnel boring machine (TBM)		Crushing

<b>Process</b>					
					
	Mine management platform & solutions	Operator guidance Payload optimization	Autonomous haulage	Operator training simulator & solutions	Operational optimization platforms for underground mining

# Roadmap to Komatsu's vision :the future mining

- Products: Improve efficiency (incl. on-machine automation), reduce CO2 emissions
- Processes: Improve efficiency throughout all workplace processes

The evolution of our solutions value



- Whole mine optimization
- Reduce waiting time between processes
- Optimization, automation of each process
- Operator assist

• Productivity improvement by connecting all mining facilities with system

Our vision

**A collaborative partner committed to optimizing safe, productive, and clean workplaces**

**Maximize customer value**

- Energy efficient
- Low carbon emission

Gemba visualization and operation improvement



Regenerative energy / Hydrogen, alternative fuel / All electric (trolley, battery) / Fuel Cell



**The evolution of our product value**

# Mining machinery business and Carbon Neutrality

Carbon neutrality is a major challenge for the mining machinery business, and it cannot be solved by one solution, but aims to solve it from multiple aspects.

	Risk (Challenges)	Action Plan
<b>Voice of customer</b> International Council on Mining and Metals (ICCM)	<ul style="list-style-type: none"><li>• by 2040: Greenhouse gas emission-free at surface mining.</li><li>• by 2025: Minimize the operational impact of diesel exhaust at underground mining.</li><li>• by 2025: Make collision avoidance technology available to mining companies.</li></ul> <p>➤ <b>Common focus of major mining companies: “safety and productivity improvement by automation” &amp; “greenhouse gas reduction”.</b></p>	<ul style="list-style-type: none"><li>• Machine efficiency improvement through operational optimization</li><li>• Electrification, zero-emissions</li><li>• Automation and traffic control technologies</li></ul> <p>➤ <b>Two-pronged approach of improvements, in “Products” and “Processes”. Create highly productive workplaces of the future.</b></p>
<b>Changes in social situation</b>	<ul style="list-style-type: none"><li>• Due to the difficulty of obtaining licenses for new mine development, it will be necessary to mine further away from residential areas than before.</li><li>• Due to the higher cost of surface mining for deeper deposits, mining at deeper depth will be necessary.</li></ul> <p>➤ <b>Mining contractors will face difficulties to secure work forces due to more severe operating site environment.</b></p>	<ul style="list-style-type: none"><li>• Remote operation (remote control)</li><li>• Automation, optimization and solution</li></ul> <p>➤ <b>Correspond to change in customer’s requirement. “Further remote places” “Further deep in underground”</b></p>

# Initiatives for GHG Reduction – Electrification of Mining Machinery

Komatsu is collaborating with major mining companies to reduce GHG emissions by electrifying mining machinery.

## Komatsu GHG Alliance

12 Major mining companies



**KOMATSU**

To provide know-how of mining operation including mine design, plan, methodology, infrastructure etc.

- No of trucks, Haul road
- Infrastructure
- Payload, cycle time
- Maintenance

To provide information of product planning, development, test, development of Power Agnostic Dump Trucks\*

\*Power Agnostic Dump Trucks : Concept for a mining haulage vehicle that can run on a variety of power sources including diesel electric, electric, trolley (wired), battery power and even hydrogen fuel cells to support customers achieve reduction of zero emission of GHG.

### ■ GHG alliance member event (May 2023)

- Invited GHG Alliance members to Arizona proving ground.
- Introduced battery charging technology using trolley system.



# Komatsu Decarbonization Ecosystem Strategy

## Mining Machinery

- **Power Agnostic** truck platform and tethered loading units
- **“Bridge” technology** (hybrid, dual fuel)
- Growing **in-house motor, power electronics, and battery expertise**, including **ABS** acquisition



Path to  
Zero CO<sub>2</sub>

## Fleet Management System

(Mining Solution Platform)

- **Open ecosystem** connecting all in-pit machineries and systems
- Proprietary fleet **optimization** apps including charging (DISPATCH)



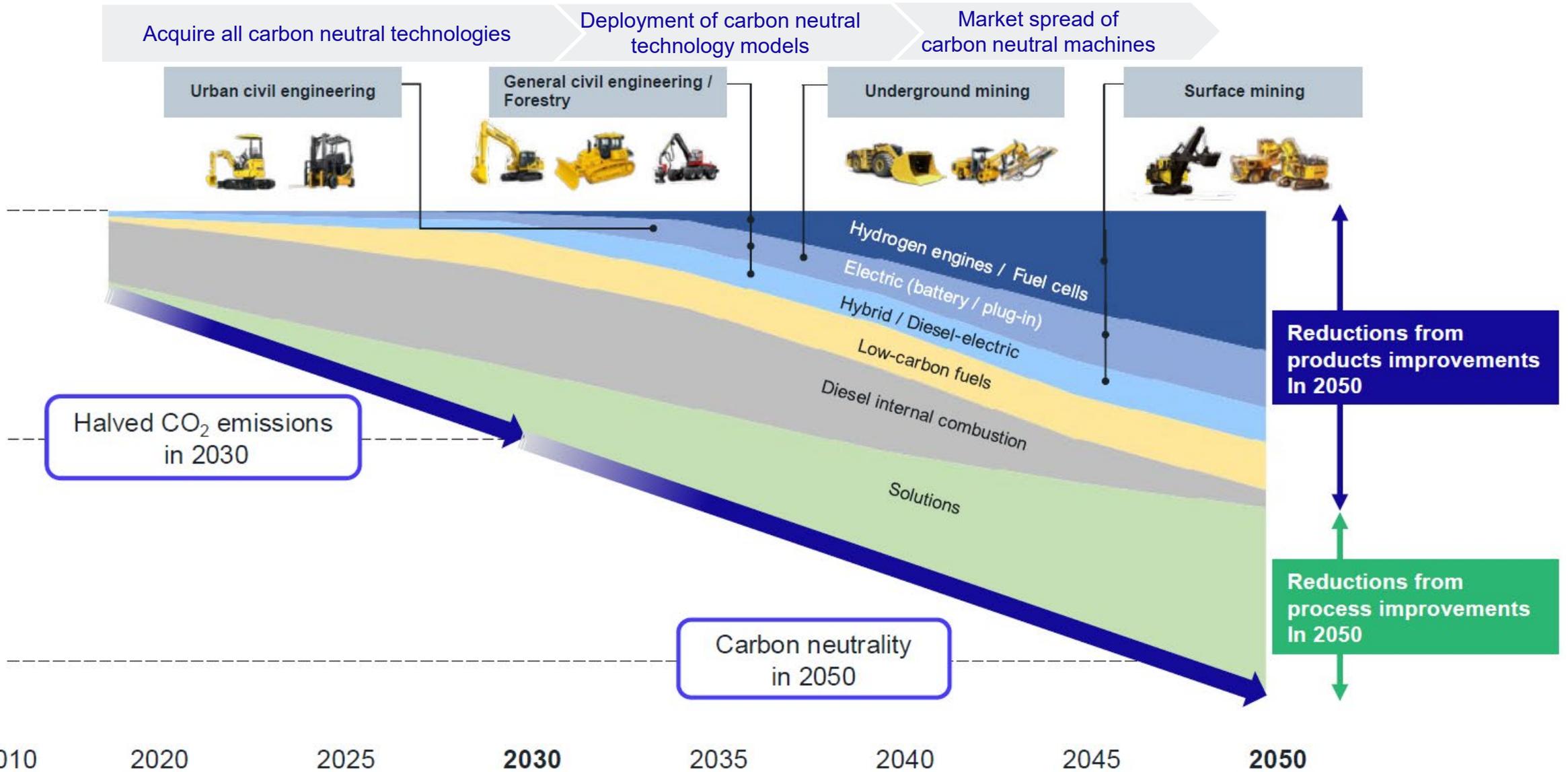
MODULAR

## AHS (Autonomous Haulage System)

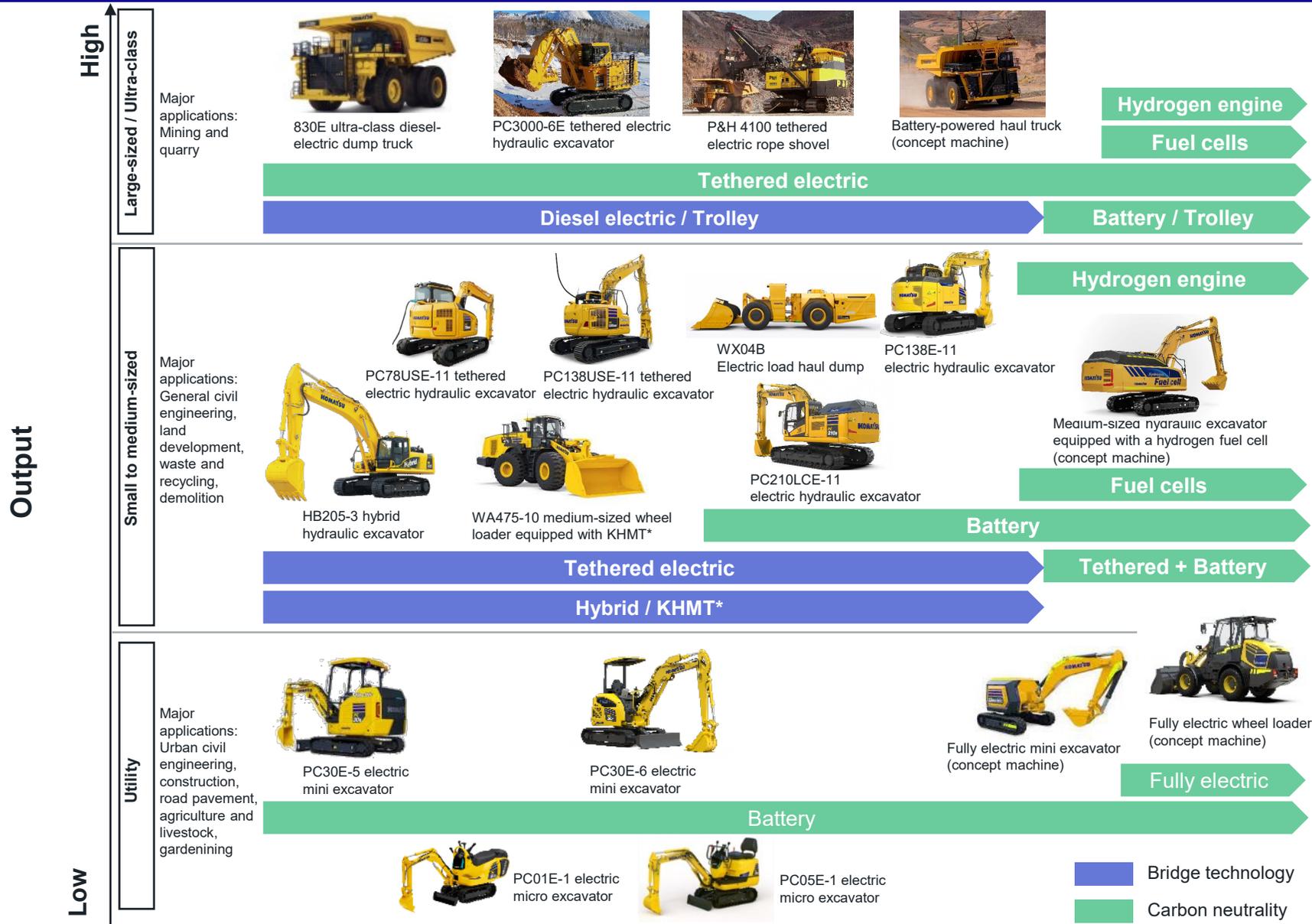
- **100% compliance** to optimization
- Improving machine **utilization**, and **TCO**
- **AHS + dynamic charging** capabilities



# Roadmap for achieving carbon neutrality



# Development roadmap for carbon neutrality by products



\*Komatsu Hydraulic Mechanical Transmission: Transmission system that realizes a 30% improvement over conventional systems by combining a high efficiency mechanical transmission with a hydro static transmission that is capable of continuously variable transmission and that uses a motor and a variable capacity hydraulic pump

# Initiatives for GHG Reduction – Power Management for Mining Machinery

## Komatsu's power agnostic truck concept

- To support mining customer's GHG reduction and achieve zero-emission, the truck is capable to run on a variety of power sources including trolley (wired), battery power and hydrogen fuel cells.
- As approaches and circumstances for reducing GHG vary for each customer, we are able to flexibly respond to various customer demands



### ■ Activity examples in surface mining

- Boliden and Komatsu started field trials for the first diesel trolley truck in its new Power Agnostic (PA) series. (July 24 2025 News Release)



Komatsu 930E diesel trolley PA truck

- GM and Komatsu collaborate on hydrogen fuel cell-powered mining truck (Dec.13 2023 News Release)

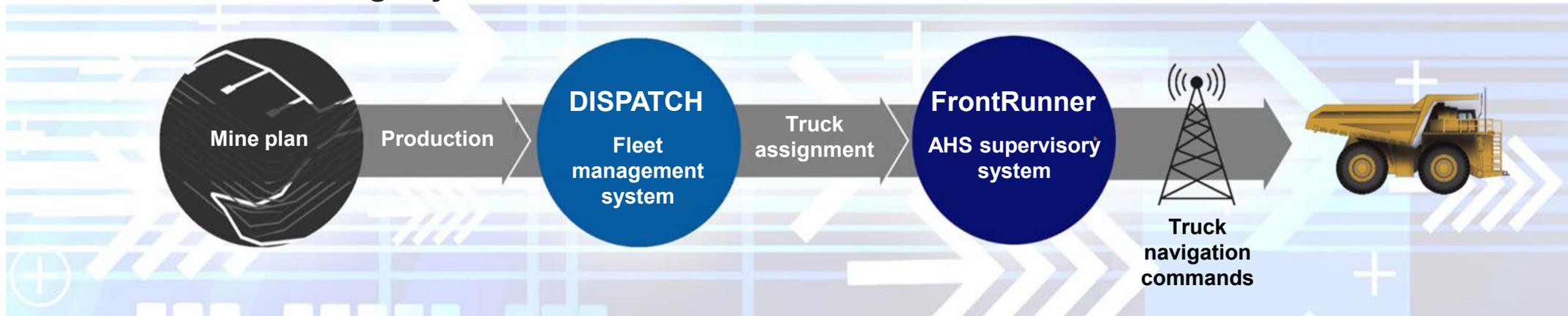


Komatsu 930E mining truck

# Efforts for Automation : Autonomous haulage system (AHS)

Komatsu's AHS contributes to safe and continuous operation, GHG reduction, and improved productivity.

How does autonomous haulage system work



## Components of autonomous haulage system

### Central control

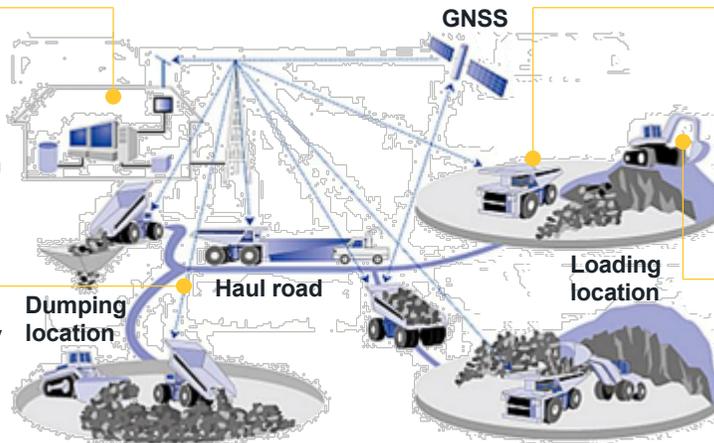


Complete control over the entire system from one central location.  
-Fleet management system  
-AHS supervisory system

### Communication network



Mine-wide connectivity with seamless worksite mobility and enterprise-grade security.



### Autonomous haul trucks (AHTs)



Haul trucks equipped with AHS hardware and software required to receive commands from AHS supervisory system.

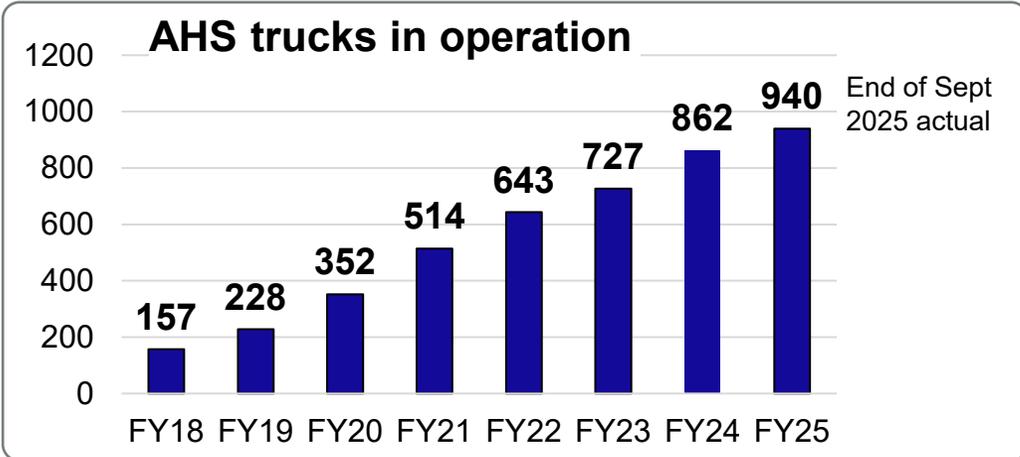
### Equipped manual vehicles (EMVs)



Loading units, support equipment and all light vehicles equipped with AHS hardware that are operated manually.

# Mining Automation – Promoting GHG reduction by the deployment of AHS

- 940 units AHS\* trucks operating worldwide (End September 2025 actual)
- AHS trucks carried over 10 Billion tons load (as of May 2025, accumulated amount)



**South America market : Copper mine**

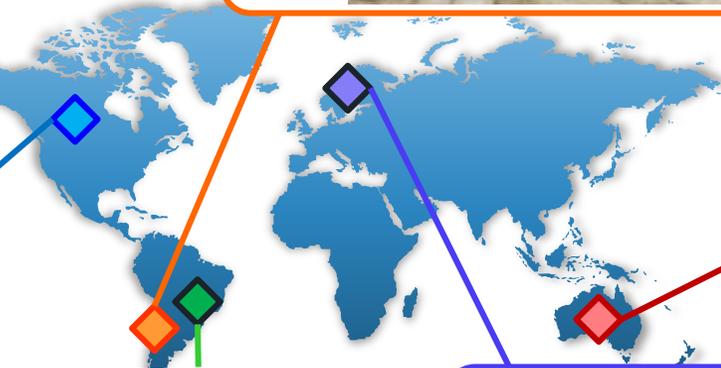
- Since 2008
- 8 mines, approx.150 units

**Oceania market : Iron ore / Coal mine**

- Since 2008
- 13 mines, approx.510 units

**North America market :**  
**Oil sand / Coal mine**

- Since 2016
- 3 mines, approx.230 units



**South America market : Iron ore**

- Since 2019
- Approx.20 units

**Europe market : Copper mine**

- Since 2023
- Approx.20 units

\*AHS : Autonomous Haulage System

# Solution business for mining and quarry customers

Komatsu through its group companies offer multiple all-makes solutions contributing for **haul mine process optimization**, **customer workforce development** for surface/underground mines and quarries to achieve **GHG reduction**.

all-makes: providing service to non-Komatsu machinery as well

## Underground Mining

## Surface Mining / Quarry

### Underground Mining Optimization

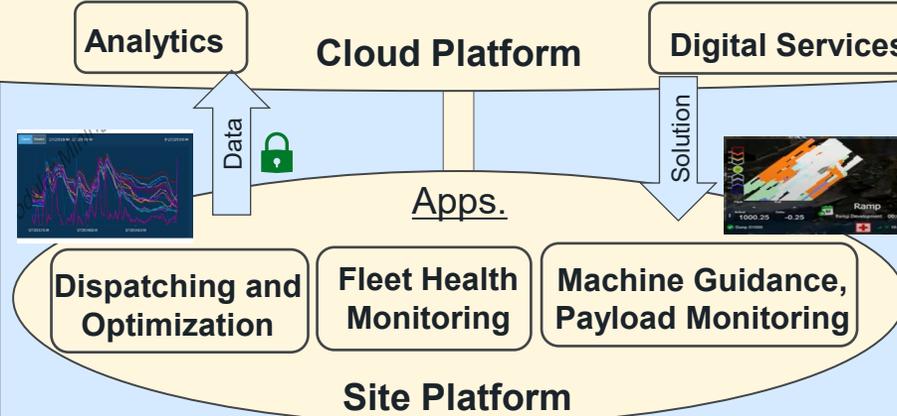
### Surface Mining Optimization

Support productivity improvement by machine operation monitoring

Provide real-time feedback to operator and supervisors.



Personnel, machinery, and production monitoring & optimization. Tele-remote and facility control.



Supported by Komatsu's Modular ecosystem



Fleet operation visualization and health monitoring at the mine sites and quarries.



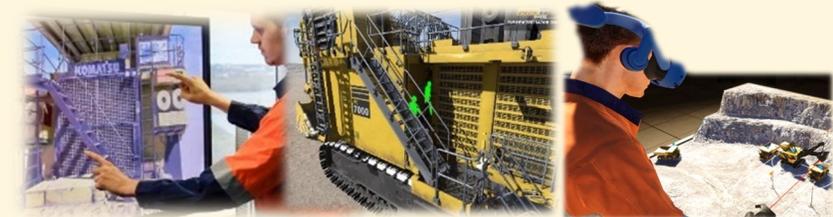
### Workforce Development



by Immersive Technologies



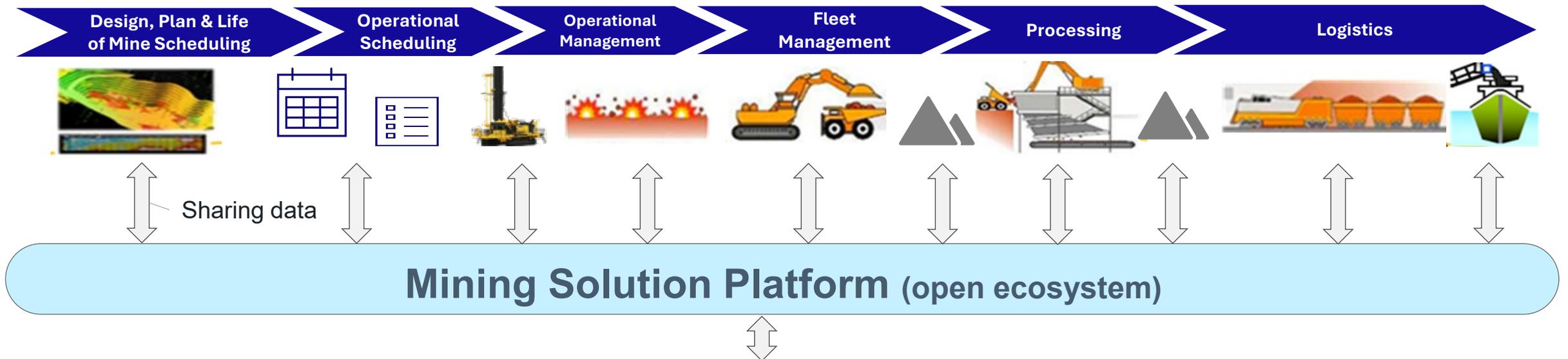
Simulator Training for Operators + Digital Learning Solutions (Pit to Port) + Training Services and Analytics.



# Whole of Mine Optimization by Solution Platform

Until now, optimization solutions within each mining operation have progressed. Each solution needs to share data on a common platform to optimize a wider range of mining operations.

## Mining Value Chain



By utilizing data between solutions, we will promote the optimization of a wider range of mining operations through budget/actual management and material flow management.

# Further improve GHG emissions by maintaining the highest level of human performance

With the aim of improving human operations of mining machinery, Komatsu provide a training UX by mining machinery simulators and new technology.



**PRO5**



**IM360**



**LX6**



**LX3**



Pre-Start Inspection



WorksiteVR Quest



eLearning & Classroom Training



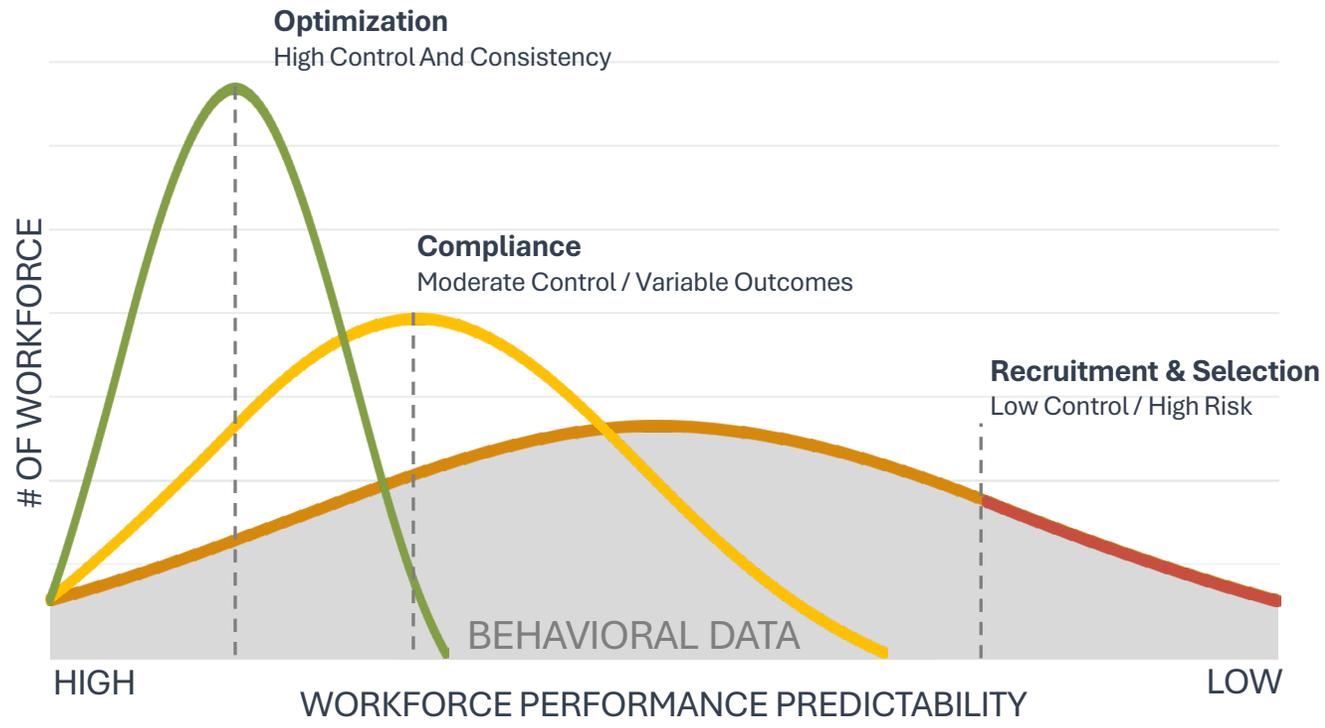
Trainer Productivity Station



Remote Operated Equipment

## Distribution Comparison Analysis

Why predictability, not just proficiency is your real competitive advantage.



# Contribution to GHG reduction by operator trainings (example)

## The case of Oceania Coal mining customer

### The customer's problem

The company had an initiative to address rising fuel costs and greenhouse gas emissions.



### Solution

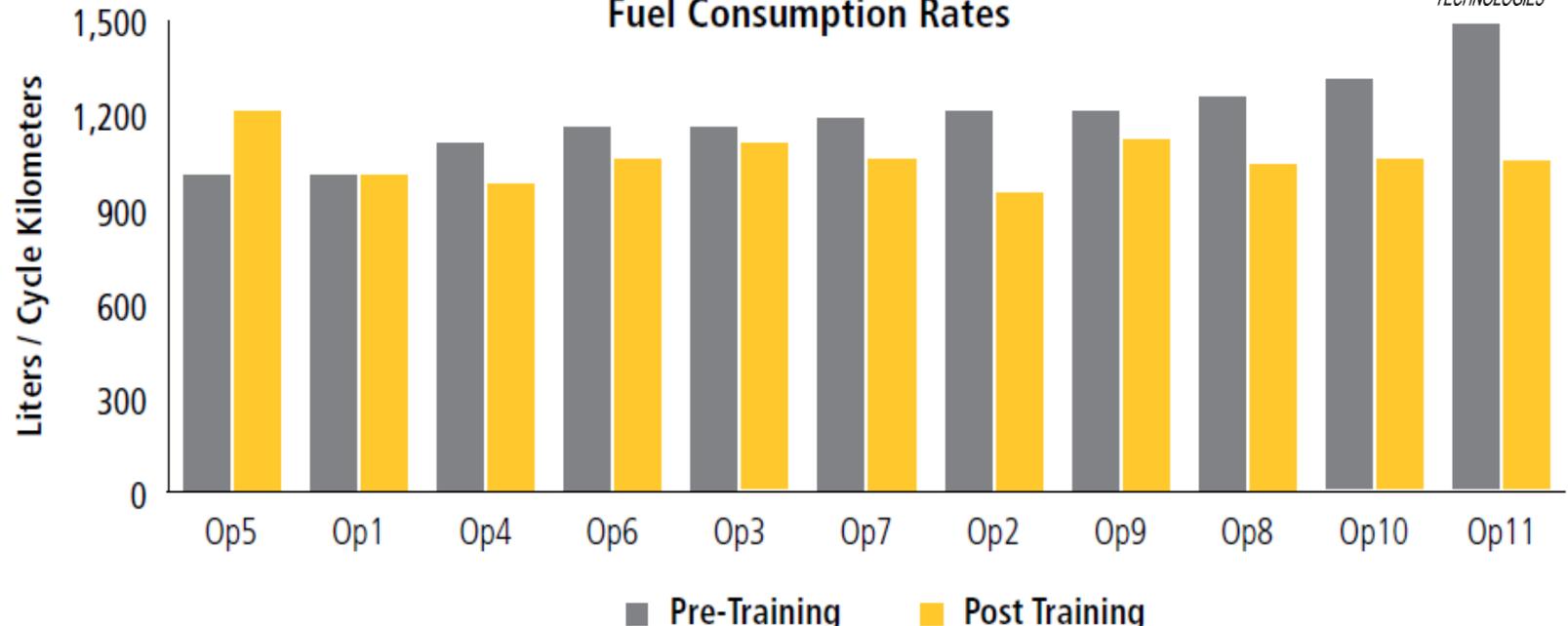
Historical fuel consumption rates were benchmarked, and operators were randomly assigned to either a training or control group. The training group received **simulator based sessions** targeting several common operating errors including aggressive throttle application, aggressive braking and speed control. The control group received no instruction.

### Results



After “Mining Machine Simulator base Training” was delivered to operators, In-field fuel scores were continuously monitored.

6.3% Improvement in Haul Truck Fuel Consumption Rates



# Contribution to Energy Efficiency by Realizing the Value Chain of Mining Machinery and Solutions

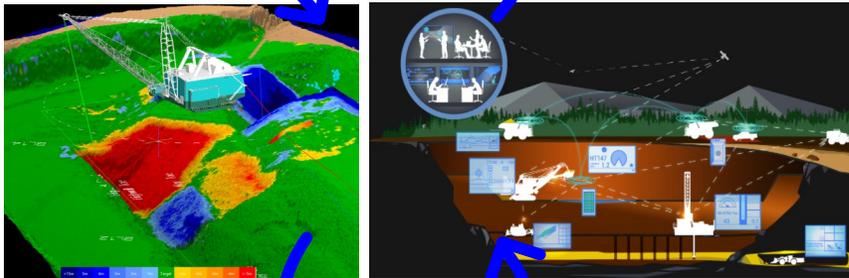
## Real Space



KOMATSU provide **smarter and greener mining machinery** for actual operations, optimize actual operations with **digital solution apps**, and provide **offline training** for personnel who operate them **to maintain continuous and advanced on-site operations and further improve efficiency.**

## Digital space

Fleet Management  
Health Management  
Material Flow  
Management



Operator Skills Management

Training by Simulator and VR



The simulator also has the aspect of I/F that connects digital space and human operators

## Solutions for Mining Machinery

- Remote support for operations from a bird's eye view.
- Data-driven guidance for optimal operations.
- Data-driven guidance for optimal maintenance.

## Solutions for Operators

- Optimal training is conducted in a simulator based on actual machine data. Strengthen your skills with repeated offline training.
- Emergency Training that is difficult to perform with the actual machine can also be carried out.
- Extracted from the simulator's training data
- Feedback points to the real world.

Thank you