The background of the slide is a dense collage of various images related to construction and industry. Overlaid on the left side of this collage is a semi-transparent portrait of a man with glasses and a mustache, wearing a suit and tie. The text is centered over the collage.

Decarbonization Approaches Construction Equipment

DOE Hydrogen Workshop

Michael Lewis | Technical Director – Komatsu

September 2021 - Virtual



Komatsu Overview

About Komatsu

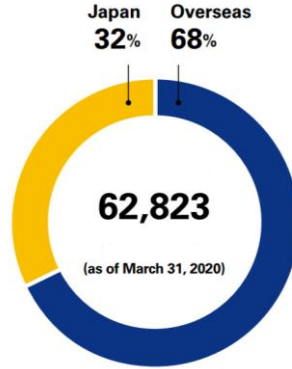
Headquarters
Tokyo, Japan

Founded
May 13, 1921

Main businesses

Manufacture and sales of construction and mining equipment, utility equipment (compact machines), forestry equipment and industrial equipment

Employees



A diverse range of products



Construction



Forestry



Forklift

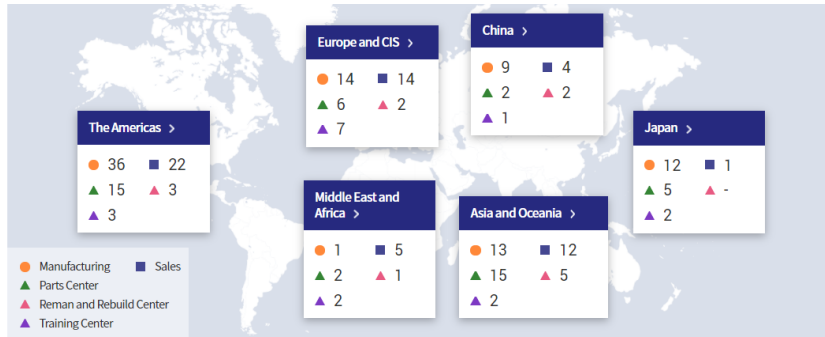


Mining



Stamping & Cutting

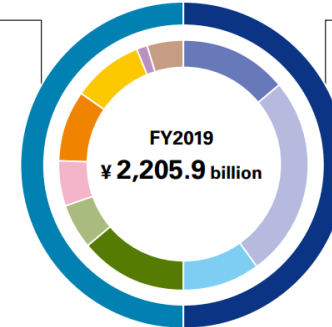
Global operations



Sales by region (Construction, Mining, Utility equipment)

Strategic Markets
50%

Latin America	¥309.2 billion
CIS	¥127.4 billion
China	¥127.0 billion
Asia	¥205.7 billion
Oceania	¥203.3 billion
Middle East	¥30.6 billion
Africa	¥98.2 billion



Traditional Markets
50%

Japan	¥310.8 billion
North America	¥573.5 billion
Europe	¥219.7 billion

Creating a sustainable future together

At Komatsu, we are committed to minimizing environmental impact through our business, focusing on:

- CO2 emissions from product use and production: **decrease by 50% by 2030**
- Rate of renewable energy use: **increase to 50% by 2030**

The UN has created 17 Sustainable Development Goals (SDGs) for global entities. Komatsu focuses on these five:



Construction, Mining, and Utility Products

Mining Equipment

Crawler excavators



Wheel loaders



Dozers



Rigid dump trucks



Construction Equipment

Crawler excavators



Wheel loaders



Dozers



Rigid dump trucks



Articulated dump trucks



Wheeled excavators



Motor graders



Utility Equipment

Mini excavators



Mini wheel loaders



Skid-steer loaders



Backhoe loaders



Forklifts



Key Issue to Consider Regarding the Energy Transformation (Construction Machinery)

- Significant investments in R&D are required for development of zero emission construction equipment, all diesel ICE equipment will have to be redesigned. Komatsu has developed Mid-size hybrid excavator and small-size battery excavators. From now on, we think that it is necessary to use batteries, hybridization, FC, and hydrogen engines for small to medium to large construction machines.
- Development of battery electric and hydrogen fuel cell are competing for the same resources and prioritization is mandatory. Serialization of development may result in a slower transition of key models than desired. Government incentives will be necessary to increase the pace of equipment development.
- Significant investment is required to create and deploy critical supporting technologies such as:
 - Green Energy (wind, solar, geothermal...) and storage
 - Hydrogen Production, Distribution, Storage, and Filling
- Zero-emission industrial equipment has not yet achieved the same performance and cost as diesel ICE machines.
 - Battery electric vehicles: high battery cost, long charging time, and more limited operating time
 - Hydrogen engine vehicles: large hydrogen tank required to achieve desired operating time
 - Fuel-cell electric vehicles: high components cost, large hydrogen tank required to achieve desired operating time
- TCO of zero-emission machines must be lower than that of diesel ICE machines to achieve fast penetration. Greenhouse tax on diesel ICE machines and subsidies on zero-emission machines will support the spread of zero-emission machines.

Key Issue to Consider Regarding the Energy Transformation (Construction Machinery) - 2

- Commercial
 - Public works will need preferences for zero-emission equipment until green energy TCO converges with ICE
 - Subsidies through 2030 for the purchase of zero-emission will be crucial to help offset higher capital costs
 - There is a strong 2nd hand construction equipment market where often used equipment is sold domestically and internationally (primarily development world) and smaller companies or developed countries may not have the infrastructure to support hydrogen powered equipment
- Mobile hydrogen supply is a large issue that will impact propagation. Hydrogen use in mining, transportation, and railroad can largely operate with fixed fueling stations, while construction will be heavily dependent on mobile refueling.
 - Variable refueling rates equipment as well as possibility of a mix of gaseous or liquified
 - Non-flat, narrow space job sites
 - Frequent advance or moves of job sites

Challenges Associated with Adoption of Hydrogen for Construction Machinery

● Application

- Rural, suburban, and urban job site.
- Wide range of environmental conditions ranging from cold district (<-30C), desert(>50C), rainforest(>90%RH)
- General expectation of customers - zero-emission equipment should have similar performance and operation time to current (ICE).

● Vehicle and on-board system

- Safety is of prime importance. Construction machinery may operate in urban areas. Hydrogen construction machinery needs to be as safe as ICE.
- Space claim of FC, battery, and hydrogen tank
- Hydrogen tanks physical size and capacity
- Hydrogen tank and machine system R&D is necessary for extending hydrogen machine operating time. (Operation time of 20t ICE excavator: 24h, 20t FC excavator with current technology: less than 8h)
- Availability, reliability, and maintainability/serviceability
- Lifetime of hydrogen related components should be longer than 10,000hrs (i.e., longer than warranty time of present construction machinery maintenance program).

Challenges Associated with Adoption of Hydrogen for Construction Machinery - 2

● Infrastructure

- Safety is of prime importance.
- Establish of on-demand hydrogen delivery service with reasonable cost is indispensable for the spread of hydrogen construction machinery.
 - ✓ Deregulation of hydrogen delivery station installation and operation
 - ✓ Subsidies for hydrogen delivery business until the spread of hydrogen construction machinery.

● Regulations and standards

- Construction machinery related regulations, standards, certification systems, recycling systems, etc. are on geared towards ICE equipment and need to be revised for hydrogen powered machine.
 - ✓ Emission, Noise, Vibration, Safety, etc.
 - ✓ Development, deregulation, and efficient operation of hydrogen related regulations and standards.
 - ✓ Harmonization and compatibility of international and local standards are necessary.
- Certification system for hydrogen powered machine is necessary.
 - ✓ Simplifying and speeding up the certification process with satisfying safety
 - ✓ Establishment of certification facilities
- Unification of standards and specifications for electricity and hydrogen supply infrastructure
 - ✓ Standardization of hydrogen related components, parts, and connection plugs.
 - ✓ Harmonization and compatibility of international and local standards are necessary.



Thank You

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