"Rail: On Track for Decarbonization"
FRA 2023 Workshop on Decarbonization of Rail Transportation
May 16-18, 2023

The current status of the development of carbon-neutral and energy-conserving rolling stock for railway systems in Japan

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Contents

1. R&D for decarbonization

GX (“green transformation”) in the transportation sector (railway, logistics, passenger)

Decarbonization by railways

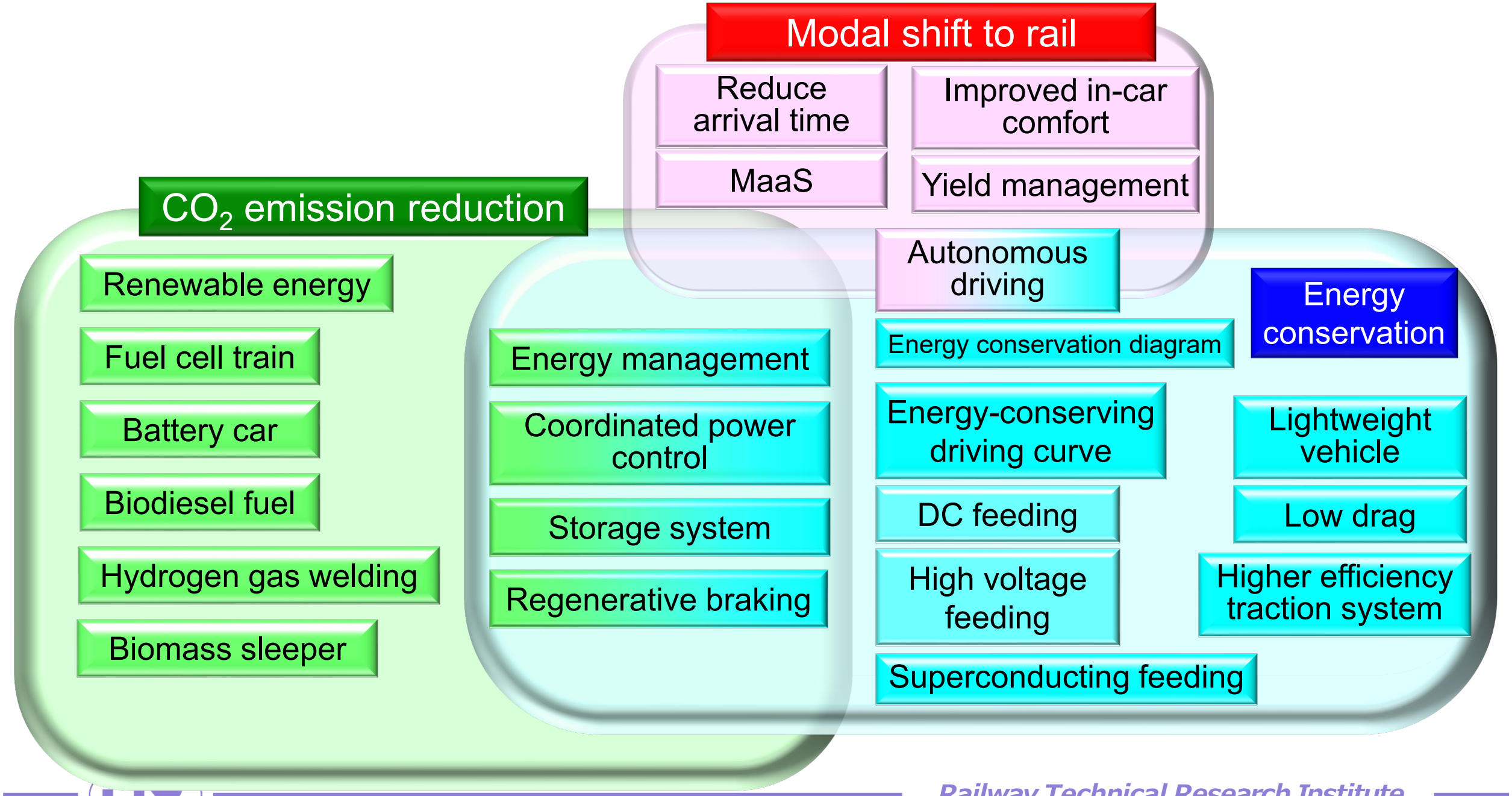
- Promoting the introduction of renewable energy using railway assets
- Modal shift from automobiles to railways and ships

Decarbonization of railways

- Popularization of energy-saving vehicles and fuel cell trains
- Demonstration test of comprehensive hydrogen station

"Basic policy for realizing GX (Green Transformation)"

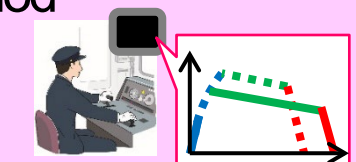
Drawn based on the cabinet decision on February 10, 2023


Modal shift to rail
Reduce arrival time
Improved in-car comfort
MaaS
Yield management
CO_2 emission reduction
Autonomous driving
Energy conservation
Renewable energy
Energy management
Energy conservation diagram
Fuel cell train
Coordinated power control
Energy-conserving driving curve
Lightweight vehicle
Battery car
Storage system
DC feeding
Low drag
Biodiesel fuel
Regenerative braking
High voltage feeding
Higher efficiency traction system
Hydrogen gas welding
Superconducting feeding
Biomass sleeper

Efforts at the RTRI for decarbonization

[CO_2 emission reduction]
Control method of smart energy storage system

[Energy conservation]
Energy-saving driving method



Aggregator

Charge/ discharge

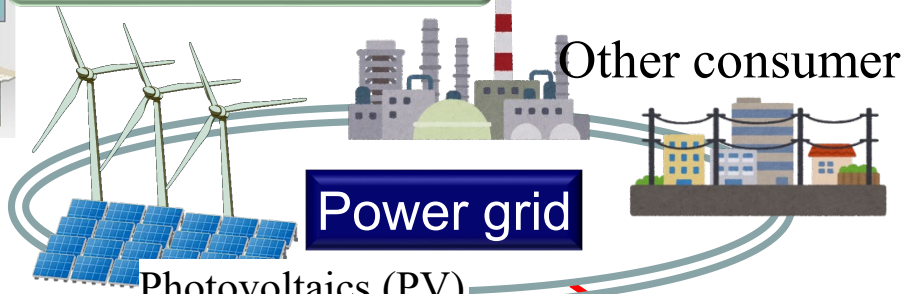
Energy network

Renewable energy

Renewable energy

Power plant

Other consumer



Power grid

Photovoltaics (PV) / Wind farm (WF)

Battery (Railway side)

Substation

Battery (Grid side)

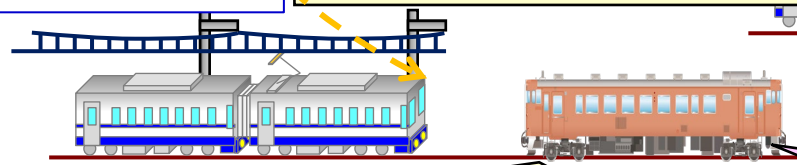
Operating status/operating command

[CO_2 emission reduction]
Improving the durability of on-board storage batteries

SOC (state of charge) / charge command

Depot

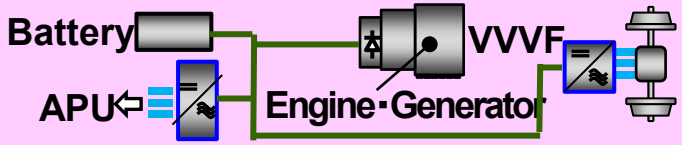
Battery



[CO_2 emission reduction]
- Fuel cell train
- Biodiesel fuel (BDF)

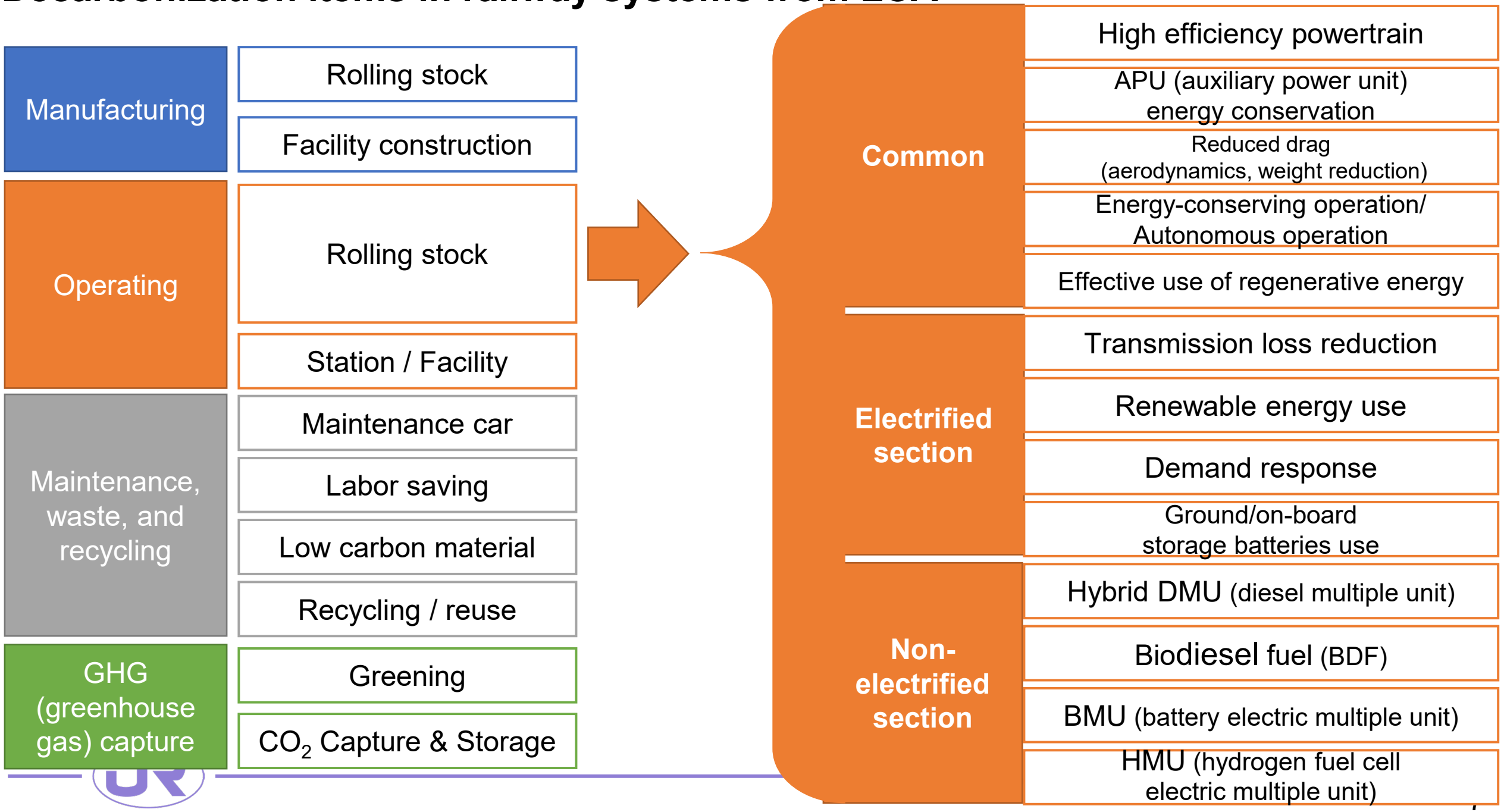
Utilize hydrogen energy

[Energy conservation]
Efficiency improvement of diesel cars

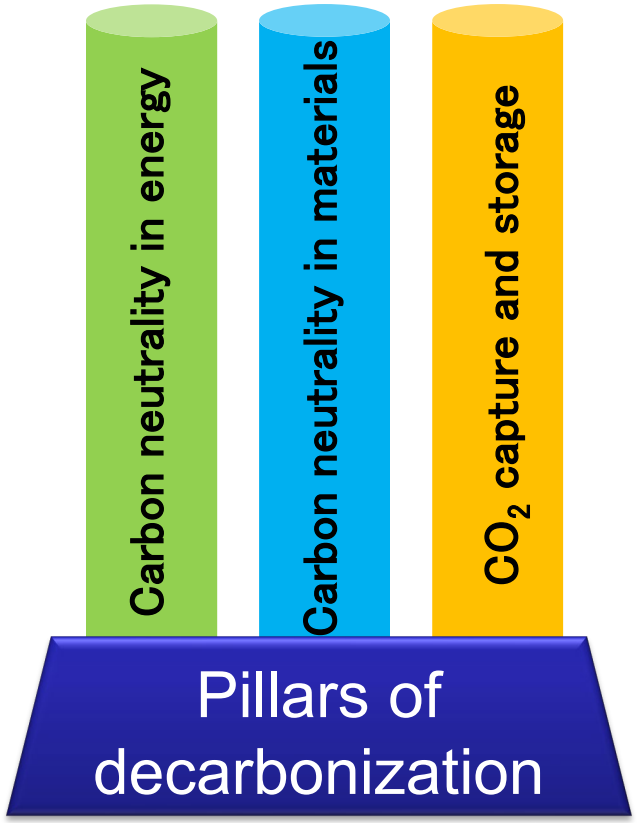


[CO_2 emission reduction]
Superconducting magnet energy storage (SMES)
/ Superconducting (SC) flywheel

Decarbonization items in railway systems from LCA



2. Decarbonization considering the life cycle

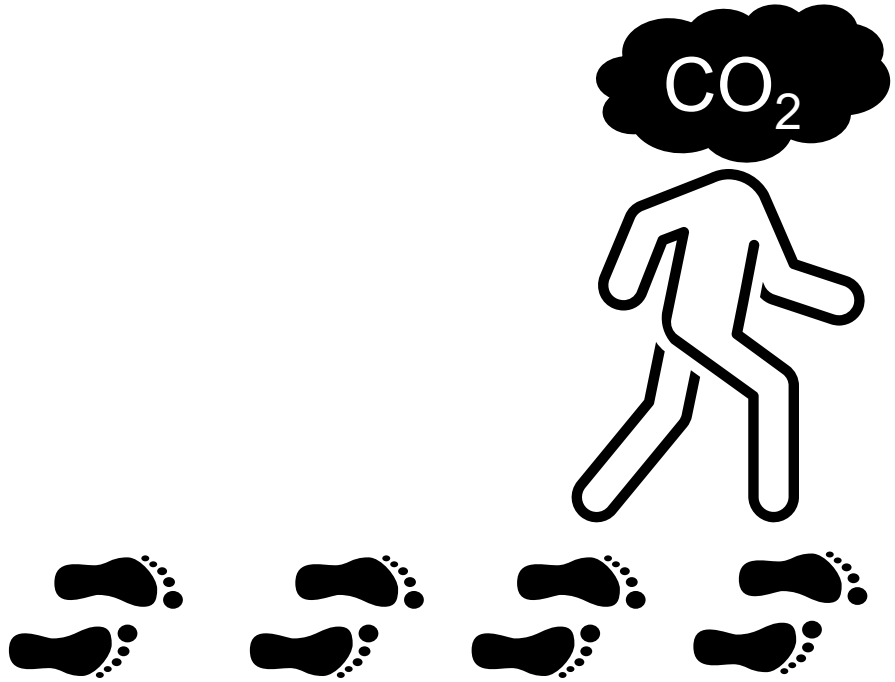


In order to achieve decarbonization,
we must understand CO_2 emissions not only in energy, but also in the life cycle.

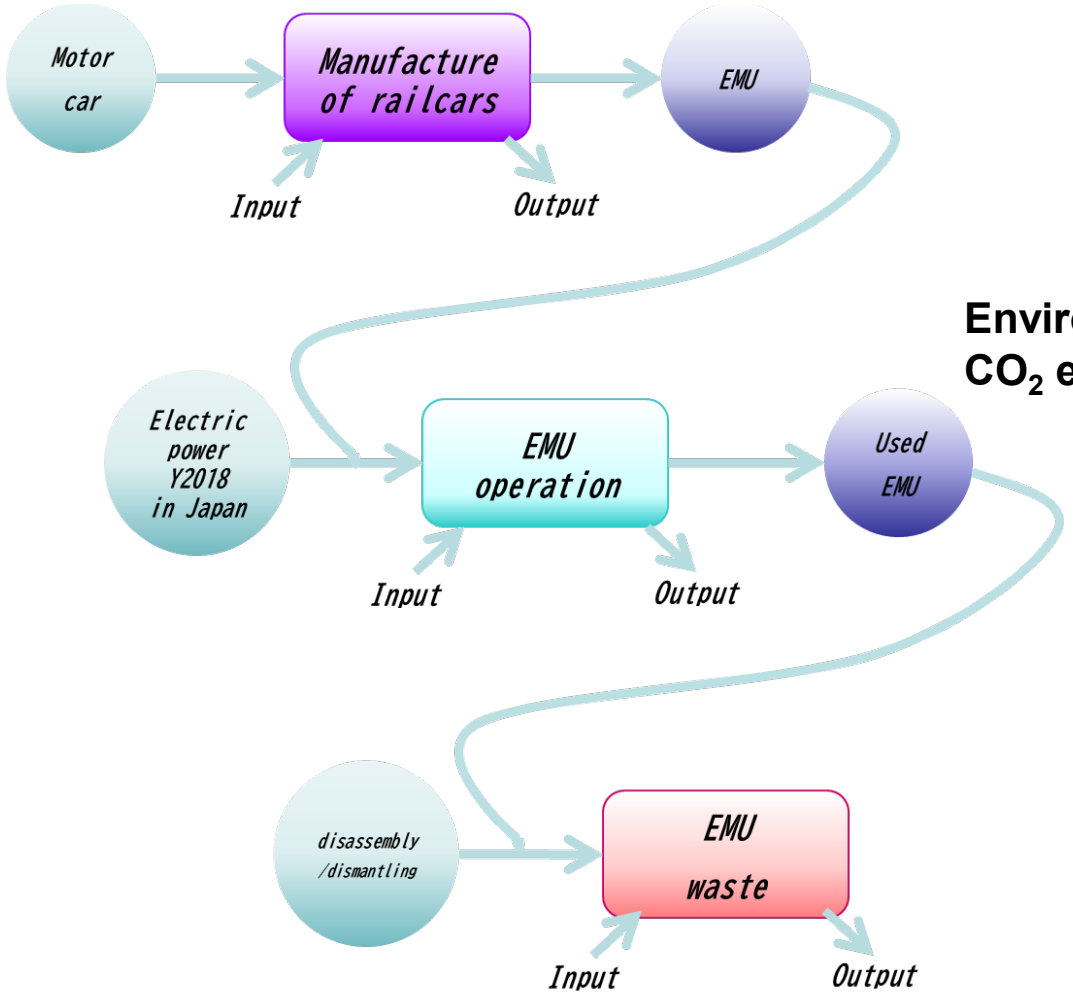
In other words, we must calculate carbon footprint.

Understanding the CO_2 emissions of raw materials

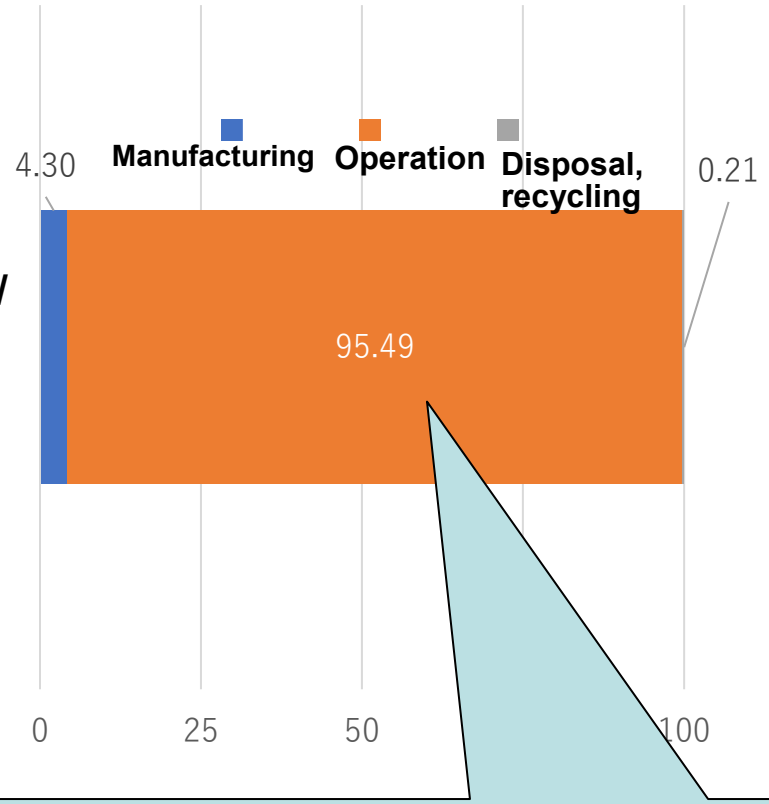
Life Cycle Assessment (LCA)



LCA of EMUs, environmental impact



Environmental impact / CO_2 emission ratio

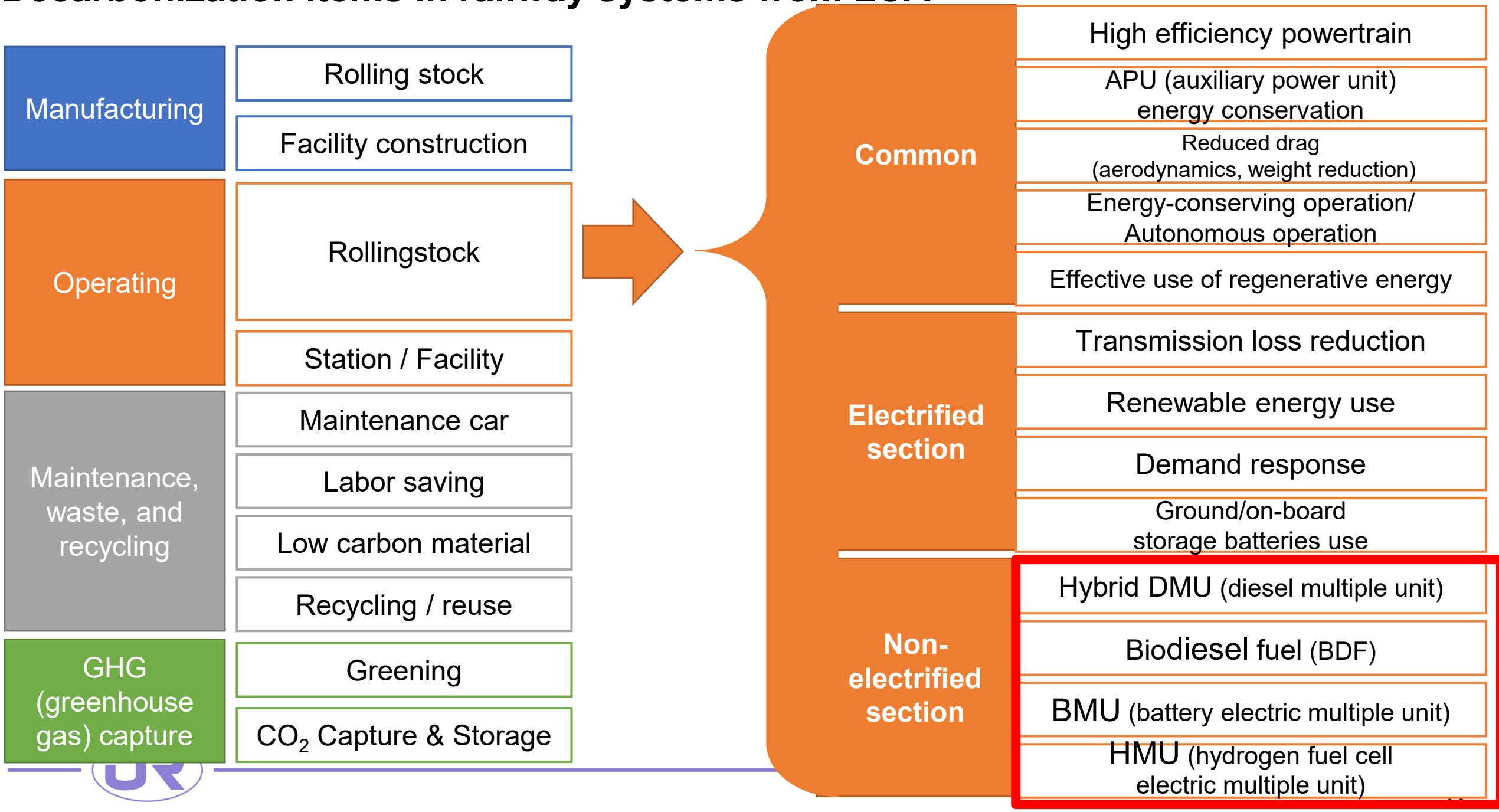


More than 95% of CO_2 emissions over the life cycle of railway systems come from the energy generated during operation.

Calculations performed using the
- “Guidebook of the LCA System MiLCA Version 3.1 (developed by: the Sustainable Development Organization)” and the
- "LCI Database IDEA Version 3 (developed by: the Society and LCA Research Group, Safety Science Research Division, National Institute of Advanced Industrial Science and Technology, and the Sustainable Management Promotion Organization)”

3. Decarbonization of railway operating energy

Decarbonization items in railway systems from LCA



Aiming for a sustainable railway system

Isumi Railway

Wikimedia Commons: Toshinori Baba

JR Kyushu

Wikimedia Commons: MK Products

33% of railway lines in Japan are not electrified.

DMUs (diesel multiple units) run in the lines.

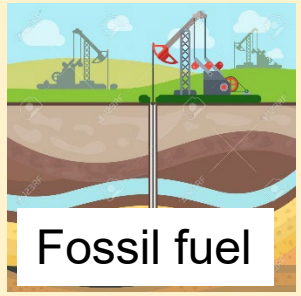
The DMUs have some problems

- Fossil fuel dry up
- CO_2 and NO_X emission
- Low energy efficiency
- Heavy noise and vibration

→ Improve these using Fuel Cells and Hydrogen

Carbon-neutral items on railways

Fossil fuel free



Fossil fuel

Decarbonized fuel

BDF (biodiesel fuel)

Power generation

Thermal power plant

Renewable energy

Photovoltaics, wind farms

Reduced energy consumption, zero emissions

Hydraulic DMU
(diesel multiple unit)

Low-fuel consumption

Hybrid DMU
(diesel multiple unit)

Zero emissions

EMU
(electric multiple unit)

BMU
(battery electric multiple unit)

HMU
(hydrogen fuel cell multiple unit)

CO2 absorption

Greening

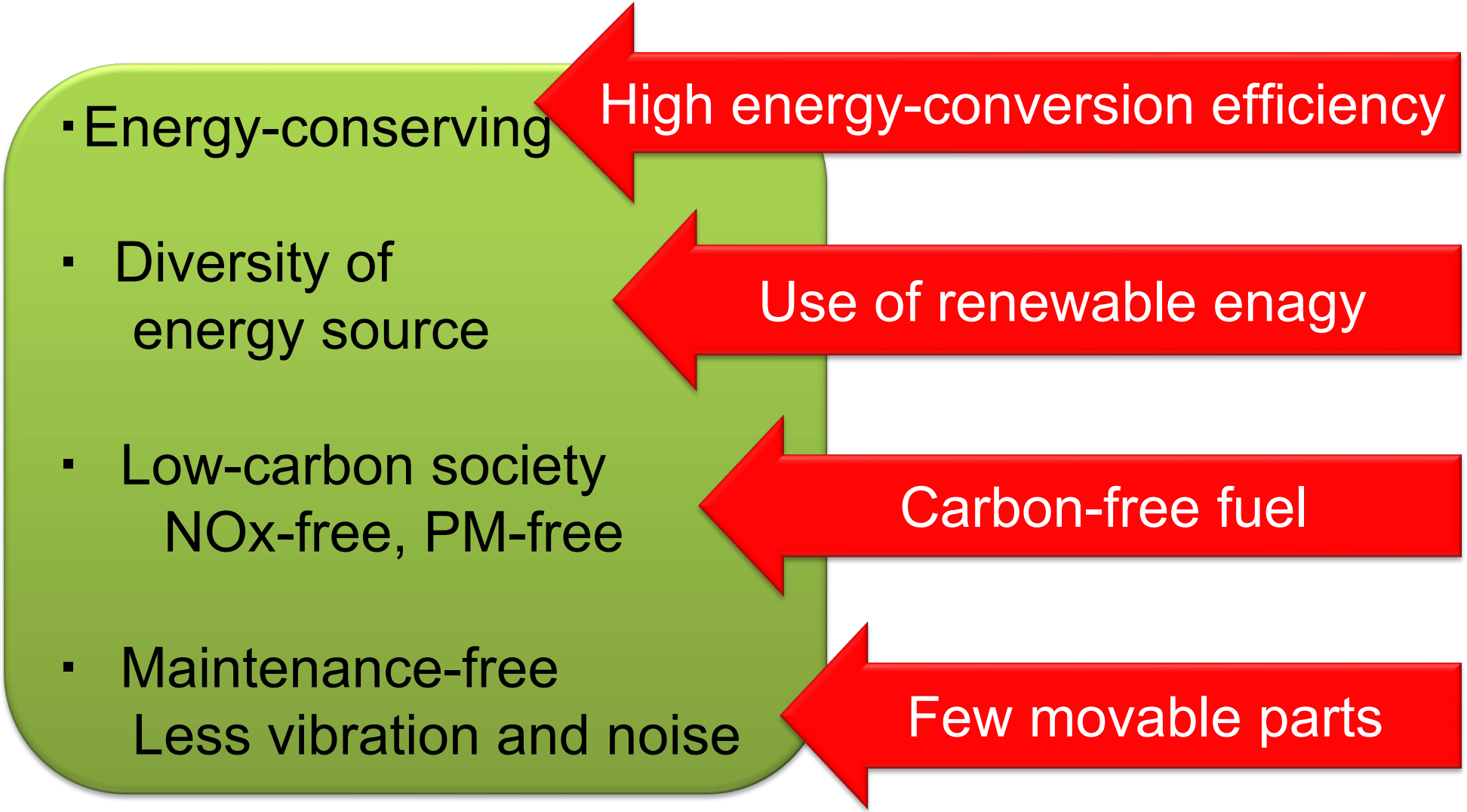
CCS

BMUs in commercial operation, (AC electrified section)

JR East Oga Line EV-E801 series
(photos taken by the speaker, at Oga Station)

JR Kyushu Wakamatsu Line BEC819 series
(photos taken by the speaker, at Orio Station)

Utilization of fuel cells and hydrogen



Development of fuel cell test vehicles in Japan

JR East Tsurumi Line & Nanbu Line

FV-E991 series (Hybari)

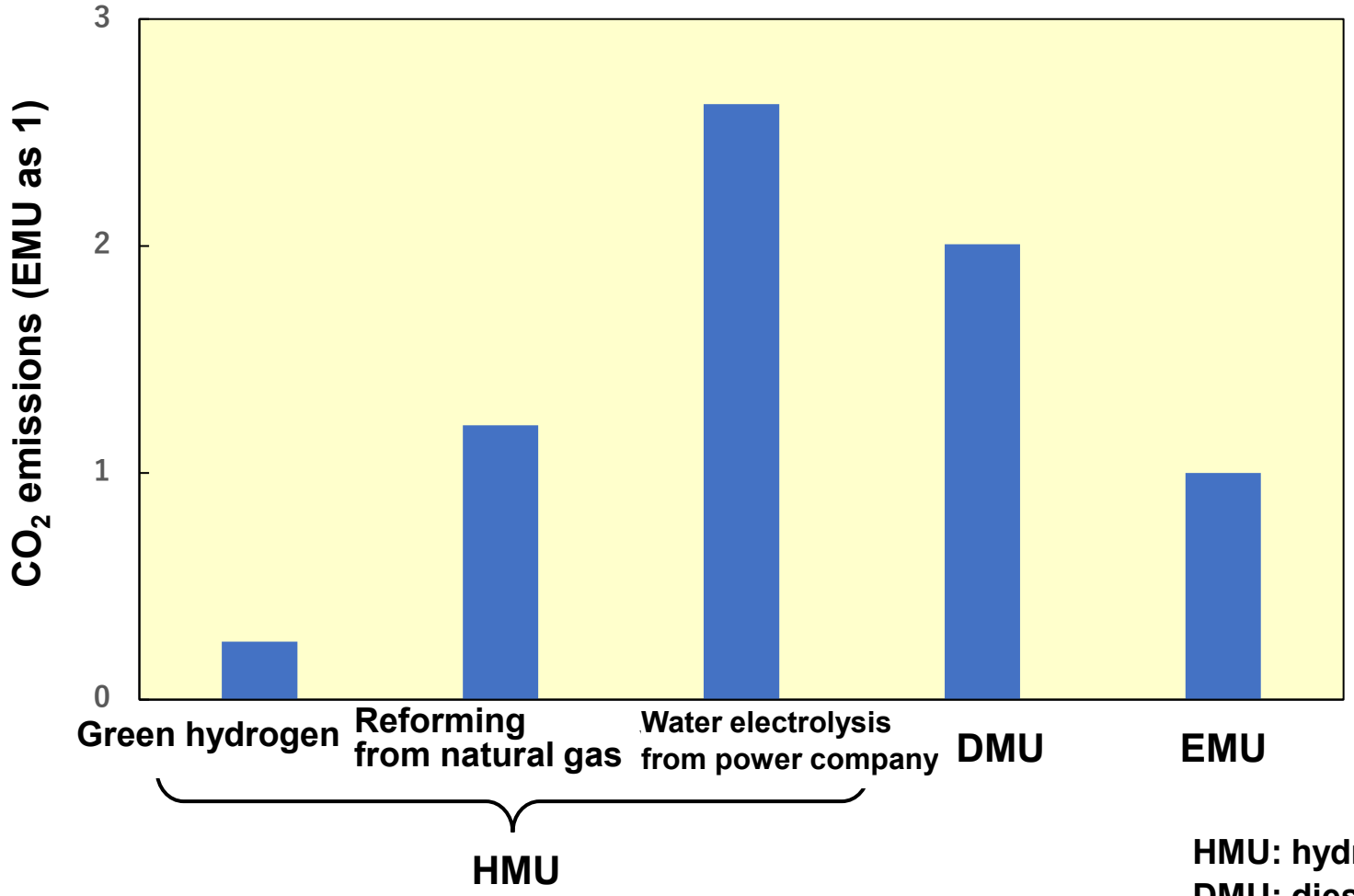
https://www.jreast.co.jp/press/2020/20201006_4_ho.pdf

Railway Technical Research Institute Kunitachi-test-track

R291 series

https://www.rtri.or.jp/rd/division/rd41/rd4150/rd41500106.html

Trial calculation of CO_2 emissions from operating energy of fuel cell trains



HMU: hydrogen fuel cell multiple unit
DMU: diesel multiple unit
EMU: electric multiple unit

Running DMUs using biodiesel fuel

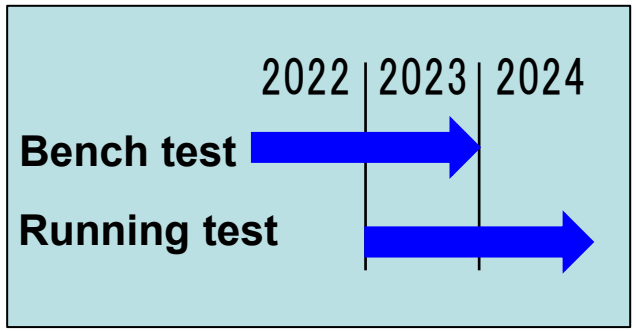
1st generation: Fatty acid methyl ester

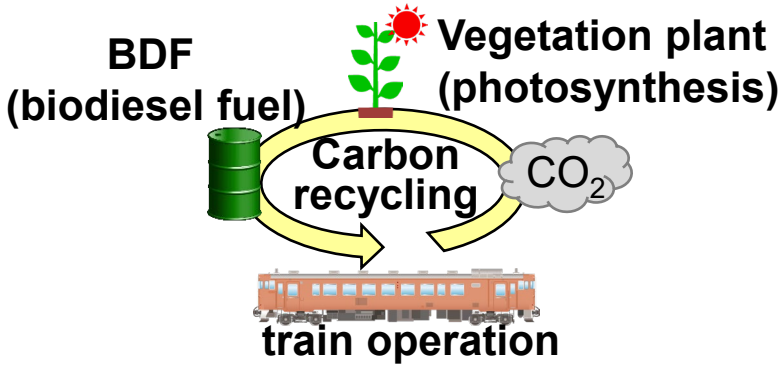
Issues such as deterioration/corrosion of parts and deterioration during long-term storage

2nd generation: Hydrogenated Vegetable Oil (HVO)

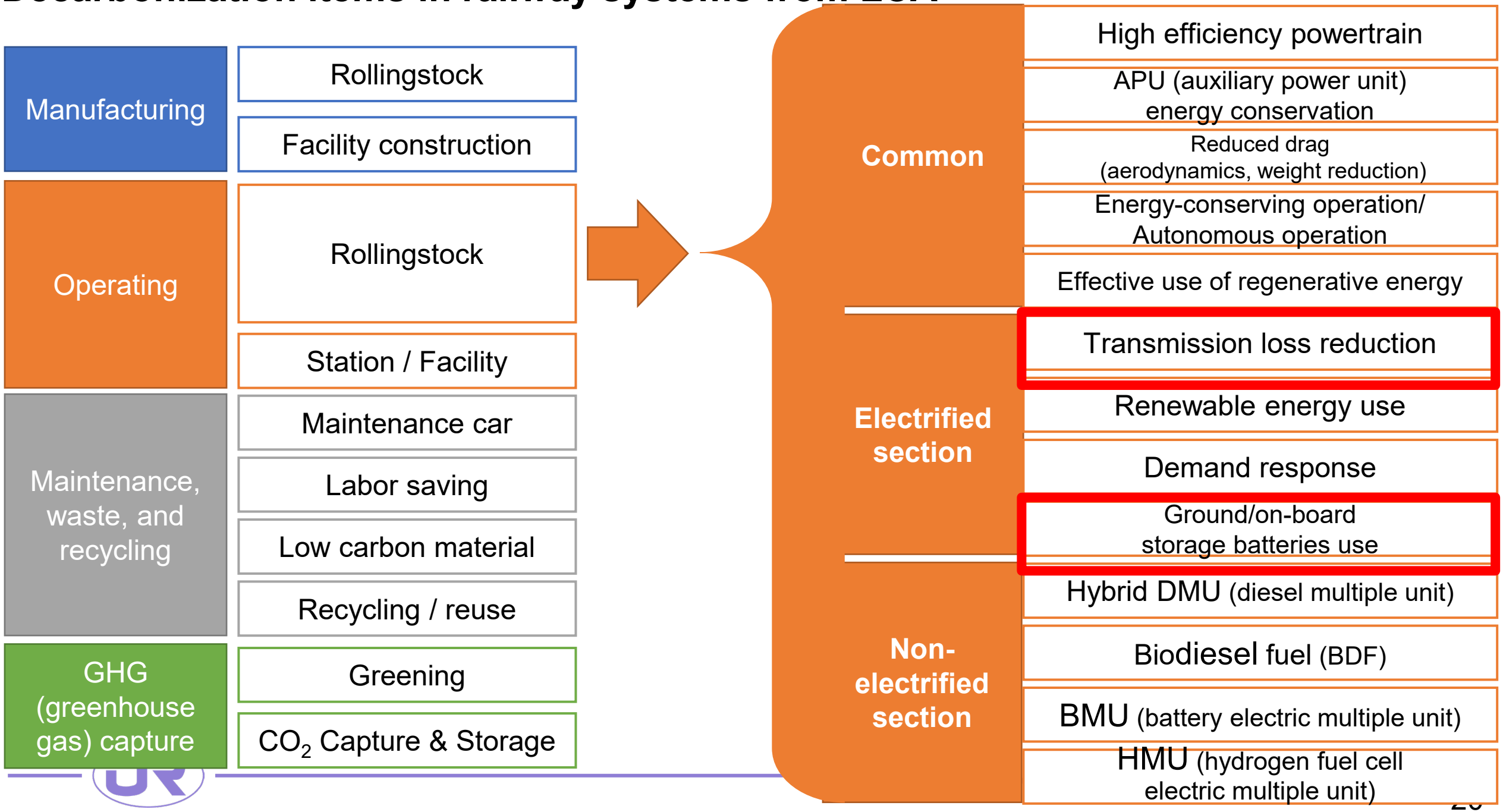
Same hydrocarbons as diesel fuel

The Railway Technical Research Institute and 7 JR (Japan Railway) companies have jointly proposed a project commissioned by the Ministry of Land, Infrastructure, Transport and Tourism, and are conducting performance evaluations of HVOs.

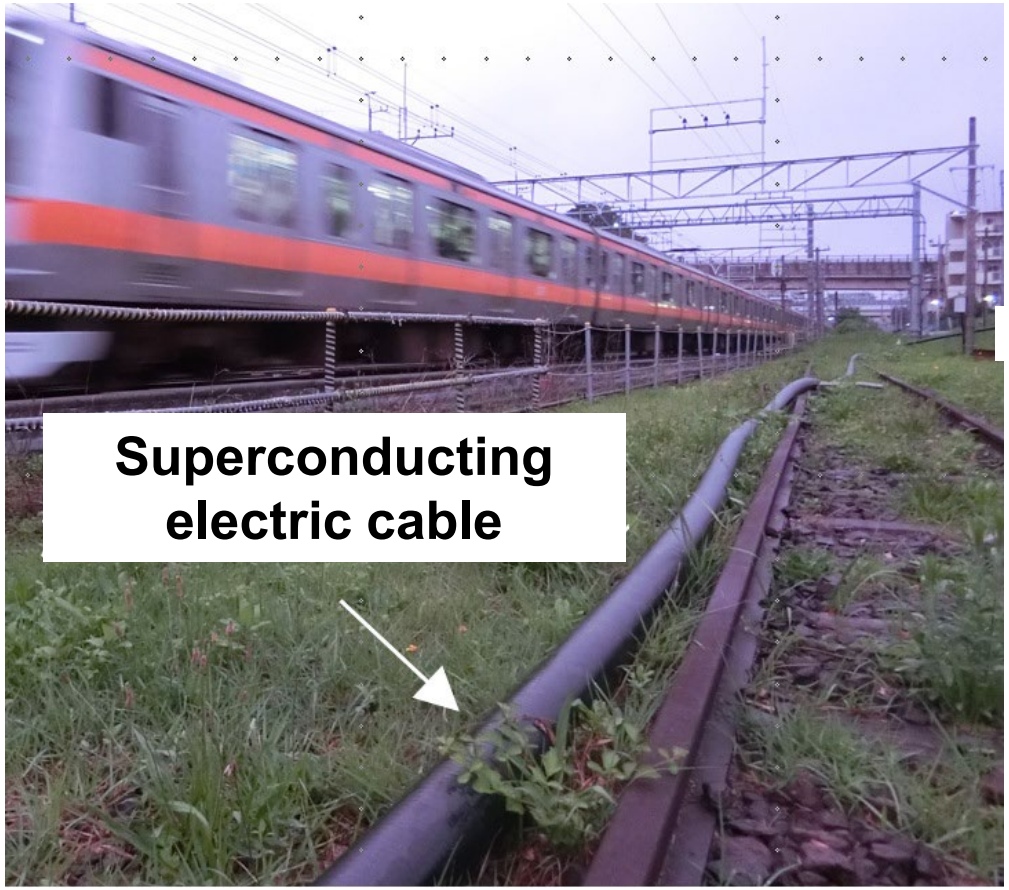


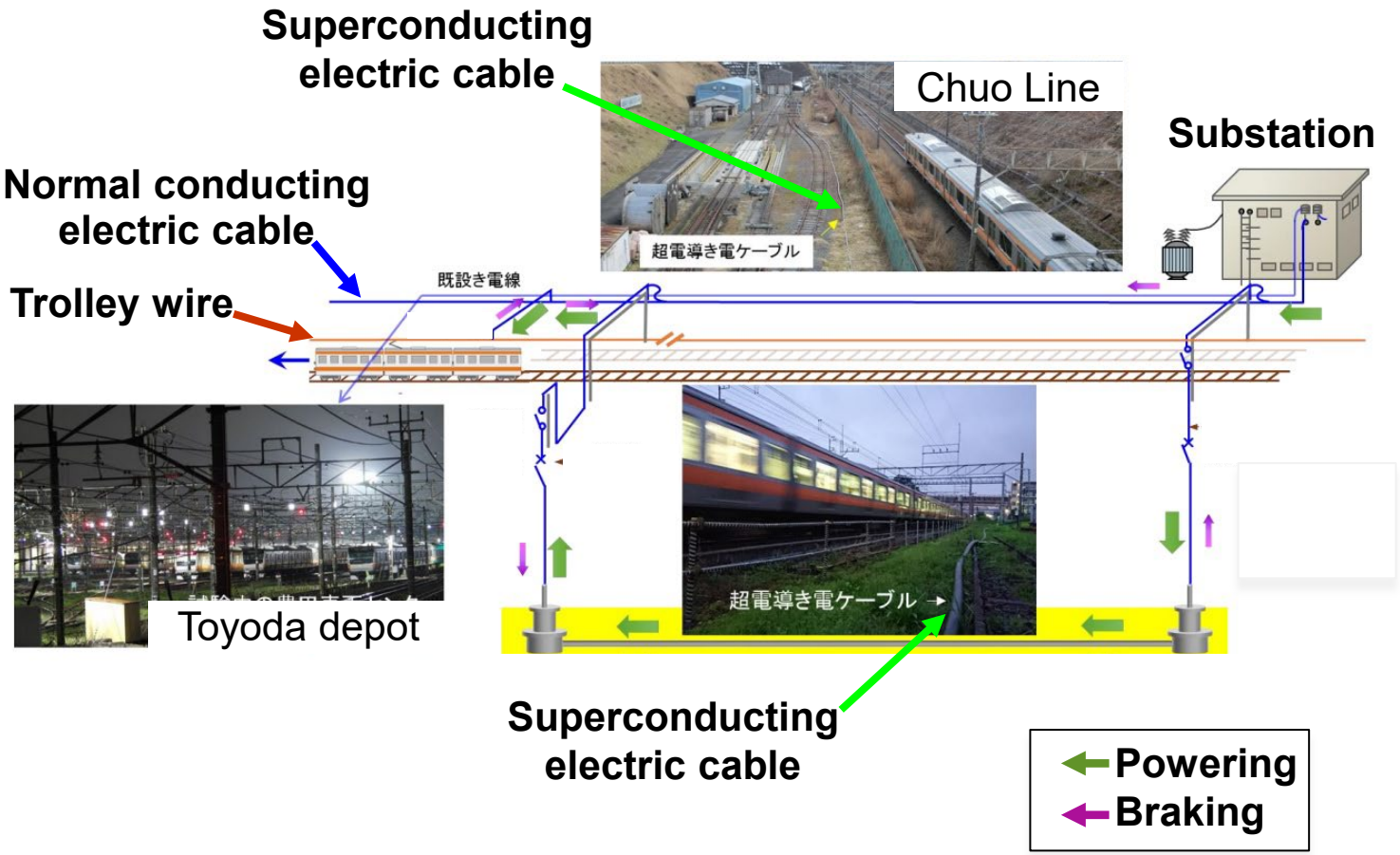


Decarbonization items in railway systems from LCA



Research and development to reduce transmission loss





Development of flywheel power storage device

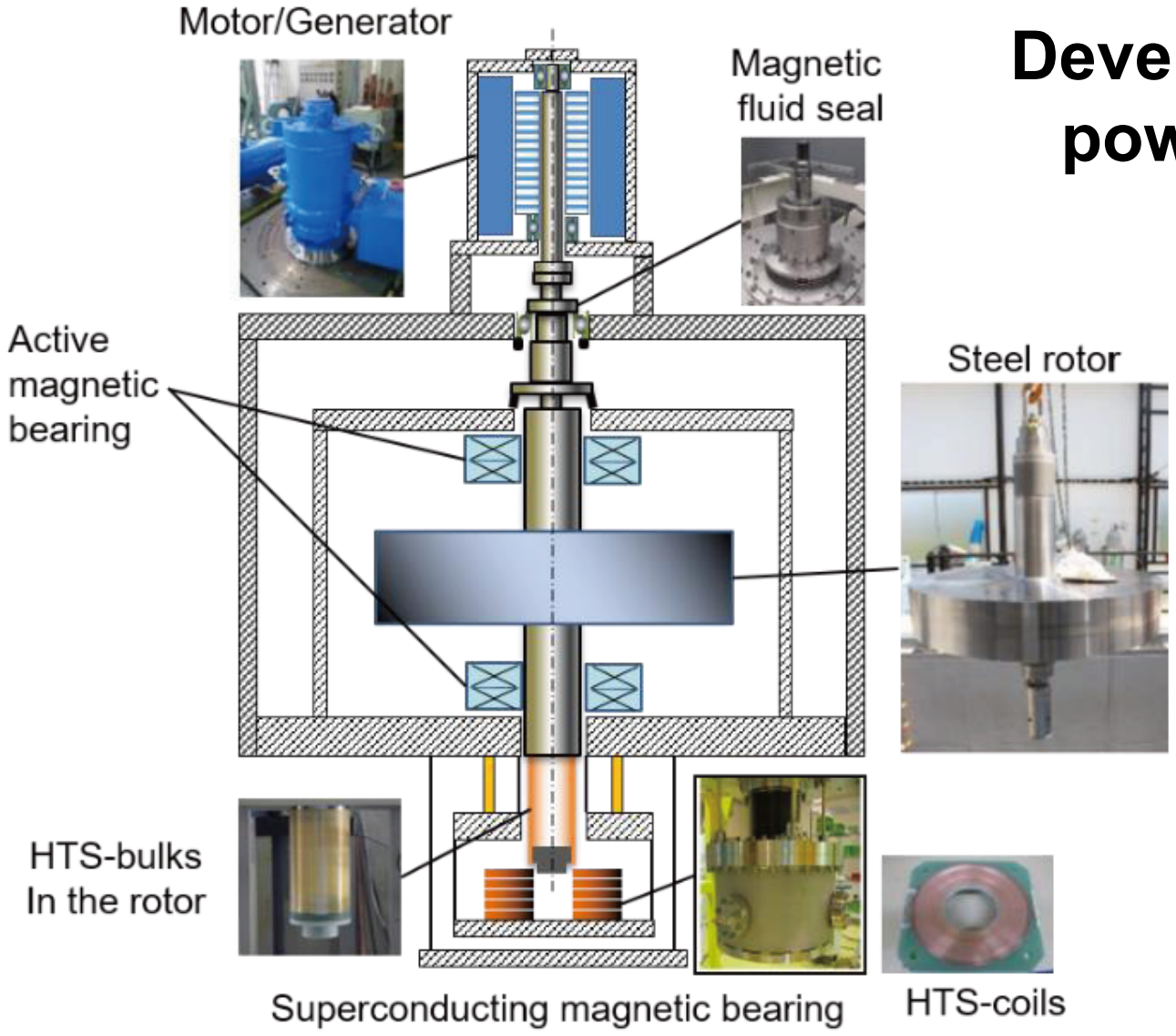
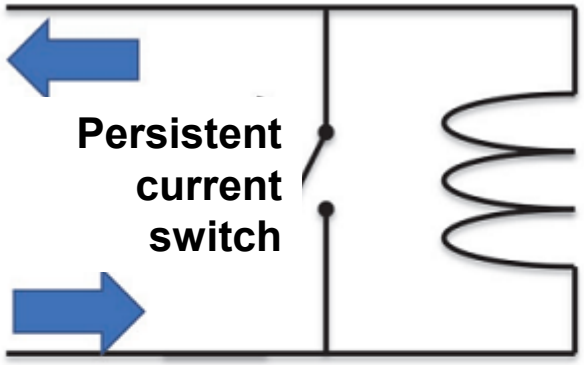


Fig. 2 Flywheel energy storage system with SMB

HTS: high-temperature superconductor
SMB: superconducting magnetic bearing

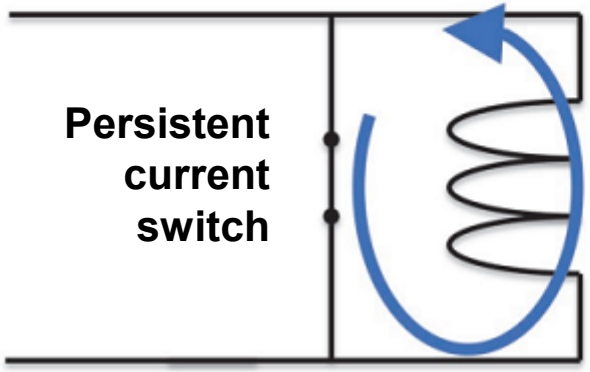
SMES: Superconducting Magnetic Energy Storage

Charging and Discharging



Superconducting coil

Storing energy



Superconducting coil

Storing magnetic energy in superconducting coils

4. Conclusions

1. Basic policy in Japan for promotion of GX (green transformation)

   Decarbonization "**by** railways" and "**of** railways"

2. Decarbonization considering the life cycle

   In railway systems, most of the CO_2 emissions are from **operational energy**.

3. Decarbonization of railway operating energy

   Energy-conserving vehicles

   BMUs (battery electric multiple units) are in practical use,
   HMUs (hydrogen fuel cell electric multiple units) are under development

   Biodiesel fuel, superconducting cables, flywheels, and superconducting magnetic energy storage are under development

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Thank you for your attention.