

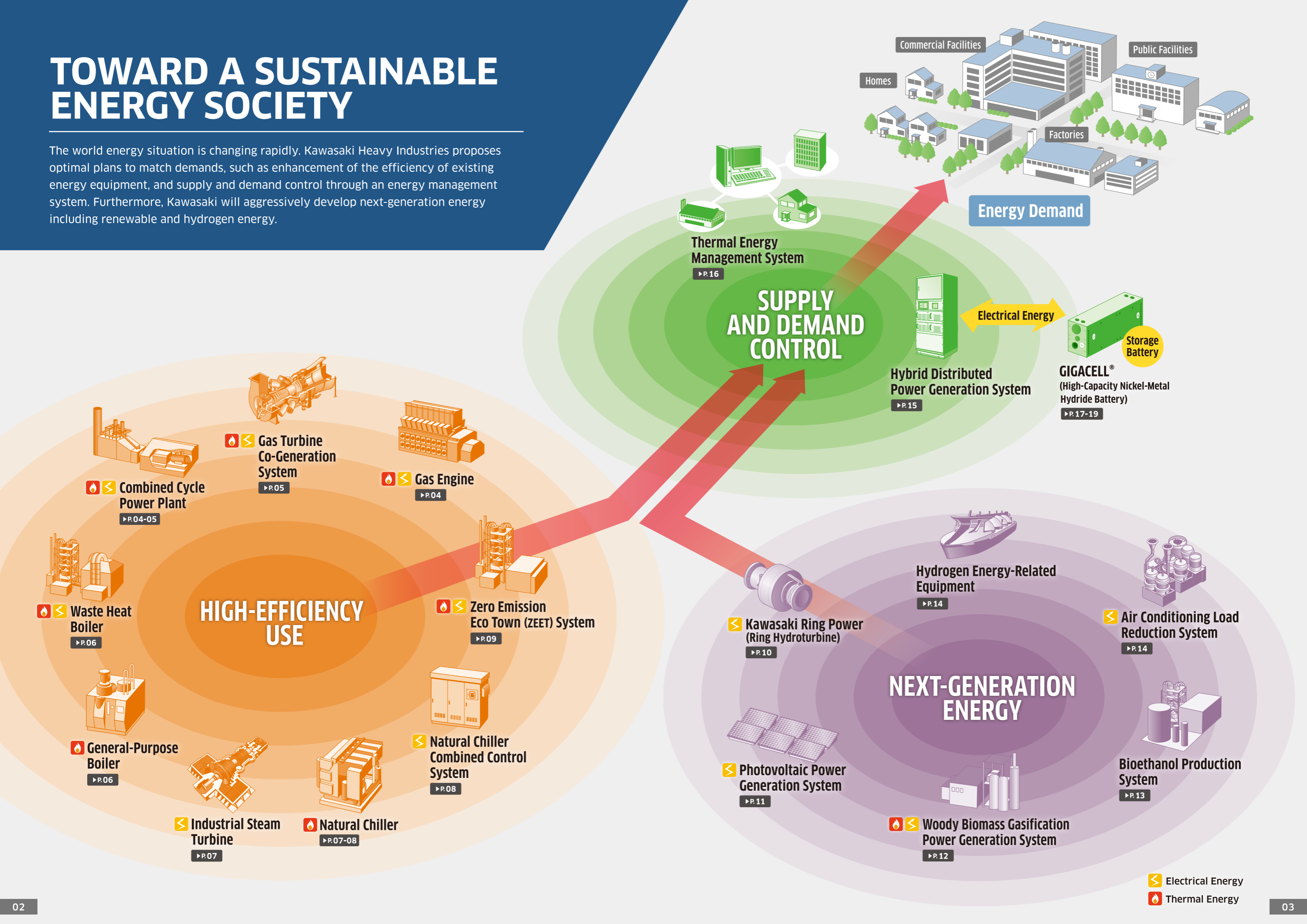
Creation of **ENERGY**

TOWARD A SUSTAINABLE ENERGY SOCIETY



TOWARD A SUSTAINABLE ENERGY SOCIETY

The world energy situation is changing rapidly. Kawasaki Heavy Industries proposes optimal plans to match demands, such as enhancement of the efficiency of existing energy equipment, and supply and demand control through an energy management system. Furthermore, Kawasaki will aggressively develop next-generation energy including renewable and hydrogen energy.



HIGH-EFFICIENCY USE

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SUPPLY AND DEMAND CONTROL

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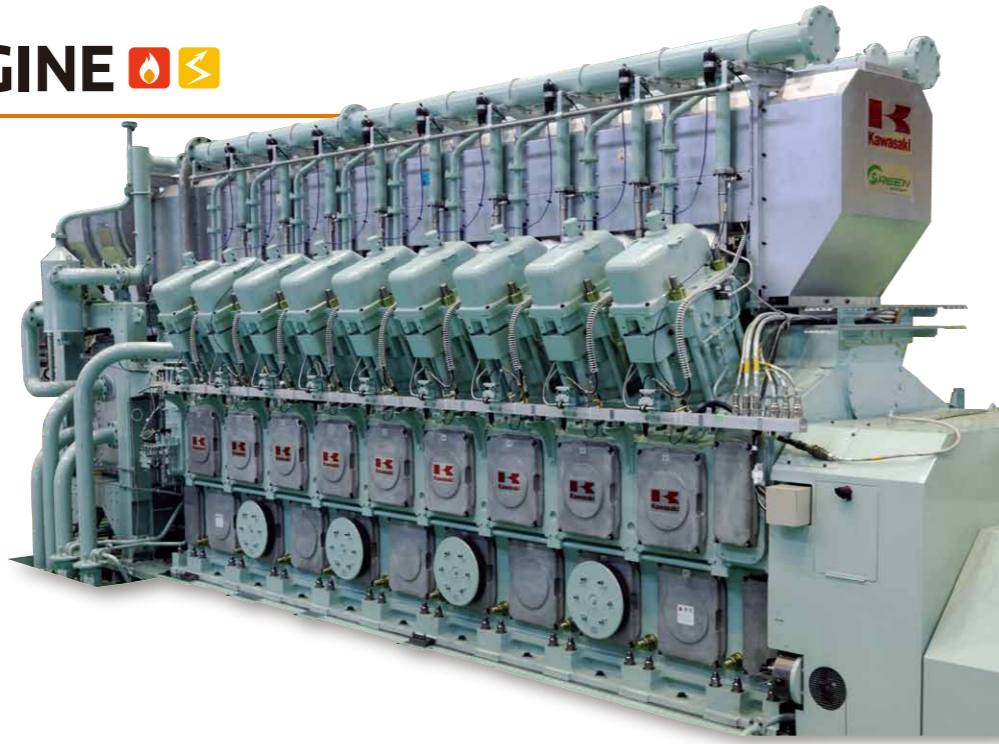
⚡ Electrical Energy
 🔥 Thermal Energy



GREEN GAS ENGINE

The world's highest electrical efficiency of 49%

Kawasaki's Green Gas Engine achieves the world's highest electrical efficiency of 49%. It has a wide operation range of 30 to 100% and maintains high electrical efficiency even under partial load. NOx emissions are kept under 200 ppm (O₂ = 0%), so NOx removal equipment and other exhaust gas treatment facilities are not needed in most cases.

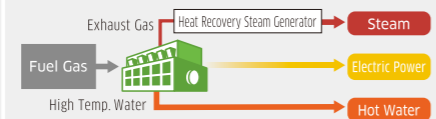


Typical applications

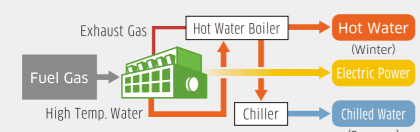
[Power Generation]



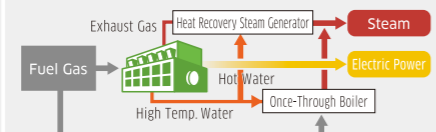
[Power + Steam + Hot Water Generation]



[Power + Hot Water or Chilled Water Generation]



[Power + Steam Generation]



Features

- World's highest electrical efficiency
Electrical efficiency of 49%
- Low NOx emission
200 ppm or less (at 0% O₂)
- Flexible operation
High partial load efficiency and wide operating range
- Quick start
10 minutes from start order to rated load

Product lineup

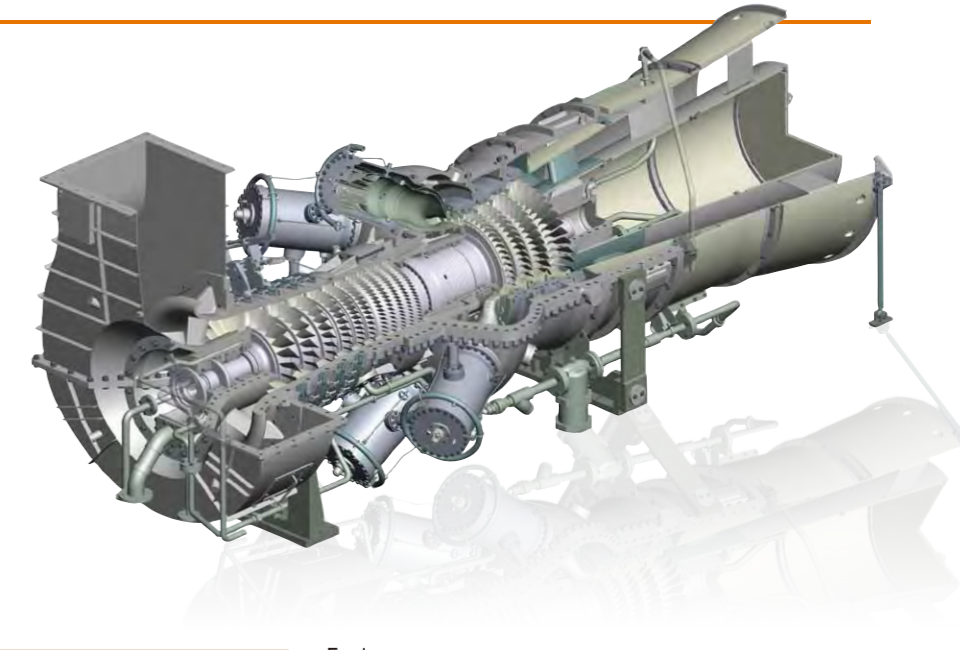
Rated output: 5.2 - 7.8 MW(50 Hz)
5.0 - 7.5 MW(60 Hz)



GREEN GAS TURBINE CO-GENERATION SYSTEM

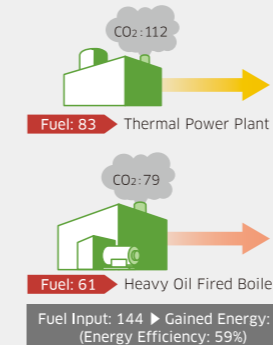
Reduces environmental impact and achieves high energy efficiency

At the same time as generating electricity with a gas turbine, the Green Gas Turbine Co-Generation System utilizes the thermal energy obtained from exhaust gas to the process of manufacture, air conditioning, hot-water supply, and others. Thanks to its high energy efficiency and low environmental impact, more than 600 units have been installed in Japan and overseas. The specifications of this system, such as the output level, system configuration, and type of fuel, can be varied depending on the intended use.

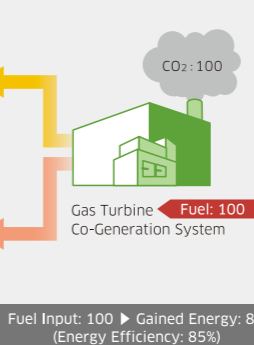


Comparison of energy saving and environmental impact (7.6 MW class)

[Existing System]



[Co-Generation System]



Features

- High efficiency
World's highest level of gross electrical generation efficiency
- Lower cost
Highest level of total efficiency achieved by using heat and electrical energy
- High fuel flexibility
City gas, LPG, kerosene, diesel oil, and other multi-fuels
- Supplying various systems
Arrange the economical and appropriate systems according to user's energy demand and intended use

Product lineup

Rated output: 0.6 - 30 MW

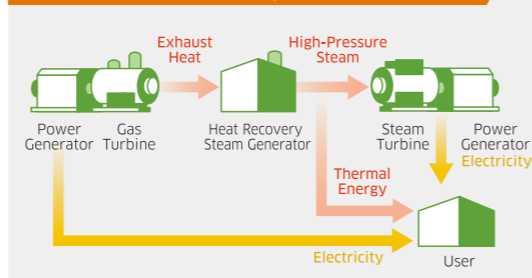
COMBINED CYCLE POWER PLANT

High energy efficiency by effective usage of exhaust heat

Our Combined Cycle Power Plant generates electric power with high energy efficiency by reusing high-temperature exhaust gas emitted from a gas turbine generator set. By generating power at the location of use, this system can avoid the loss upon

transmission of electricity that is inevitable in large-scale centralized power generation systems with a power station at a remote place. The system also reduces CO₂, NOx, and SOx emissions by using natural gas as the fuel source and can handle variable heat-to-power ratio.

Mechanism of Combined Cycle Power Plant (CCPP)



Features

- Effective utilization of exhaust heat, which is not utilized in large-scale centralized power generation systems
- High fuel flexibility
- Withstands DSS (Daily Start and Stop) operation, which is harsher than normal continuous operation



Example of installation to a food manufacturing complex

WASTE HEAT BOILER

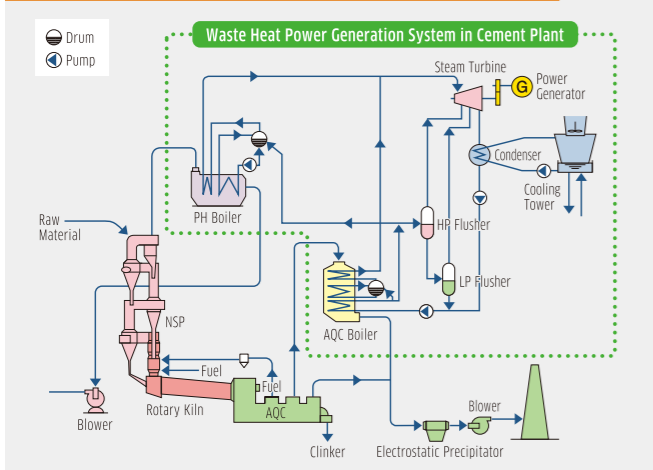
Improves the energy efficiency by utilizing the heat of exhaust gas

Our waste heat boiler recovers heat from exhaust gas and uses it for steam

turbine power generation or as process steam in a plant, thereby dramatically improving energy efficiency. Thanks to its compact design and high reliability, we have achieved a large number of installations in Japan and overseas.

Kawasaki is working with cement manufacturing plants, sinter coolers in ironworks, power plants utilizing waste heat generated by gas turbines, and others industries to improve energy efficiency and reduce CO₂ emissions.

Outline of system (utilization of waste heat in cement plant)



Example of the introduction of a combined cycle power generation system (TNP in Thailand, 114 MW)

GENERAL-PURPOSE BOILER

High-efficiency general-purpose boiler for applications ranging from heating to manufacturing processes

These general-purpose boilers are used for various purposes: heating, manufacturing, drying etc. The products are completely assembled and undergo legal manufacturing inspections in the

factory, allowing the product to be installed quickly and easily. Our broad range of boilers allows the ideal model to be selected for the intended use.

Once-through boiler

The new type of once-through boiler is widely used since it requires no special qualifications to operate. The steam quality, load following capability, and ease of maintenance of the product have been dramatically improved by enlarging the capacity.

Features

- **High boiler efficiency**
Gas burner type: 98%
- **PI control of combustion and water supply (Standard equipment)**
 - Gas combustion control range: 16.7 - 100%
 - Stable steam pressure: +/- 0.01 MPa (Under static load)



By-product fuel fired boiler

The by-product fuel fired boiler utilizes heat-containing gas and liquid generated as by-products in manufacturing processes as fuel (e.g. hydrogen, vegetable oil, biogas, and VOC) generated in manufacturing process as fuel.

Features

- **Wide variety of usable by-products**
Usable by-product fuels: Hydrogen, vegetable oil, biogas, VOC, etc.
- **Applicable to various types of boilers**



INDUSTRIAL STEAM TURBINE

Achieves high efficiency and suitable for various steam conditions thanks to unique technologies

Kawasaki has achieved a high efficiency by applying the state-of-the-art blade

shape and developing unique technologies including hydrodynamic improvements. We provide steam turbines of up to 150 MW mainly for power generation; they are suitable for various industries and are easy to inspect and maintain thanks to the

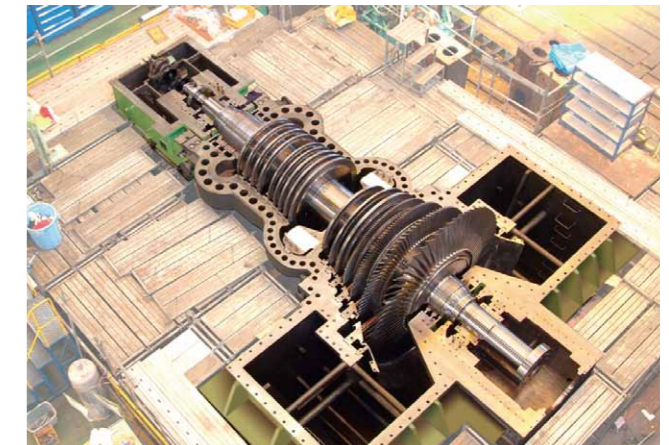
horizontal-split type casing. Featuring package installation, this product significantly reduces the footprint and installation time. It can also handle a wide variety of special steam conditions, including the use of excess steam and geothermal power generation.

Application examples

[Condensing Turbine]



[Back-Pressure Turbine]

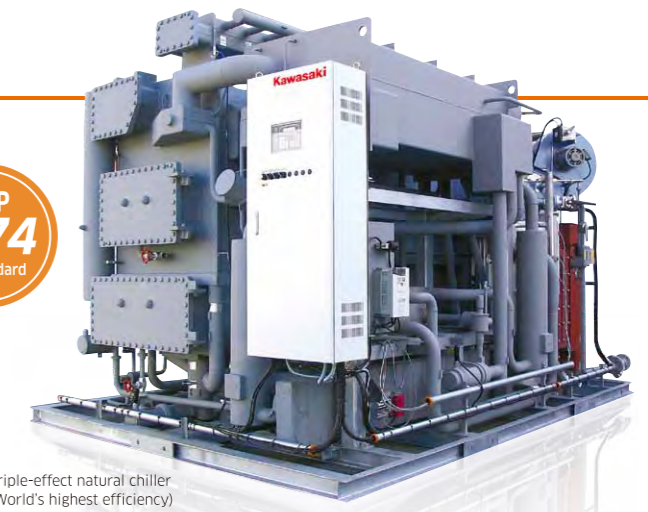


NATURAL CHILLER

Air conditioning heat source that supplies hot and cold water utilizing various heat sources

The natural chiller (absorption chiller/heater) is a high-efficiency, Freon-free, environmentally-friendly heat source which dramatically reduces power consumption compared with electric chillers even in the daytime in summer when the power demand reaches its peak (it uses gas, oil, steam, waste heat, etc. as heat sources).

COP 1.74
JIS Standard



Triple-effect natural chiller (World's highest efficiency)

Features

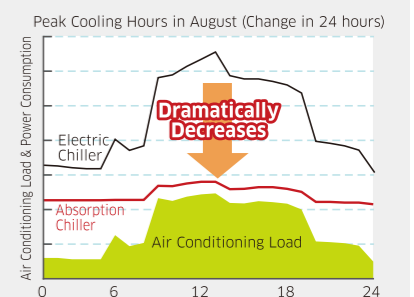
- Centralized air conditioning heat source both for cooling and heating
- Reduces environmental load by using natural refrigerants (Reduces ozone emissions and global warming)
- Uses waste heat and solar heat, in addition to gas, oil, and steam, as heat sources
- Dramatically reduces power consumption for air conditioning
- Huge saving daily and yearly peak
- Contributes to society and the environment by leveling power consumption

Product lineup

Cooling output: 141 - 9,124 kW

Our simulation

The product dramatically reduces power consumption by using gas, oil, and waste heat as heat sources. It contributes to reducing peak power consumption in the daytime in summer when air conditioning demand is highest.



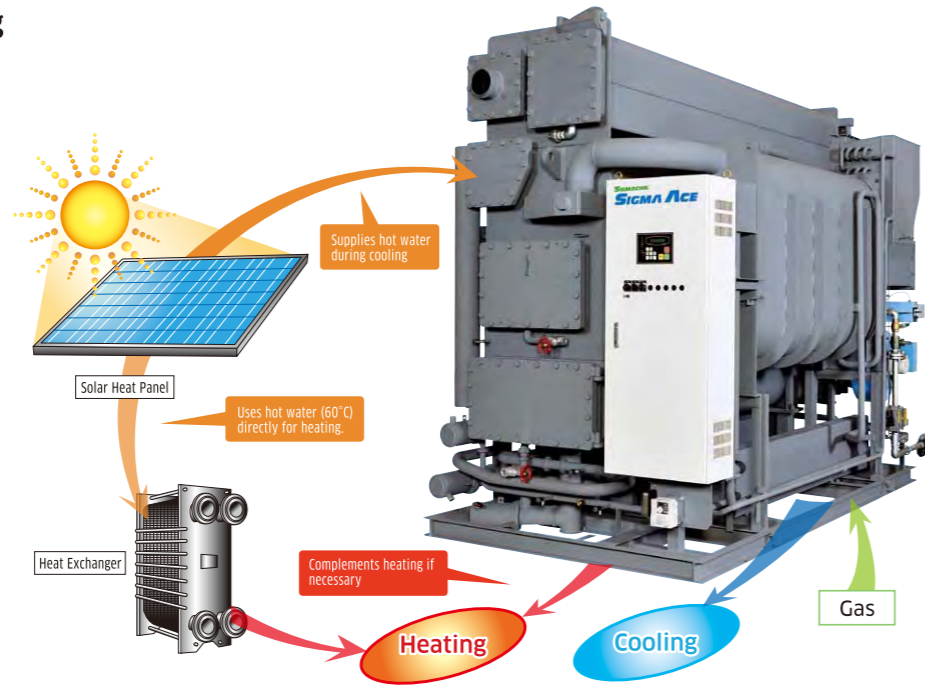
SOLAR NATURAL CHILLER

Supply chilled water using solar heat as the main energy source.

Solar heat may be the most effective type of renewable energy. Solar heat can recover solar energy more efficiently than photovoltaic power generation.

Features

- Using renewable energy
- Saves energy and reduces CO₂ emissions
- The system uses hot water and gas combustion by good balance to ensure stable output.







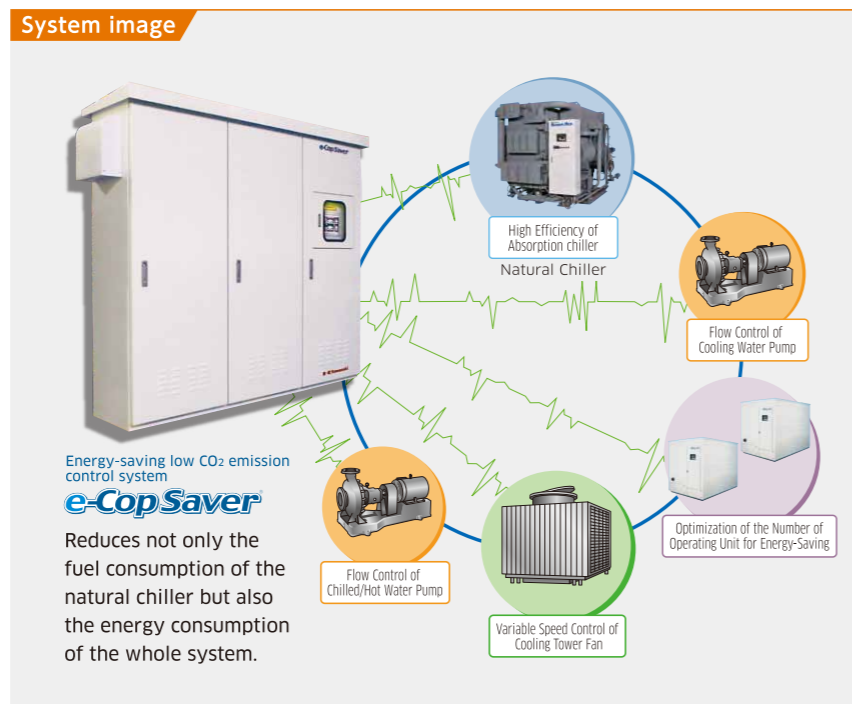
NATURAL CHILLER COMBINED CONTROL SYSTEM

Saves energy by comprehensively controlling the Natural Chiller and its auxiliary equipment.

The combined control system comprehensively controls the Natural Chiller and its related energy-saving equipment. This product optimally controls each device while maintaining high efficiency and safety of the system.

Benefits

-  **[High efficiency]**
Optimum efficiency control of absorption chiller
-  **[Variable speed control]**
Variable speed control of cooling tower fan
-  **[Flow control]**
Flow control of chilled/hot water pump
-  **[Flow control]**
Flow control of cooling water pump



ZERO EMISSION ECO TOWN (ZEET) SYSTEM

Greatly reduces CO₂ emissions by utilizing refuse

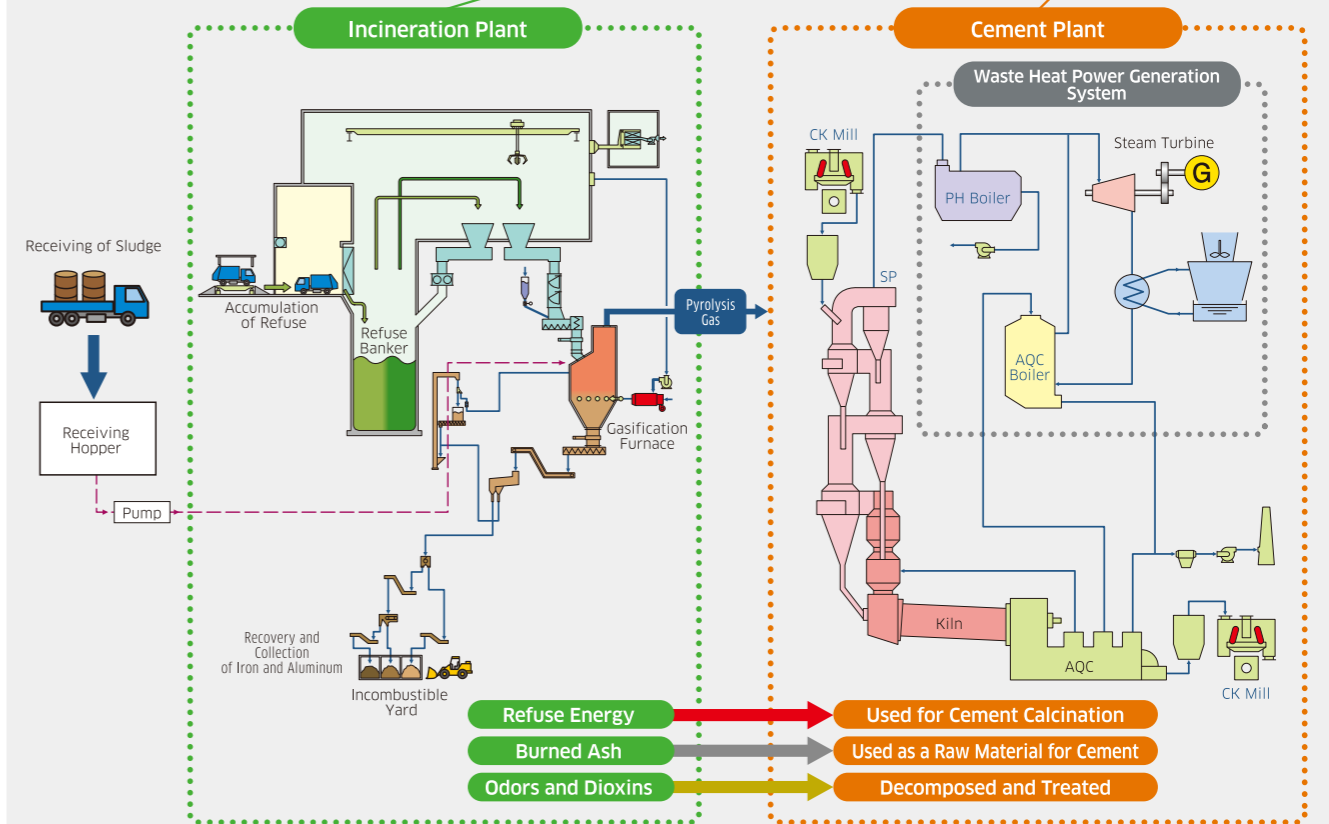
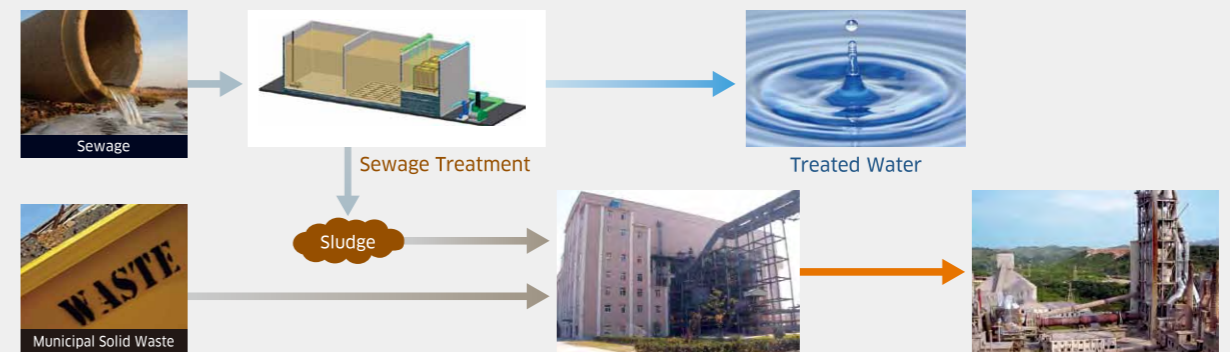
The Zero Emission Eco Town (ZEET) System treats refuse and sludge

hygienically, and processes into energy and raw materials for cement manufacturing. This system reduces the fuel consumption for cement manufacturing by obtaining energy from gasified refuse. Since the burned

ash is used as a raw material for cement, the final disposal of the ash is no longer required. This system reduces CO₂ emissions as compared to disposal by landfill.

ZEET (Zero Emission Eco Town) System

This system further reduces waste by recycling the waste water.



GENERATOR BUILT-IN TYPE

KAWASAKI RING POWER

Power generation system that enables use of untapped hydraulic energy

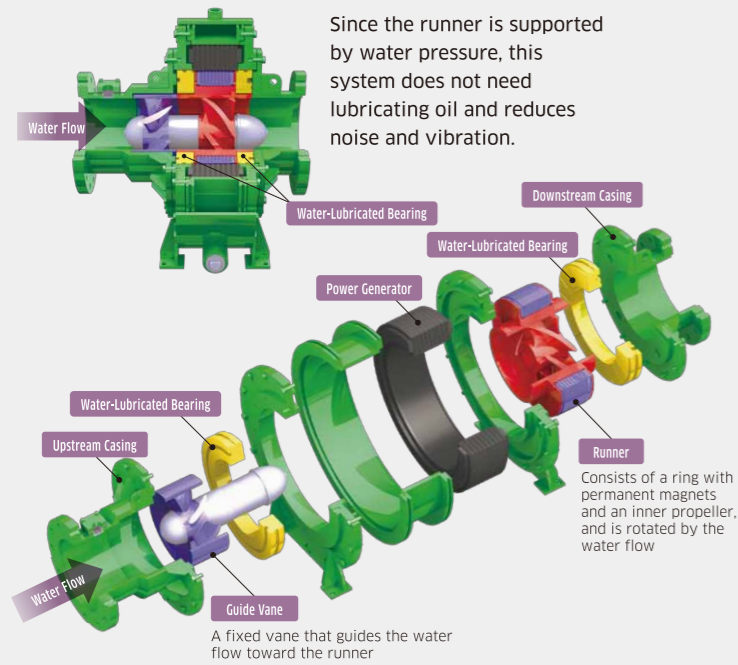
The small hydropower system generates power on a small scale for homes and local regions utilizing untapped hydraulic energy of up to 1,000 kW with minimal environmental

load. The compact and integrated structure of the generator and hydroturbine enables installation in narrow spaces. This product generates low noise and vibration and so can be installed virtually anywhere.



Example of installation at the Masaki Dam (Tokushima prefecture)

Integrated structure of a hydroturbine and generator with water-lubricated bearings

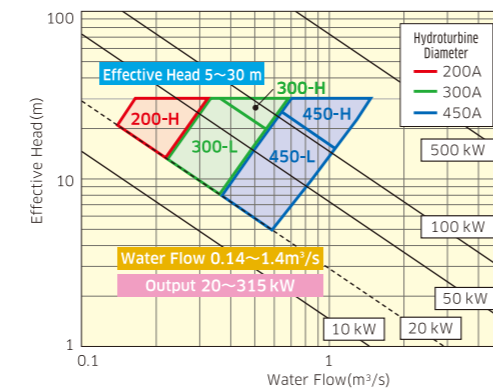


Features

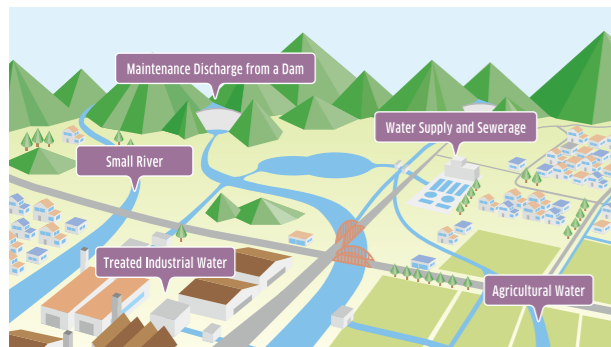
- ◎ **Compact**
Less than half the size of traditional in-line hydroturbines
- ◎ **Low environmental load**
Oilless water-lubricated bearings having no influence on the water quality
- ◎ **Maintenance-free**
Requires no daily maintenance such as changing oil or parts

Product lineup

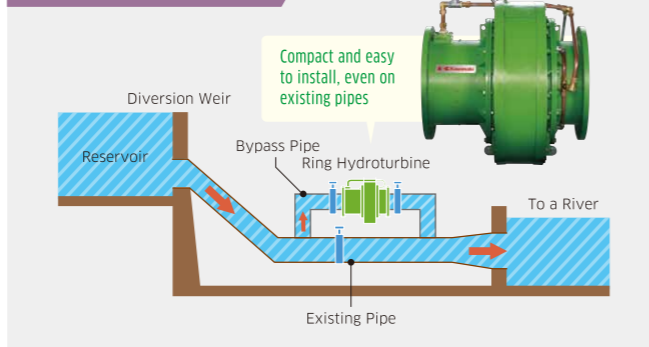
Five models cover a wide range of applications



Examples of untapped hydraulic energy



Schematic of installation



PHOTOVOLTAIC POWER GENERATION SYSTEM

Clean power generation system with no CO₂ emissions

The photovoltaic power generation system is a clean power generation system that utilizes unlimited sunlight energy and emits no CO₂. Combined with storage batteries, this system

lowers the peak of electricity import. The system also enables independent power generation in case of systematic power outage.

Features

- ◎ **Combinable with storage batteries**
 - Reduces electricity import while maintaining a comfortable environment without stopping air conditioning during summer afternoons
 - Emergency power supply at night and on rainy days, when photovoltaic power generation is not available
- ◎ **Optimum system design with any model**
- ◎ **Various construction options, such as on roofs, on structures, and in high places**
- ◎ **Enables construction of an independent electrical system by combining generators and storage batteries**



Location: First Gymnasium in Yachiyoshoin Gakuen School
Capacity: 100 kW + GIGACELL Start of operation: July 2005



Location: Former Iwaoka landfill
Capacity: 1,500 kW Start of operation: March 2014



Location: First Nagoya Plant of Kawasaki Heavy Industries
Capacity: 750 kW Start of operation: January 2011



Location: West-Kobe Plant of Kawasaki Heavy Industries
Capacity: 200 kW Start of operation: February 2009

WOODY BIOMASS GASIFICATION POWER GENERATION SYSTEM

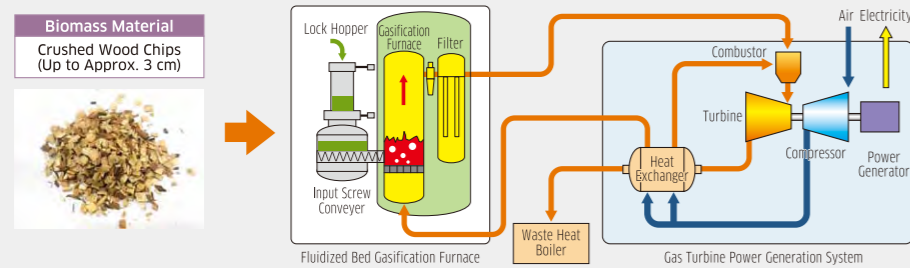
Small-scale, high-efficiency power generation system that utilizes organic sources

A small-scale dispersed power generation system that uses woody biomass such as waste wood from timber mills, and cuttings and thinned wood from forests. The system helps avoid troubles due to tarry

substances generated during gasification and achieves thermochemical regeneration utilizing exhaust heat. The two differing systems can handle biomass with diverse properties.

Fluidized bed gasification / gas turbine power generation system

This system effectively generates electricity as well as heat.



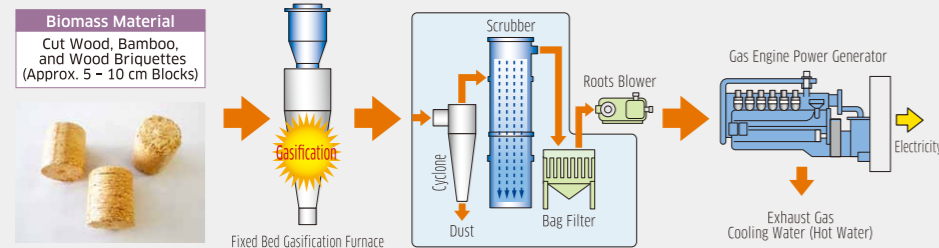
Biomass Feed Rate	350 kg/hour (Moisture: 45%)
Generated End Output	150 kW
Heat Use	Steam: 400 kg/hour
Hot Air Generation	350 Mcal/hour
Generated End Efficiency	15%
Total Efficiency (Electrical Power + Heat Use)	72%

Features

- **Not necessary to dry biomass**
Can use moist biomass
- **Compact design**
Compact layout without a water treatment system
- **Avoidance of tar troubles**
Complete combustion generating no tar
- **High energy efficiency**
Makes maximum use of biomass energy including heat

Fixed bed gasification / gas engine power generation system

This system is effective mainly for generating electricity.



	Type A	Type B
Biomass Feed Rate	80~100 kg/hour (Moisture: 10%)	200~250 kg/hour (Moisture: 10%)
Generated End Output	70 kW	175 kW
Heat Use	Hot Water 13 t/hour (80°C)	Hot Water 32 t/hour (80°C)
Hot Air Generation	55 Mcal/hour	140 Mcal/hour
Generated End Efficiency	20%	
Total Efficiency (Electrical Power + Heat Use)	51%	

Features

- **High electrical efficiency**
Electrical efficiency of 20%
- **Avoidance of tar troubles**
Dramatically reduces tar generation by gasification of woody biomass
- **High reliability**
High reliability by simple equipment configuration
- **Requires only 30 minutes to start up**
Starts up quickly and operates according to demand

BIOETHANOL PRODUCTION SYSTEM

Generates alternative energy without competing with food supply

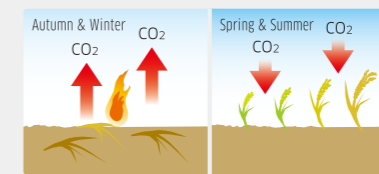
This technology produces bioethanol from materials such as rice straw which does not compete against food supply. Future of this system is that it uses "hot water-saccharification method" in saccharification process.

Unlike other existing systems this system does not use sulfuric acid so acid-resistant vessels and recovery equipment are not required and costs are lower because it does not use enzyme.

Circulation and utilization of carbon such as waste rice straw

The straw, which remained in the paddy field after harvest, is decomposed by microbe and becomes CO₂, which is emitted into atmosphere. When a rice grows, this CO₂ is absorbed by photosynthesis from the atmosphere. Thus, by utilizing the "carbon neutral" bioethanol manufactured from biomass as a fuel for automobile instead of gasoline, it can suppress the emission of CO₂.

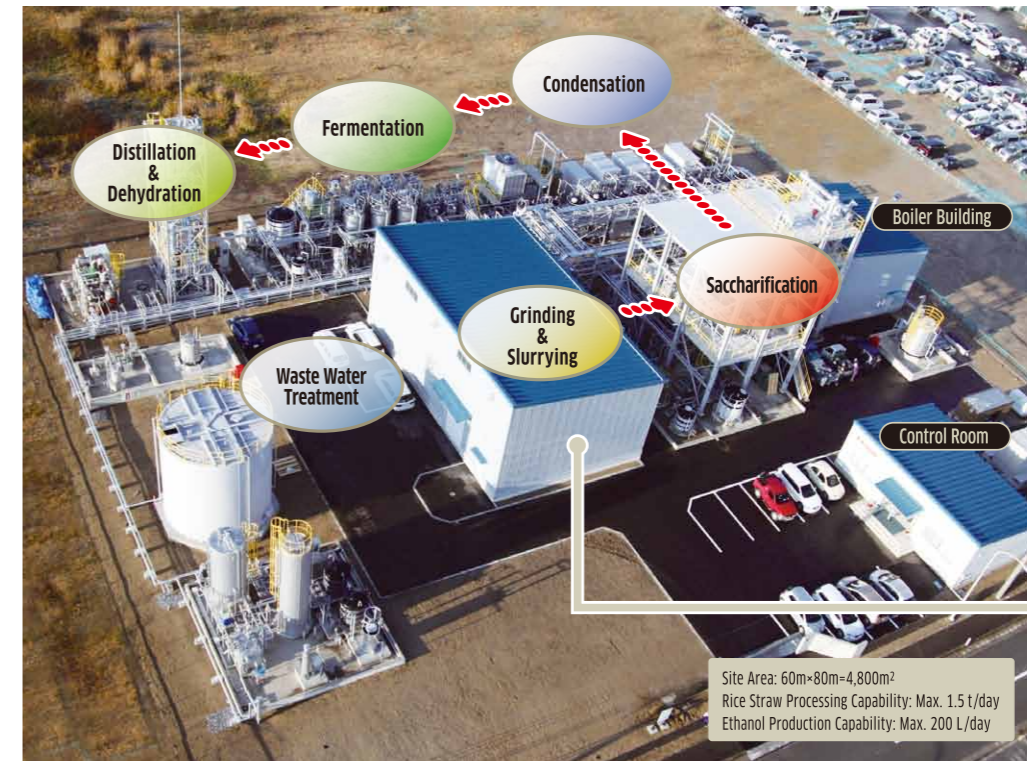
[Carbon Neutral]



[Image of Using Bioethanol]



Biofuel production system



Rice straw stored in the facility



Input into a cutting machine



Grinder

Actual running test

Proving test drive was performed with US made Flexible Fuel Vehicle (FFV) by using produced bioethanol (E100 = 100%) as fuel in the Ogata Solar Sports Line (full length: 31 km). Startup and driving tests in winter were also conducted and the results showed the availability of using ethanol in cold region.



Ogata Solar Sports Line



FFV

AIR CONDITIONING LOAD REDUCTION SYSTEM

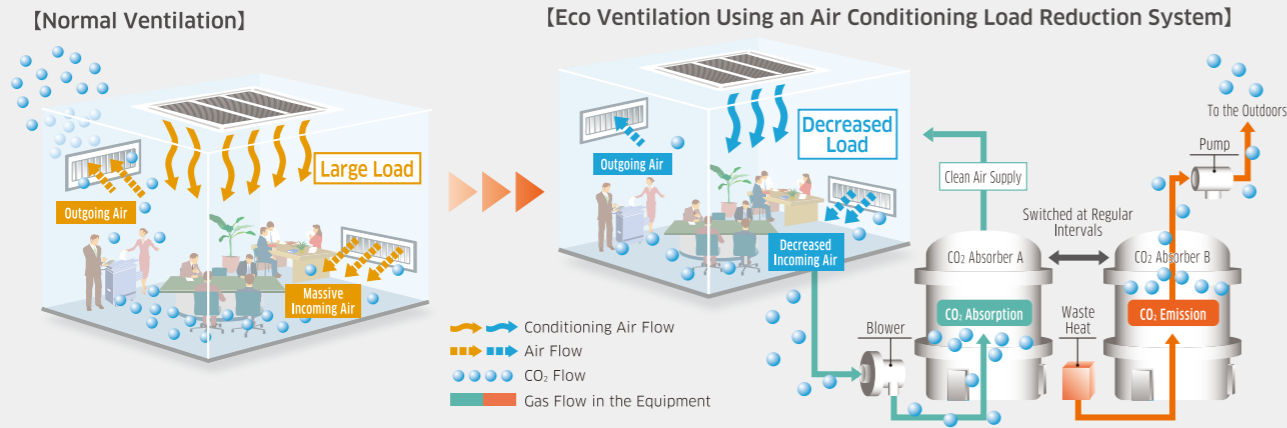
Under testing *At Kobe Plant Annex of Kawasaki Heavy Industries

Reduces power consumption for air conditioning by restricting heating and cooling air flows

Applying our unique CO₂ adsorbent technology, the Air Conditioning Load Reduction System keeps the CO₂ concentration below 1,000 ppm in

closed spaces (or rooms). The product reduces power consumption for air conditioning by restricting heating and cooling air flows.

Difference between normal and eco ventilation



HYDROGEN ENERGY-RELATED EQUIPMENT (TRANSPORT, STORAGE, USAGE)

Essential for the use of ultimate clean energy

Hydrogen is expected to be used full scale in the future as the ultimate clean energy that will emit no CO₂ or harmful gas during usage. Kawasaki

Heavy Industries is working hard to develop equipment for transporting, storing and using hydrogen energy.

Hydrogen energy

Produce

Produce clean and low-cost hydrogen using various methods.

Produce hydrogen from renewable energy such as brown coal, which is an unused resource, wind and photovoltaic power.

Transport/storage

Transport/storage technology, which is essential for diffusing hydrogen energy.

Liquid hydrogen transport container, Japan's largest liquid hydrogen storage tank, liquid hydrogen carrying vessel

Use

Sustainable future realized with hydrogen energy

Hydrogen gas turbine that does not emit CO₂ during combustion, hydrogen gas engine, fuel cell powered vehicle, etc.

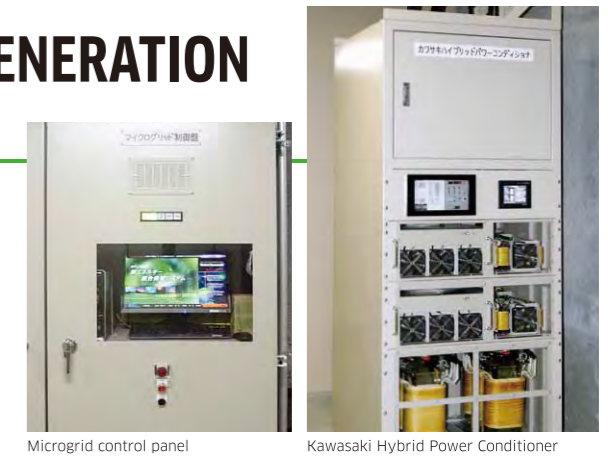
HYBRID DISTRIBUTED POWER GENERATION SYSTEM

KAWASAKI HYBRID POWER CONDITIONER

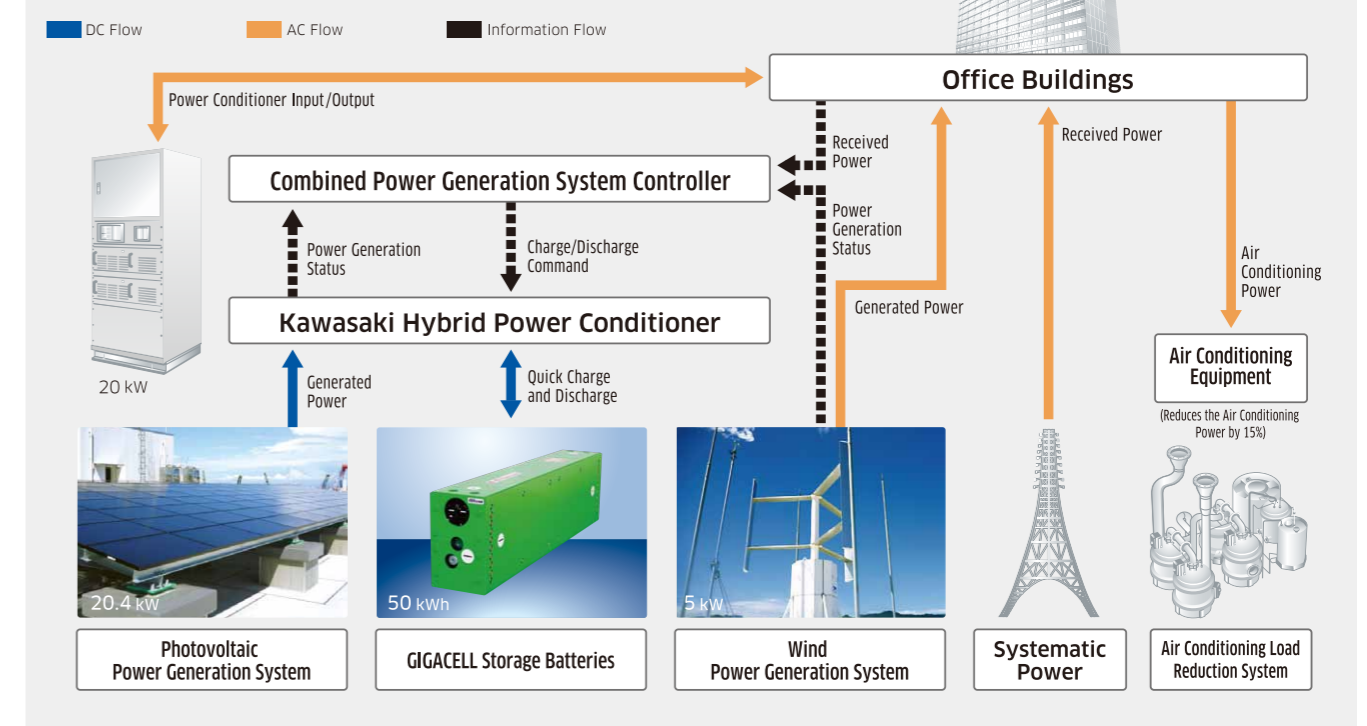
Shaves peak power consumption and ensures power supply during emergency, utilizing natural energy

charging and discharging performance of GIGACELL batteries, this system levels the output, shaves peak power consumption and provides spare power in case of a power outage.

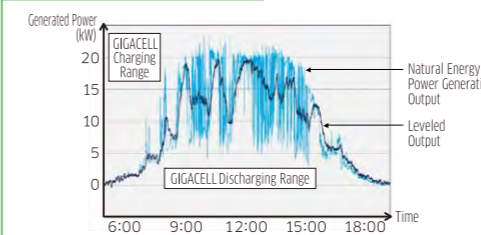
A hybrid power system that combines GIGACELL batteries with solar and wind power. By fully utilizing the quick



System flow (e.g., Kobe Plant Annex of Kawasaki Heavy Industries)

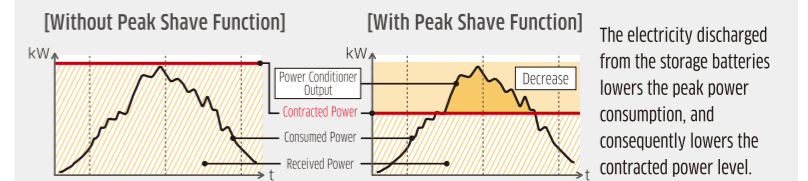


Output leveling function



The combination of power generation systems and storage batteries reduces power fluctuations and supplies stable power to the system. Even if a system outage occurs due to a natural disaster, this system can supply electricity by utilizing natural energy and discharging electricity from the batteries.

Peak shaving function



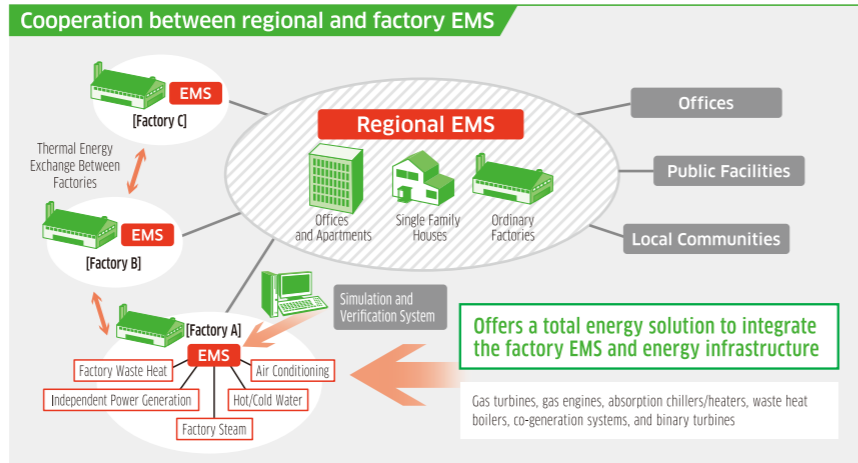
Power supply function in case of power outage

This system can supply electricity by utilizing natural energy and discharging electricity from the batteries even if a system outage occurs due to a natural disaster, such as lightning, hurricane, or earthquake.

THERMAL ENERGY MANAGEMENT SYSTEM *EMS: Energy Management System

Efficiently utilizes untapped thermal energy

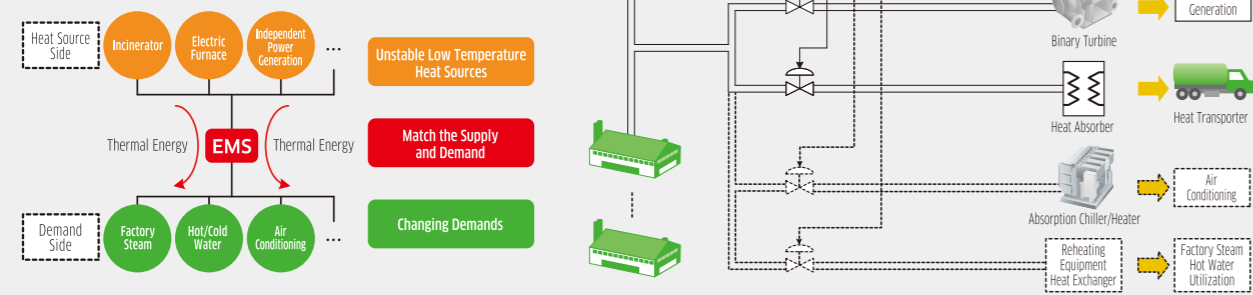
The Thermal Energy Management System is a solution to utilize various energy systems effectively. By introducing energy management systems into a given region as well as factories, it is possible to optimize the supply and demand for energy, including energy exchange among some factories and utilization of untapped thermal energy.



Concept of Thermal Energy Management System

The system effectively utilizes unstable low temperature heat sources by matching the supply and demand.

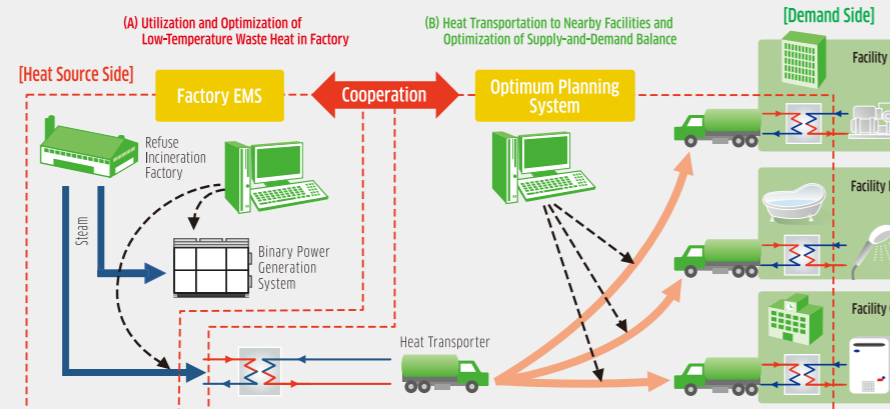
[Schematic Drawing]



Next-Generation Energy Technology Verification Project

Optimum utilization of thermal energy

Kawasaki, Osaka Gas, Osaka city, and Osaka prefecture are engaged in the Next-Generation Energy Technology Validation Project promoted by Japanese Government Ministry of Economy, Trade and Industry. This project develops EMS by using untapped low-temperature waste heat after refuse combustion power generation for binary power generation and transporting the combustion heat to nearby facilities that can use it.



GIGACELL® HIGH-CAPACITY NICKEL-METAL HYDRIDE BATTERY

Next-generation eco-friendly large size battery

GIGACELL's bipolar 3D design increases the capacity of each cell and its number per module. GIGACELL can be utilized in many applications: trams, railroad wayside energy storage systems, ancillary regulation, renewable energy integration and more. No lead, mercury, or cadmium is used, and its non-welded manufacturing process enables easy recycling. GIGACELL is a safe and eco-friendly battery.

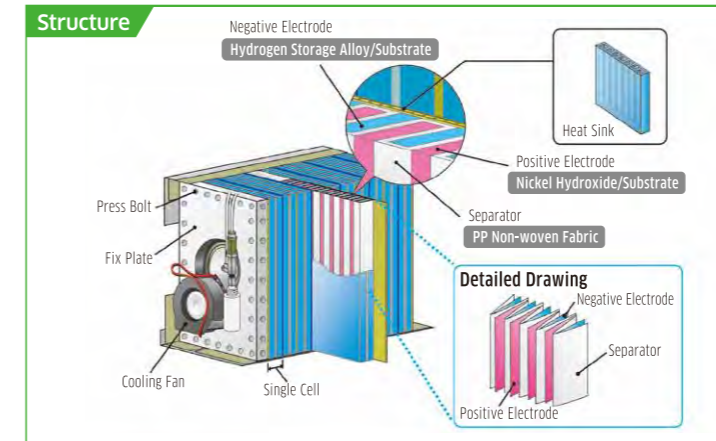
Specifications (30-K6)

Rated Voltage (V)	36
Rated Capacity (Ah)*1	141
Energy Capacity (kWh)	5.1
Outside Dimensions (mm)L-W-H*2	1287×218×350
Weight (kg)	248

*1: Discharge capacity when charged to 120% of rated capacity. As the recommended capacity will depend on the operating conditions, please discuss the exact needs of your application with our representative.
*2: Mounting hardware not included.



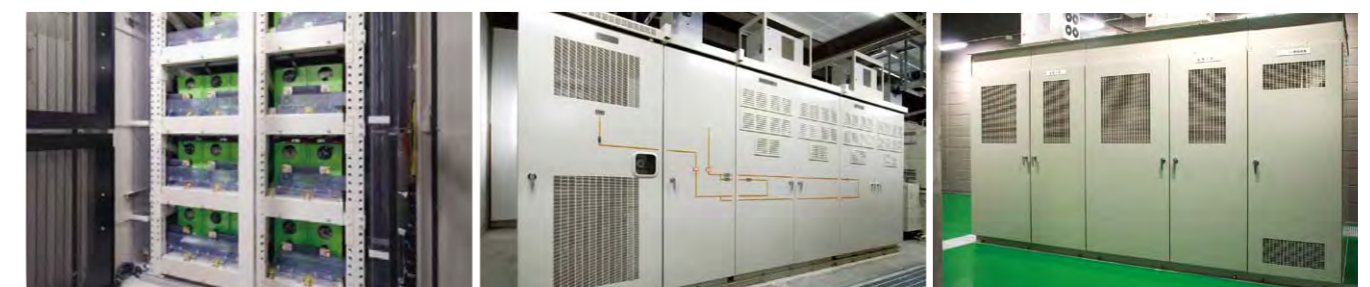
Structure



Features

- **High-capacity**
High capacity achieved by increasing the number and size of electrodes as well as the number of series cells
Flexible system design applicable to high-capacity and high-output use
- **Rapid charge and discharge**
Low internal resistance enables fast charging and discharging
- **Highly recyclable**
No welding is used, enabling easy disassembly for recycling

Application examples of GIGACELL



Battery Power System (BPS) for railways (205 kWh)

GIGACELL RENEWABLE ENERGY SMOOTHING

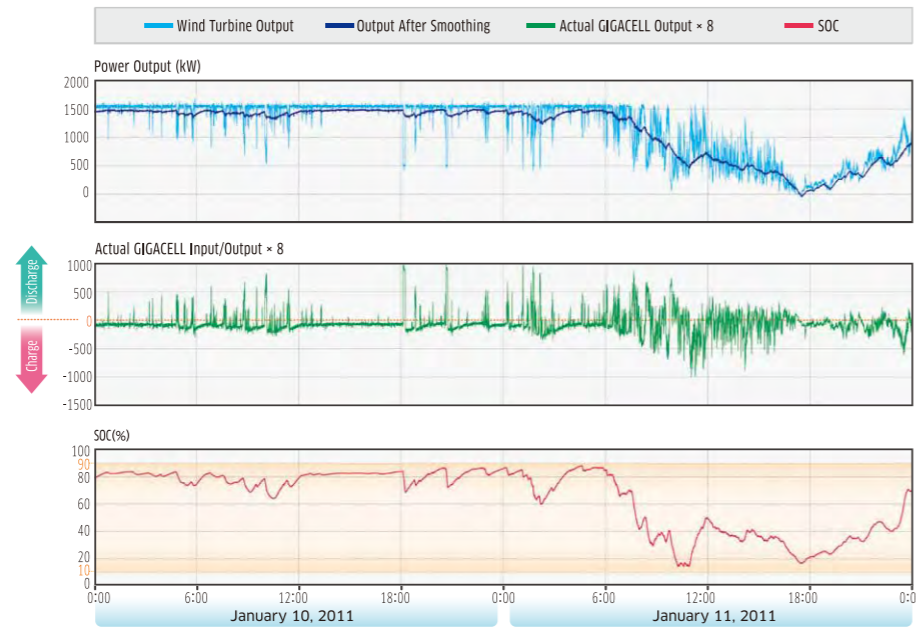
Optimum smoothing and ramp control

GIGACELL's fast response will smoothen fluctuating power output of renewable energy and enable stable connection to the power grid.

Nishime Wind Farm (Fuji Green Power Co., Ltd.) in Yurihonjo city, Akita prefecture



Example of smoothing wind power output (Verification test at Nishime Wind Power Plant) Joint research with Fuji Electric



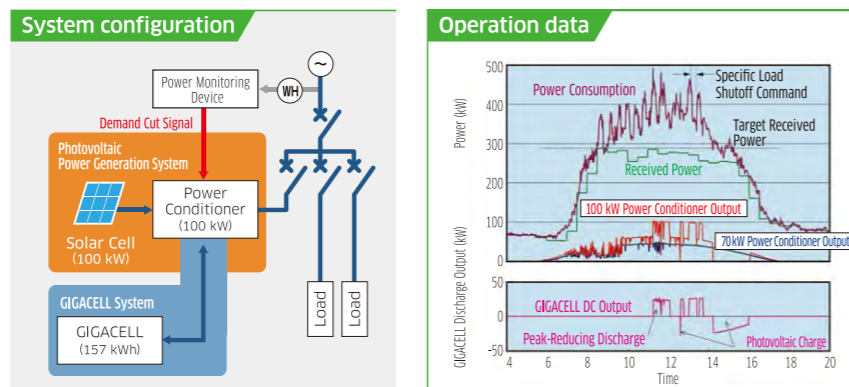
GIGACELL PHOTOVOLTAIC POWER GENERATION + GIGACELL BATTERIES

Photovoltaic power generation combined with GIGACELL batteries

Charging and discharging of electricity from GIGACELL batteries responds to fluctuations in the photovoltaic output and enables stable connection to the grid.

Features

- **Peak demand reduction**
The combination of photovoltaic power generation and the GIGACELL reduces peak power demand, and lowers contracted power utility costs
- **Independent back-up operation**
Provides power to important loads in case of power outages



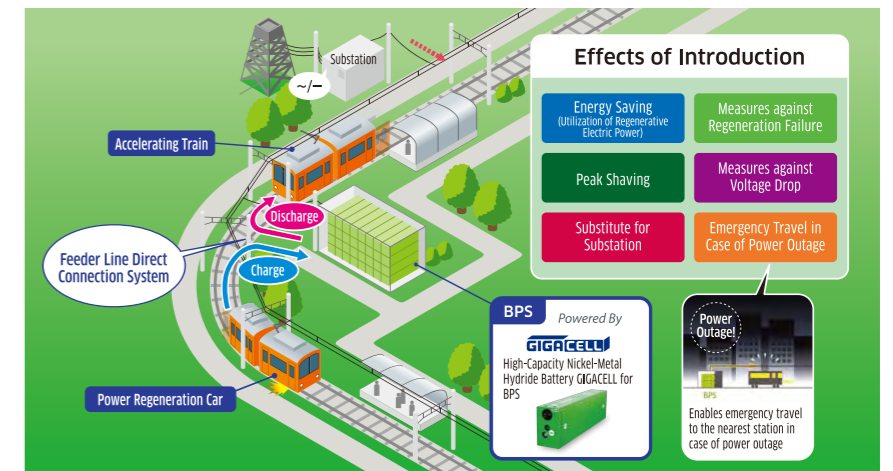
PV + GIGACELL system for Yachiyochoin Gakuen School



GIGACELL BATTERY POWER SYSTEM FOR RAILWAYS (BPS)

Stores regenerative energy and enables emergency runs

The BPS stores and reuses regenerative energy generated by braking trains. In case of power outages, the BPS enables trains to travel safely to the nearest station. This equipment can also substitute substations where space limitations make it difficult to construct new substations.



NEXT-GENERATION LIGHT RAIL VEHICLE (LRV) SWIMO

A new face in the environmentally friendly world

Runs smoothly even without power lines

The SWIMO can run using the electricity stored in GIGACELL batteries eliminating catenary lines and improving the city views.

GIGACELL REMOTE ISLAND FREQUENCY REGULATION

Enable more renewable energy on small, remote islands

Installing large quantities of renewable energy with unstable output in a small system on an isolated island increases the fluctuations in the system frequency. However, with GIGACELL batteries, which are capable of quick charging and discharging, a stable power supply can be achieved by complementing the regulating ability of existing power generators, thus suppressing variations of the system frequency.

Minamidaito Island Frequency Regulation System for the Okinawa Electric Power Co., Inc. (OEP) NEDO Subsidized Project: Development of a Large-scale Energy Storage System with High-safety and Cost Competitiveness



Features

- Provide alternative to generator governor adjustment
- Prevent frequency decline during renewable output drop
- Reduce grid frequency fluctuations due to unstable power

Conceptual diagram of the system

