Proactive Development and Full Adoption of Renewable Energy Options

The Kyuden Group is working to develop and incorporate renewable energy as part of our operations, recognizing its terrific potential as a source of domestically produced energy which can be effectively utilized, as well as a means of fighting global warming. We are undertaking a variety of renewable energy projects through which we seek to develop 4 million kW of renewable energy (2.04 million kW more than currently) domestically and overseas by 2030, focusing primarily on geothermal and hydroelectric energy.

Kyuden Group Renewable Energy Generation Facility Map Miyawaka Mega Solar Power Station Renatosu Soma Solar Park Asty Solar Power Station *Joint venture with Fukuoka Clean Energy Kyuden Mirai Energy partners Mega Solar Omuta Power Station Munakata Solar Power Station Ideura Water Treatment Plant Mega Solar Power Station Imari Mega Solar Power Station Karita Mega Solar Power Station Matsuura Mega Solar Power Station Higashi Hiroshima Mega Solar Power Station Washiodake Wind Power Sasebo Mega Solar Power Station Sugawara Binary Power Station Omura Mega Solar Power Generation Units 1-4 Takigami Power Station Hatchoubaru Power Station Hatchoubaru Binary Power Station **Otake Power Station** umamoto Kikuchi Mega Solar Power Station Miyazaki Biomass Recycling Power Station Miyazak Nagashima Wind Power Station Matsubara Power Station Koshikijima Wind Power Station Yanagimata Power Station Noma-misaki Wind Park Morotsuka Power Station Tsukabaru Power Station Ogiri Power Station Iwavado Power Station Yamagawa Power Station Yamagawa Binary Power Station Hitotsuse Power Station Amami Oshima Island Kamishiiba Power Station Oyodogawa Daini Power Station Oyodogawa Daiichi Power Station Aya Mega Solar Power Station Amami Oshima Wind Power Station ... and 131 other (hydroelectric) facilities As of March, 2018

Renewable Energy: Advantages & Disadvantages -

Advantages It produces no CO₂ during power generation.

It is essentially inexhaustible.

Disadvantages

Output susceptible to weather and other natural conditions (solar, wind).

High generation costs (solar)

Limited feasible locations (hydroelectric, geothermal)



CO₂ Emission Reductions Achieved Using Renewable Energy at the Kyuden Group (FY2017)



*See the section on environmental data (p. 49) for information on CO₂ emission reductions by generation method.

Harnessing Kyushu's Abundant Geothermal Resources

Unlike other forms of renewable energy power generation, such as solar and wind, geothermal facilities are not dependent on weather conditions and times of day. We have long sought to harness the potential of geothermal power generation, and now operate around 40 percent of all geothermal power stations in Japan, including the country's biggest facility: Hatchoubaru Geothermal Power Station in the town of Kokonoe, in the district of Kusu, Oita Prefecture, which is capable of generating 110,000 kW.

The Kyuden Group is working hard to develop facilities in areas with sustainable resources in Kyushu, throughout Japan, and around the world. To that end, we are surveying geothermal resources in the village of Minamiaso in Kumamoto Prefecture, as well as Yufu City, Oita Prefecture and the area to the south of Yamashita Lake in Kusu.

Sarulla Geothermal Power Station, the world's largest, commenced full-scale operation

The Sarulla Geothermal IPP* Project began when Kyushu Electric Power acquired the concession to extract resources in October 2007. Full-scale construction began in Sumatra, Indonesia, in May 2014, and all three generators were brought online in May 2018, with a capacity of approximately 330,000 kW.

This project is a prime example of how our technology and expertise, amassed through long experience in the entire geothermal power generation process from development to supply, can be applied for global benefit.

*IPP stands for "independent power producer," a business that generates power and sells it wholesale to distributors. This is in contrast to power companies, which handle all processes from generation through to retail.



Units 2 and 3 of the Sarulla Geothermal Power Station, the biggest IPP project in the world

Commenced operation of binary power stations utilizing untapped geothermal energy

In February 2018, Kyuden Mirai Energy, one of the Kyuden Group companies, commenced operation of the **Yamagawa Binary Power Station (4,990 kW)** on the site of our existing Yamagawa Geothermal Power Station in Ibusuki, Kagoshima Prefecture.

The binary power station uses energy that remains unused by the existing geothermal generation facilities and would otherwise be returned underground. We supply the heat (in the form of reinjected hot water) and Kyuden Mirai Energy operates the binary generation facilities—a real group effort!



The Yamagawa Binary Power Station uses untapped energy

Promotion of Solar Power Generation Utilizing Idle Land

Kyuden Group companies are developing our unused land and sites of disused power stations into mega solar facilities.

Commenced Mega Solar operation with a maximum output of 43,500 kW

In June 2017, Kyuden Group companies Kyuden Mirai Energy and Kyudenko teamed up with private-sector partners Orix and two other companies in a joint venture called **Renatosu Soma Solar Park, LLC.,** to build and operate **a mega solar power station** in Soma City, Fukushima Prefecture. The facility has a maximum capacity of 43,500 kW (see p. 20 for photos).

Floating solar power generation facility overseas

Kyuden Mirai Energy, a group company, has begun to make inroads overseas, including a solar power generation system comprising an array of floating solar cell modules on a reservoir at the Tree Valley Life Science Museum in Tainan, Taiwan. This project, too, is a joint venture with partners including Kyudenko, Tokyo Century and one other company. The facility, which began operations in April 2018, has a capacity of 1,130 kW.



The floating modules at the Tree Valley Life Science Museum in Taiwan

Promotion of Biomass Generation which Contributes to Waste Reduction

Biomass power generation is economically advantageous, and there is always a steady supply of fuel. We are working with partners concerning the construction of, and other matters related to, woody biomass power stations.

Work begins on one of Japan's largest biomass power generation projects

Buzen Biomass Power Station

In October 2016, Kyuden Mirai Energy and Kyudenko teamed up with Erex to create a joint venture, **Buzen New Energy, LLC.** Together, the participating companies are constructing one of Japan's largest woody biomass power station in Buzen City, Fukuoka Prefecture (photos on p. 20). The facility, which is scheduled to commence operations in January 2020, will have a capacity of 74,950 kW.

Shimonoseki Biomass Power Station

Shimonoseki Biomass Energy, LLC., a joint venture established by Kyuden Mirai Energy, Nishinippon Plant Engineering and Construction, and Kyuden Sangyo, is planning to construct another woody biomass power station to be counted among Japan's largest. The facility, which is scheduled to commence operations in January 2022, will have a capacity of 74,980 kW.



An impression of how the Shimonoseki Biomass Power Station will look upon completion

Collaboratory initiatives between industry, academia and government use biomass power generation to promote the forestry industry and reforestation

Kyuden Mirai Energy and Kyudenko, together with four partners including Soyano Kenzai, are planning to construct a woody biomass power station in **Shiojiri City**, **Nagano Prefecture**, as part of a partnership involving the prefectural and municipal governments. The facility will seek to generate new demand for wood and promote cyclical use of natural resources **by using the heretofore abandoned waste from forest thinning operations and offcuts from wood processing facilities as biomass fuel**. The facility, which is scheduled to commence operations in October 2020, will have a capacity of 14,500 kW.



The planned site of the power station on the grounds of Soyano Wood Park

Tidal Power Demonstration Project

Technologies that use the incoming and outgoing motion of tides to generate electricity are ideal for an island nation like Japan and have minimal environmental impact. This testing facility is aimed at developing this new form of renewable energy power generation.

Japan's first commercial-scale tidal power generation demonstration project

Kyuden Mirai Energy is part of a consortium with three partners including the Nagasaki Marine Industry Cluster Promotion Association that was selected for the Project for the Promotion of Practical Applications of Tidal Power Generation Technology in 2016. At present, the consortium is designing instruments based on tidal studies with the aim of developing **a commercial-scale (2,000 kW-level) tidal power generation facility at Naruseto off the coast of Goto City, Nagasaki Prefecture**. Testing is scheduled to start in 2019.

Maximal Purchasing of Electricity Generated from Renewable Resources

Configuring to maximize generation and use of renewable energy sources

We strive to make and buy as much electricity as possible from renewable energy sources like sunlight and wind, but these are limited by weather conditions and time of day, so where necessary we augment them with in-house thermal and pumped-storage hydro power generation facilities.

Also, the Buzen Power Station is home to the Buzen Storage and Transformer Substation, one of the world's largest-capacity storage battery systems, which is capable of storing 300,000 kWh and has an output capacity of 50,000 kW. The substation was established in March 2016, and helps balance demand and supply by storing energy into the batteries or discharging it in response to solar energy output.

Moreover, in order to make more accurate predictions of generation from renewable energy sources, we use satellite images to estimate sunlight and make output projections, and are developing wind speed models.

Demand and Supply Results for May 3 (Thurs), 2018

Around 80 percent of the electricity supplied to customers between 12 p.m. and 1 p.m. was solar power, the highest ratio of solar power to overall demand we have achieved so far.



Hydroelectric Pumped-Storage Generation System

Two large regulating reservoirs are created at a power station, one above and one below the facility. When demand is high, water in the upper reservoir is released, and its momentum as it flows down into the lower reservoir is used to generate electricity. Then, when the supply of electricity is higher than demand, the surplus is used to drive the pumps that return the water to the upper reservoir.



Improving the Supply and Demand Balance with Large-Capacity Batteries

A substation with batteries that can store enough electricity to power 1,000 homes for a month

The **Buzen Storage and Transformer Substation** was built to improve the balance between supply and demand. With 252 sodium-sulfur (NAS) batteries,* the substation is able to store enough electricity to power a thousand regular households for a month (300,000 kWh), and has an output capacity of 50,000 kW.

In practice, electricity is utilized efficiently by storing energy during the hours when solar power generation increases (between 9 a.m. and 3 p.m.), discharging it during darker hours when power consumption, such as for lighting, is higher.



Buzen Storage and Transformer Substation

*NAS batteries are storage (secondary) batteries that use the chemical reactions between sulfur and sodium ions to charge and discharge electricity. They are smaller than lead batteries and last longer.

Demonstration Project Aimed at Improving Demand and Supply Balance

In June 2018, a group of five companies—the Central Research Institute of Electric Power Industry, Nissan Motor, Mitsubishi Motors, Mitsubishi Electric, and Kyushu Electric Power—began **testing**^{*1} "**vehicle-to-grid**" (**V2G**)^{*2} **technology**, which seeks to use electric vehicles as a means of regulating the balance between electricity demand and supply.



*1 The testing project is partially funded by the government through the Ministry of Economy, Trade, and Industry, Agency for Natural Resources and Energy's Project for Testing Virtual Power Plants*³ that Use Demand-Side Energy Resources.

*2 Vehicle-to-Grid systems take energy stored in electric vehicle batteries to power the grid.

*3 Virtual Power Plants are systems that use high-level aggregation technology to manage the discrete energy sources in homes, factories, and other such facilities remotely via the Internet of Things in order to regulate the balance of electricity demand and supply.