Kawasaki

Kawasaki Gallery

Heizo Kanayama's World

Untitled (*Danmari* fight-in-the-dark scene from *Marutsukayama*), date unknown, 22.9 x 30.2 cm, oil on paper, from the collection of Hyogo Prefectural Museum of Art.

Reminiscence of Childhood: A Work from the *Shibai-e* Series

Shusaku Sagara, **Associate Curator, Hyogo Prefectural Museum of Art**

While he was working on a large-scale mural, *Nisshin Eki Heijo Sen* (The Battle of Pyongyang During the Sino-Japanese War), for the Meiji Memorial Picture Gallery in September 1928, Kanayama fell gravely ill. He barely survived after surgery, and was not able to recover enough strength to work outdoors. It was then, on a whim, that he began working on a series of *Shibai-e* (kabuki-themed paintings), inspired by his memories of childhood in Kobe. These paintings, which he continued to produce over the years, were kept private except from a few fellow artists, such as Takeji Fujishima, and were first made available to the public in 1960 at the exhibition *Kanayama Heizo Shibai-e To Kinsaku Ten* (Heizo Kanayama Exhibition of Shibai-e and Recent Works), in Nihonbashi, Tokyo.

The painting describes a scene, *Marutsukayama No Ba,* from the kabuki play *Nansō Satomi Hakkenden* (The Chronicles of the Eight Dog Heroes of the Satomi Clan of Nanso), in which two warriors, Dosetsu Inuyama and Sosuke Inukawa, fiercely fight in the dark. These fighting scenes in the dark are called *Danmari,* and Kanayama demonstrates his exceptional gift of precise depiction, fully incorporating the stage elements including a trap-door.

Kanayama is often dubbed a master painter of existing scenery, but these Shibai-e reveal a different side. They tell us that Kanayama was in fact an artist who carefully and diligently worked out his compositions, and had a very distinctive perception of body movement, which can also been seen in his dance photographs.

Heizo Kanayama and Kawasaki

Heizo Kanayama (1883 -1964) went to Europe in 1912, after graduating at the top of his class from the Tokyo University of the Arts. He won the second prize at the Ministry of Education Art Exhibition in 1916, and went on to create many masterpieces in which nature is a recurring theme. Kanayama left an indelible imprint on the history of modern art in Japan.

The Shipyard, exhibited at the Ministry of Education Art Exhibition in 1917 (and featured in *Scope 83*), is the work that first brought Kawasaki and Kanayama together. Toward the end of Kanayama's life, Kawasaki agreed to the artist's request to permanently house 138 pieces of his artwork. Kawasaki has since donated a major portion of this collection to the Hyogo Prefectural Museum of Art.

July 2012

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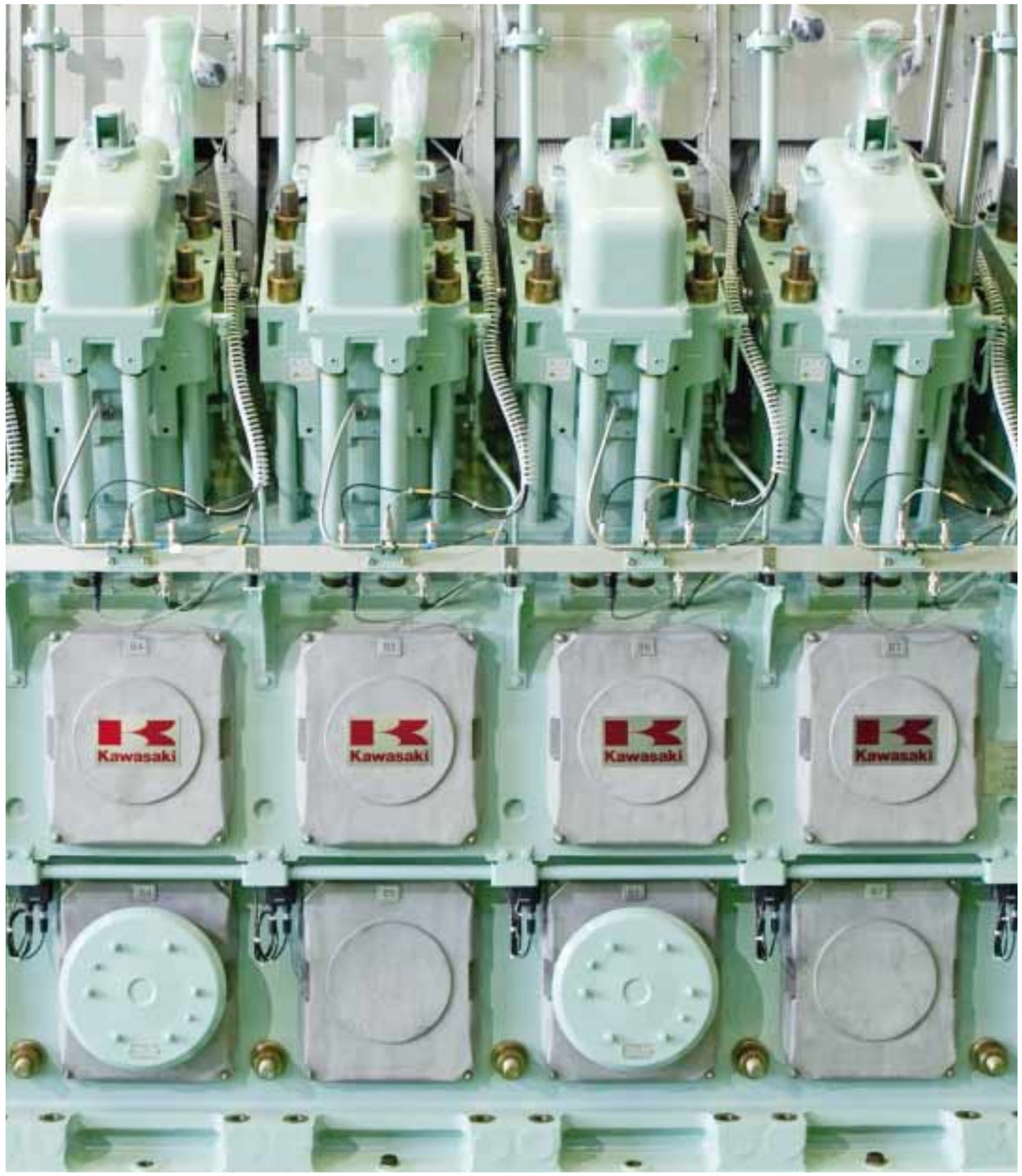
Scope

Kawasaki Heavy Industries Quarterly Newsletter

Kawasaki



Kawasaki Heavy Industries
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in this issue...

About the Cover
The cover is a closeup of the Kawasaki Green Gas Engine's ignition system and other components. This issue's Frontline features a story on the Green Gas Engine, now rapidly gaining attention both at home and abroad.

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Part I

Dawn of a New Era in Electrical Energy

The Appeal of Kawasaki Green Gas Engine

Without electricity, life as we know it would be unthinkable.

The March 2011 earthquake-triggered disaster that befell the Fukushima Daiichi nuclear power plant marked a turning point for Japan in terms of how electricity is produced, supplied and used. An increasing number of factories are introducing private power generators, and a new breed of independent electric power suppliers, called PPS (power producer & supplier), has been steadily expanding operations.

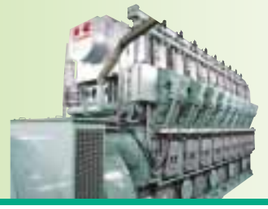
Against this backdrop, Nihon Techno Co., Ltd., a PPS whose main lines of business include maintenance services for high-voltage substations and energy efficiency consulting, is building a 110 MW power plant dubbed Sodegaura Green Power.

This power plant will produce electricity using Kawasaki's proprietary Green Gas Engines—14 in total—boasting a world-leading generating efficiency of 49.0%. When complete, it will be the largest gas-engine-based power plant in Japan.

This issue's *Frontline* offers an in-depth look at Nihon Techno's epoch-making power plant and the appeal of the Kawasaki Green Gas Engine.

The Green Gas Engine assembly plant at the Kobe Works bustles with activity. Engines are assembled on the right side of the aisle, while test runs are performed on the left side.

110 MW Power Plant with 14 Green Gas Engines



Construction Making Steady Progress

Construction of Nihon Techno's new power plant is now underway in Sodegaura City, Chiba Prefecture.

The plant will generate electricity using 14 Kawasaki Green Gas Engines (Model KG-18-V), each of which boasts an output capacity of 7,800 kW and the world's highest power-generating efficiency of 49.0%. With a power plant this large, gas turbines are usually the norm. A power plant consisting entirely of gas engines with a combined generating capacity of over 100 MW will be a first for Japan. Kawasaki is providing a full turnkey solution for the project, including plant design, manufacture and installation of the power generators, and civil engineering.

Green Gas Engines were chosen for Sodegaura Green Power, as the plant is called, not just because they are efficient, environmentally friendly and enable a quick turnaround—they were chosen because Nihon Techno, a PPS with a customer base of approximately 39,000 businesses nationwide, considered them ideal for ensuring a safe, reliable supply of electricity.

PPS Business as an Added Service

With numerous electrical engineers on its payroll, including some 750 contractors, Tokyo-based Nihon Techno offers a broad range of services, including the maintenance of high-voltage substations and energy efficiency consulting.

Lately, there has been a surge of interest in smart meters, which enable two-way communication with the power supplier, feeding back data on electricity consumption. Nihon Techno began tracking energy consumption from as early as 1996, and it has helped a variety of businesses save energy, including small factories and retailers. Based on the know-how it built up over years of helping businesses improve operations, it offers the option to reduce utility bills through its low-cost energy. The primary beneficiaries are businesses that see little result from energy-saving efforts because of energy prices that remain constant due to fluctuating demand. Nihon Techno is not the run-of-the-mill kind of PPS; it provides a one-stop solution to all things concerning electricity, from maintenance and energy efficiency consulting to energy provision.

The goal has always been to optimize electricity use for customers. In PPS businesses as well, Nihon Techno has been searching for power-generation equipment that can respond flexibly to electricity demand, so that it can offer low-cost electricity to customers with low electrical loads. Kawasaki Green Engines, which enable flexible output levels while maintaining high generating efficiency in any situation, make an ideal choice.

Engines to Begin Operation this Summer

At Sodegaura Green Power, half of the Green Gas Engines started operating on July 1 this year, with the remaining half becoming operational in the middle of August. Construction began in November 2011, meaning it has taken only a year to get a 110 MW power plant up and running, including the planning phase. Short lead time is another big appeal of the Green Gas Engine.

At the construction site, installation of gas engines and extra-high-voltage equipment began in early April, and construction work is moving ahead at fever pitch.

Over 20 Engines Ordered in 2011

Kawasaki received orders for a total of more than 20 Green Gas Engines in 2011, including the 14 for Sodegaura Green Power. The other orders came from a variety of end users, such as chemical companies, automakers and food producers.

Kawasaki's Kobe Works also has one installed—Model KG-12—with an output capacity of 5,000 kW. This gas engine has been in use since January 2010, with the aim of accumulating greater operational know-how through actual use, and to apply that know-how to making more effective proposals covering the entire gamut from introduction to operation and aftersales services.

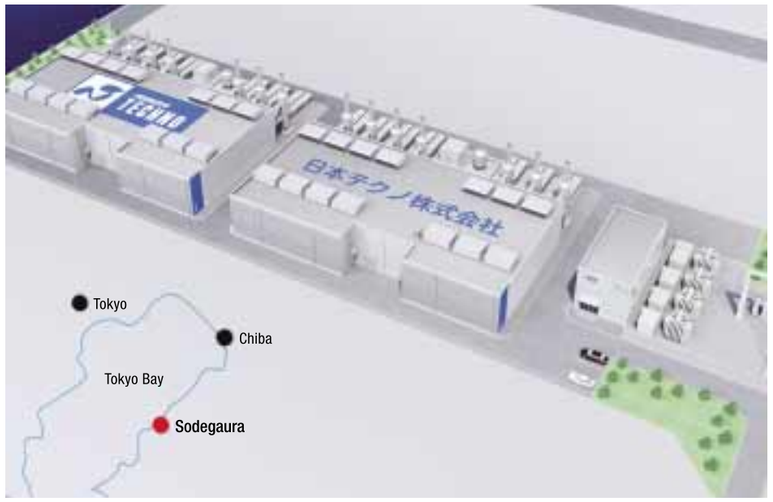
Two of the gas engines ordered, both Model KG-18-V (7,800 kW), will be shipped overseas, to be used at Singapore's first LNG terminal. They are scheduled to begin operation in January 2013.

Tapping into Markets Overseas

Since the focus has been on the domestic market after the Tohoku Earthquake, sales of Green Gas Engines have mostly taken place at home. But the original target was overseas markets.

There is ever-increasing demand for electricity in the emerging economies, driven by industrialization and economic growth. Distributed power generation, including private power generation and small-scale power plants, fulfills the need.

In Southeast Asia, Kawasaki has been marketing to Japanese companies operating in the region. To further expand sales efforts, Kawasaki has joined forces with an Indonesian engineering firm through whom it supplies Kawasaki Green Gas Turbines. Similar efforts are also being undertaken in other parts of the world.



An image of the Nihon Techno Sodegaura Green Power complex after it is completed.

Construction of the power plant proceeds (Photo 1) while Kawasaki Green Gas Engines are brought in (Photos 2 & 3) to the Sodegaura Green Power construction site. All 14 engines at the power plant are slated to begin operation by mid-August of this year. It will have taken just one year to get a 110 MW power plant operating, thanks to the short lead time of the Green Gas Engine.

World-Leading Generating Efficiency and Superior Environmental Performance

"GREEN" as an Expression of Eco-Friendliness

Ever since it started pioneering diesel engines in 1919, Kawasaki has developed and manufactured a variety of engines. The Green Gas Engine was completed as a result of four years of development efforts, combining the gas engine project of Kawasaki's Gas Turbine & Machinery Company and the Technical Institute. The proprietary flow analysis technology Kawasaki established through the development of motorcycle engines was also leveraged.

The word "GREEN" in the engine brand name is actually an acronym standing for "Get Reliable, Eco-friendly Energy Now," encapsulating the concept of an environmentally friendly engine.

By employing clean natural gas and city gas for fuel, and by improving generating efficiency and environmental performance, these engines have significantly reduced environmental impact.

Complete Combustion with Minimal Knocking

Engines generally work by igniting fuel inside cylinders to set off an explosion (expansion), which generates pressure that causes the reciprocal motion of pistons, and then converting this motion into rotational energy. While diesel engines and gasoline engines use liquid fuel, gas engines—though the engine mechanism itself is the same—use gas for fuel.

When Kawasaki embarked on the development of Green Gas Engines, the power-generating efficiency (the amount of electricity generated compared to the energy content of the gas used) of existing gas engines was around 46%. Kawasaki set its sights on developing a gas engine with the world's best performance. The key to fulfilling this goal was optimizing the shapes of the main and auxiliary combustion chambers and regulating the amount of gas and air in each cylinder.

The combustion chambers were optimized using Kawasaki's proprietary flow analysis technology, cultivated through the development of various types of engines. The shape of the piston heads is another innovative feature.

The main and auxiliary combustion chambers are supplied with fuel gas through separate solenoid valves, so the timing and amount of injection are always optimized. The gas solenoid valves, ignition timing, knocking (abnormal combustion) and the air-fuel ratio of all 12 or 18 cylinders are centrally controlled by a main control unit. These design features helped reduce knocking, which works against improving generating efficiency, and as a result, complete combustion is attained more quickly and robustly.

The Green Gas Engine. Having attained the world's highest generating efficiency of 49.0%, Kawasaki is continuing efforts to reach 50%.

Going From 48.5% to 49.0%

With the Green Gas Engine, Kawasaki attained the world's highest generating efficiency, 48.5%. Subsequently, a higher-efficiency model was developed that employs variable nozzles for the supercharger (a generic name for devices that send compressed air into the engine), further improving generating efficiency to 49.0%. This is an increase of approximately 3 percentage points—an extremely large figure in this field—over the level when Kawasaki started development.

Green Gas Engines use a spark plug ignition system, eliminating the need for liquid fuel, and are capable of reaching full load just 10 minutes from standstill. With a wide operating range spanning 30% to 100%, they also maintain high generating efficiency at partial load.

World-Class Low-NOx Emission

Since gas engines normally use environmentally clean natural gas for fuel, they emit approximately 30% less CO_2 and 90% less NOx than diesel engines, which use liquid fuel. The environmental performance of Green Gas Engines goes even further, reducing CO_2 emissions by over 5% and NOx emissions by about 50% compared to existing gas engines. NOx emission is kept to within 200 ppm (at 0% O_2), the lowest level in the world. Even if an additional DeNOx system is needed to satisfy local regulations, consumption of ammonia and urea that are used as DeNOx catalysts is kept at a minimum. In regions where the regulation requires 200 ppm, the DeNOx system itself is not needed.

At the processing plant, state-of-the-art automatic processing machines efficiently handle high-precision work.

High Interest both at Home and Abroad

The current Green Gas Engine is available in standard and high-efficiency models, with a generating efficiency of 48.5% and 49.0%, respectively. When the number of cylinders—12 and 18—is accounted for, the total comes to four models. The power-generating unit supports frequencies of both 50 Hz and 60 Hz, catering to a variety of needs.

The engine is attracting numerous inquiries and orders, both in and out of the country. To meet the growing demand, Kawasaki expanded its production capacity to four engines per month. The Kobe Works, where Green Gas Engines are manufactured, is now in the midst of a boom.

Kawasaki is currently pursuing development of a new model that would attain an astounding generating efficiency of 50%.

Work proceeds on schedule at the assembly plant. Kawasaki raised the production capacity of Kobe Works to four engines a month, to meet the growing demand both at home and abroad.

Preparations are made for the test run of completed engines.

Waste Incineration Facility for Clean, Eco-Friendly Combustion: How Kawasaki's Advanced Stoker System Works

Kawasaki Advanced Stoker System Installations

Kishiwada Kaizuka Clean Center
Daily incineration capacity: 531t (177t x 3 furnaces)
Power-generating capacity: 12,000 kW
Completed: March 2007

Hirakata Tobu Waste Incineration Plant
Daily incineration capacity: 240t (120t x 2 furnaces)
Power-generating capacity: 4,500 kW
Completed: December 2008

Gumi City MSWIP*, South Korea
Daily incineration capacity: 200t (100t x 2 furnaces)
Power-generating capacity: 2,940 kW
Completed: December 2010

*MSWIP: Municipal Solid Waste Incineration Plant

High-Temperature Combustion Gas Flows in Parallel with Waste for Complete Combustion

Demand has grown in recent years for waste incineration facilities that comply with ever-stricter environmental regulations and make more efficient use of combustion energy.

The Kawasaki Advanced Stoker System was developed to answer this call. Since it completely burns waste at high temperatures, emission of such toxic substances as CO (carbon monoxide) and dioxin is kept to an absolute minimum. Because the system achieves complete combustion at a low air ratio, the amount of gas released into the atmosphere is reduced as well. And the clean ash that remains after combustion contains no unburned material, so it can be put to effective use — as a raw material for cement, for instance.

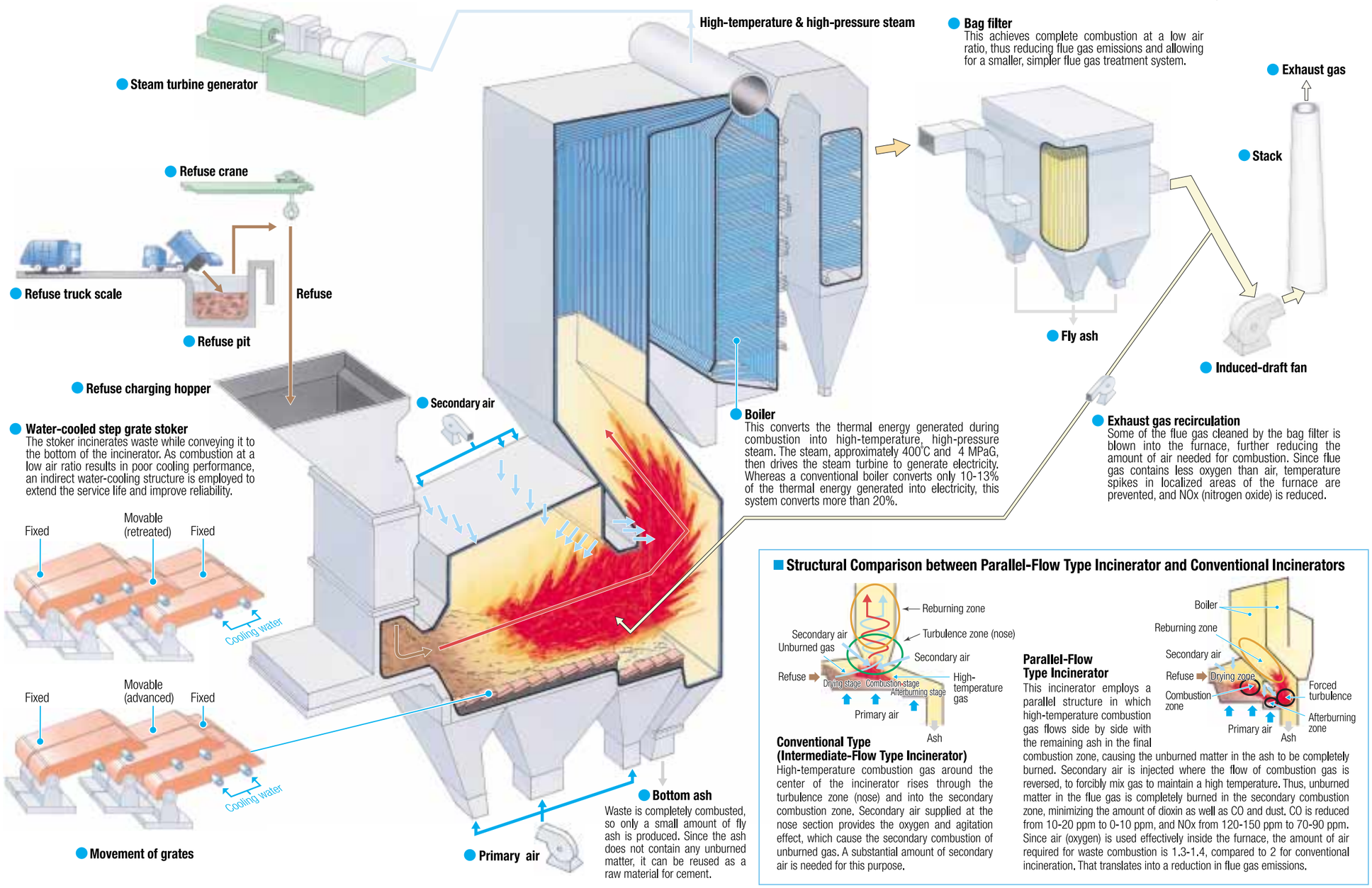
Kawasaki's proprietary parallel-flow type incinerator differs from a conventional intermediate-flow type incinerator in that high-temperature combustion gas flows side by side with waste, allowing waste to be burned completely.

Easy Maintenance, High-Efficiency Power Generation: Harnessing Combustion Energy

The thermal energy generated when waste is burned can be harnessed to generate electricity by converting it into high-temperature, high-pressure steam using a high-performance boiler, and then using the steam to drive a steam turbine.

The stoker continuously incinerates regular household waste while conveying it to the bottom of the incinerator. Its indirect water-cooling structure ensures a long service life, making the system easy to maintain.

The Kawasaki Advanced Stoker System has been delivered to four locations in Japan and three overseas, and three more are under construction domestically.



Structural Comparison between Parallel-Flow Type Incinerator and Conventional Incinerators

Conventional Type (Intermediate-Flow Type Incinerator)
High-temperature combustion gas around the center of the incinerator rises through the turbulence zone (nose) and into the secondary combustion zone. Secondary air supplied at the nose section provides the oxygen and agitation effect, which cause the secondary combustion of unburned gas. A substantial amount of secondary air is needed for this purpose.

Parallel-Flow Type Incinerator
This incinerator employs a parallel structure in which high-temperature combustion gas flows side by side with the remaining ash in the final combustion zone, causing the unburned matter in the ash to be completely burned. Secondary air is injected where the flow of combustion gas is reversed, to forcibly mix gas to maintain a high temperature. Thus, unburned matter in the flue gas is completely burned in the secondary combustion zone, minimizing the amount of dioxin as well as CO and dust. CO is reduced from 10-20 ppm to 0-10 ppm, and NOx from 120-150 ppm to 70-90 ppm. Since air (oxygen) is used effectively inside the furnace, the amount of air required for waste combustion is 1.3-1.4, compared to 2 for conventional incineration. That translates into a reduction in flue gas emissions.

New 30 MW Class Gas Turbine Launched

The Kawasaki L30A gas turbine—the flagship model of its fleet, with one of the highest efficiency ratings in the world in its class—was launched in June. Combining Kawasaki's expertise in developing small- and midsize industrial gas turbines and its sophisticated component technology in the area of aircraft engines, the L30A features thermal efficiency of more than 40.1%, achieved through such improvements as a higher compressor pressure ratio, newly developed heat-resistant materials and enhanced turbine-cooling technologies.

The turbine's proprietary Dry Low Emission (DLE) combustion system reduces NOx emissions to below 15 ppm (O_2=15%), making it the lowest emission level in the world in this class. Its modular design also offers excellent maintainability and significantly reduced lifecycle costs.

In the worldwide market, energy security has become a prominent issue as on-site power generation needs grow. This ever-increasing demand requires more efficient technology, with reduced emissions to match increasingly stringent environmental protection regulations. The L30A provides a flexible solution for such demands, and when combined with a heat recovery steam generator, it is the ideal gas turbine for use in combined heat and power and/or combined cycle applications.

Kawasaki installed the first L30A package in Japan, and anticipates receiving first orders from its international sales and marketing network in Europe, the Americas, Asia, the Middle East and the Far East. The company will extend its gas turbine business globally through the sales of the L30A, as well as its existing models.

Large LNG-Fueled Container Ship Developed

Kawasaki recently completed development of an LNG-fueled 9,000 TEU container ship and obtained Approval in Principle (AiP) from Det Norske Veritas (DNV).

LNG produces far less earth-warming CO_2 and acid rain-causing NOx and SOx than conventional fuels, and it is rapidly gaining attention as a cleaner alternative to heavy fuel oil for powering large cargo ships.

The new LNG container ship is equipped with a fuel tank large enough for the ship to cross the Pacific both ways, as well as to navigate the North American and European Emission Control Areas (ECAs). It features a dual-fuel propulsion system, which enables heavy fuel oil to be used as backup fuel.

Adopting a "two-island" design concept, the ship separates the accommodations and the engine room to maximize the container space. Installing the fuel tanks under the accommodations is another design consideration for securing cargo space. LNG fuel is stored in a newly developed IMO Type B independent prismatic tank, which provides high volume efficiency and features proprietary heat insulation technology, the Kawasaki Panel System, to minimize natural evaporation of LNG fuel.

The ship is powered by an electronically controlled, dual-fuel, low-speed diesel engine which, coupled with a fully optimized hull form, reduces environmental impact with its excellent combustion efficiency.

Compared with container ships that run on heavy fuel oil, LNG-fueled container ships reduce CO_2 emissions by approximately 30%. To meet the new IMO SOx and NOx (Tier III) regulations slated to take effect in 2015 and 2016, respectively, these ships are designed to reduce emissions of NOx by as much as 80% and SOx by nearly 100%.

With a wealth of know-how acquired over the years through its experience with LNG carriers, Kawasaki plans to make new inroads into the field of LNG bunkering vessels in an effort to create new values. Building on the latest development efforts, Kawasaki will continue to add to its offerings of eco-friendly ships.

New 85Z7 and 90Z7 Wheel Loaders Released

KCM Corporation, a Kawasaki group company, recently launched its new 85Z7 and 90Z7 wheel loaders, compliant with the U.S. Tier 4 Interim emission standards, in North America.

The 85Z7 and 90Z7 were developed jointly by KCM and Hitachi Construction Machinery Co., Ltd., combining the expertise of the two companies. While preserving the merits of existing models, the new models redefine the wheel loader in every aspect—including safety, cost performance, operational performance, exterior design and operator comfort—to deliver a product that satisfies varying levels of user needs in the global market.

The 85Z7 and 90Z7 significantly reduce air-polluting NOx and PM exhaust emissions to meet the latest Tier 4 Interim emission standards* mandated in the U.S. They also come equipped with a new hydraulic control system and engine output control mechanism, which reduce fuel consumption by 10-20% while greatly improving operational performance.

*New emission standards for non-road diesel engines set by the U.S. Environmental Protection Agency, covering most construction, agricultural and industrial machinery.

Kawasaki Participates in Smart City Project

Kawasaki recently announced that it has been participating since 2011 in the Smart City Project—which plans to export Japan's homegrown low-carbon "smart city" concept throughout the world—with Tokyo Gas Co., Ltd. and four other companies to leverage technologies and know-how.

Kawasaki aims to strengthen system integration and solution business capabilities. Smart technology is considered one of the leading solutions for integrating a variety of green products. Those technologies are necessary in the future business of infrastructure export.

In the field of energy infrastructure business, Kawasaki has provided a diverse range of eco-friendly products and technologies to the project, including rail cars for transportation infrastructure and energy equipment such as gas turbines and gas engines. It offers power generators that produce electricity from renewable sources such as hydraulic power generators and biomass, the nickel-metal hydride battery Gigacell, which offers rapid charging and discharging capabilities, and the Green Gas Engine, which boasts the world's highest power-generating efficiency. Kawasaki hopes to contribute to the development of low-carbon cities and disaster prevention centers with energy systems that make use of these technologies.

There are now 23 companies working as one under the Smart City Project to jointly develop a one-stop total solution to the needs and restrictions that exist. The market size of smart cities is estimated to reach a total of approximately 4,000 trillion yen over the next 20 years.

SMART CITY PROJECT

Recent Executive Appointments

Kawasaki announced on April 1 that Mitsutoshi Takao, who had been serving as senior vice president, was appointed senior executive vice president.

On June 27 at the General Meeting of Shareholders, managing executive officers Joji Iki, Masahiko Hirohata, Eiji Inoue and Yoshinori Kanehana were elected as new directors, and then appointed as senior vice presidents at the Board of Directors meeting that followed the shareholders' meeting. Director Yuichi Asano became an advisor and Director Toshikazu Hayashi became a strategic advisor after resigning their former positions on the same date.

Mitsutoshi Takao
Senior Executive Vice President

Joji Iki
Senior Vice President

Masahiko Hirohata
Senior Vice President

Eiji Inoue
Senior Vice President

Yoshinori Kanehana
Senior Vice President