Plant & Infrastructure Company products and technologies

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Preface

In October 2014, Kawasaki announced its Group Management Model 2018 laying out its medium- and long-term goals. In it the Plant & Infrastructure Company has set out its goal of becoming a unique plant manufacturer that provides the energy and environment sector with products and services designed to contribute to environmental conservation while maximizing customer satisfaction. In this effort, the Company will build on a firm foundation of technologies that set it apart from the rest of the pack, a foundation held together by superior product development and engineering capabilities, as well as top-notch quality that customers can count on.

This article takes an up-close look at the outstanding features of the Company's unique product lines and the technologies at work behind them as well as the technological developments on the horizon.

1 About the Company

The Plant & Infrastructure Company has taken over and integrated various Kawasaki projects and technologies focusing on:

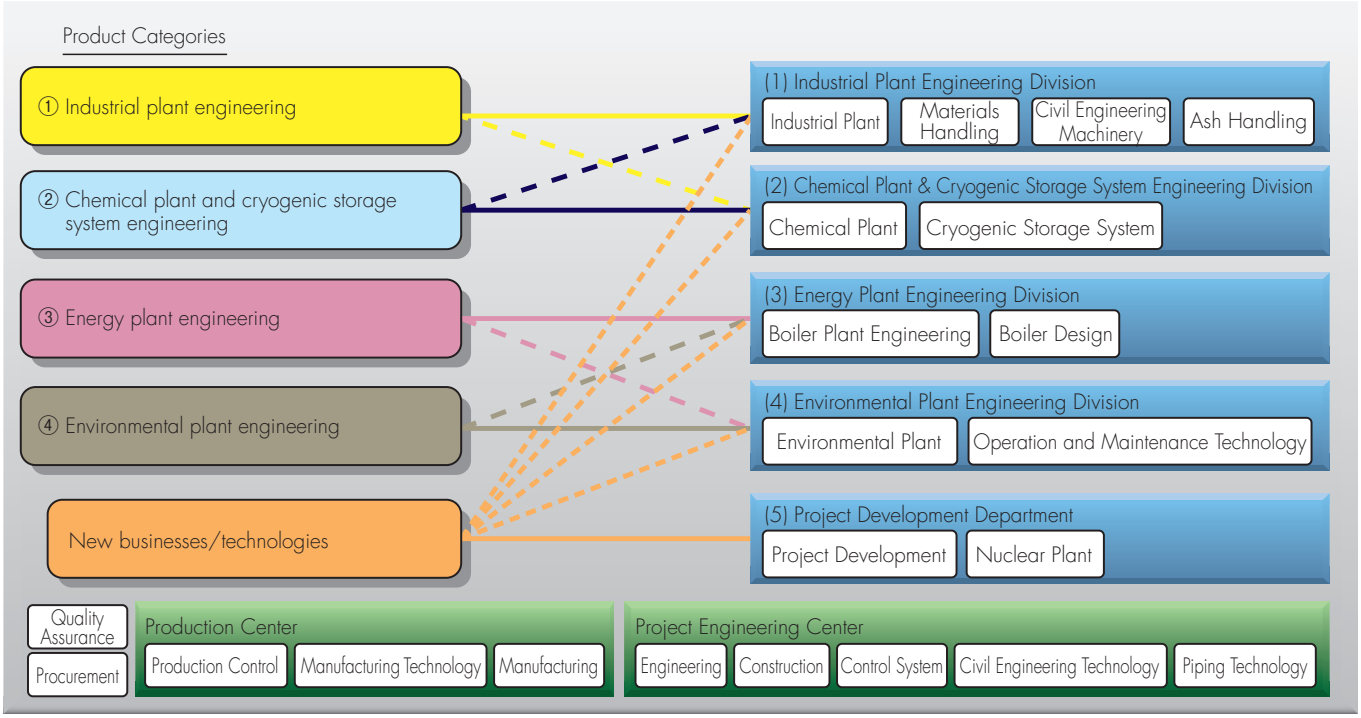

Fig. 1 Product categories and responsible departments

① industrial plant engineering, including cement plants, material handling plants, ash handling plants, and civil engineering machinery;
② chemical plant and cryogenic storage system engineering, including chemical plants and LNG tanks;
③ energy plant engineering, concentrating on boilers and power generation plants;
④ environmental plant engineering, concentrating on waste incinerators and sewage treatment facilities; and
⑤ the Production Center (Harima Works), serving as the Company's mother factory.

Boasting a world of product lines, the Company has had a hand in building industrial and social infrastructures around the globe.

Its extensive line of products spanning a wide range of fields adds a unique edge to its technological development. It can build on the basic technologies it uses in a specific field or integrate technologies employed in different areas to cultivate something new with even greater added value.

The CONCH Kawasaki Kiln (CKK) System that is featured in this issue turns waste into gas, which is then used to fuel a cement plant where the ash from the waste incineration process is used as the raw material to make the cement. The system is the brain child resulting from the marriage of Kawasaki's industrial plant and environmental plant engineering. This kind of dynamic is at work throughout the Company. It not only drives research and development forward but it also enables the Company to incorporate the best qualities of different departments as it creates new value through the overhaul of its business and organizational framework.

Figure 1 provides an overview of the Company's current product categories and the departments handling them.

2 Major products and technologies of each department

(1) Industrial plant engineering

(i) Industrial plants (cement plants)

Kawasaki got its start in the cement machinery manufacturing business back in the 1930s. As Japan's rapid economic growth in the mid 1950s through the early 1970s fueled demand, Kawasaki established itself as an industry leader that could deliver quality on top of quantity. Leveraging the technological expertise in cement plant manufacturing that it gained over the years has enabled Kawasaki to become one of the world's top cement plant manufacturers. Today it provides 360 degree plant engineering services along with a full line of state-of-the-art cement processing equipment built to do everything from mining limestone (a raw material for cement) to shipping finished products.

The Japanese cement industry is working hard to come up with some of the most advanced energy-saving solutions the world has ever seen. Keeping pace with these developments, Kawasaki has engineered a precalciner fitted with a suspension preheater designed to cut fuel consumption. It has also developed the CK Mill, a power-saving vertical roller mill, as well as the CKP Mill, a vertical roller mill designed for use with a pre-grinding system. A number of these products are currently up and running at facilities across the globe. Given a head start on plant exports, Kawasaki's cement plant business has delivered about 90 plants worldwide since 1961.

Harnessing the strength of its cement plant technologies, Kawasaki also supplied a ferronickel smelting plant to Indonesia's PT Antam Tbk in 2007. It then delivered one of the world's largest nickel plants (with a production capacity of 30,000 tons/year) to Korea's SNNC Co., Ltd. in 2009, whose production capacity was upped to 54,000 tons in 2015.

(ii) Material handling systems

Kawasaki's material handling business supplies equipment designed for excavating, stacking and reclaiming, and transporting coal, iron ore, soil, etc. In addition to that it delivers a cohesive running system for unloading, conveyance, storage, and loading anywhere the steel, power, mining, cement, and chemical industries operate. Not only does Kawasaki design and manufacture the main components of these systems, it provides comprehensive material handling engineering services that are all backed up by a solid performance track record and outstanding technical capabilities.

Kawasaki also developed the Flow Dynamics Conveyor (FDC), an idlerless conveyor featuring an air floating belt that cuts the noise and vibration of conventional conveyors while completely eliminating dust emissions for environmentally-friendly and energy-saving operations. A number of FDCs are currently at work across the globe. In 2015, Kawasaki delivered six FDCs to be used for transporting coal at Taiwan's Linkou Thermal Power Plant. Two of these FDCs have a conveyor capacity of 2,000 tons per hour while the remaining four have a capacity of 4,400 tons per hour. Altogether they stretch a total length of four kilometers.

(iii) Ash handling plants

In 1963 Kawasaki formed a technical alliance with United Conveyor Corporation (UCC), a leading manufacturer of ash handling equipment for coal-fired power plants that enjoys a lion's share of the U.S. market. Since then Kawasaki has supplied ash handling plants to the majority of utilities and independent coal-fired power plants in Japan. After a technical alliance with Italy's Magaldi in 1994 to introduce the dry bottom ash handling technology, Kawasaki made

improvements to its ash handling equipment and developed peripheral systems based on the newly acquired technology. After building up an excellent track record of delivering state-of-the-art ash handling systems designed to meet customers' exact needs, Kawasaki now enjoys a glowing reputation in the industry plus a huge market share. A flood of orders for ash handling systems are now flowing in as the number of coal-fired power plant projects for independent power producers (IPPs) is growing ahead of the scheduled 2016 liberalization of the electricity market.

(iv) Civil engineering machinery (tunneling machines)

Kawasaki's tunneling machines include shield machines used for underground construction work, tunnel boring machines (TBMs) designed for excavating hard rock, as well as vertical boring machines.

Built for shield tunneling, the shield machine moves forward to excavate the earth, leaving a cylindrical shield (segmented ring) in its path that prevents the newly formed tunnel from collapsing. Kawasaki manufactures all types of shield machines, including slurry, earth-pressure balanced, mechanical, semi-mechanical, and hand-mining shield machines, and leads the industry in the large-diameter category. In 2012, its earth-pressure balanced shield machine with a diameter of 12.55 meters completed excavation for the construction of Tokyo's Central Circular Route Shinagawa North Line (which went into service in March 2015). By the end of fiscal 2014, Kawasaki delivered a total of 35 slurry shield machines to Singapore to be used by Singapore Power as well as to build a subway.

A TBM is a machine designed to bore through hard rock in order to dig tunnels for motorways, railways, headrace channels, as well as water and sewer systems. A pioneer in Japanese TBM technology, Kawasaki boasts an excellent track record when it comes to supplying TBMs for small and medium-scale hydropower development and sewer work, as well as road and rail tunneling such as the Channel Tunnel running beneath the Dover Channel that links France with England. In total Kawasaki has delivered about 1,400 shield machines and TBMs across the globe.

(2) Chemical plant and cryogenic storage system engineering

(i) Chemical plants

The Plant & Infrastructure Company's chemical plant business boasts a wealth of experience and technological capabilities. When it comes to engineering coal-chemical, fertilizer, ethylene, methanol, flue gas desulfurization, petrochemical, and chemical synthetic fiber plants, the Plant & Infrastructure Company has it all covered. On top of that it manufactures all the core components of these plants like reactors, towers, vessels, heat exchangers, furnaces, and more.

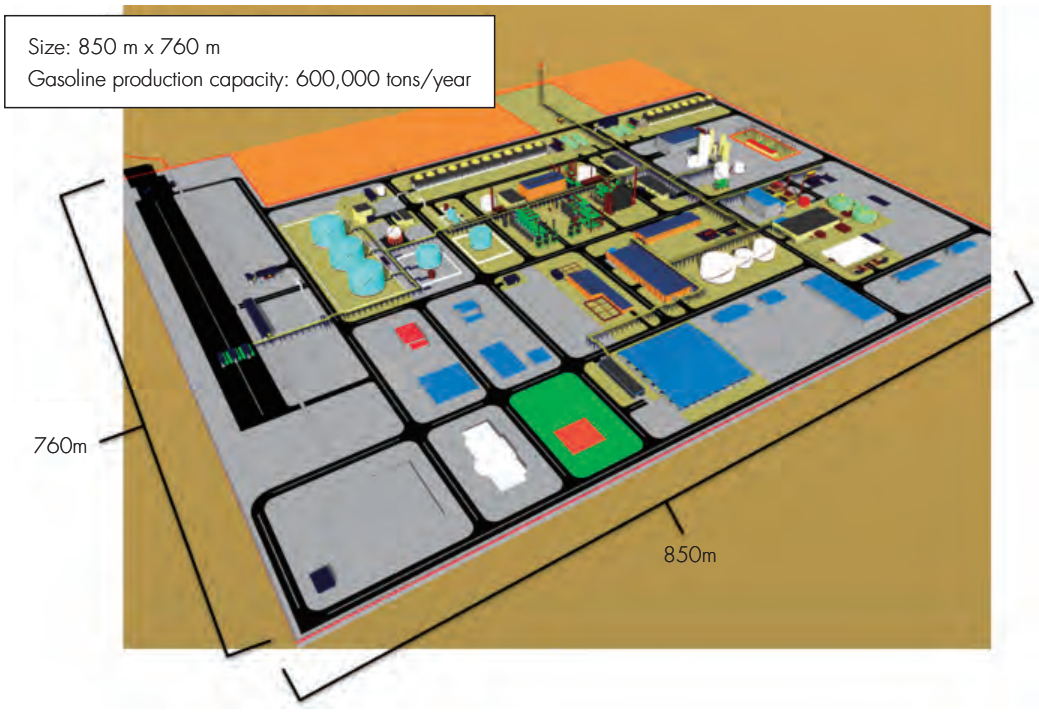

Fig. 2 GTG plant for Turkmenistan

The Company has built up a solid reputation for its fertilizer, ethylene, and methanol related plants. It has delivered seven fertilizer plants, including an ammonia plant to Nigeria's Federal Ministry of Industries in 1981 via a consortium with M. W. Kellogg Limited (now KBR, Inc.). More recently in 2009 it delivered a fertilizer complex to the State Concern Turkmenhimiya, Turkmenistan's state-owned petrochemical company. The fertilizer complex is the largest in the country. In 2014, Kawasaki received an order for a gas-to-gasoline (GTG) plant from Turkmenistan. When completed, it will be the world's largest GTG plant (with an annual production capacity of 600,000 tons), producing high quality gasoline from natural gas (Fig. 2).

The Company's flue gas desulfurization systems employ Kawasaki's proprietary limestone-gypsum process designed for large-scale thermal power plants. It also developed a comprehensive flue gas treatment system for coal-fired power plants as well as its own integrated computer control system, non-leakage gas heater, and new reversal-flow absorber. So far 97 orders have come in from across the globe for Kawasaki flue gas desulfurization systems, including orders from China, Vietnam, and Saudi Arabia.

Kawasaki is currently working on developing a technology to produce bioethanol from non-food soft cellulose. Unlike existing methods, this technology uses hot water in the saccharification process not using sulfuric acid or enzymes. Working jointly with the Akita Agriculture Public Corporation, Kawasaki conducted a demonstration to produce the bioethanol more economically using rice straw and other raw materials under a subsidized Akita soft cellulose utilization project. In the demonstration operation conducted through March 2013, Kawasaki achieved an ethanol production efficiency of 153.5 liters per ton of raw material (dry). Kawasaki is currently working on cutting costs further with a view to commercialization while applying the technology to commercial biochemical plants and more.

(ii) Cryogenic storage systems

Kawasaki has earned high marks for supplying various types of aboveground flat bottom cylindrical tanks with a conical, dome, or floating roof, as well as spherical tanks for storing high-pressure gas such as liquefied or compressed gas. It was one of the first in the industry to explore low temperature and ultra-low temperature engineering and worked on research and development of flat bottom cylindrical low-temperature tanks for LPG and liquefied ammonia as well as land-based LNG storage tanks. Kawasaki has pioneered unique design and construction techniques, including the welding of materials with superior cryogenic toughness.

Most notably it boasts enormous experience in supplying all types of large-scale LNG storage tanks. These include double-containment in-pit tanks whose inner tank is made of 9% nickel steel and aluminum alloy, full containment LNG storage tanks outfitted with a prestressed concrete (PC) dike, in-ground membrane tanks made of thin stainless steel, and more. Kawasaki now claims more than 50% of the Japanese market for large-scale LNG storage tanks. Overseas, it recently brought in an order for four full containment cryogenic tanks to be employed in Australia's Ichthys project, which is being headed up by INPEX Corporation, along with an order for three LNG storage tanks to be constructed at the Taichung LNG plant of CPC Corporation, a state-owned oil and gas company of Taiwan.

Demand for LNG is soaring across the globe as an alternative to petroleum, and Kawasaki is keeping pace as it works hard to expand the scope of its operations to include not only storage tanks but also the construction of LNG terminals.

Kawasaki developed the containers used to transport liquefied hydrogen and the compressed hydrogen trailers, by applying its advanced insulation technology accumulated over the years. It is an investment that has made the dream of transporting large quantities of hydrogen a reality and laid the foundation for a hydrogen energy supply chain. The widespread use of fuel cell vehicles and hydrogen power plants is expected to usher in the era of hydrogen energy, and Kawasaki is poised to leverage its technological expertise in producing, transporting, storing, and using hydrogen as it zeroes in on realizing its concept of a hydrogen energy supply chain.

(3) Energy plant engineering

Since its beginning Kawasaki has manufactured extensive lines of unique thermal power plant products for both land and marine applications. Designed to meet a world of customer needs, these products have been delivered to markets across the globe. These power plants can be applied to various types of fuels, including heavy oil, coal, LNG, biomass (like wood chips and "black liquor" discharged from pulp plants), petroleum residue, waste fuel, as well as other types of special fuels. Kawasaki offers a wide range of combustion boilers designed to make optimal use of each fuel type and best meet each customer's individual needs.

(i) General fuel-fired boilers

Across the industrial spectrum there is strong demand for coal and petroleum residue fired boilers to use in-house as cogeneration systems that can supply businesses with the large amount of electricity and steam they need. Kawasaki has provided these boilers to businesses that produce everything from chemicals to paper and more. In recent

years the Company has been working with a keen focus on marketing the U-KACC, an ultra-low NOx, low dust emission boiler that uses solid asphalt pitch produced in the oil refinery process. More information about the U-KACC boiler can be found elsewhere in this issue.

(ii) Fluidized bed boilers
Kawasaki has developed proprietary fluidized bed boilers designed to efficiently recover heat from the process of burning woody biomass and waste fuel. Kawasaki's internal circulation fluidized bed boiler employs a superior combustion technology that enables it to burn multiple types of fuels with varying calorific values along with corrosive fuels altogether. Today there are three Kawasaki boilers currently in use, including one at Tokushu Tokai Paper Co., Ltd.'s Shimada Mill, with orders from South Korea for two more refuse paper and plastic fuel (RPF) fired boilers in the works. Since the boiler cuts down on greenhouse gas emissions, demand for this viable green energy solution is expected to increase.

(iii) Marine boilers
Kawasaki has over a century of experience in supplying marine boilers used on power-driven vessels. Drawing on this depth of knowledge, Kawasaki developed a new boiler in 2013 for the Prelude, the world's first floating liquefied natural gas (FLNG) facility. Seven marine boilers (Fig. 3), each with a steam generating rate of 220 tons/hour, have been delivered to the new FLNG that is being built off the coast of Australia by the Dutch petroleum giant, Shell. As plans to develop new gas fields off the coast of Australia take shape and the appetite for LNG continues to grow, Kawasaki expects to see more orders begin flowing in.

(iv) Waste heat recovery boilers
A waste heat recovery boiler recovers waste heat from steel, nonferrous metal, chemical, and cement manufacturing facilities as well as waste incinerators and converts it into usable thermal energy. It helps boost thermal efficiency, saves energy, and prevents pollution all at the same time.

Over the years Kawasaki has supplied numerous waste heat recovery power generation systems that apply waste heat boilers to recover waste heat from cement production process and generate electricity. Working with our joint venture partner in China, we have delivered a total of 1,041 units to China, Europe, and Turkey.

(4) Environmental plant engineering
Working in light of mounting concerns over global warming and with an eye to the 3R (reduce, reuse, and recycle), Kawasaki is moving forward to meet the public's growing demand for more efficient waste-to-energy solutions. At the same time Kawasaki is zeroing in on ways to minimize and eliminate harmful substances like dioxins that may be released into the atmosphere during the waste treatment (incineration) process.

Japan's leading waste treatment facility manufacturer,

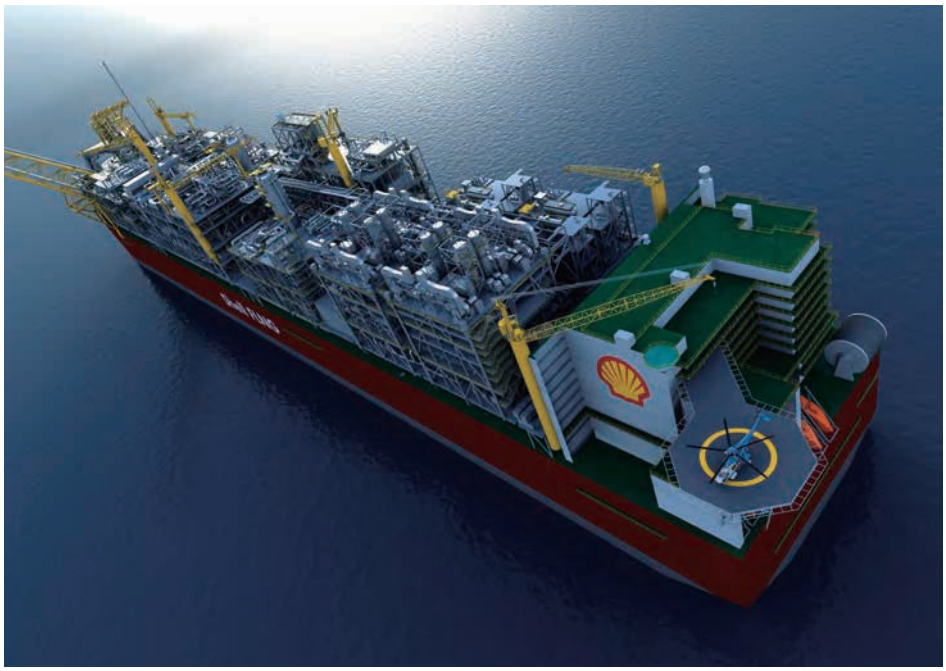

Fig. 3 Shell's Prelude FLNG fitted with seven 220 t/h boilers

Kawasaki supplies waste treatment plant solutions that combine incinerator, exhaust gas and waste water treatment, power generation, and other related technologies all in one. As of the end of fiscal 2014, Kawasaki received a total of 175 orders for its plant solutions (some of which are under construction) from around the world.

(i) High efficiency power generation plants
As of the end of fiscal 2014 Kawasaki delivered 43 waste incinerators equipped with waste heat power generation systems and received orders for 12 of its high efficiency power generation plants. These power plants employ the same technology that is behind the Kawasaki Advanced Stoker System to raise the steam pressure to 4 MPa and the steam temperature to 400°C.

(ii) Waste treatment and biogas generation complex
Kawasaki has developed a waste treatment complex that is providing a renewable solution to the world's growing energy problems. The complex combines biogasification and waste incineration facilities for high efficiency power generation while reducing greenhouse gas emissions. It mechanically separates out combustible waste suitable for biogas generation, which is then converted into biogas via a dry thermophilic methane fermentation process in the biogas generation facility. The generated biogas is used as a heat source for superheating the steam generated by the waste heat boiler. Unused waste and methane fermentation residue are incinerated at a high temperature and low air ratio in a parallel flow type incinerator with a mechanical stoker for efficient energy recovery. The construction of the first waste treatment complex was completed in the city of Hofu, Yamaguchi Prefecture, in 2014. It earned the distinction of being named one of the year's ten best new products by the Nikkan Kogyo Shimbun Ltd.

(iii) Waste treatment system using a cement kiln
Kawasaki recently developed the CKK System, a new type of waste incineration system that combines a cement manufacturing facility and waste incineration, and started selling it in China and other emerging markets. This revolutionary system features a fluidized-bed type gasification furnace where waste is gasified. The resulting pyrolysis gas and unburnt char are fed into the cement production facility along with ash to be used as fuel and raw material for cement manufacturing. So far Kawasaki has received orders for 19 of its CKK Systems, including one with a waste treatment capacity of 300 t/d that was delivered to Tongling City in China's Anhui Province in 2010. This and four more CKK Systems are currently in operation there, processing 200 to 400 t/d. We are also working on commercializing the Zero Emission Eco Town (ZEET) System, which integrates sewage sludge and sewage treatment functions into the CKK System.

(5) Production Center (Harima Works)
The Harima Works is the Company's mother factory. Everyone working there is committed to steadily manufacturing its products, such as large-scale boilers, aboveground/in-ground LNG storage tanks, and large diameter shield machines, maintaining short lead time and high quality. Furthermore, the Harima Works is making the most of its toolbox full of advanced manufacturing technologies to set Kawasaki far apart from everyone else. Currently, it is shaping up its comprehensive manufacturing capabilities with a focus on production technology and control, response capability to the challenges of globalization, and the power of worksites in manufacturing operations. For example, it is focusing on making its laser cutting technology more sophisticated than ever, enhancing bending technique for large tank heads, expanding the scope of applications for its high-efficiency welding technique, honing the vacuum technology used in the production of large capacity liquefied hydrogen storage tanks, and putting 3D inspection and measurement technologies to practical use.

Closing

The Plant & Infrastructure Company offers extensive lines of products designed to meet the needs of a diverse spectrum of business categories and is continually working to find innovative solutions to the challenges that lie ahead. Offering products that meet the needs of a number of different industries gives the Company a big leg up. The ability to harness different technologies to create new ones while incorporating the best qualities of different departments has been a source of new growth.

Demand for electricity and energy is expected to be fueled by emerging markets around the globe, and Japan is moving forward on the deregulation of electricity market. Working against this backdrop, the Company will continue to leverage its diverse product lines and technologies as well as its plant engineering capabilities to bring products to the world as it helps fulfill Kawasaki's commitment to working as one for the good of the planet.