

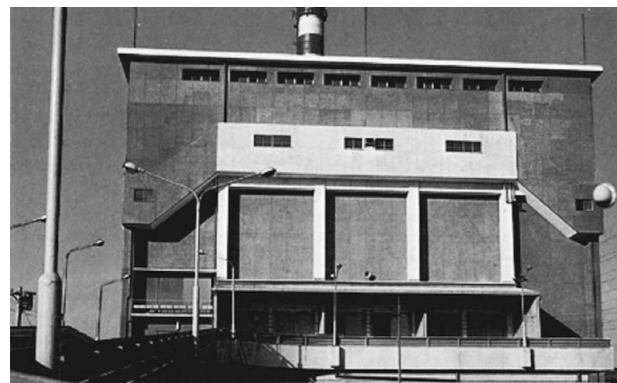
## 1. Activities of Our Municipal Solid Waste Treatment Plant Business

### A leading company in the industry

Since completing Japan's first fully continuous mechanical waste incineration plant in Osaka City in 1963, Takuma has built more than 350 waste incineration plants in the country, more than any other company in the industry.

We have consistently led the municipal solid waste treatment industry, for example by starting operation of Japan's first combined facility comprised of biological gasification plant and municipal solid waste incineration plant and building more than 80 bulk garbage and resource waste recycling plants.

Takuma will continue to contribute to the realization of a recycling-based society as the industry's leading company.



Japan's first fully continuous mechanical waste incineration plant (Sumiyoshi Plant, Osaka City)



State-of-the-art Energy from Waste plant (Ota Incineration Plant, Clean Authority of Tokyo 23 cities)



Composite facility combining biogas and waste incineration plants (Nantan Bio, Thermal and Material Recycle Center, Nantan) (Integrated Administration of a Large Region Work Association)

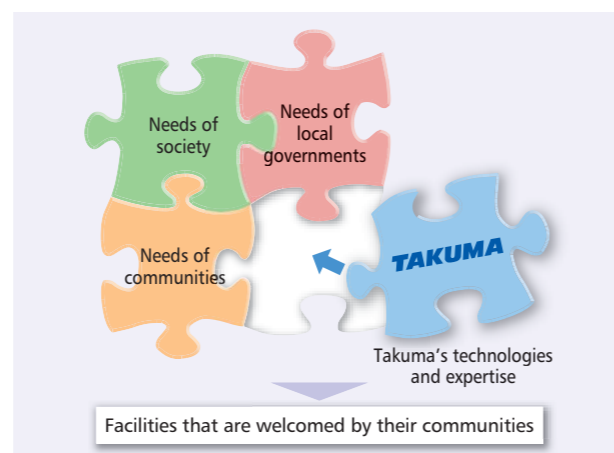


Large-scale recycling plant (Numagami Resources Circulation Center, Shizuoka City)

### From construction to after-sales service

Takuma's municipal solid waste treatment plant business consists of four components: plant construction, primary equipment improvement, maintenance, and long-term turnkey operation.

In each area of operations, we draw on technological capabilities and expertise based on our extensive experience to precisely meet the needs of local governments, regions, and society, allowing us to offer facilities that are welcomed by their communities.

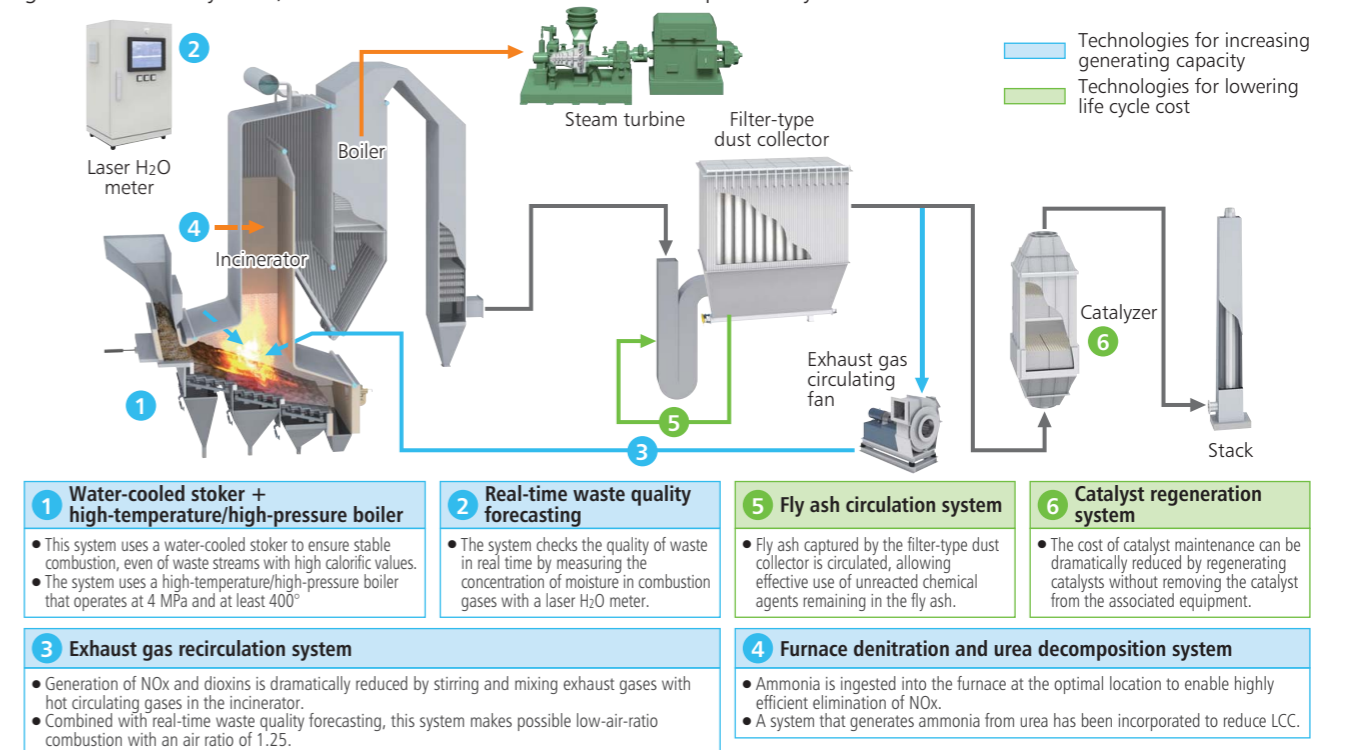


### 1 Plant construction

#### Stoker-type incinerators

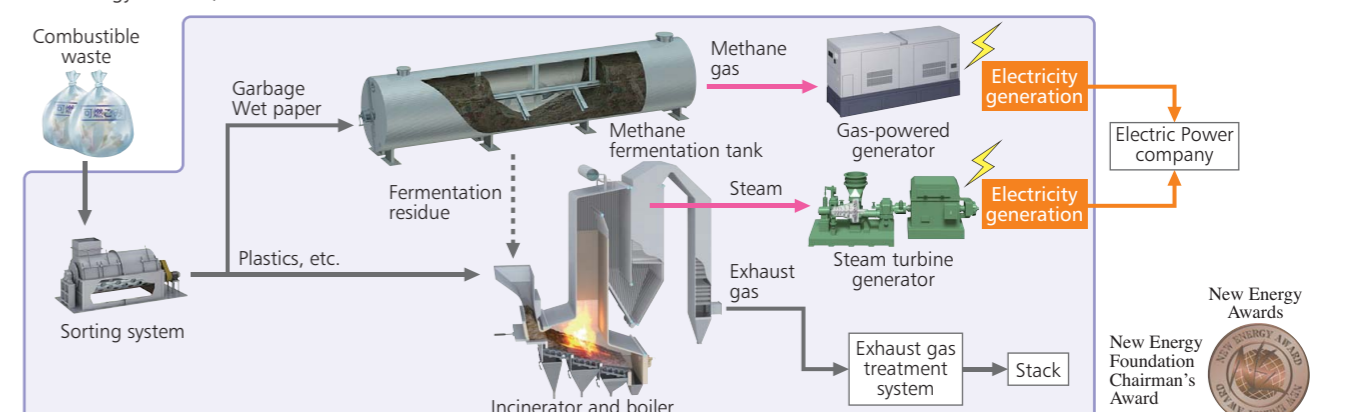
Most Energy from Waste plants use stoker-type incinerators. Takuma has been delivering stoker-type incinerators to customers for half a century, allowing us to accumulate a variety of expertise in areas such as stable combustion, exhaust gas treatment, and waste-fueled power generation.

Based on this well-established base of technological capability, we build and supply highly efficient waste treatment systems by integrating the latest technologies, for example water-cooled stokers, real-time waste quality forecasting, exhaust gas recirculation systems, and furnace denitration and urea decomposition systems.



#### Biogas facilities

Recently the Ministry of the Environment has been encouraging the introduction of biogas facilities for use with municipal solid waste. This is an area where Takuma is helping further lower CO<sub>2</sub> emissions with a combined system of methane fermentation and incineration for municipal solid waste to recover the maximum amount of energy from the waste treatment and utilize it in high-efficiency power generation. (The system received the New Energy Foundation's Chairman Award at the FY2014 New Energy Awards.)






## Activities of Our Municipal Solid Waste Treatment Plant Business

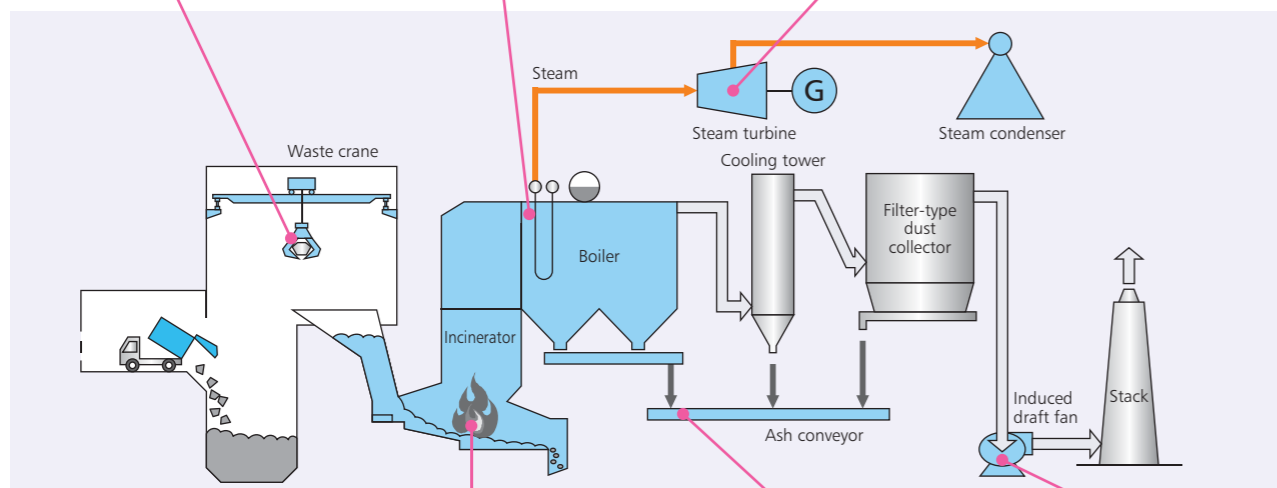
### 2 Primary equipment improvements





#### Implementing high-value-added renovations

Although waste treatment plants are required to operate over extended periods of time, equipment must be renovated once 20 or more years has passed since the plant began operating. In addition, changes in the regulatory environment and society sometimes make large-scale renovations necessary.

Takuma draws on the sophisticated heat utilization technologies and energy-saving technologies it has accumulated as a boiler and environmental plant manufacturer to carry out high-value-added and large-scale renovation projects. In this way, we are able to help extend facilities' service life while lowering CO<sub>2</sub> emissions.

Installation of inverters on cranes	Improvement of heat recovery	Improvement of steam turbine capacity
<ul style="list-style-type: none"> <li>Reducing power by installing speed control-type inverters</li> </ul> 	<ul style="list-style-type: none"> <li>Installing boilers on water-injection furnaces</li> <li>Expanding boilers' heating surface</li> </ul> 	<ul style="list-style-type: none"> <li>Improving generating capacity by increasing steam intake capacity and optimizing design features</li> <li>Improving the capacity of steam condensers</li> </ul> 



Enhancement of combustion equipment efficiency	Adoption of high-efficiency motors	Installation of inverters on fans
<ul style="list-style-type: none"> <li>Improving stable combustion by changing furnace shape and stabilizing the volume of steam generation and power generation</li> <li>Reducing the volume of exhaust gases and increasing the volume of heat recovery by adopting low-air-ratio combustion technology</li> </ul>  	<ul style="list-style-type: none"> <li>Reducing power use by adopting high-efficiency motors</li> </ul> 	<ul style="list-style-type: none"> <li>Reducing power use by installing speed control-type inverters</li> </ul> 

Examples of primary equipment improvement works

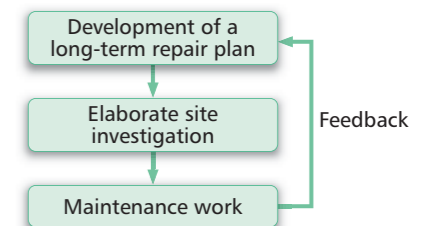
### 3 Maintenance

#### Ensuring stable waste treatment

Annual maintenance is essential in order to ensure stable operation of waste treatment plants.

However, maintenance demands both sophisticated technological capabilities and experience, both because waste treatment plants draw on a range of expertise and because the manner in which their equipment deteriorates over time varies with the properties of the waste they process.

Takuma takes maximum advantage of its accumulated expertise to contribute to stable waste treatment and long-term facility operation by developing long-term repair plans, carrying out elaborate site investigations, and then performing maintenance that has been optimized in terms of both timing and content.



Repairing an incinerator's refractory



Measuring the thickness of boiler water tubes



Maintaining a conveyor

### 4 Long-term turnkey operation business

#### Safe, secure facility operation

In recent years, the number of long-term turnkey operation projects such as DBO\* projects that involve long-term outsourcing of operation and maintenance management over 10 to 20 years has been increasing. The Takuma Group is pursuing this business actively, and as of June 30, 2016, we were operating 12 facilities and preparing for the start of operation of 4 more.

Against this backdrop, we are dedicated to pursuing safe, secure facility operation through initiatives that are designed to help establish a basis for future operations and to strengthen our capabilities in this area, for example by developing plant plans with a view toward operation, developing a turnkey operation and maintenance management support system, and strengthening self-monitoring.

\* DBO projects: A business approach in which local governments secure funding and then place a single order encompassing facility design, construction, and operation.



Kurume Municipal Miyanojin Clean Center, which began operation in FY2016

#### Opening facilities to the community

While waste treatment plants play an essential role in daily life for nearby residents, the facilities are also prone to be perceived to be a nuisance.

Takuma strives to spread understanding of the facilities it operates and the need to practice the 3Rs by hosting various events in an effort to open facilities to the surrounding community.



At an event (Kashiwara Eco Summit)

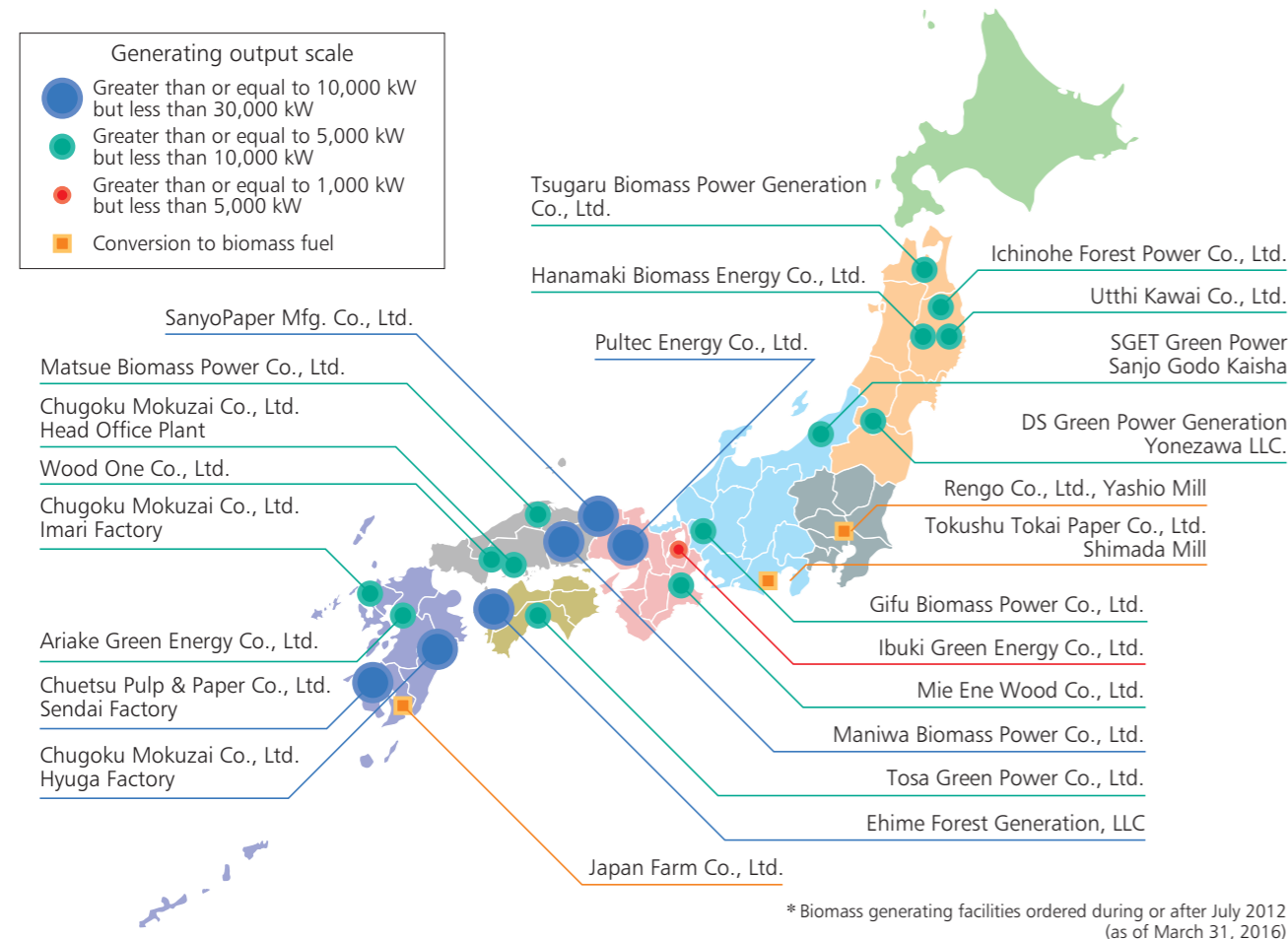


# Activities of Our Energy Plant Business

## —Pursuing biomass power generation

Biomass fired power plants comprise one of our most skilled product areas. Activity in the segment has been sparked by the prospect of stable profits made possible by the launch of Japan's feed-in tariff system for renewable energy in July 2012, and Takuma has received orders for numerous plants.

We have also received multiple orders for boiler fuel conversion projects to provide electricity and steam for internal plant use.



### Biomass fuel under the feed-in tariff program [JPY per kWh]: Unit price for sale of electricity under the FIT program (FY2016)

**Unused timber** (Generating plant with output of 2,000 kW or greater) [JPY 32 per kWh]  
(Generating plant with output of less than 2,000 kW) [JPY 40 per kWh]

In the forestry industry, leftover timber that cannot be used and trees that have been felled during thinning but whose value does not merit harvesting have gone unutilized. By setting a purchase price for this type of wood that is higher than that of other biomass materials, the feed-in tariff program is intentionally promoting use of these resources.

**General timber** [JPY 24 per kWh]

Timber other than unused timber and recycled timber is collectively known as general timber. This category includes mill ends, sawdust, bark, pruned branches from farms and other sources, as well as driftwood from dams and imported materials such as palm kernel shells (PKS).

**Waste products** [JPY 17 per kWh]

This category includes waste biomass such as municipal solid waste and sewage sludge, biomass from the livestock industry such as livestock excrement, and industrial biomass such as paper sludge and black liquor.

**Recycled timber** [JPY 13 per kWh]

This category includes construction waste, for example from the demolition of houses. Construction waste has been used as a primary fuel in wood biomass boilers for some time, and at present it constitutes the most commonly used wood fuel.

## Proposing combustion furnaces that can accommodate the fuels customers use

For biomass power plants, combustion furnaces play an important role as core power generation equipment, and the choice of combustion furnace type exerts a significant influence on biomass power businesses. This page introduces some typical Takuma combustion methods that are widely used in wood biomass power generation.

### Step grate stoker

This combustion method, which derives from waste incineration technology, can be used to uniformly burn fuels with different calorific values, moisture content, shapes, and sizes. Another characteristic of this method is that it requires less power to operate (known as facility power) than other types.



#### Installation example: Sendai Factory, Chuetsu Pulp & Paper Co., Ltd.

Chuetsu Pulp & Paper Co., Ltd., is a large general paper manufacturer that manufactures, processes, and sells pulp and paper products.

The facility we delivered at the company's Sendai Factory uses a step grate stoker that can accommodate biomass fuels with a variety of properties and shapes in anticipation of the future diversification of fuels.

[Equipment overview]

- Location: Satsumasendai City, Kagoshima Prefecture
- Generating output: 23,700 kW

### Traveling stoker

With a traveling stoker, fuel is distributed in the furnace so that longer combustion times are secured for fuel with larger volumes. As with a step grate stoker, combustion is comparatively gradual, and the system can accommodate a wide range of fuels with different calorific values, moisture content, and shapes.



#### Installation example: Maniwa Biomass Power Co., Ltd.

Maniwa Biomass Power Co., Ltd., one of only a few wood biomass-fueled power generating companies in Japan, was established by 10 public- and private-sector investors, including Meiken Lamwood Corporation, Ltd., one of Japan's largest manufacturers of laminated lumber.

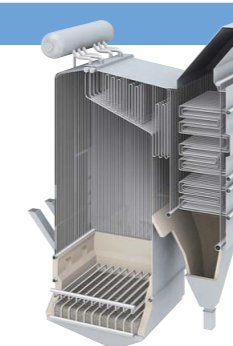
The company's generating plant, which utilizes unused lumber from the Maniwa region as its primary source of fuel, is expected to contribute to the growth of the area's forestry and lumber processing industries and to local job creation.

[Equipment overview]

- Location: Maniwa City, Okayama Prefecture
- Generating output: 10,000 kW

### Bubbling fluidized bed

Since sand that has been fluidized by high-pressure air burns away the surface of the chips, little unburned fuel remains, making high boiler efficiency a characteristic of fluidized bed systems. They can accommodate a variety of different types of fuel, including fuels with high moisture content.



#### Installation example: Gifu Biomass Power Co., Ltd.

Gifu Biomass Power Co., Ltd., is a wood biomass-fueled power generating company established with Gisen Co., Ltd., as an investor.

This system is designed specifically to burn unused lumber, which had been considered to have low utility value due to its high moisture content compared to traditional construction waste-type fuels, as well as general lumber, which is a manufacturing plant byproduct, as biomass fuel, allowing these resources to be effectively utilized.

[Equipment overview]

- Location: Mizuho City, Gifu Prefecture
- Generating output: 6,250 kW

### Circulating fluidized bed

Heated, fluidized sand burns fuel as it circulates, keeping temperatures inside the furnace uniform to enable stable combustion. Since little waste remains unburned, boiler efficiency is high, and the system can accommodate a broad range of mixed fuels with different caloric values.



#### Installation example: Hyuga Factory, Chugoku Mokuzai Co., Ltd.

Chugoku Mokuzai Co., Ltd., is a large general lumber company that offers an extensive product line ranging from lumber to laminated lumber and pre-cut lumber.

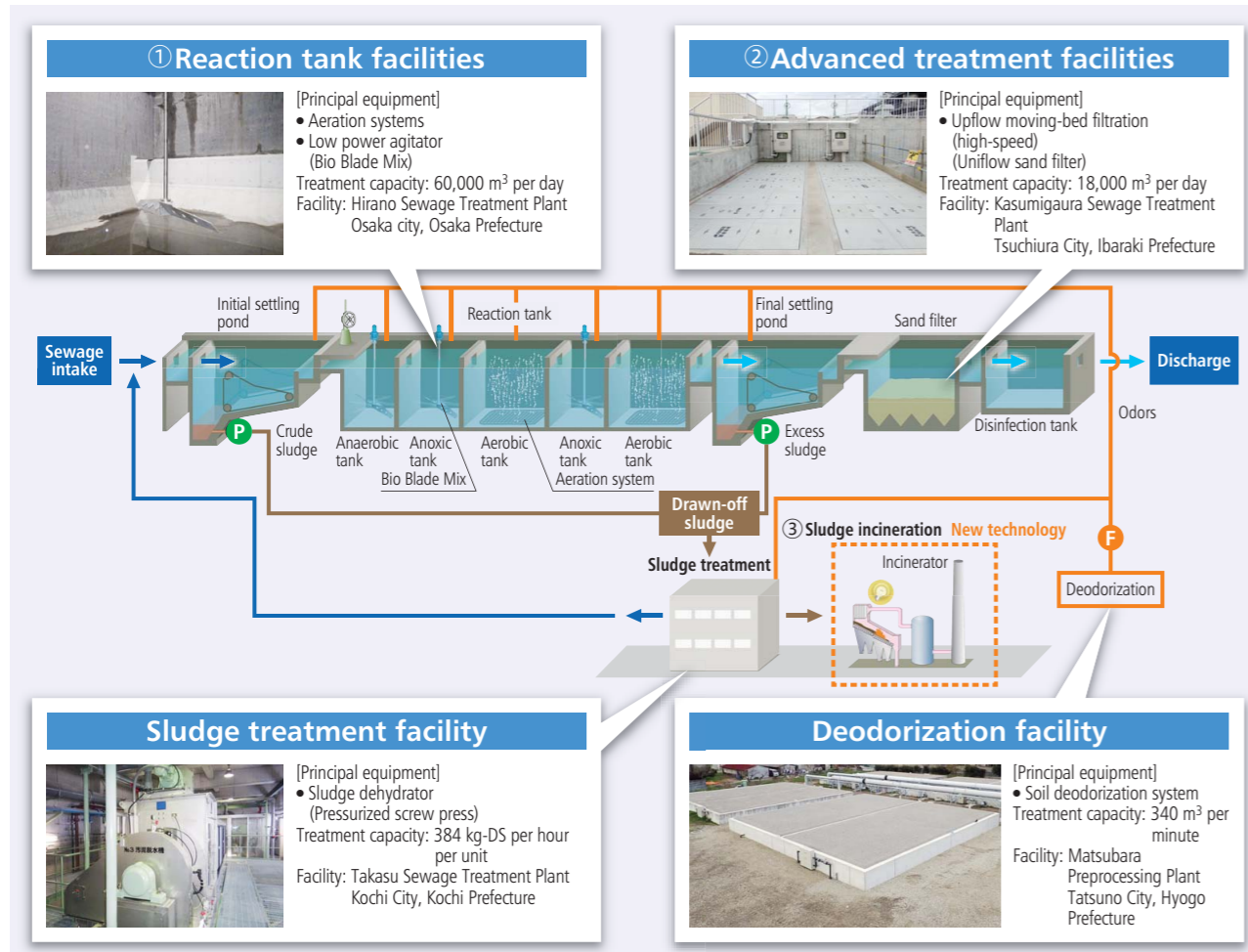
The facility delivered by Takuma to the company's Hyuga Factory uses a circulating fluidized bed boiler that can accommodate the customer's need to effectively utilize a wide range of biomass fuels.

[Equipment overview]

- Location: Hyuga City, Miyazaki Prefecture

### 3. Activities of Our Water Treatment Plant Business

Takuma contributes to the preservation of the water environment by providing a variety of water treatment facilities. In addition, we are working to develop new technologies to accommodate ongoing changes in society, for example by utilizing renewable energy and reducing emissions of greenhouse gases.



Installation examples of water treatment facilities delivered by Takuma

#### ① Reaction tank facility

The reaction tank facility consists of an aerobic tank that supplies oxygen (aeration) and oxidizes and breaks down organic matter through the action of microorganisms known as activated sludge. Anaerobic and anoxic tanks are also provided for the purpose of biologically eliminating nitrogen and phosphorus.

Takuma has developed energy-saving stirring machines to stir the contents of the anaerobic and anoxic tanks. We have commercialized a low-power stirring machine in which two specially shaped stirring blades are powered by an above-water drive unit. We have delivered 68 of these machines, which provide stirring capacity of about 1.0 W per cubic meter at about 1/10 the power of a conventional machine, to sewage treatment plants and other sites in Japan.

#### ② Advanced treatment facility

Measures undertaken to improve the quality of public water sources and the need to reuse treated sewage are spurring demand for more advanced water treatment. In order to reuse treated water, it is necessary to reduce the biochemical oxygen demand and suspended solid concentration in that water. Sand filtration is typically used as a technology for eliminating suspended solids, and both fixed-bed and moving-bed systems are available. Takuma has delivered a cumulative total of more than 2,500 upflow moving-bed sand filtration systems (uniflow sand filters).

Since the filtration differential pressure can be kept low in upflow moving-bed filtration ponds thanks to a purification mechanism that continuously purifies the sand, the amount of power used by lifting pumps can be reduced. In addition, Takuma has developed a high-speed sand filtration system that allows filter speeds of up to 1,000 meters per day, about three times that of conventional systems, while simultaneously using less space than those systems. There are already five of these facilities in operation.

#### ③ Sludge incineration

Sewage sludge is a type of biomass, and it is expected to be used as a form of renewable energy. Past sludge incinerators have required auxiliary fuel and used large amounts of electricity, making them net consumers of energy. Takuma has developed a sludge incineration system based on a new concept that shifts operation to an energy-saving and energy-yielding footing, and we are working to develop a broad range of businesses using the system as a technology that can lower costs at sewage treatment plants while simultaneously reducing energy use and greenhouse gas emissions.

##### ● Demonstration Study of Power Generation System with Sewage Sludge Incineration

This energy-yielding system consists of three technologies: sludge dehydration using an inside double coagulation type centrifugal dehydrator, energy recovery using an innovative step grate (with boiler), and energy conversion using steam generators (both centrifugal and binary-type).

The technology was adopted by the Ministry of Land, Infrastructure, Transport and Tourism's Breakthrough by Dynamic Approach in Sewage High Technology Project (B-DASH) in FY2013, and we constructed a full-scale demonstration plant capable of incinerating 35 tons (wet) per day at the Wakayama Municipal Central Sewage Treatment Plant. Based on data obtained from the plant's operation, we were able to conclude that it delivered the target level of performance that we had envisioned at the outset, that operation is stable even without auxiliary fuel, that it generates electricity using heat recovered by means of steam, and that it generates more power than the incineration facility uses. The results from the demonstration project were published in September 2015 by the Ministry of Land, Infrastructure, Transport and Tourism National Institute for Land and Infrastructure Management in the form of a series of "Guideline for Introducing a Technology (draft)."

##### ● High-temperature energy-saving sludge incinerator

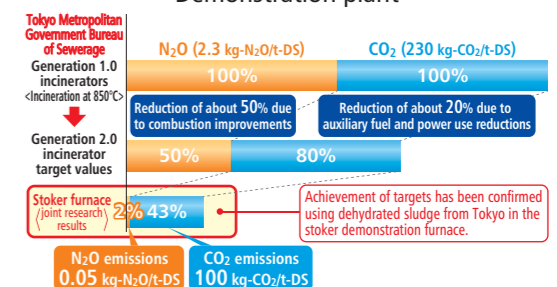
As a result of joint research, we were able to verify that stoker furnace-based sludge incineration technology satisfies the standards for high-temperature energy-saving incinerators as put forth by the Tokyo Metropolitan Government Bureau of Sewerage (for Generation 2.0 and 2.1 incinerators), which require incinerators to address global warming, improve energy savings, and reduce maintenance and management costs. Consequently, the incinerator was approved as a compliant facility.

##### ● Energy self-reliant sludge incinerator

As a result of joint research, we were able to verify that our system combining stoker furnace-based sludge incineration technology with steam-driven power generation technology satisfies the standards for energy self-reliant sludge incinerators as put forth by the Tokyo Metropolitan Government Bureau of Sewerage (for Generation 3.0 incineration systems), which require that incinerators to generate more power than they use, that incinerators do not require auxiliary fuel (with the exception of special operations such as incinerator startup and shutdown<sup>(\*)</sup>), and that incinerators help reduce the CO<sub>2</sub> emissions associated with power use. Consequently, the incinerator was approved as a compliant facility.

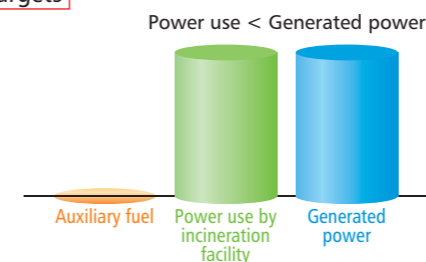


Demonstration plant



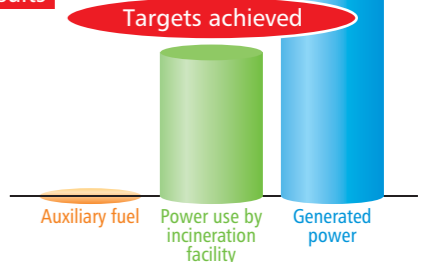
Joint research results of high-temperature energy-saving incinerator

#### Targets



Energy self-reliant sludge incinerator  
N<sub>2</sub>O emissions: 1.15 kg-N<sub>2</sub>O/t-DS or less  
Power use: 161 kWh/t-DS or less<sup>(\*)</sup>  
Unit price of generated power: JPY 14/kWh or less

#### Results



Research results of stoker furnace  
N<sub>2</sub>O emissions: Target achieved  
Power use: Target achieved  
Unit price of generated power: Target achieved

<sup>(\*)</sup> Except during incinerator startup and shutdown, when dehydrated sludge moisture content exceeds 74%.  
<sup>(\*)</sup> When incinerating dehydrated sludge with a moisture content of 74% and an incineration capacity of 300 tons per day. Some generated power may be used to operate the facility.

Joint research results for an energy self-reliant sludge incinerator

## 4. Activities of Our Overseas Business

—Sales of biomass-fired power plants, municipal solid waste incineration plants, and Energy from Waste plants overseas

For more than half a century, Takuma's biomass boilers have contributed to industrial growth and economic development in Southeast Asia. In addition, our power plants help materialize coexistence of both environmental protection and energy supply.

### Biomass-fired power plant sales in the Southeast Asian market

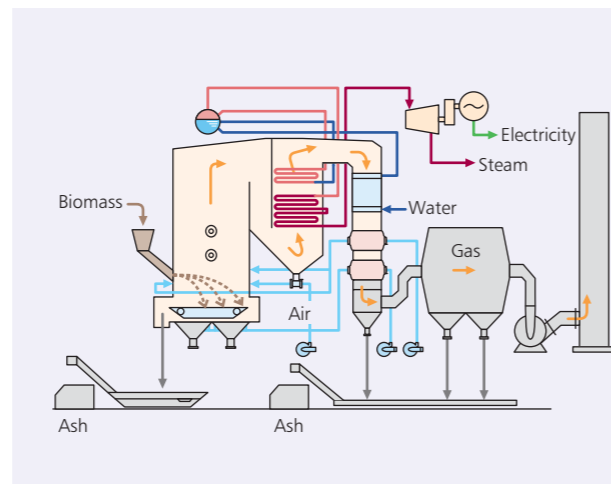
In the Southeast Asian market, the sugar industry in Thailand is undergoing a transition from a sector that focused on expanding sugar production volume to an energy-supplying industry in which sugar production is joined by electricity sales and bioethanol production as core business operations. Specifically, companies are combining bagasse (fiber remaining after sugarcane is crushed and sugar extracted) as a main fuel with eucalyptus wood chips, rubber wood chips, cane leaves, rice husks, and other materials as auxiliary fuels to effectively generate electricity, using comparatively high-temperature, high-pressure steam on the order of 10 MPa and 520°C, for sale to the grid.

Furthermore, impetus to this major change is being given by programs that give exemptions on import duties for building power plants using biomass and other renewables, that lower corporate taxes for operators during a specific period and that maintain advantageous purchase prices for power by means of feed-in-tariff (FIT) mechanisms. As a result, there continues to be a voracious appetite for investment in the Thai sugar industry despite the recent decline in sugar prices on international markets.

There is also a noteworthy trend on the part of other countries in Southeast Asia toward using the Thai programs as a model in the use of biomass and other renewables.

Takuma will continue to draw on its extensive experience and outstanding technology to meet market demand by supplying highly reliable power plants that deliver efficient and stable combustion of biomass.

In addition, we are confident that we will be able to make an even broader contribution by building on our record of success through delivery of biomass mixed-firing high-efficiency, high-temperature/high-pressure boiler power plants to the sugar industry in Thailand and thereby earning praise in the market so that we can supply highly reliable plants to the markets in nearby countries such as Indonesia, Myanmar, Vietnam, Cambodia and Laos.



High-temperature/high-pressure boiler



- Steam capacity: 165 tons per hour
- Design pressure: 12.5 MPaG
- Steam pressure: 10.5 MPaG
- Steam temperature: 520°C
- Design: Single drum, Vertical type, Natural circulation, Membrane design
- Combustion method: Traveling stoker
- Fuel: Bagasse
- Principal emissions treatment: Electrostatic precipitator

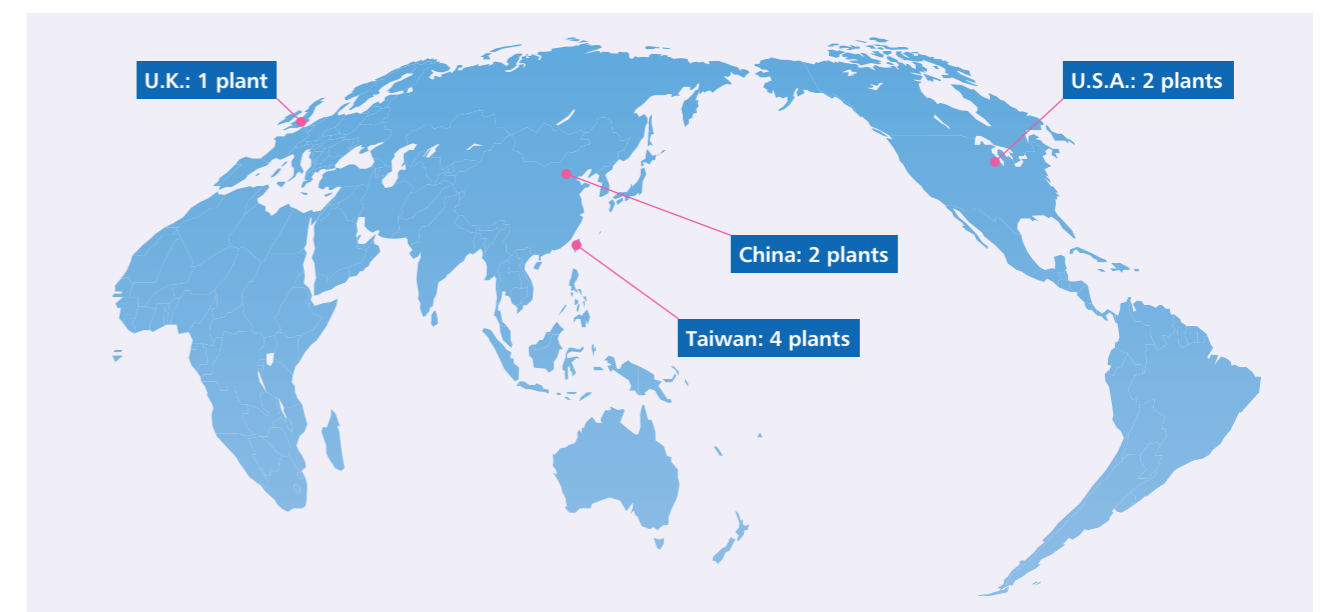
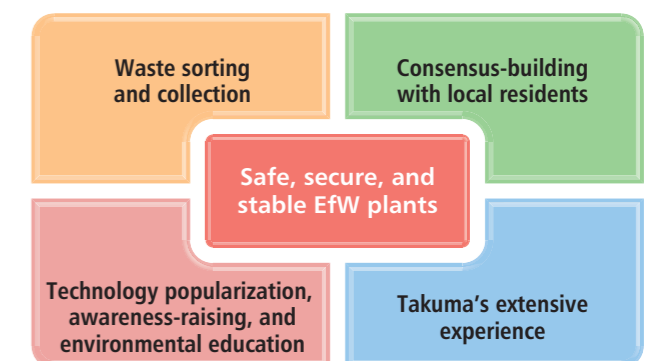
### Overseas Energy from Waste plant business

Through its overseas market research, Takuma has become aware that demand for Energy from Waste (EfW) plants is growing rapidly worldwide against the backdrop of urbanization and growing environmental awareness. Particularly in developing countries where urbanization is occurring, there is pressure to take environmental factors into consideration along with infrastructure development (for example by preventing global warming through the use of renewable energy), and interest in building EfW plants is rising rapidly.

At the same time, most developing countries need appropriate diagnostic information, advice, and guidance concerning this type of facility, and due to the need to understand waste treatment in each of these markets, it will be essential for Takuma to strengthen partnerships with stakeholders in each country and obtain more accurate information in order to pursue its business.

Takuma has been able to take advantage of its extensive experience and track record, coming from the holding top market share in Japan and the high praise that the nine EfW plants delivered overseas have earned for stable operation and other performance, to provide optimal proposals in response to each country's unique needs while exchanging detailed information with stakeholders. We are interested in working with Japanese local governments to help the public and private sectors in overseas countries come together to resolve waste-related issues, and we expect our expertise in areas such as waste sorting and collection, EfW technology popularization and awareness-raising, environmental education, and consensus-building with local residents to play an important role. We are confident that we can provide safe, secure, and stable plants to the people of these countries and regions by pursuing these initiatives.

Although the market and competitive environment worldwide are becoming more challenging as Asian and European companies join their domestic counterparts in competing for project orders, Takuma will conduct feasibility studies to gauge the viability of building optimal business models that will enable it to take advantage of its strengths as the first step after choosing target markets. In this way, we plan to contribute to environmental protection by building overseas EfW plant businesses that are optimally suited to each country and region.



EfW plants delivered by Takuma overseas