Riverside EfW plants, London UK（2,332t/d　65MW）

Hitachi Zosen Corporation

Waste to Energy

– Heat recovery from waste

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Hitachi Zosen

February 25, 2015

Hitachi Zosen Corporation Company Profile

A major global player in the business domains of Renewable Energy, Social Infrastructure and Disaster Prevention

We have developed a wide range of technologies based on strong capabilities in the Waste to Energy market worldwide.

Corporate Data and Business

Founded	1881
Incorporated	1934
Employees	9,171 (consolidated)*
Paid-in Capital	45 billion yen (483 million US$) *
Net Sales	333 billion yen (2,822 million US$) *
Headquarters	Osaka and Tokyo

Environmental Systems

- Waste to Energy plants
- Material recycle system
- Water & sludge treatment etc.

Industrial Plants

- Desalination Plants
- Power generation facilities
- Renewable energy etc.

Infrastructure

- Shield tunneling machines
- Bridges
- Disaster prevention systems etc.

Process Equipment

- Pressure vessels
- Spent nuclear fuel storage cask & canister(container) etc.

Machinery

- Marine diesel engines
- Press machines
- Precision machinery etc.

*(As of March 31, 2014)

1. WASTE TO ENERGY

Waste to Energy Plant

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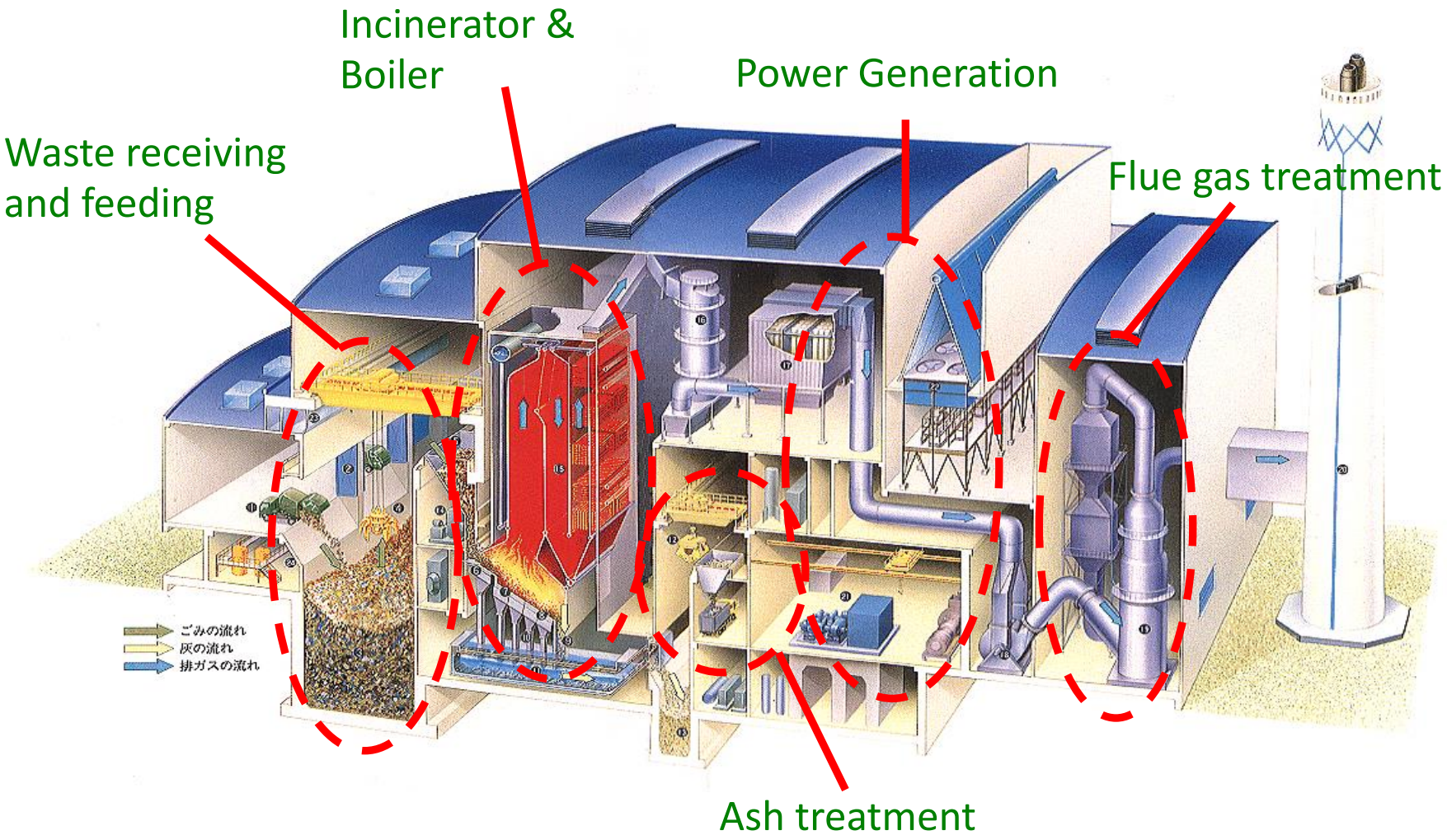
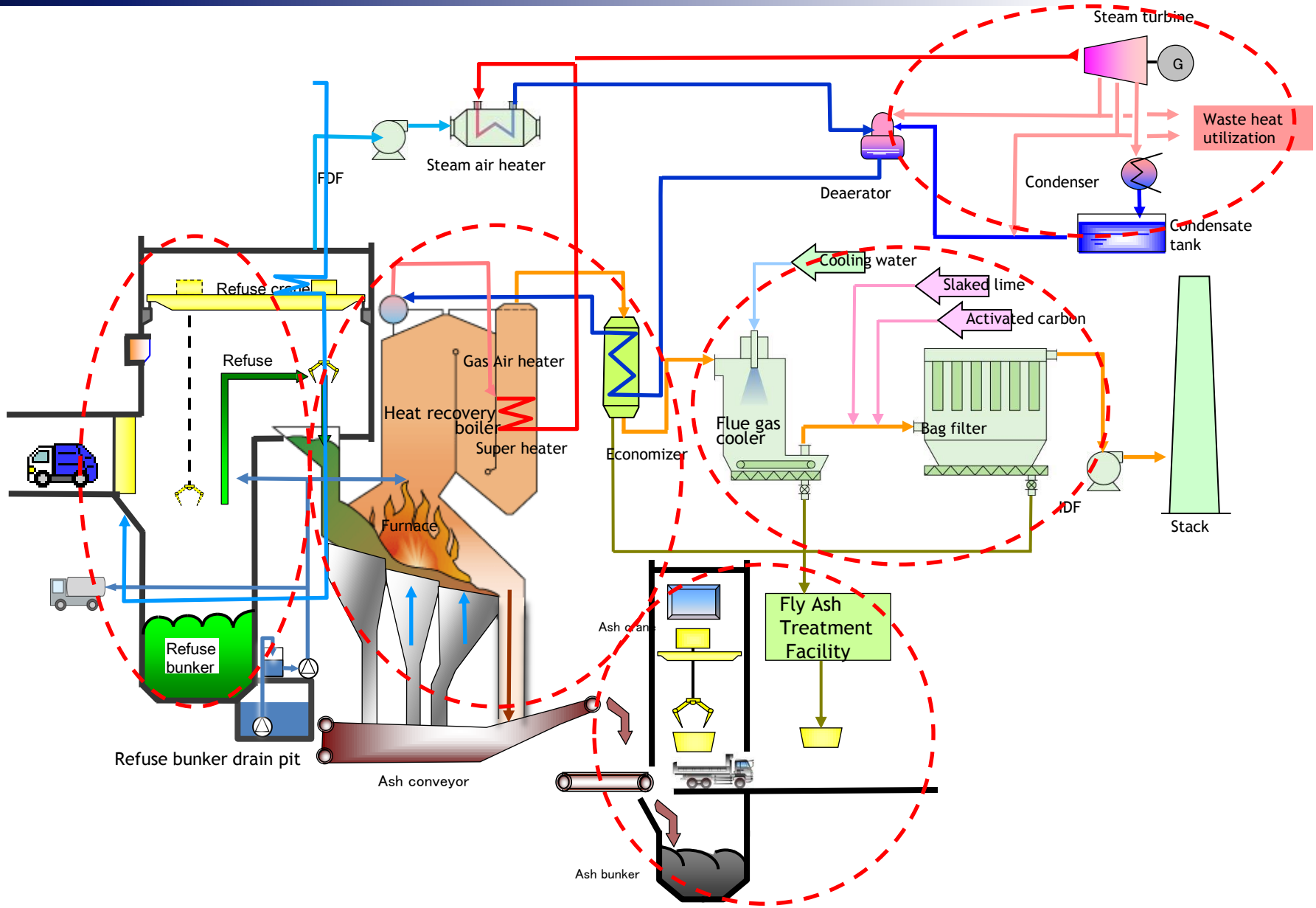


Process Flow Diagram



Why to combust Mixed Waste

- Less landfill space required
- Thermal Utilization of Energy Content
- No ground leakages
- No uncontrolled gas emissions
- Reduction of green house gas emissions
- Material Utilization
- Reduction of transportation distances

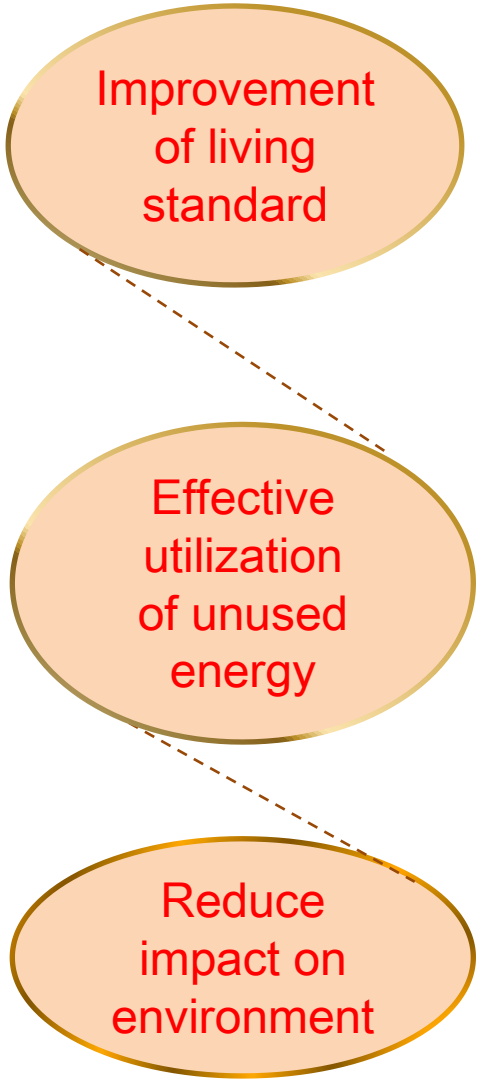
Many industralized countries have banned MSW landfills

Some Fact about WtE

- Sanitary waste treatment ➔ Improvement residential environment and Health
- Mass treatment possibility
- Good adaptability for treatment of various wastes
- Volume reduction of Waste (over 90%)
  ➔ Landfill life-extension

- WtE is considered as Green Energy / Renewable Energy world wide.
- Waste heat utilization & Power Generation
- Stable clean energy

- Greenhouse Gas Reduction (Carbon emission credits)
- It meets all Environmental norms in Japan or in Europe



Power Generation by WtE installation in Japan

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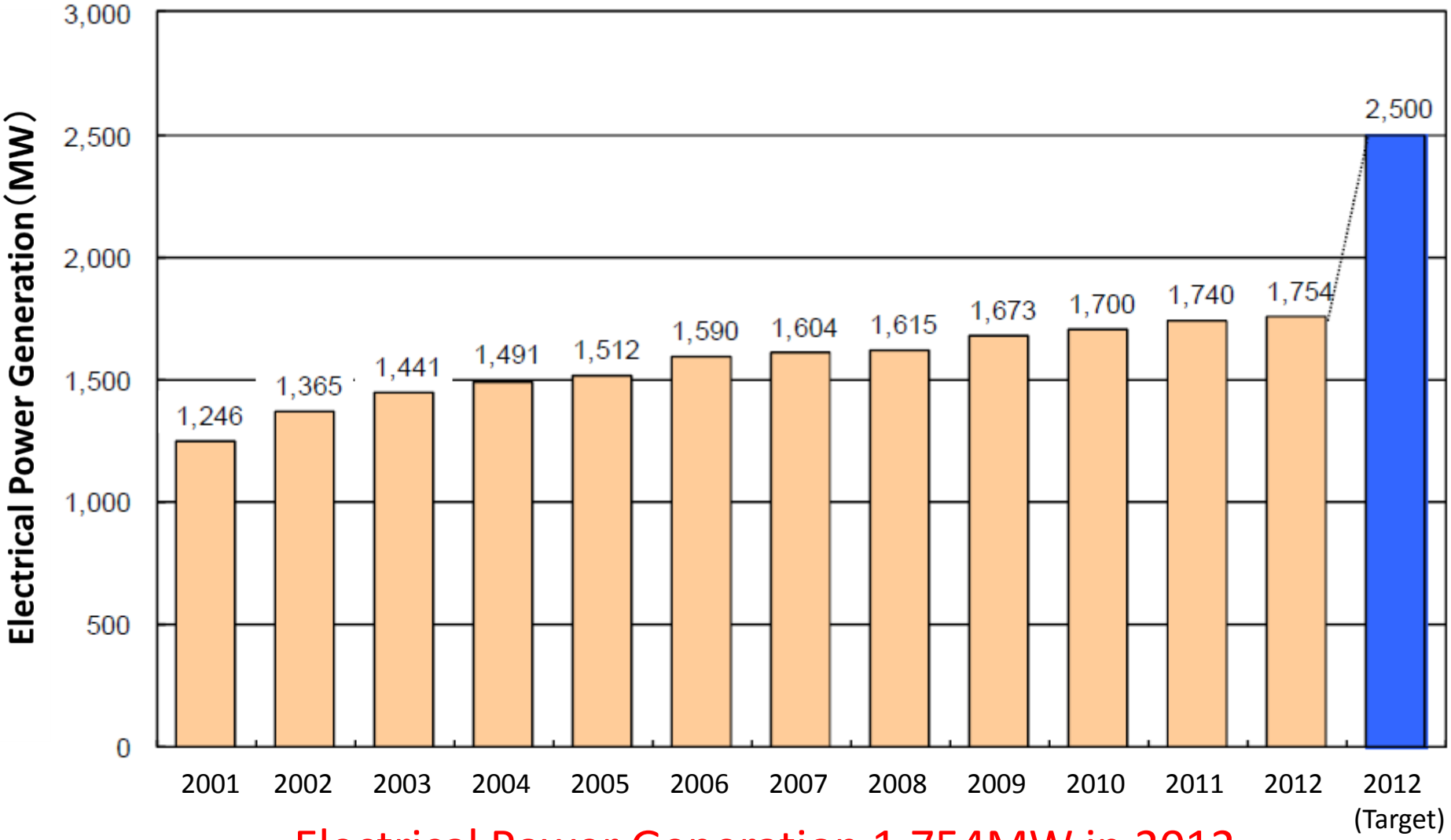
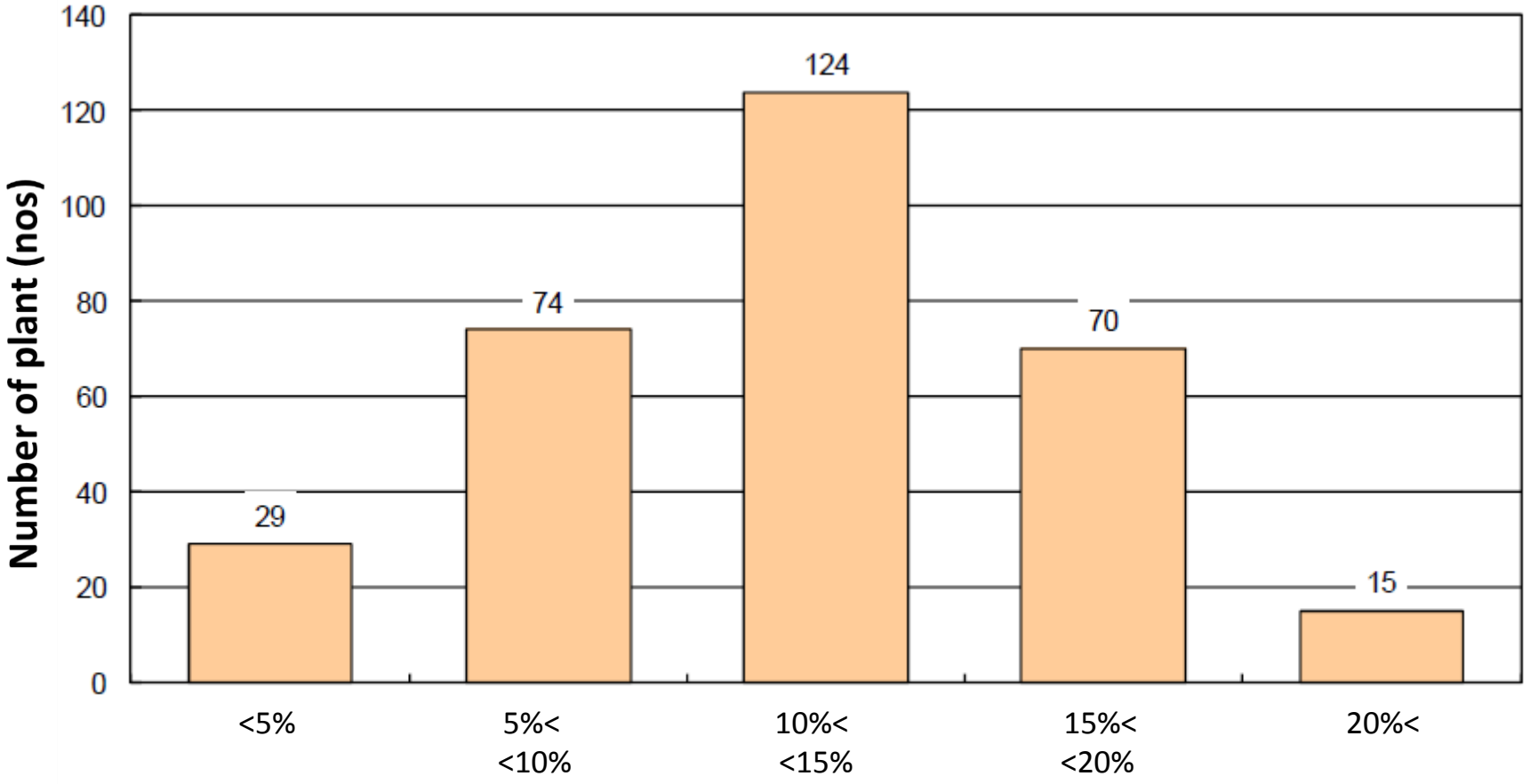


Electrical Power Generation 1,754MW in 2012

Resource: Ministry of Environment

Power Generation Efficiency by WtE in Japan



Resource: Ministry of Environment

Global reference of WtE

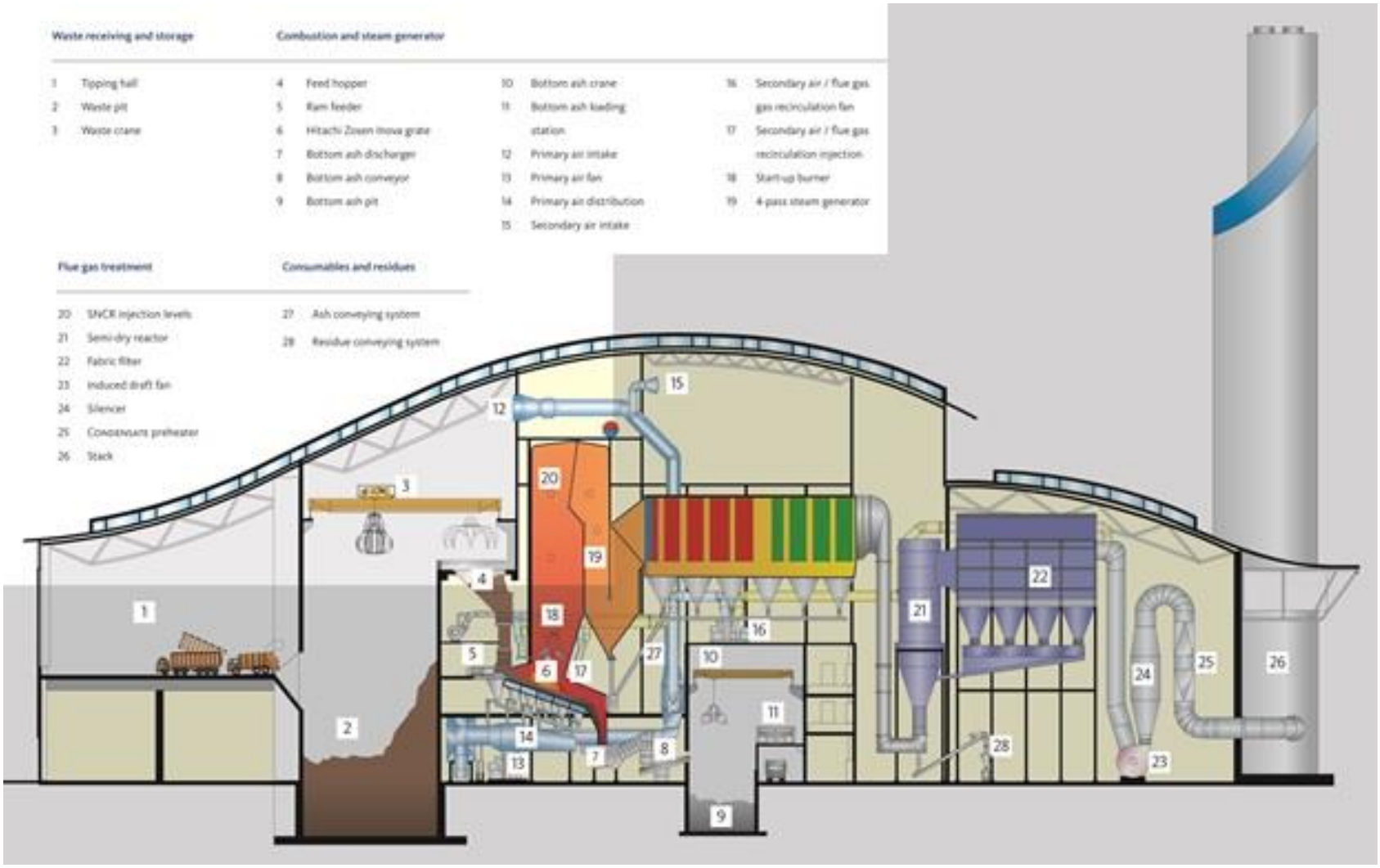
Riverside (London), United Kingdom

- Largest EfW facility in the UK
- Hitachi Zosen Inova was full turnkey contractor including jetty and road works
- 80% of waste delivery via barges from Thames River
- Highly efficient plant (27%) at higher steam conditions
- Steam goes to 72.4 MW_{el} turbine
- Plant operation during first 4 years carried out by Hitachi Zosen Inova

Key Data

Client	**Riverside Resource Recovery Ltd.**
Start-up	**2010**
Technology	
Furnace	Grate furnace (air-cooled)
Energy recovery	4-pass boiler, turbine
Flue gas treatment	SNCR, semi-dry process
Technical Data	
Fuel	Municipal waste
Waste capacity	2,290t/d (763t, 3 lines)
Net calorific value	9.0 MJ/kg
Thermal capacity	3 x 79.5 MW
Steam	3 x 54 t/h (72 bar, 427° C)

Flow sheet of London Riverside plant



Global reference of WtE

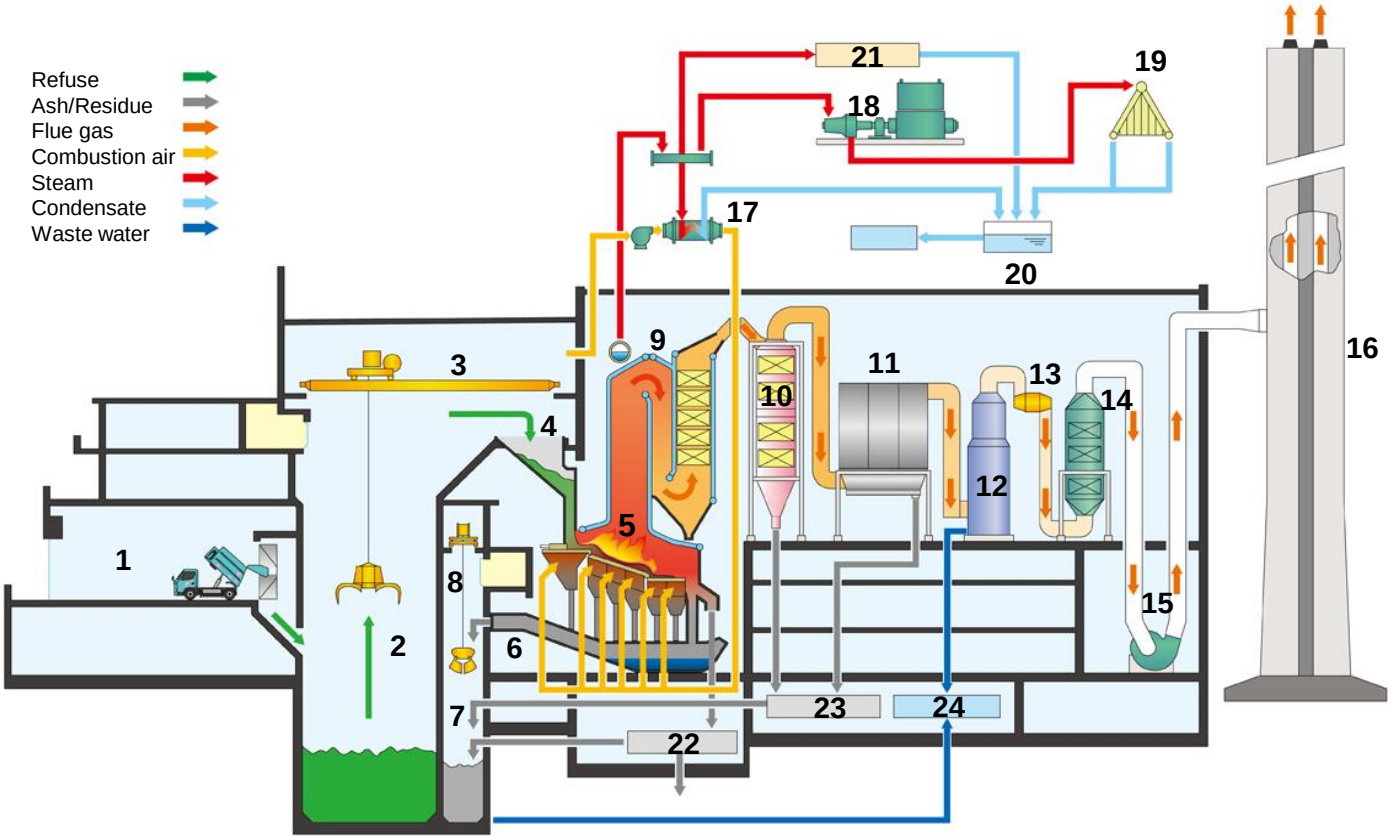
- Hitachi Zosen is EPC contractor for Turn-key basis excluding building works
- Highly efficient plant (20.4% @ DP) even though wet scrubber and SCR in flue gas treatment sysetem
- Hitachi Zosen providing Periodical Maintenance Services since start-up.

Osaka Hitashiyodo, Japan

Key Data

Client	**Osaka city**
Start-up	**2010**
Technology	
Furnace	Grate furnace (air cooled)
Energy recovery	4-pass-boiler
Flue gas treatment	dry + wet scrubber, SCR
Technical Data	
Fuel	Municipal waste
Waste capacity	400 t/day (200t/d, 2 lines)
Thermal capacity	2 x 29 MW
Power out put	10MW
Steam	2 x 74 t/h (40 bar, 400° C)

Flow sheet of Osaka Higashiyodo plant



1 Tipping hall
2 Waste pit
3 Waste crane
4 Feed hopper
5 Reciprocating incineration grate
6 Bottom ash discharger
7 Bottom ash pit
8 Bottom ash crane
9 3-pass steam generator
10 Economizer
11 Fabric filter
12 Wet scrubber
13 Gas reheater
14 SCR
15 IDF
16 Stack
17 Combustion air preheater
18 Turbine Generator
19 Air cooled steam condenser
20 Condensate tank
21 Available waste heat facility
22 Residue screening system
23 Fly ash treatment system
24 Waste water treatment system

- Capacity: 200t/D x 2 units
- Power Generation Capacity: 10,000kW
- Steam Condition: 4MPa x 400℃
- Generating Efficiency: 20.4%

Power generation efficiency at WtE in India

Hitachi Zosen India has developed standard WtE plant for Indian market: LoCal Plus

Design Point: **Waste throughput 600t/d**
Net calorific value 1650 kcal/kg
Power generation 11.5MW

Total waste quantity: W kg/h	= 25,000 kg/h = 600t/d
Net Calorific Value: NCV kcal/kg.	= 1,650 kcal/kg
Energy recovery potential (kWh)	= 1.16 x 10^{-3} x NCV x W
	= 1.16 x 10^{-3} x 1,650 x 25,000
	= 47,850 kW
Power generation (kW)	= 11,500 kW
Power generation efficiency (%)	= 11,500 / 47,850 x 100 = 24.0

Electric Power

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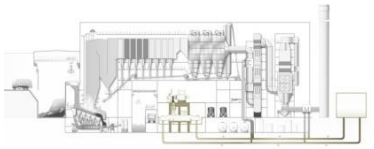
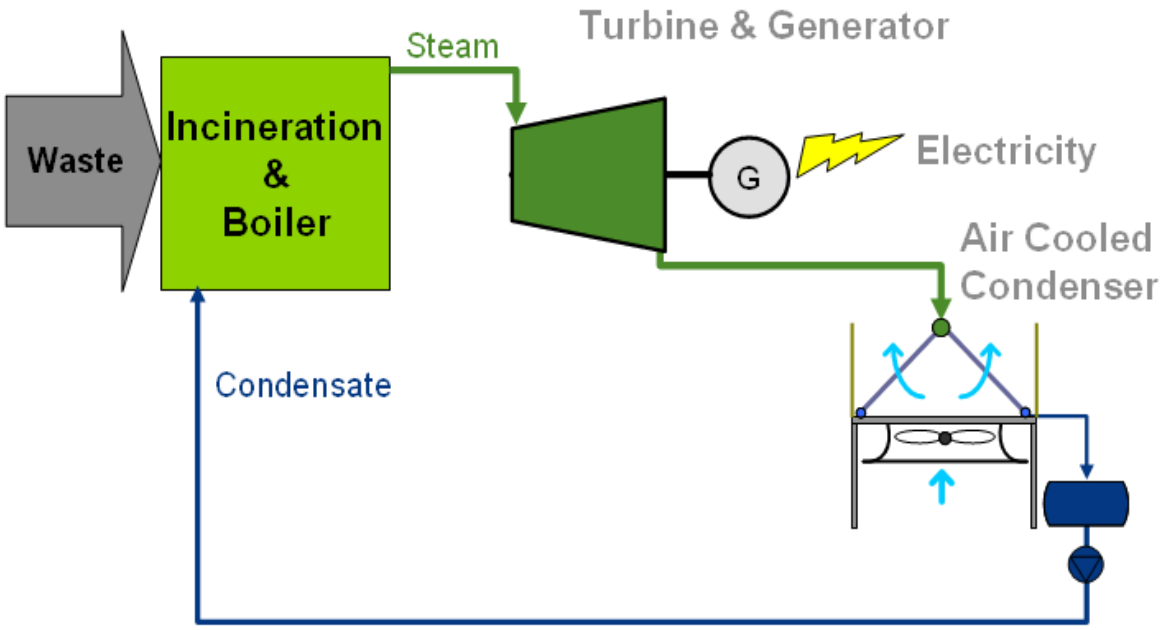
Main Features

- Only electricity production without heat utilization

Efficiency

- Up to 27%





Combined Heat and Power

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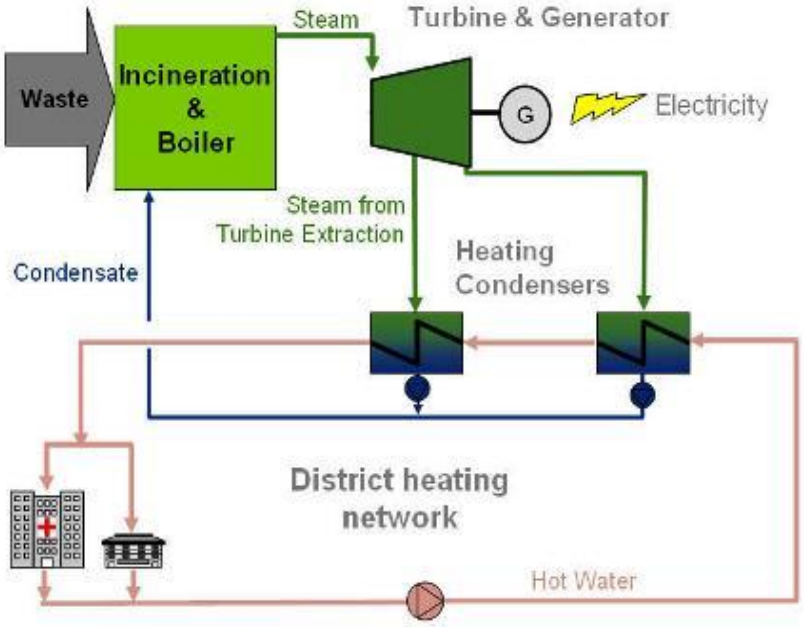
Main Process

- Combined heat and power with high heat demand and heat export throughout all or most of the year

Efficiency

- Up to 84%

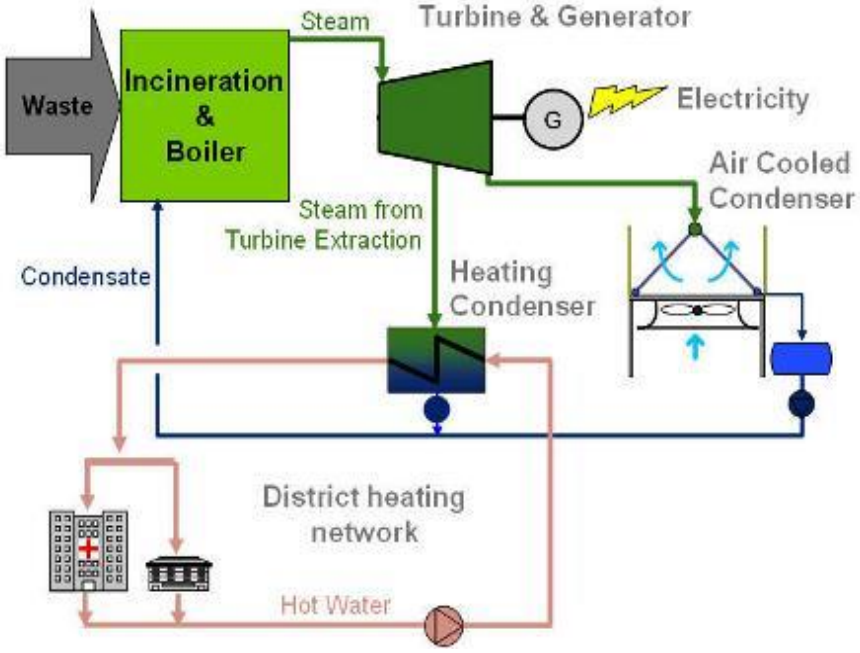


Main Process

- Combined heat and power with moderate heat demand part time or throughout the whole year

Efficiency

- Up to 62%



Combined Cold and Power

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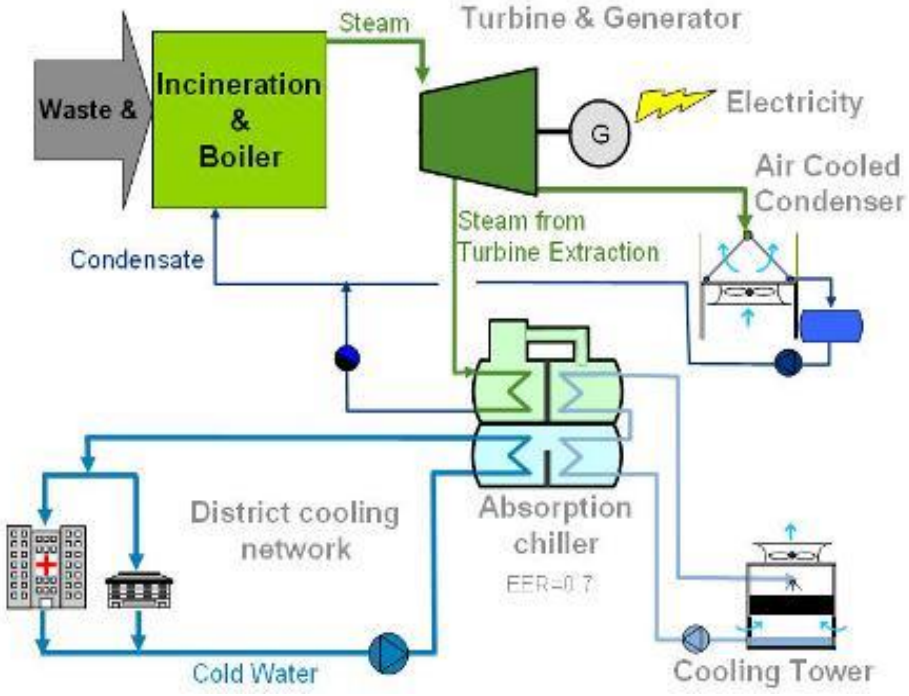
Hitachi Zosen

Main Process

- Combined cold and power with moderate heat demand part time or throughout the whole year

Efficiency

- Up to 50%



Reference of Heat Utilization

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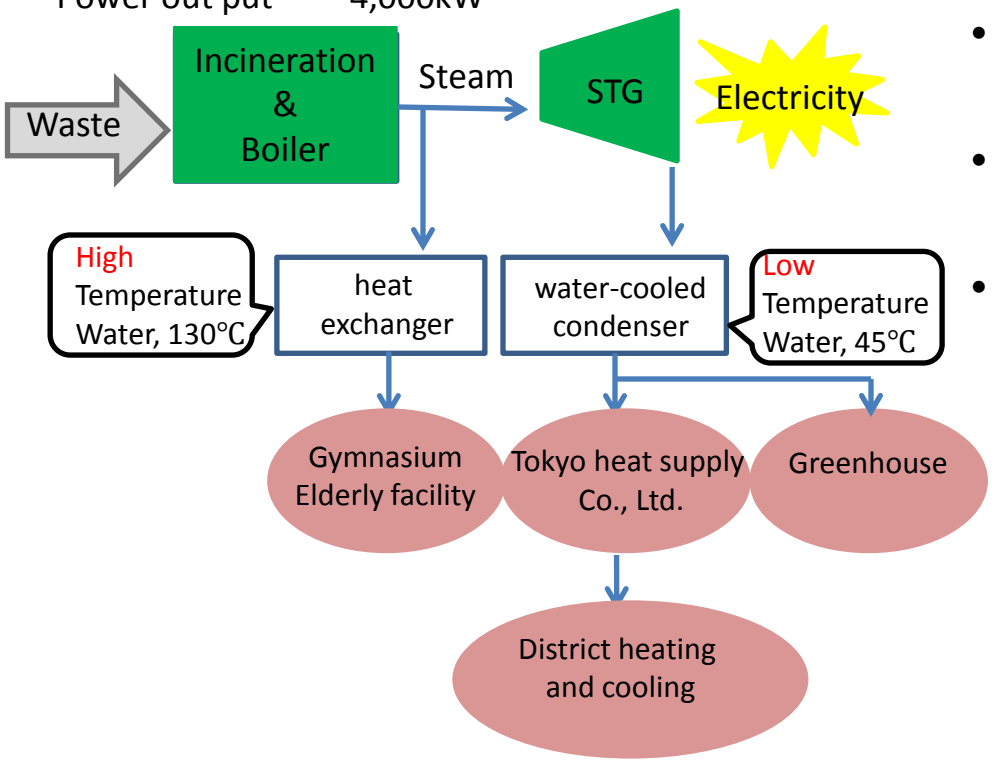
Name	Heat source	Method	Medium	Temp.	Heat recovery amount	Heat user
Hikarigaoka, Tokyo	Turbine exhaust	Water condenser	Hot water	45℃	36GJ/h	District heating and cooling, Greenhouse
Nakatsugawa	Melting furnace cooling water	Trans heat container	Heat medium	70℃	3.6GJ/container	Hot water supply and air conditioning at hospital
Taishou, Osaka	Boiler steam	Trans heat container	Heat medium	130℃	0.9GJ/container	Hot spring, Steelworks, District heating and cooling
	Turbine exhaust	Binary generation	Electricity	-	155kW (Net)	Power provider
Morinomiya, Osaka	Boiler steam	Boiler	Steam	220℃	150GJ/h	District heating and cooling
Ichihara	Turbine exhaust	Water condenser	Hot water	80℃	7.0GJ/h	Greenhouse for agricalcure
Higashi Saitama	Turbine exhaust	Heat pump	Hot water	90℃	20.9GJ/h	Swimming pool
Toubu, Kobe	Scrubber exhaust heat	Heat exchanger	Hot water	45-60℃	19.88GJ/h	Hot water provider in Rokkou island CITY

From 廃棄物処理施設における高効率熱利用（2014.12）廃棄物対応技術検討懇親会報告書

Case1: Hikarigaoka, Tokyo

Client	**Clean Association of Tokyo 23 Hikarigaoka, Tokyo**
Start-up	**1983**
Technology	
Furnace	Grate furnace
Technical Data	
Waste capacity	300 t/day (150t/d, 2 lines)
Power out put	4,000kW



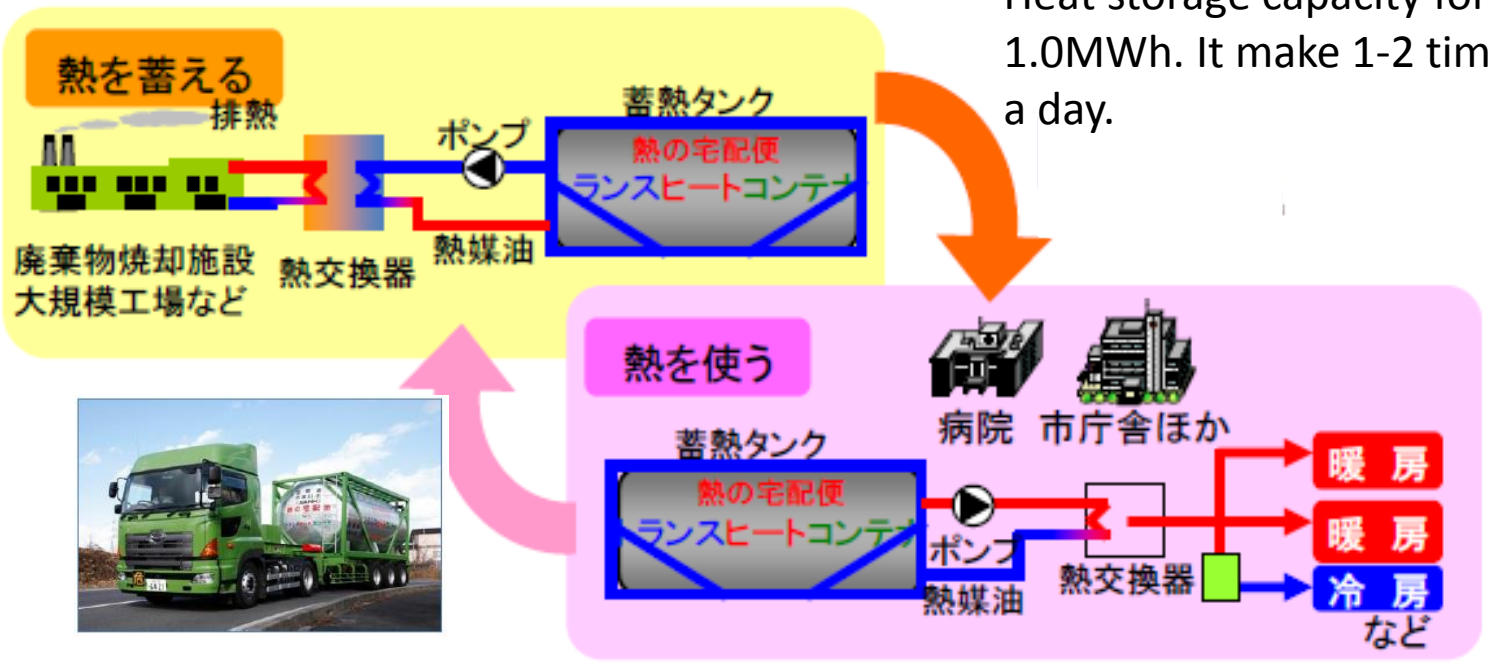
- Low-temperature water recover heat from turbine exhaust with a water-cool-condenser.
- Low-temperature water is supplied to Tokyo heat supply Co., Ltd. and greenhouse.
- Tokyo heat supply Co., Ltd. supply to district heating and cooling.
- High-temperature water recover heat from the steam with a heat exchanger.
- High-temperature water is supplied to gymnasium and elderly facility.

From 廃棄物処理施設における高効率熱利用（2014.12）廃棄物対応技術検討懇親会報告書

Case2: Nakatsugawa

Client	**Environment Center Nakatsugawa, Gifu**
Start-up	**2004**
Technology	
Furnace	Gasifying and melting furnace
Technical Data	
Waste capacity	98 t/day (49t/d, 2 lines)
Power out put	900kW

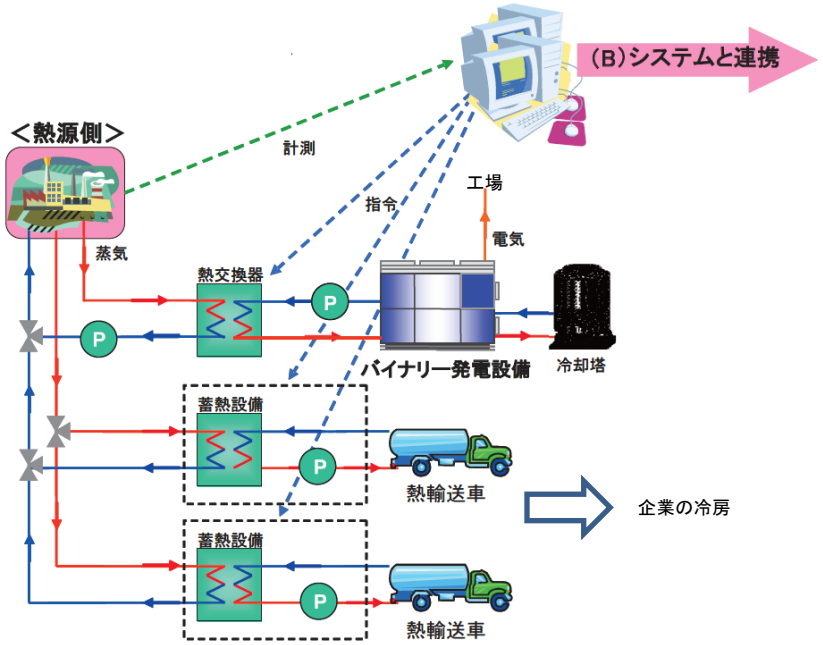
- The exhaust heat generate from facility accumulate in a trans heat container. Heat is supplied to the city hospital.
- Metaling furnace cooling water is 70-80 ℃, Supplied Heat is 40-50℃.
- Transport distance of the container is 3km.
- Heat storage capacity for one container is 1.0MWh. It make 1-2 times of heat storage a day.



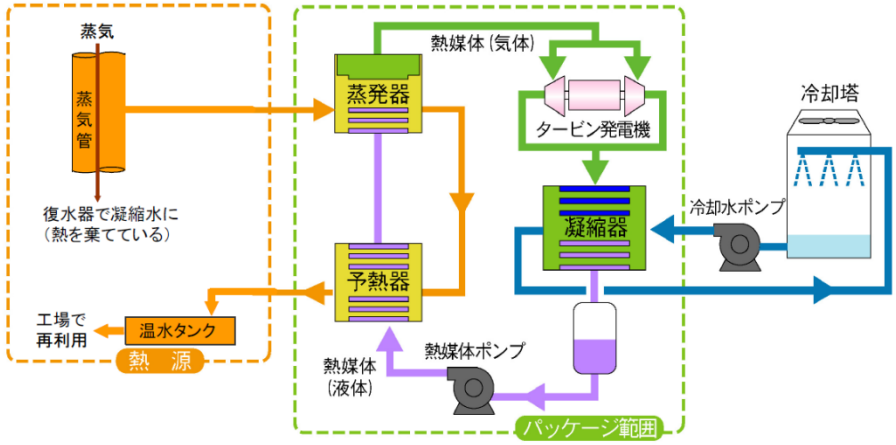
From 廃棄物処理施設における高効率熱利用（2014.12）廃棄物対応技術検討懇親会報告書

Case3: Taishou, Osaka

Client	**Osaka City Environment Bureau Taishou, Osaka**
Start-up	**1980**
Technology	
Furnace	Grate furnace
Technical Data	
Waste capacity	600 t/day (300t/d, 2 lines)
Power out put	3,000kW(Steam turbine) 250kW(Binary generation)



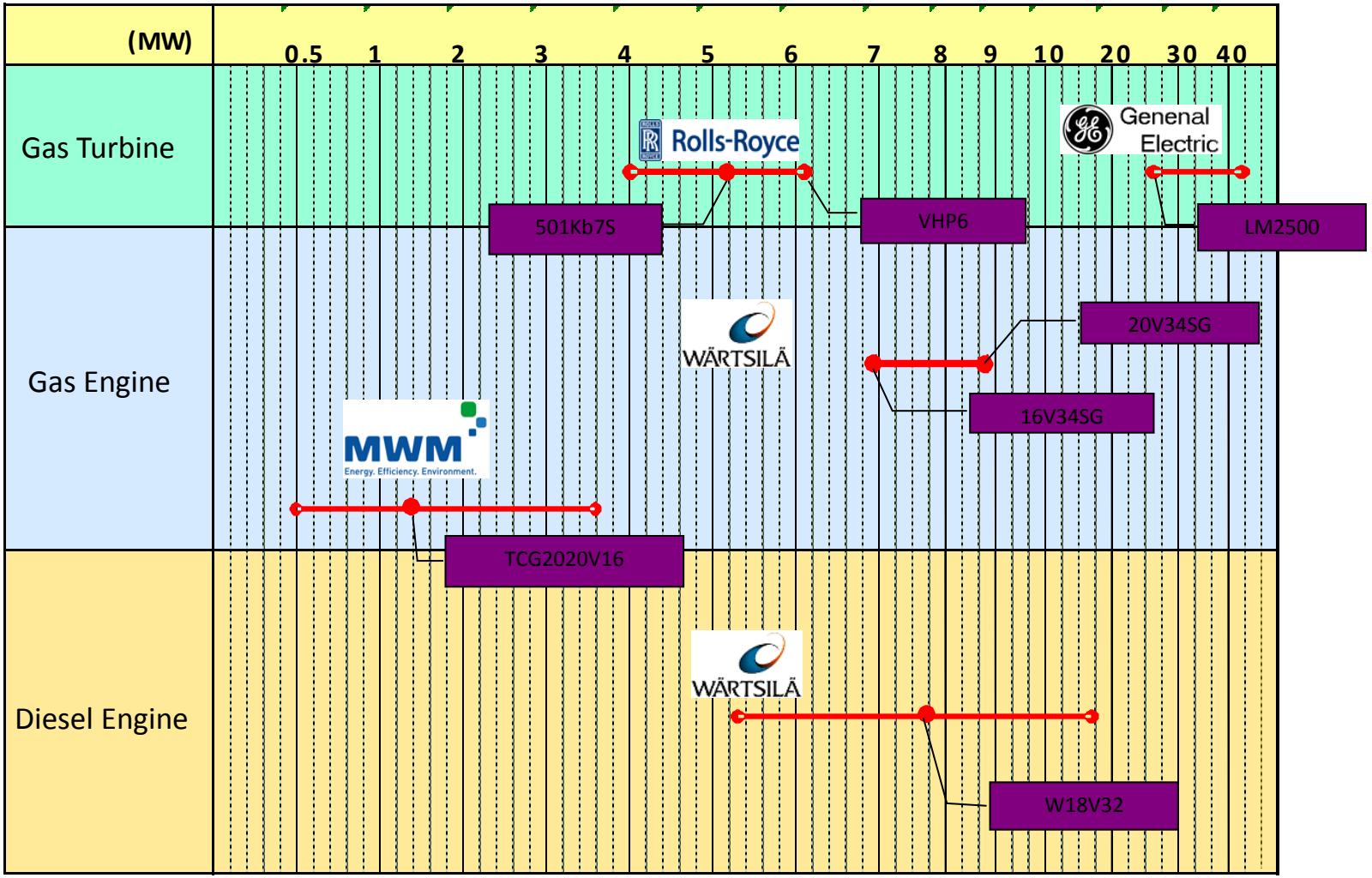
- Binary generation is carried out by the turbine exhaust steam of facility.
- Heat storage transportation is carried out by boiler steam.
- The electricity which generated by binary generation is sold and the heat supplied to Hot spring, Steelworks, District heating and cooling by the heat storage transportation.
- Transport distance of the containers is 2-7km.



From 廃棄物処理施設における高効率熱利用(2014.12)廃棄物対応技術検討懇親会報告書

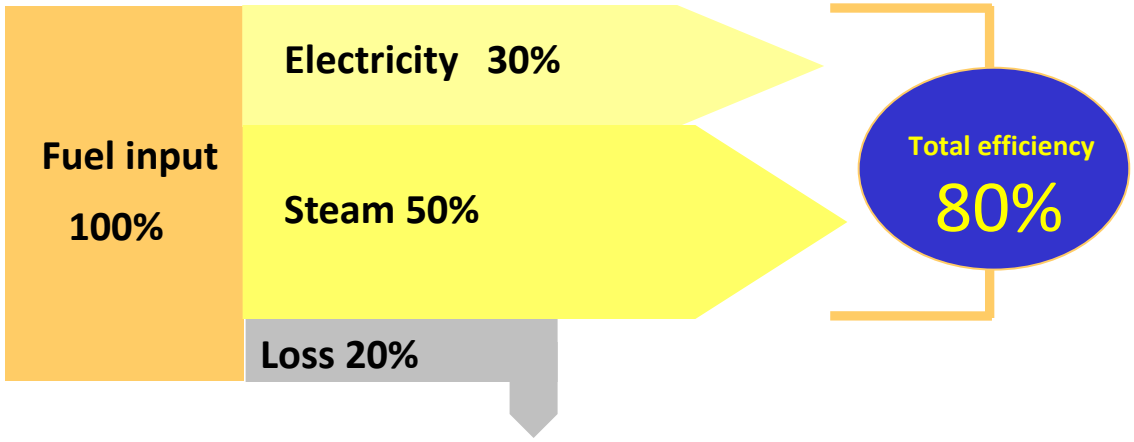
2. CO-GENERATION SYSTEM

Hitachi Zosen Power Plant Line-Up



Co-Generation System

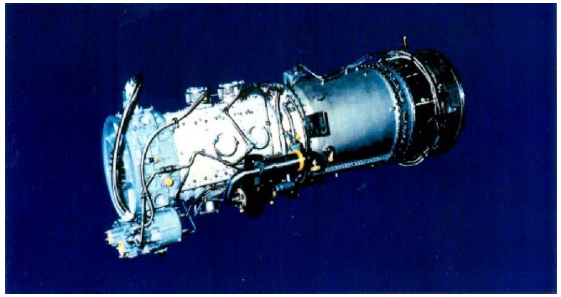
- Power generation system with a total efficiency exceeding 80% achieved with heat recovery from exhaust gas.
- Environmental-friendly system by reducing GHG emissions.
- Self-standing power generating system even in the grid black-out situation.
- Peak-cut operation is possible



Gas Turbine Cogeneration- Achievement

Gas Turbine	Number of Plants	Number of Engines	Total
GT-10 (4,000kW)	10	16	54,300kW
GT-13 (5,000kW)	3	3	14,500kW
GT-15 (6,000kW)	1	3	16,200kW
VHP6 (6,000kW)	27	34	208,280kW
LM-2500 (22,000kW)	3	4	106,100kW
Others	12	21	335,800kW
Total	56	81	735,180kW

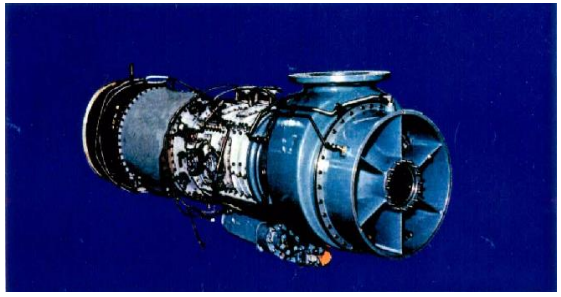
Middle Class Gas Turbine – Line Up



GT-10

RRC 501-KB5S

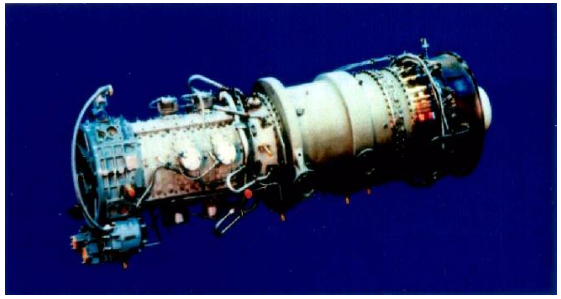
Power Output	4,100 kW (Simple Cycle)
Steam	11.0 t/h
Efficiency	Electricity 27.0% Steam 50.8% Total 77.8%



GT-13

RRC 501-KB7S

Power Output	5,490 kW (Simple Cycle)
Steam	12.2 t/h
Efficiency	Electricity 29.5% Steam 45.2% Total 75.4%



VHP-6

RRC 501-KH5

Power Output	6,100～4,200 kW（Variable）
Steam	0.4～8.7 t/h
Efficiency	Electricity 39.0～29.9% Steam 1.9～46.6% Total 40.9～76.5%

Middle Class Gas Turbine – Features

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- Controlled by Hitachi Zosen's Original Governors 'Hicot'
- Powered by Rolls–Royce Aero Derivative Gas Turbine
  - ✓ Light Weight & Compact but High Performance

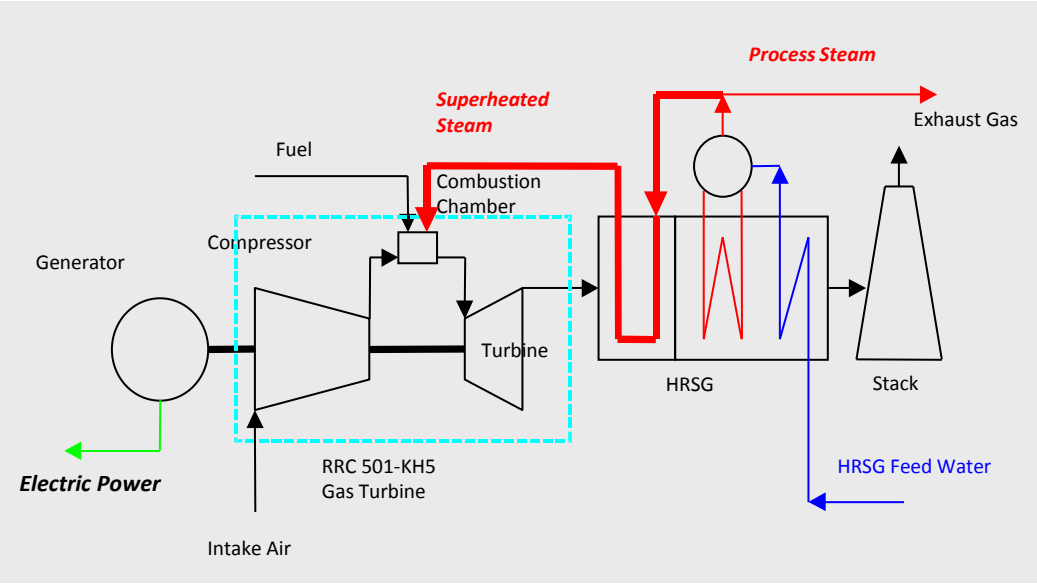
Rolls-Royce

- High Reliability
  - ✓ More than 13,000 units for Aero, 1,900 units for Power Generation
- Easy Maintenance
  - ✓ Sectioned in 6 modules
  - ✓Spare Engines available, anytime dispatchable for an emergency GT replacement work (only few hours)
- Durable for Daily Start & Stop operation
  - ✓ Designed for frequent Start & Stop operation inherited by Aero industry
  - ✓ Not affected in operational hours by the number of starts & stops

Difference between VHP6 and Simple Cycle

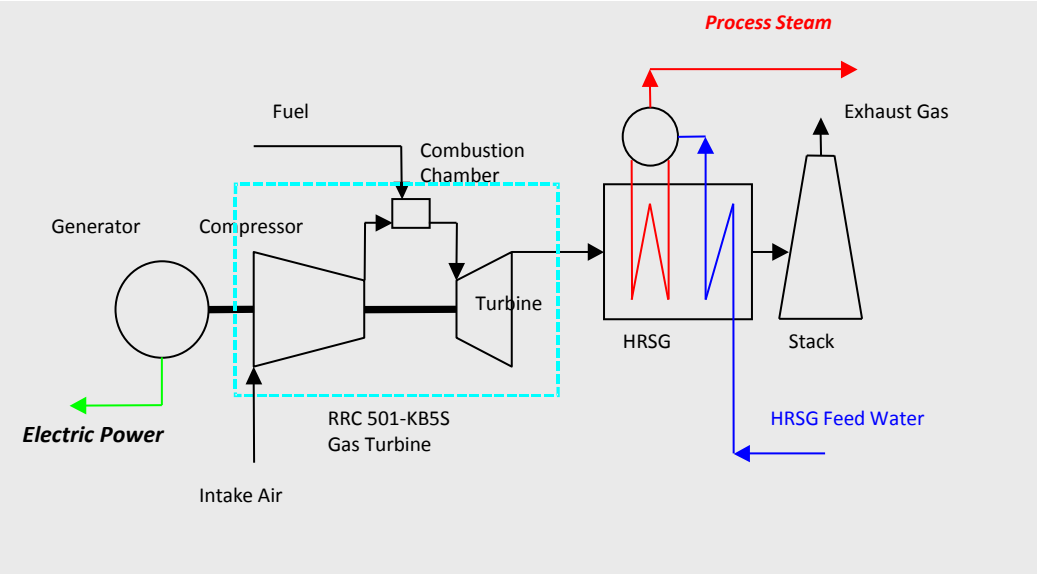
- **VHP6**

Variable Heat and Power Operation is Possible by Steam Injection



- **SIMPLE CYCLE**

Constant ratio of Heat and Power Operation

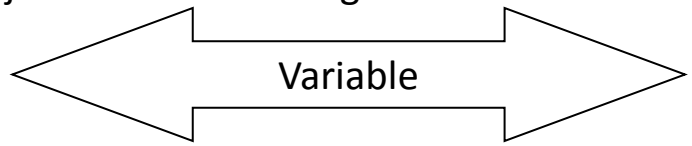


Feature of VHP System

- **Variable heat and power operation is possible without shut down.**

  When you need more power and less steam (e.g. Summer season), you can generate 6MW power with 0.4t/h steam by injecting excess steam to gas turbine to increase power.

  When you need more steam and less power (e.g. Winter season), you can generate 4MW power with 10t/h steam by no injection of steam to gas turbine.

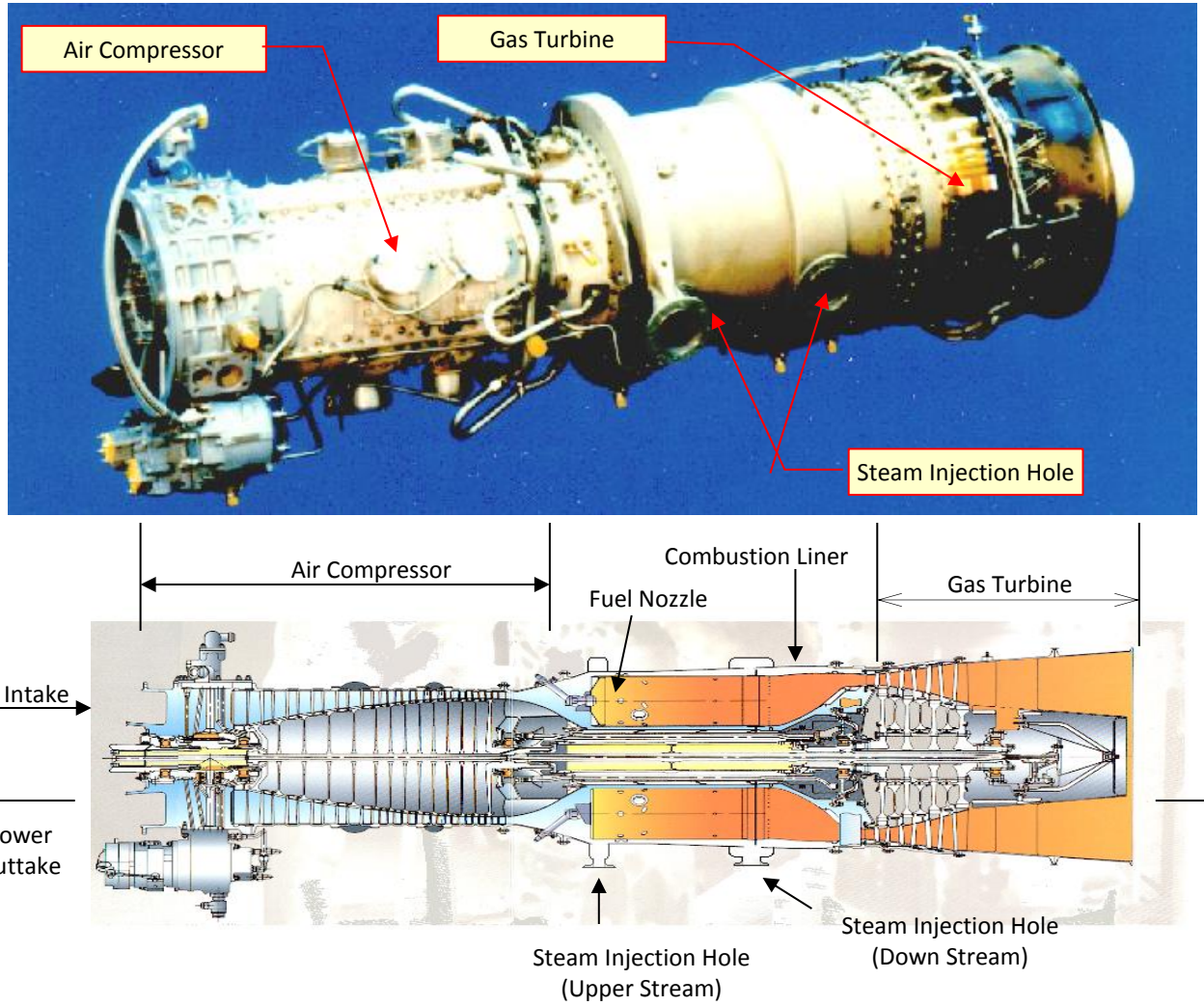


		Mark Ⅰ	Mark Ⅱ
Ambient Temp.	℃	15	15
Power Output	kW	6,100	6,120
Steamf for GT	kg/h	9,792	9,792
Steam for Factory	kg/h	400	3,500
Fuel Consumption	kcal/kW	2,207	2,370
Electrical Efficiency	%	39.0	36.3
Efficiency incl. Steam	%	40.9	51.9

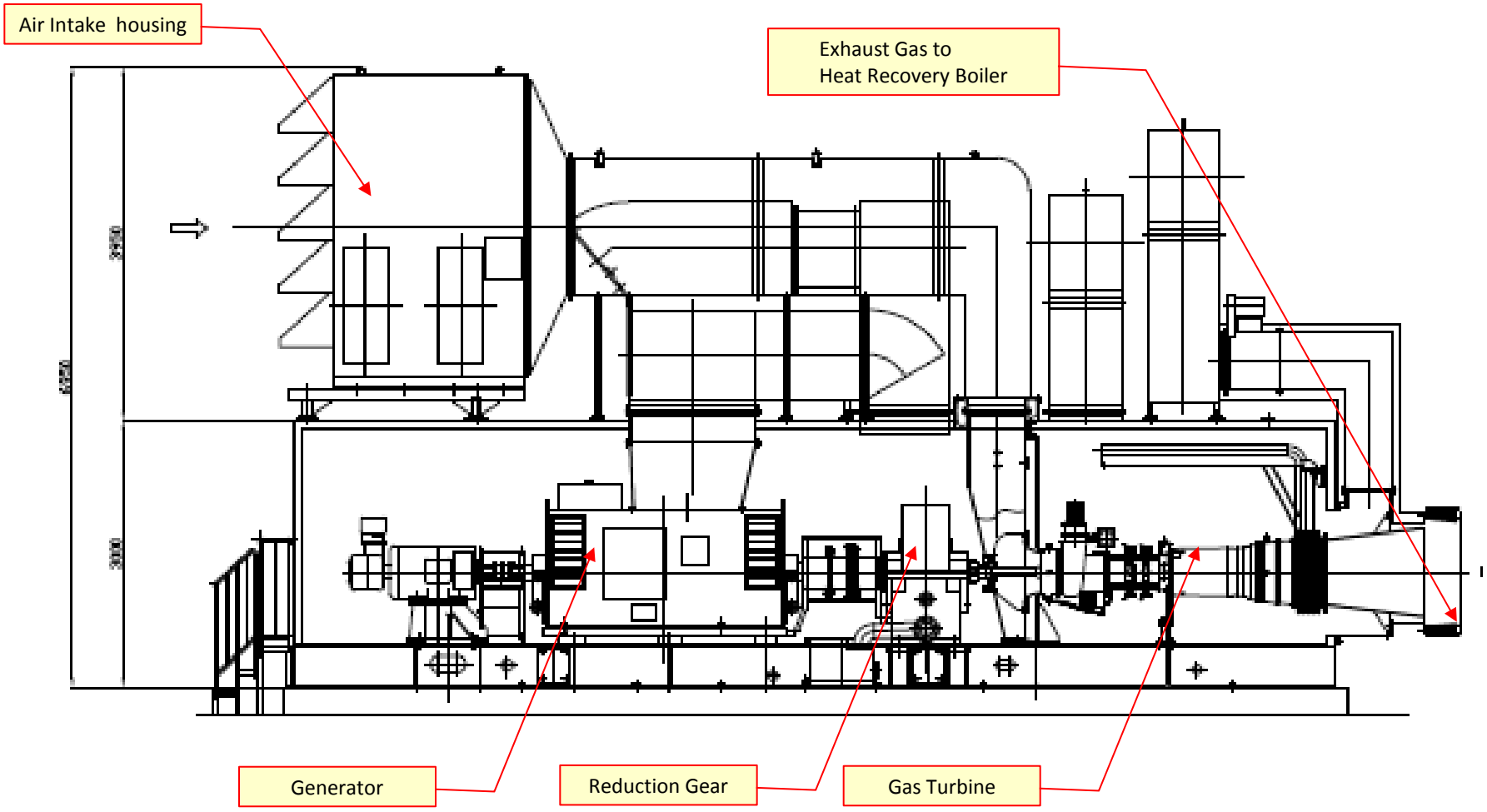
		Mark Ⅰ	Mark Ⅱ
Ambient Temp.	℃	15	15
Power Output	kW	4,200	4,220
Steamf for GT	kg/h	2,052	2,054
Steam for Factory	kg/h	8,678	9,408
Fuel Consumption	kcal/kW	2,878	2,881
Electrical Efficiency	%	29.9	29.9
Efficiency incl. Steam	%	76.5	81.4

NO Energy is Wasted!!

501-KH5 Gas Turbine for VHP6



Gas Turbine Generator Package



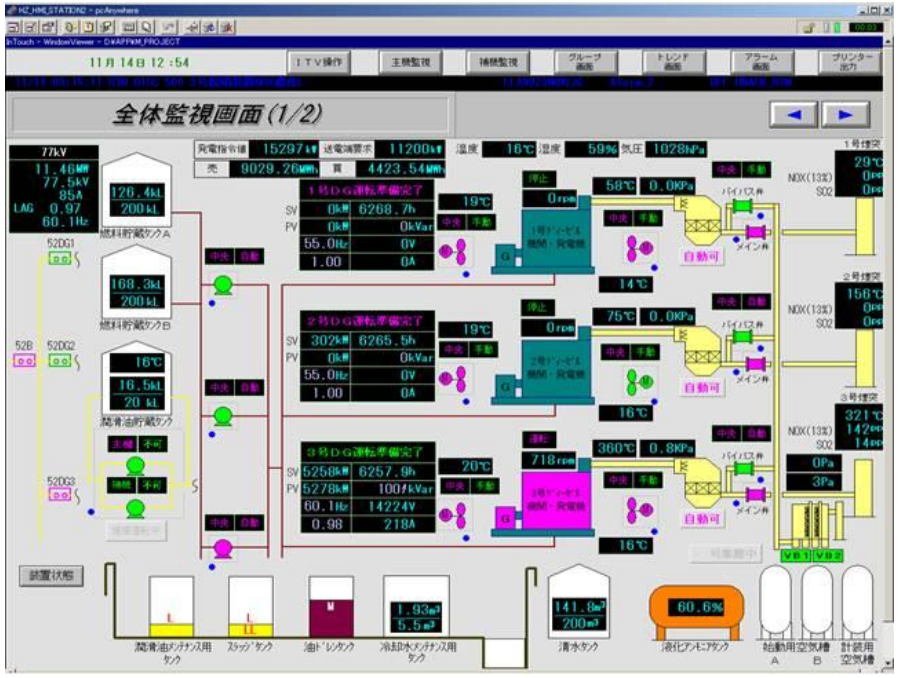
Hitz VHP6(1)

6MW-VHP6 Gas Turbine Power System (Himeji, Japan)

Hitz VHP6(2)

On-Line Monitoring System-Cogenet

1. 24hours On-Line monitoring system
2. Monitored by Hitachi Zosen technicians for 24hours
3. Advisory service for Preventive Maintenance is available
4. Share the same information by both parties, Customer and Hitachi Zosen regardless the plants location for initial diagnosis



Thank You

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