DISCUSSION PURPOSE ONLY

JFE's Holistic Approach for Waste Treatment

Hokubu Sludge Treatment Center, Yokohama

June, 2018

JFE Engineering Corporation

JFE

- **Introduction of JFE Engineering**
- **WTE Technology (Incineration)**
- **WTE (Biogas/Sewage Sludge)**
- **Technology Comparison**
- **Business Structuring**

DISCUSSION PURPOSE ONLY

JFE Group Structure

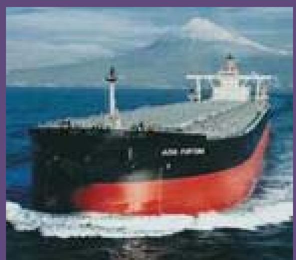
NKK
Est. 1912

KAWATETSU
Est. 1951

JFE Holdings, Inc.
(est. 2002)

Equity-method affiliate

Japan Marine United



JFE Engineering

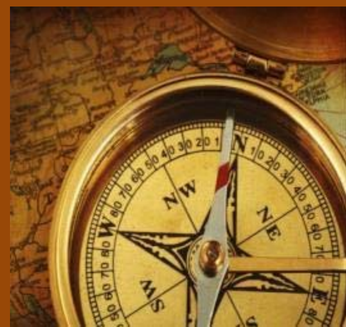
Net Sales(million $)
3,900
Employees
9,300

JFE Steel

Net Sales(million $)
27,200
Employees
44,400

JFE Shoji Trade

Net Sales(million $)
19,100
Employees
6,800



(FY2017)

DISCUSSION PURPOSE ONLY

Global Network

CEO Mr. Oshita

Tokyo / Yokohama
(Headquarters)

America

Long Beach (USA)

Europe

Duisburg (Germany)
Rome (Italy)

Middle East

Al Khobar (Saudi Arabia)

Asia & Oceania

Singapore
Kuala Lumpur (Malaysia)
Jakarta (Indonesia)
Hanoi, Ho Chi Minh (Vietnam)
Bangkok (Thailand)
Yangon (Myanmar)
Manila (Philippines)
Delhi, Pune, Mumbai (India)
Shanghai, Beijing (China)

Smart Infrastructure for Global Environment

JFE offers the world leading technology

- Introduction of JFE Engineering
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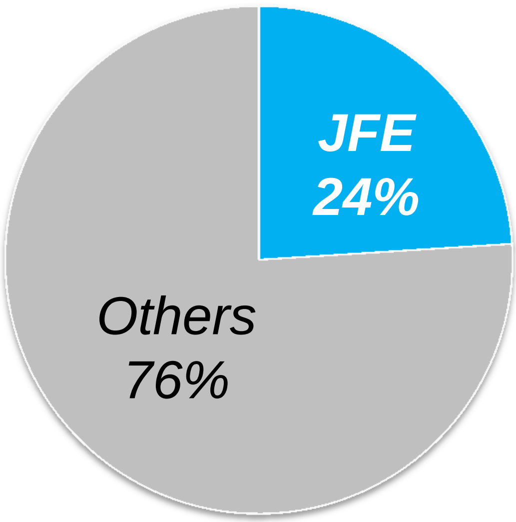
DISCUSSION PURPOSE ONLY

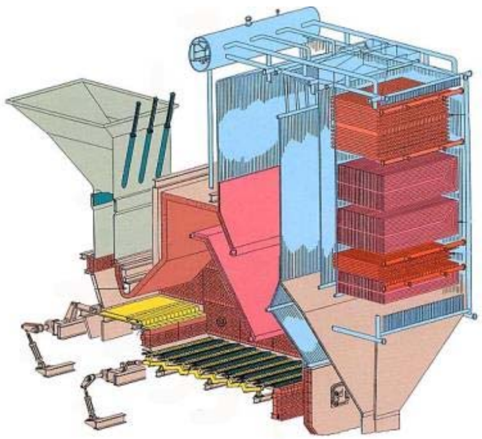
Waste to Energy (Incineration)

Total solution from EPC to O&M for Stoker furnace & Gasification

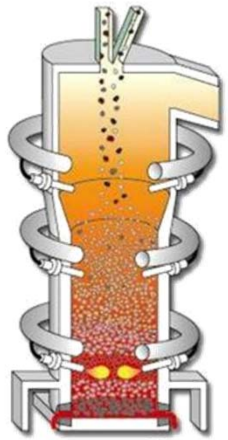
- ✓ ***No. 1 Market Share in Japan***
- ✓ ***Possess both Stoker Furnace & Gasification technology***

Market Share
('08-'17)





Stoker Furnace



Gasification

Either technology is applied to 90% of WTE plant in Japan

Meguro WTE Plant

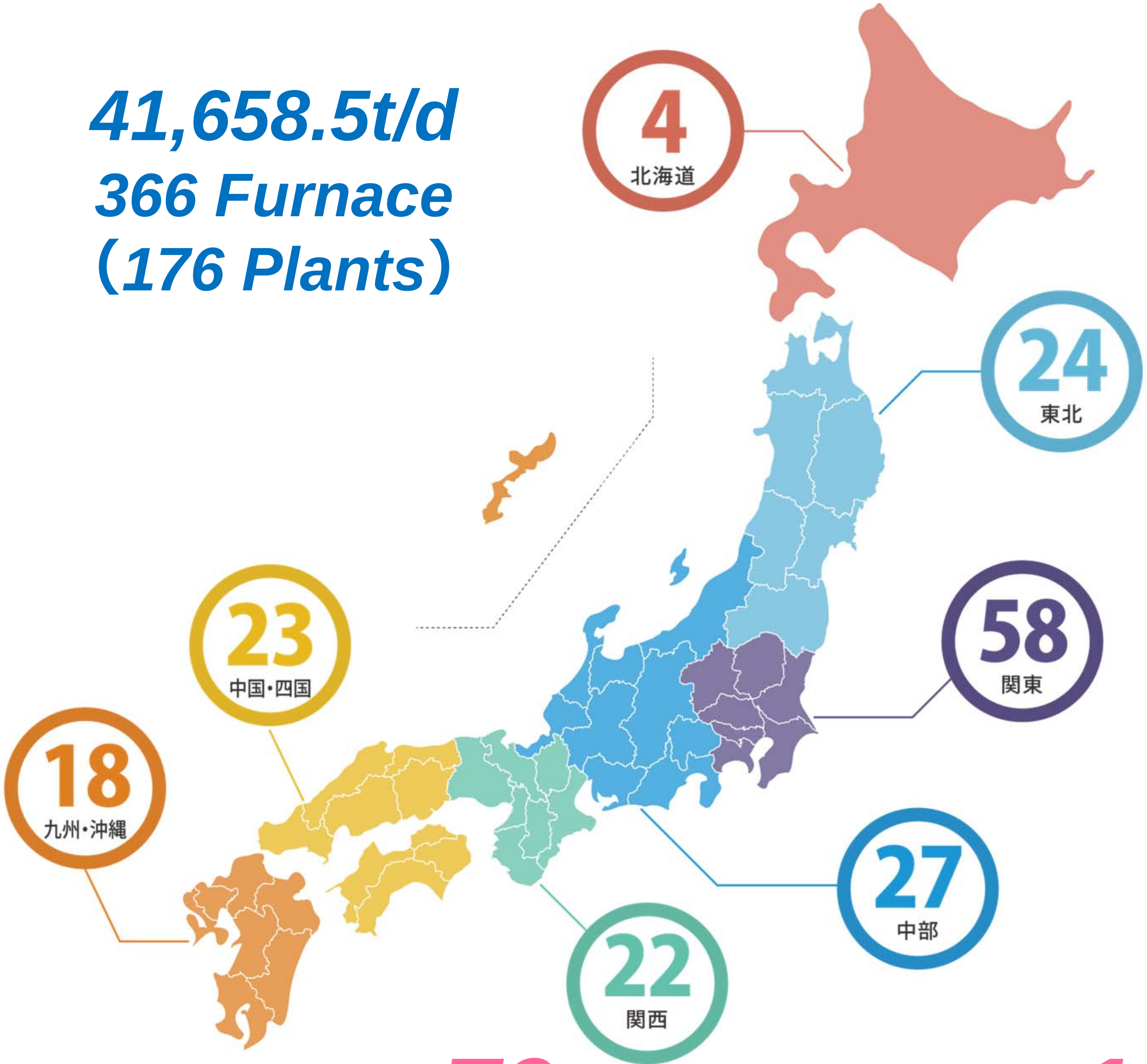
Kumamoto WTE Plant

DISCUSSION PURPOSE ONLY

Track Record in Japan

EPC

41,658.5t/d
366 Furnace
（176 Plants）



O&M

Operation: 79, Maintenance: 110

DISCUSSION PURPOSE ONLY

Environmentally Conscious WTE in Tokyo

JFE

Completion	Nov 2015
Capacity	500 tpd (250tpd×2 lines)
Power Gen.	18.7 MW
Site Area	Approx. 15,000m2
Flue gas treat.	dry-type flue gas treatment system, bag filter, wet scrubber, deNOx reactor
Ignition Loss of Bottom Ash	≦5%

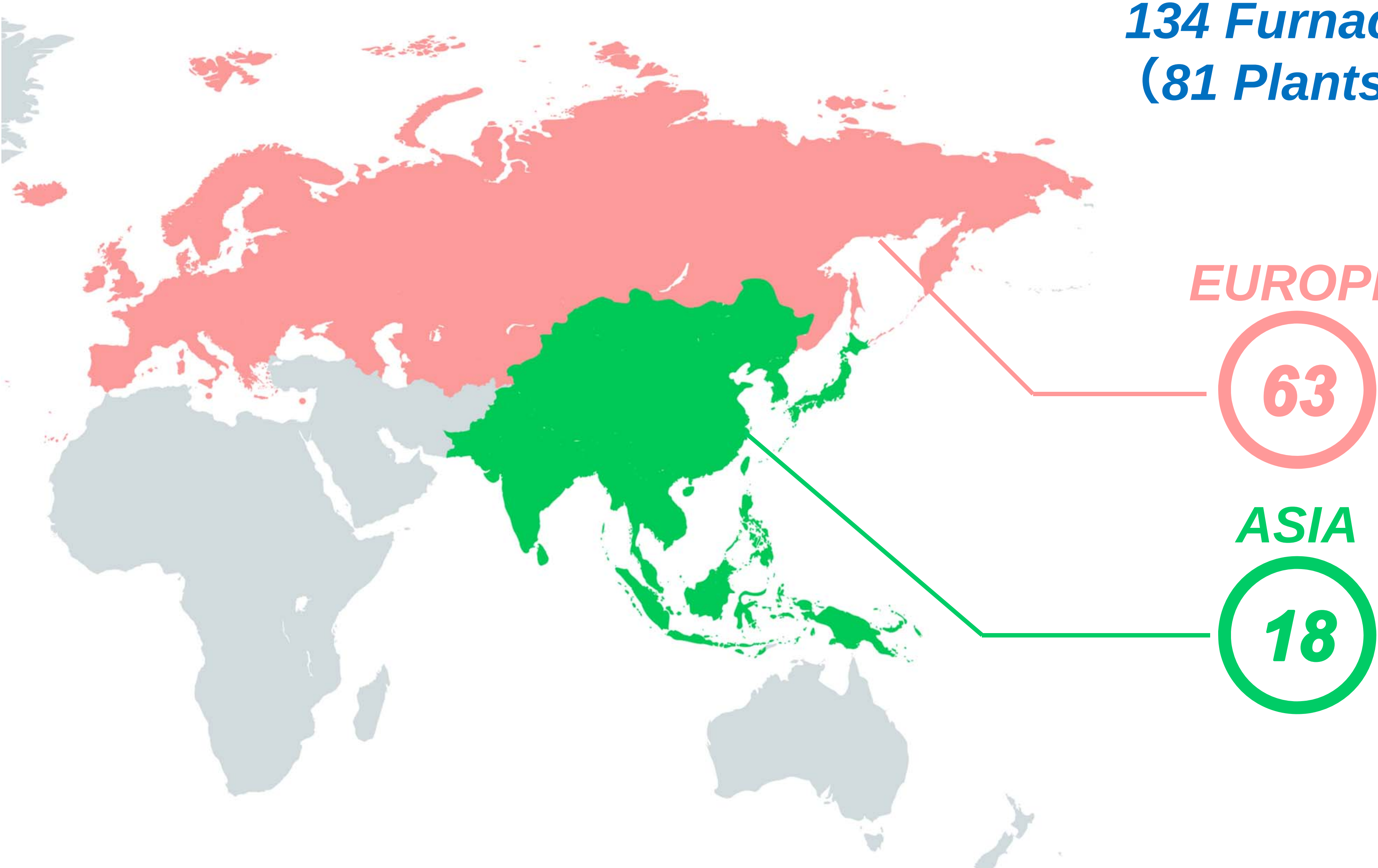
Design Calorific Value of Waste		
Min. LHV 7,100 kJ/kg 1,700 kcal/kg	Ave. LHV 10,200 kJ/kg 2,400kcal/kg	Max. LHV 14,300 kJ/kg 3,400 kcal/kg

	Emission Performance	Regulatory Standards
Dust & Fly Ash	**0.01 g/Nm3**	**0.04 g/Nm3**
SOx	**10 ppm**	**91 ppm**
NOx	**50 ppm**	**85 ppm**
HCl	**10 ppm**	**430 ppm**
DXN	**0.1 ng-TEQ/Nm3**	**0.1 ng-TEQ/Nm3**
Hg	**0.05 g/Nm3**	**Unregulated**

DISCUSSION PURPOSE ONLY

Global Track Record

EPC 45,616.4t/d
134 Furnace
(81 Plants)



DISCUSSION PURPOSE ONLY

First WTE in Myanmar

Counterpart	Yangon City Development Committee
Site	Mingalardon area, Yangon City, MYANMAR
Technology	Waste to Energy(WTE) Incinerator : 60ton/day Generator : 0.7MW
GHG Emission Reduction	4,700t-CO_2/year

Facility Opening Ceremony on April 7th

DISCUSSION PURPOSE ONLY

Expected GHG Emission Reductions

4,732 tCO_2 / year

(2,358tCO_2 accounts for the energy-originated CO_2)

- ✓ The calculation is based on the condition of 60t of waste treated per day and operation of 310days per year, 24 hours per day (operating ratio: 85%).
- ✓ The emission factor refers to the latest CDM project in Myanmar (0.8tCO_2/MWh).

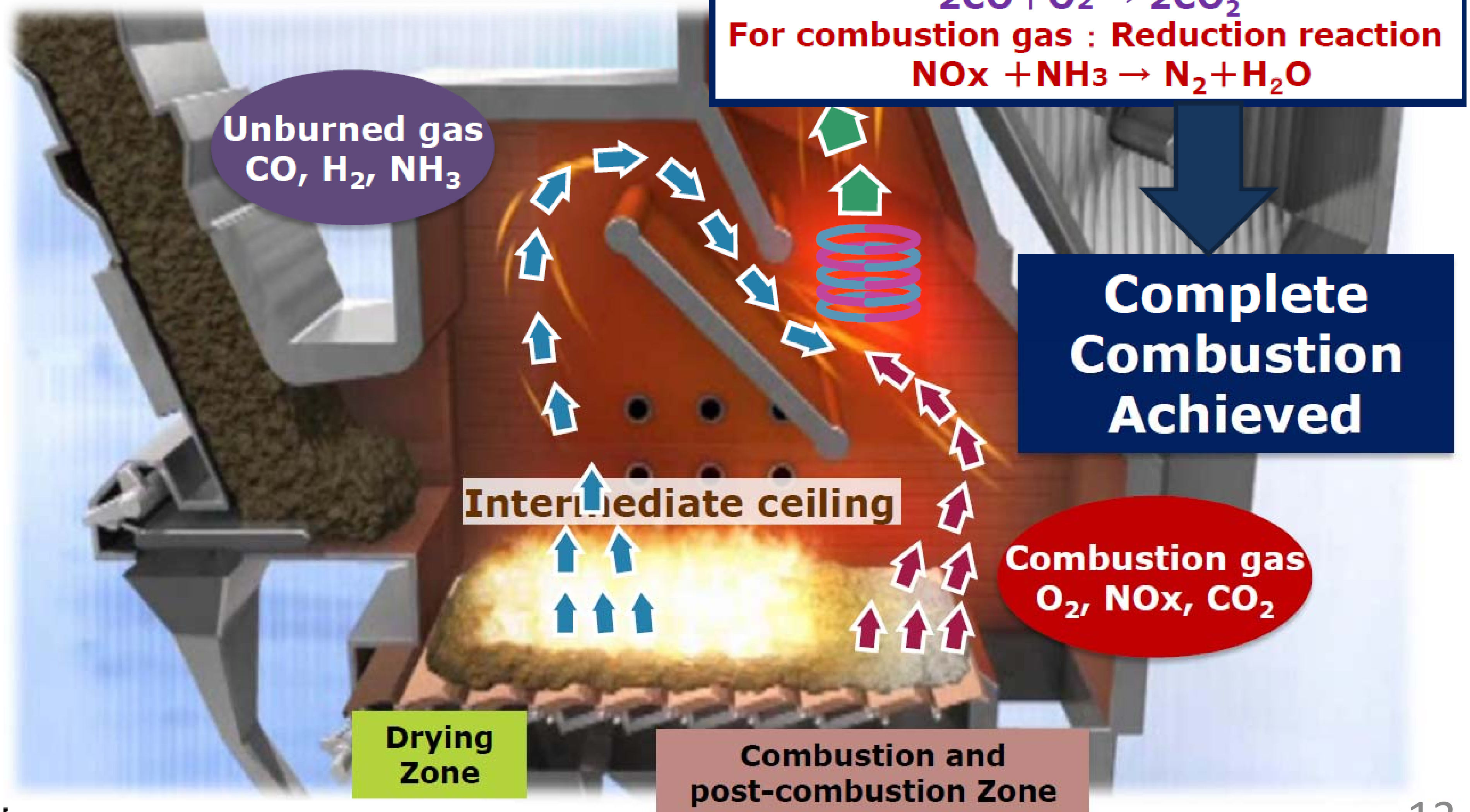
DISCUSSION PURPOSE ONLY

Superiority of JFE Hyper Stoker

JFE

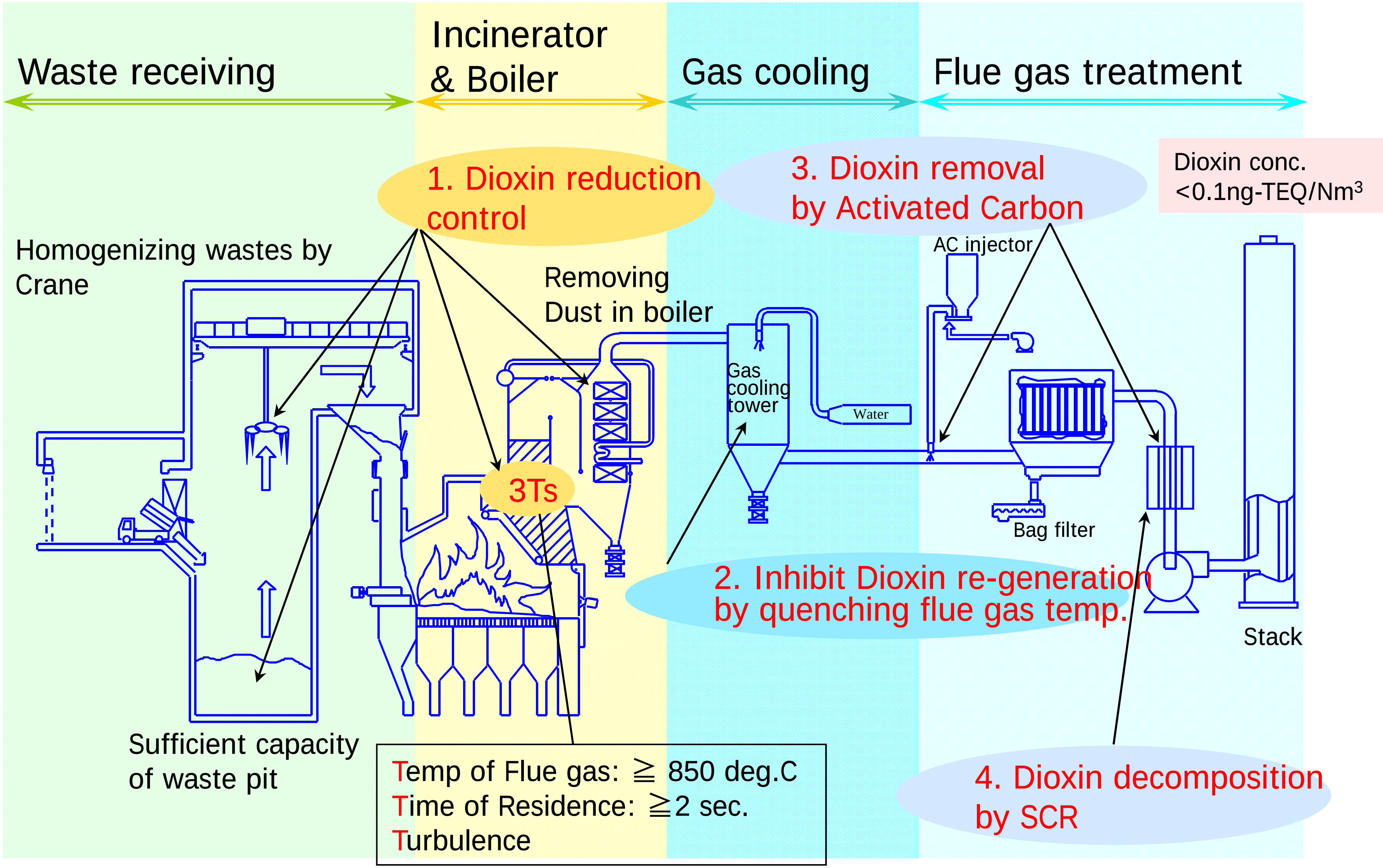
Secondary Combustion Zone

For unburned gas : Oxidation reaction
$2CO + O_2 \rightarrow 2CO_2$
For combustion gas : Reduction reaction
$NOx + NH_3 \rightarrow N_2 + H_2O$



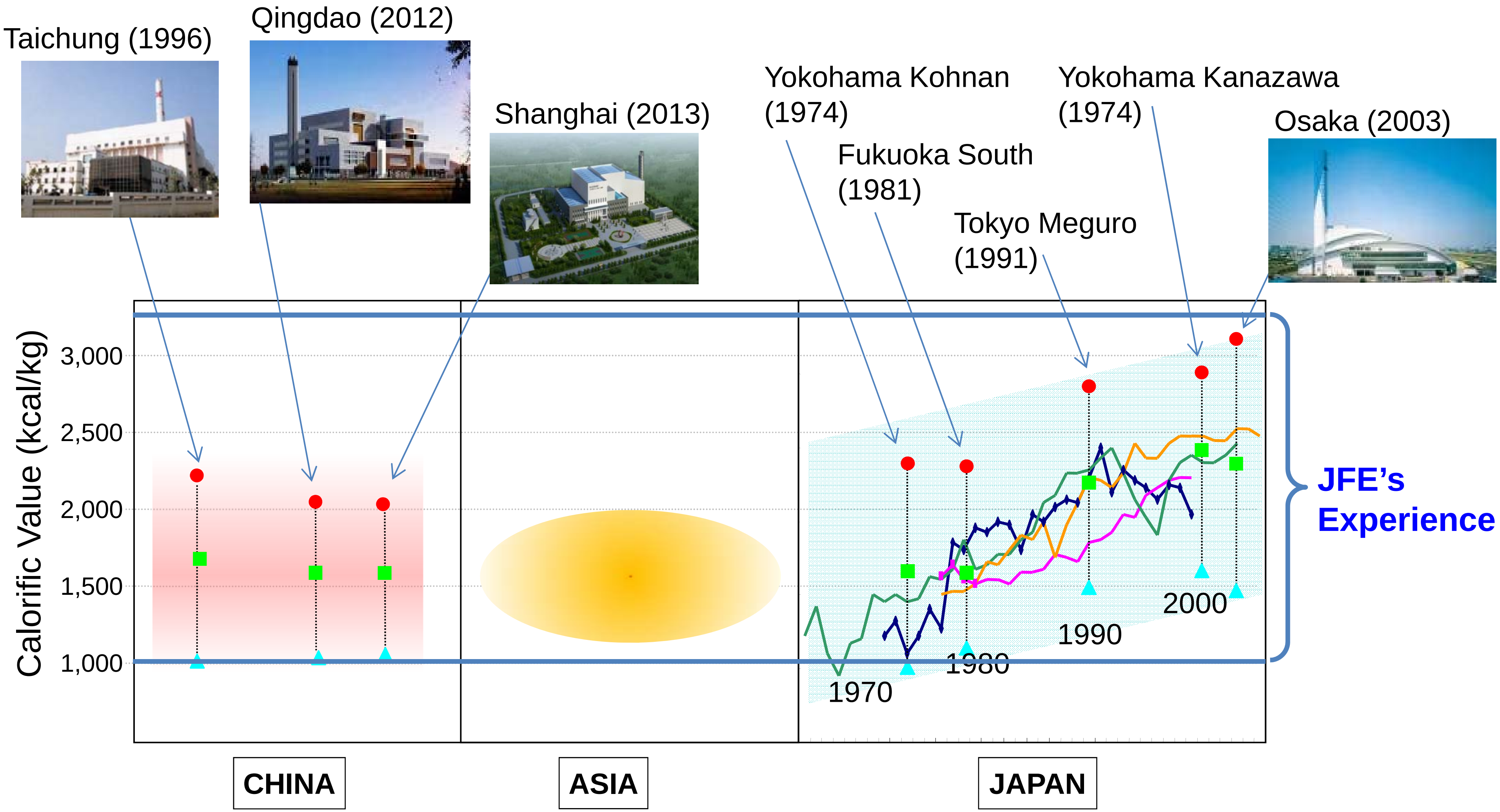
DISCUSSION PURPOSE ONLY

Anti-DIOXINs Technology



DISCUSSION PURPOSE ONLY

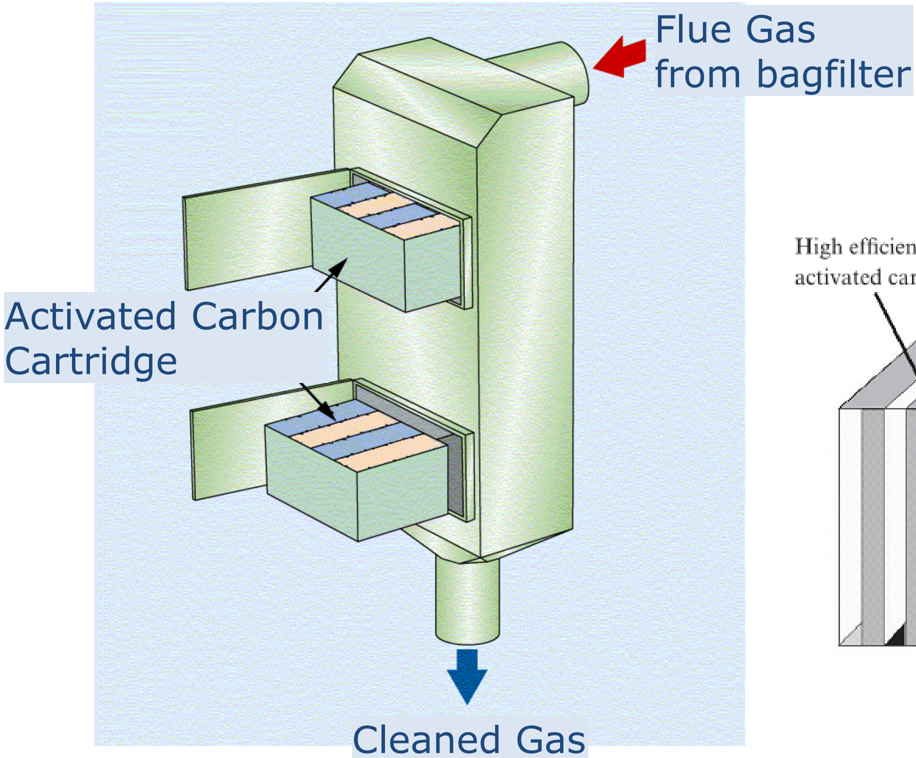
Low Calorific Value Waste Experience

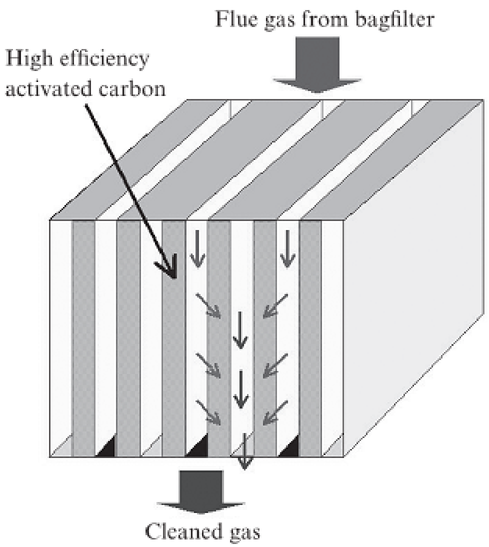


How to Manage Mercury Emissions from WTE

- Waste incinerators are identified in the **MINAMATA Convention** as one of the major industrial sources of mercury emissions. -

JFE's High Efficiency Activated Carbon Absorber **"Gas Clean DX"**





Inlet : 65μg/m3

Outlet : below detection limit of 5μg/m3

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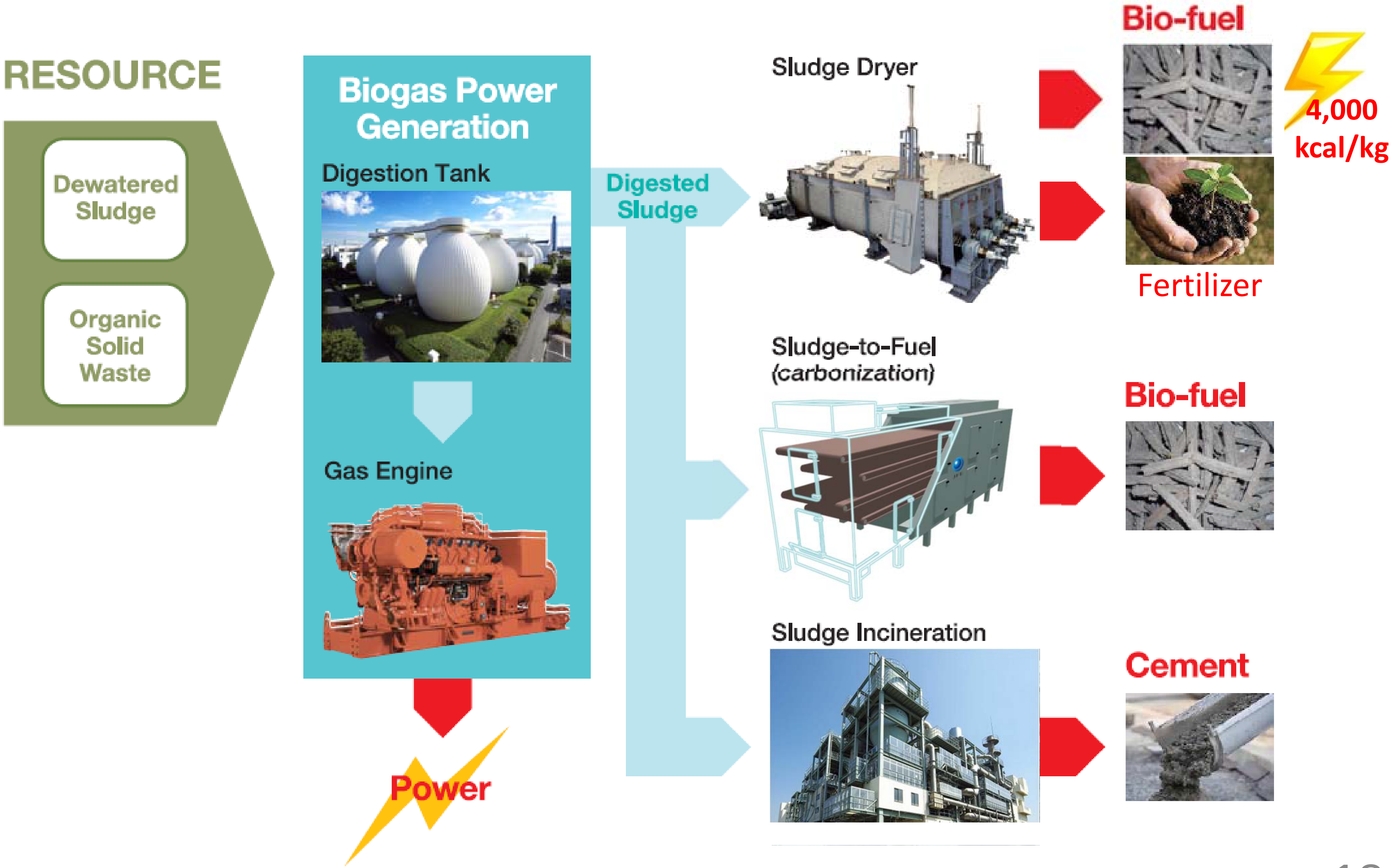
DISCUSSION PURPOSE ONLY

Utilizing Sludge with ZERO Emission



DISCUSSION PURPOSE ONLY

Largest Sludge Biogas Power Generation

Client	Yokohama City
Capacity	12,500 m3/day (wet sludge)
Output	4,500kW (900kWx 5)
Scheme	BTO (Build Transfer Operate)
O&M	20 years
Remarks	CO_2 reduction(588ton/day) Volume reduction: 100%

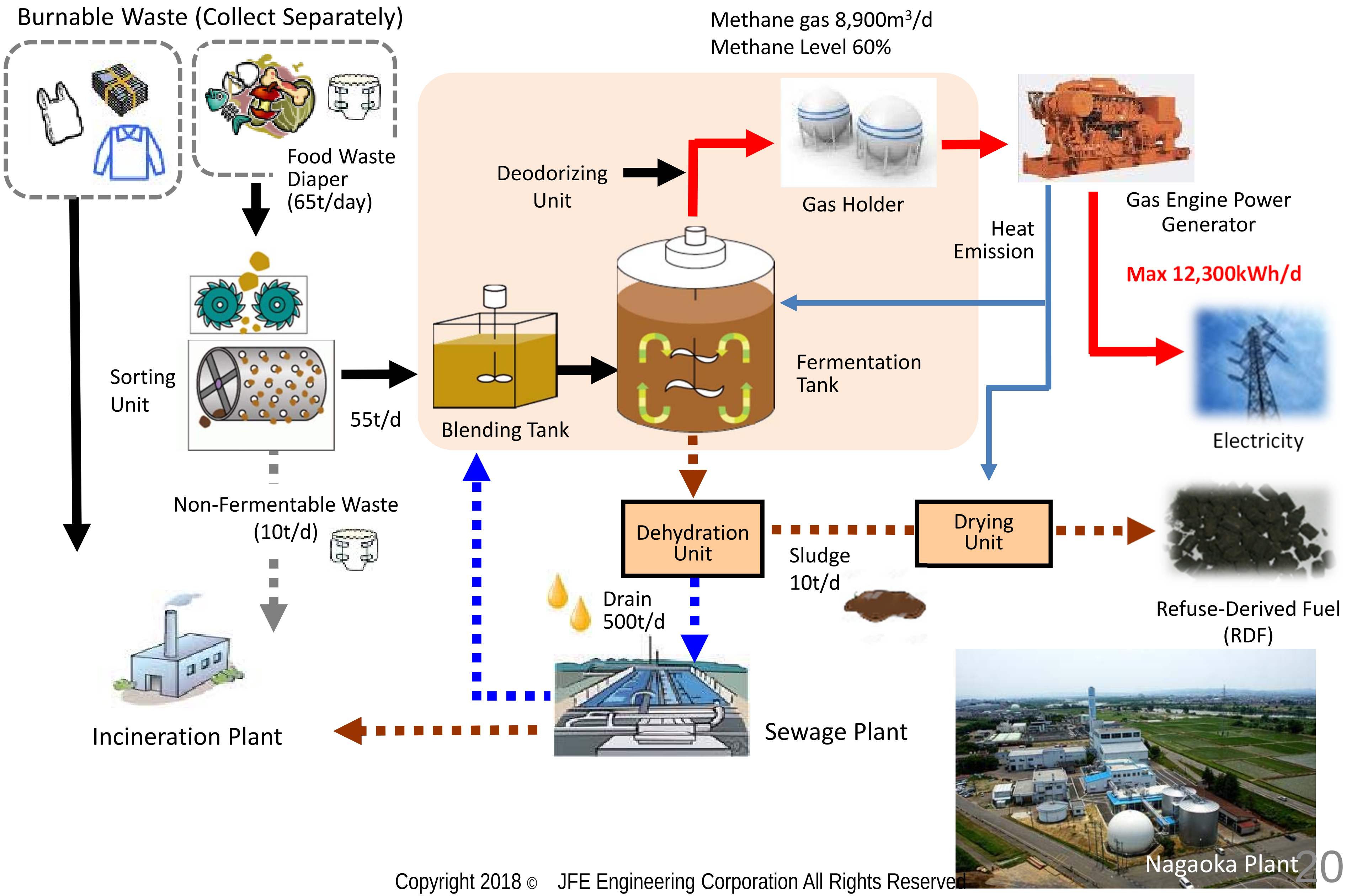
Biogas

Electricity
80MWh/day

Digested Sludge

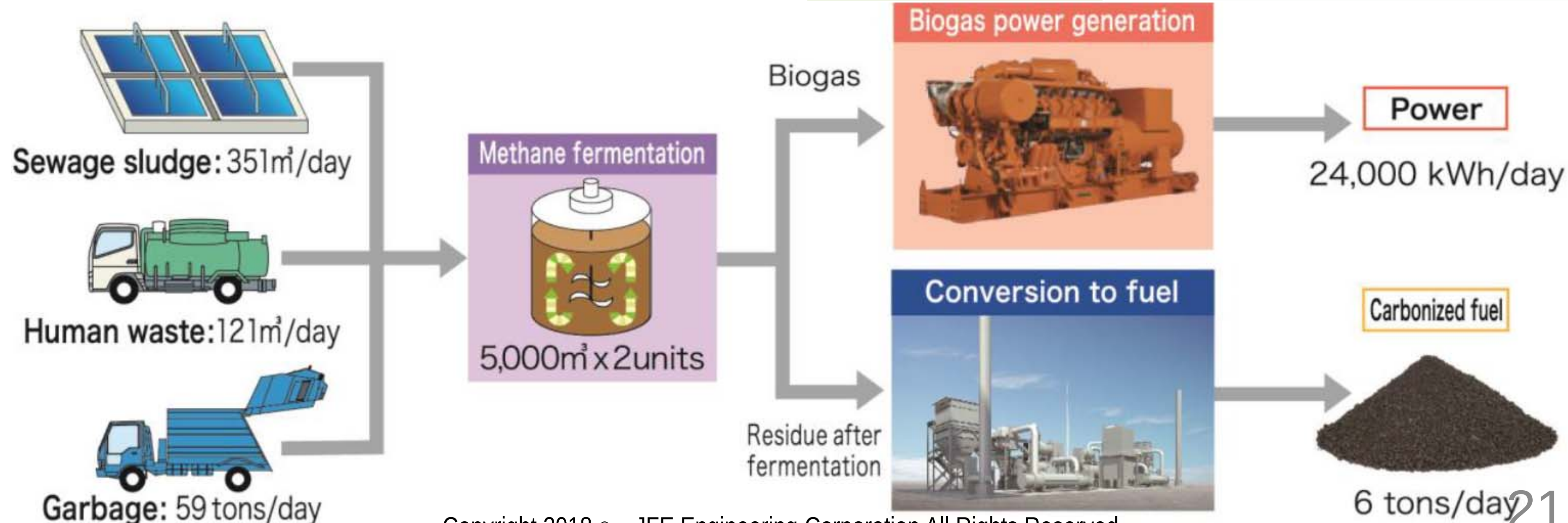
DISCUSSION PURPOSE ONLY

Multi Processing / Utilization in Bio-treatment in Nagaoka



World's First Multi-Bio Waste Treatment

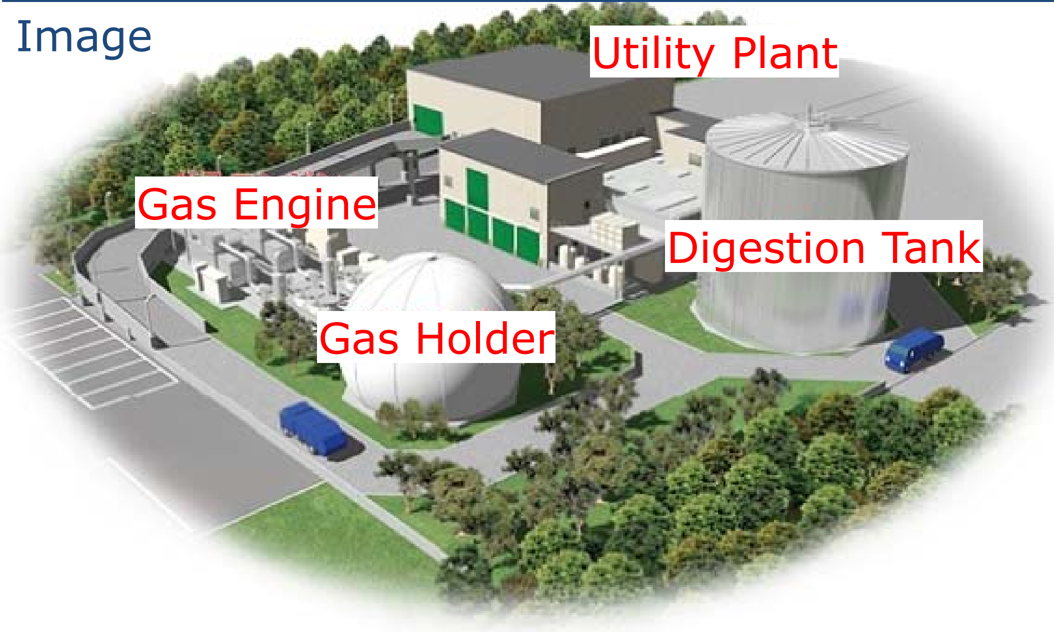
Client	Toyohashi City, Aichi Pref.
Capacity	472 m3/d (sewage sludge) 59 t/d (kitchen waste)
Output	1,000 kw
Scheme	BTO
O&M	20 years
GHG Reduction	3,900 CO2-t /year



DISCUSSION PURPOSE ONLY

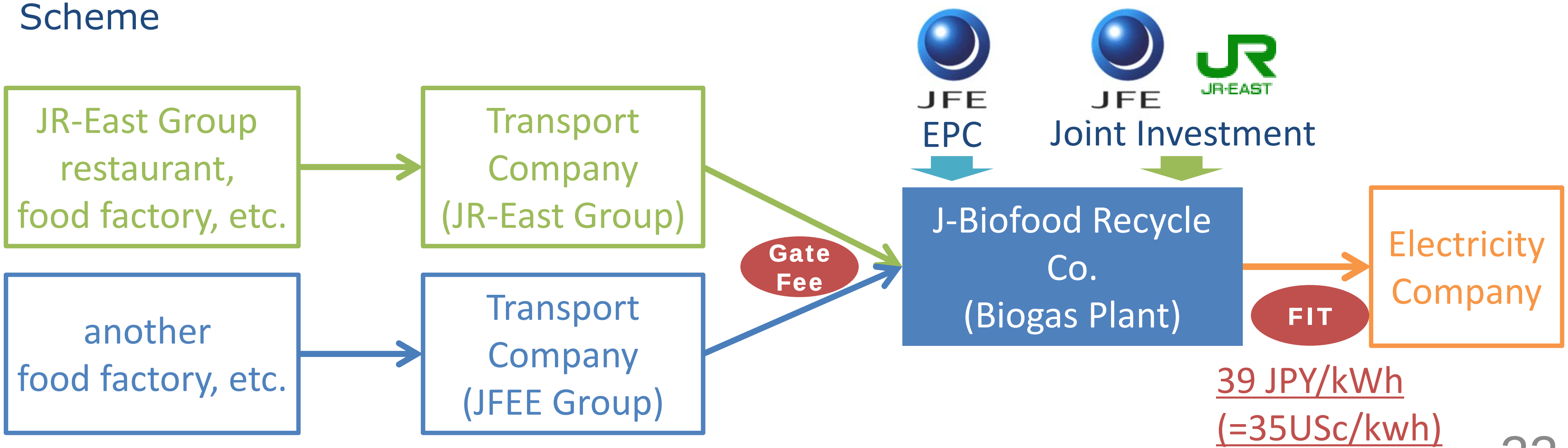
Food Waste Biogas Power Generation

Image



Location	Yokohama City
Facility Area	6,900m2 (approx.)
Capacity	80t/d (max.), 1,800kw
Power Generation	11 mil. kWh/year *equiv. 3,000 households
GHG Reduction	5,500 t-Co2/year
CAPEX	3 bil. JPY (approx.)
Operation Start	August 2018

Scheme



JFE

- Introduction of JFE Engineering
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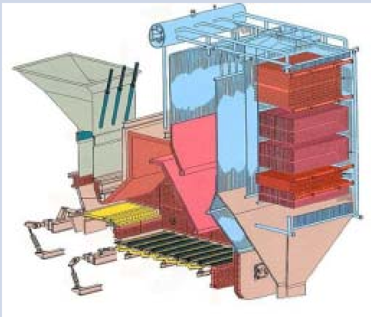
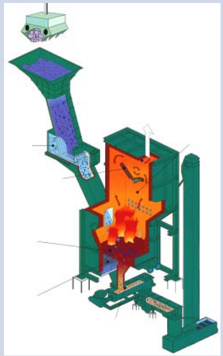
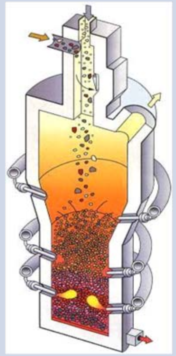
DISCUSSION PURPOSE ONLY

Comparative assessment of WTE Technology

Stoker	Fluidized bed	Gasifying and Direct Melting	Plasma Gasification
			
• The conventional and reliable system in the world • Large capacity of a furnace(400-500t/d) is widespread.	• No movable part inside furnace • Pretreatment is required for stable combustion. • It is difficult to meet waste fluctuation due to rapid combustion.	• Slag can be utilized. • Coke is necessary for ash melting. • High GHG emission and High Operation cost due to coke usage.	• No commercial operation • Slag can be utilized. • Synthesis gas can be introduced to gas engine. • Large amount of self electric consumption

DISCUSSION PURPOSE ONLY

Comparative analysis of the solutions (1/3)

JFE

	Incineration and Power generation "WTE=Waste to Energy"	Non Incineration	
		MBT (mechanical composting)	Bio-gasification
Waste to be treated	Municipal solid waste, industrial waste	Mainly for organic wastes such as kitchen wastes or night soil treatment residue	Mainly for organic wastes such as kitchen wastes or night soil treatment residue
Sorting and selections	Not necessary	Careful sorting and selection necessary	Careful sorting and selection necessary
Recoverable Resource	Electric power	Compost	Biogas (can be used as fuel)
Final residue	Bottom ash, fly ash	Residue after selection	Residue after selection
			

DISCUSSION PURPOSE ONLY

Comparative analysis of the solutions (2/3)

JFE

	Incineration and Power generation "WTE=Waste to Energy"	Non Incineration: MBT (mechanical composting)	Non Incineration: Bio-gasification
Merit	･It can -treat various types of wastes -flexibly adapt to waste characteristics changes • Large amount of waste can be treated in large-scale plants • Technology is mature as many plants have been constructed and operated • The power for operation can be self-supplied • Power generation efficiency can be improved by simple pre-treatment for some waste quality	･It can - be introduced in a small scale - treat wastes that are not adaptable for incineration such as those with high water content - does not generate combustion exhaust gas • If an independent facility for this technology is to be constructed, its CAPEX would be lower than incineration facility	

DISCUSSION PURPOSE ONLY

Comparative analysis of the solutions (3/3)

JFE

	Incineration and Power generation "WTE=Waste to Energy"	Non Incineration: MBT (mechanical composting)	Non Incineration: Bio-gasification
Demerit	• If it is introduced in a small scale, the cost-effectiveness will lower • Cost is relatively high	･Facility to treat residue after selection must also be constructed. • If an independent facility for this technology is to be constructed, it must be equipped with odor prevention facilities. • Production of high-quality product will require high quality pre-treatment. • If an independent facility for this technology is to be constructed, as there would be no power generation facility, power would have to be purchased. • The market price of compost will largely affect the revenue.	• Facility to treat residue after selection must also be constructed. • If an independent facility for this technology is to be constructed, it must be equipped with odor prevention facilities. • Safe operation will require high-quality pre-treatment • If biogas is to be sold instead of electric power (as selling biogas is generally more profitable than selling electric power), the bio-gasification plant would have to purchase electric power for its operation

- Introduction of JFE Engineering
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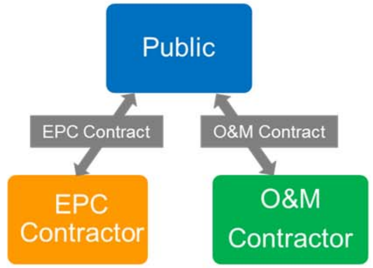
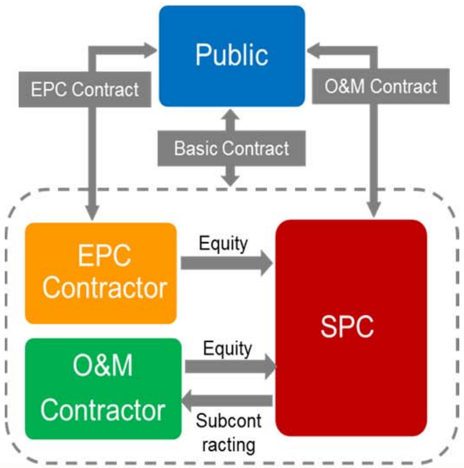
DISCUSSION PURPOSE ONLY

Business Scheme of WTE in Japan

Scheme	Public-build and Public-operate	DBO (Design Build Operation)	PFI (Private Finance Initiative)

Scheme form





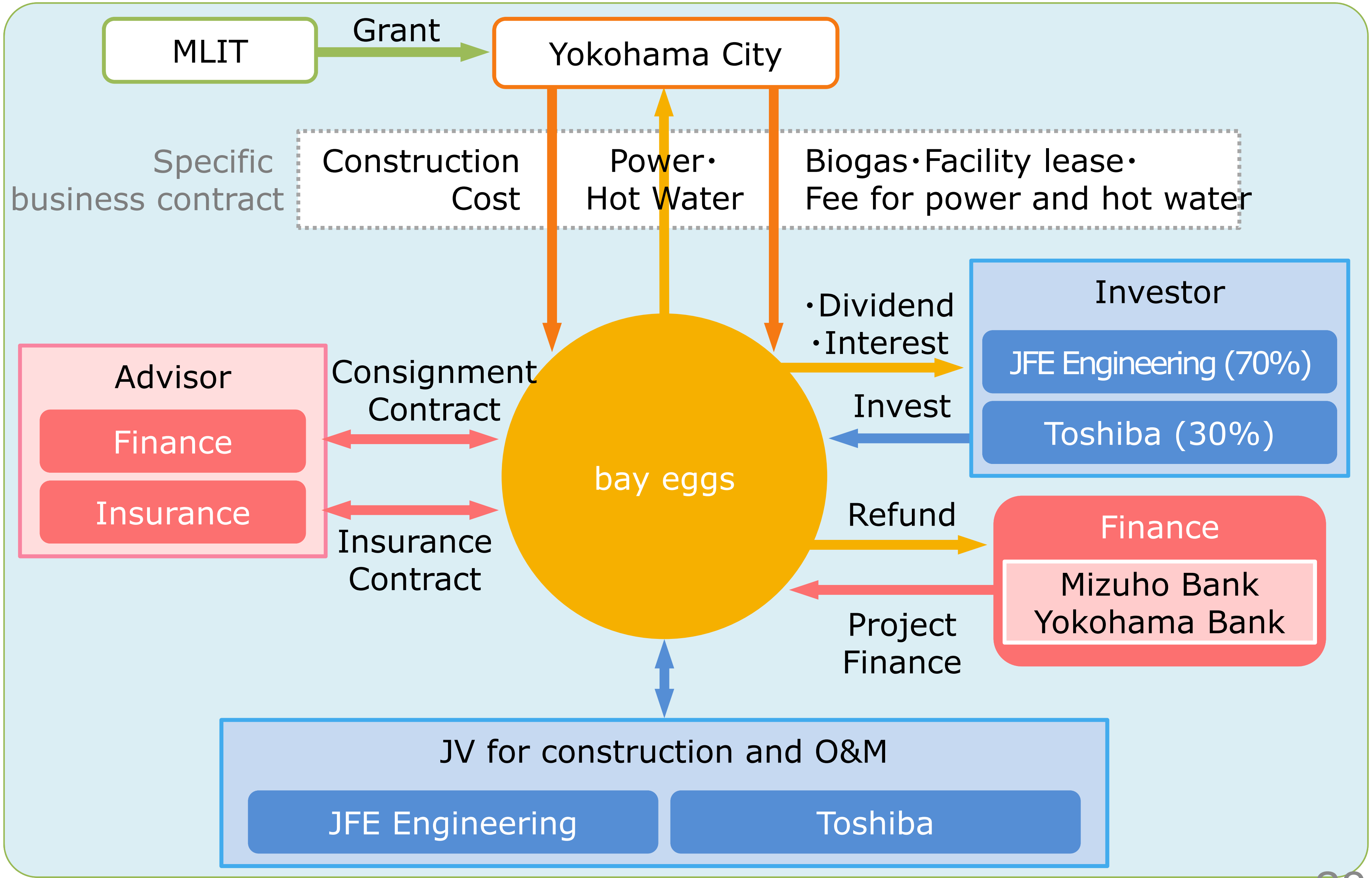
Division of roles

Scheme	Public-build and Public-operate	DBO (Design Build Operation)	PFI (Private Finance Initiative)
Basic planning	Public	Public	Public
Financing	Public	Public	Private
Design and Construction	Public	Public / Private	Private
Operation and Maintenance	Public	Private	Private
O&M monitoring	—	Public	Public / Private

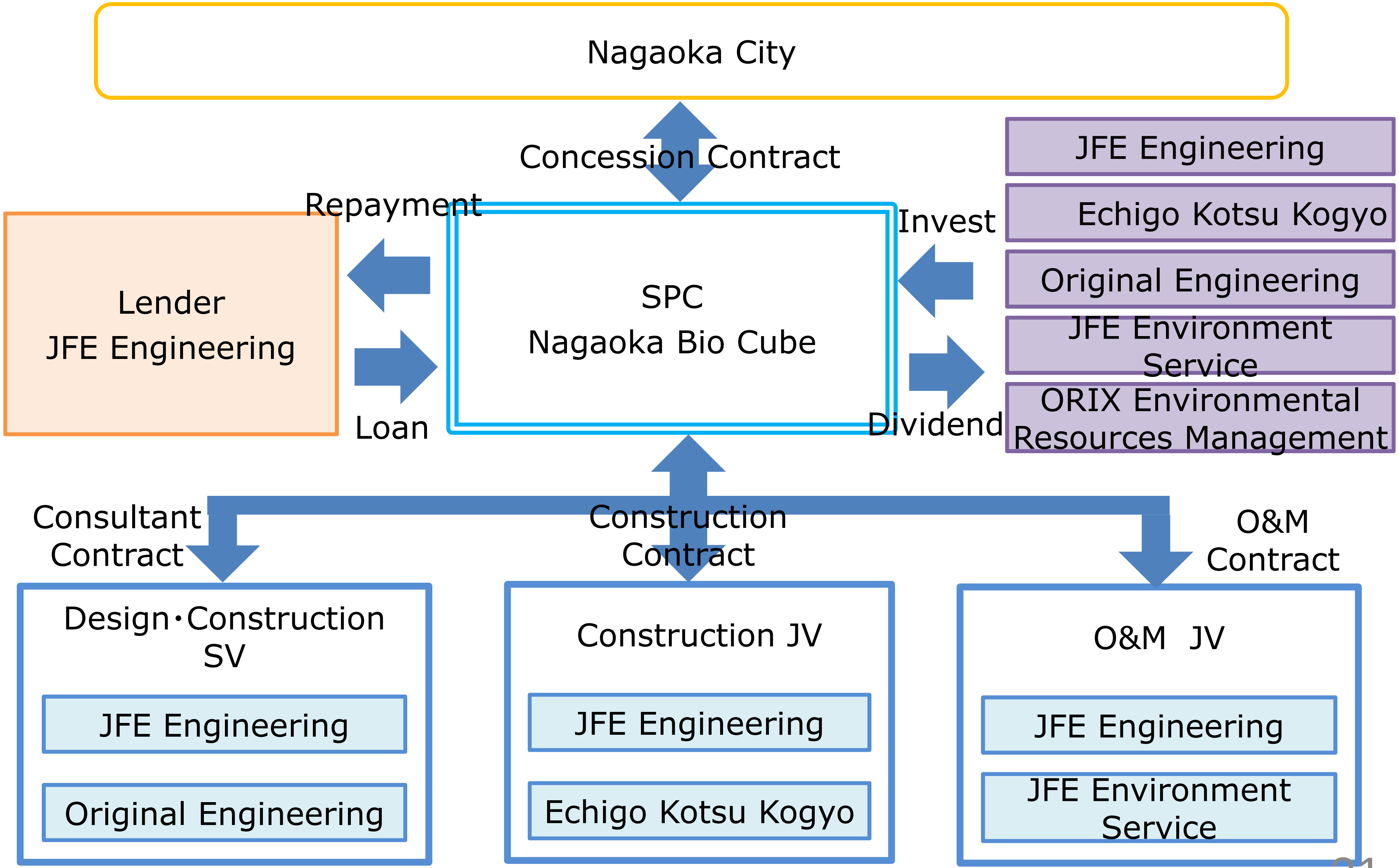
Source : Japan Environmental Facilities Manufacturers Association (JEFMA)

DISCUSSION PURPOSE ONLY

Business Structure (Yokohama Biogas)



Business Structure (Nagaoka Biogas & Bio Fuel)



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WTE PPP Projects by JFE in Japan

JFE

Name of Facility	Seibu Incineration Plant	Clean Ene-Park Nanbu
Owner/Employer	City of Kumamoto	Southern Fukuoka Region Environment Enterprise
Contract Scheme	**DBO**	**DBO**
Contract amount	15.9B JPY (159M USD)	29.1B JPY (291M USD)
Construction period	01/2012 – 02/2016	04/2013 – 03/2016
Operation period	03/2016 – 03/2036 (20 years)	04/2016 – 03/2041 (25 years)
Type of furnace	JFE HYPER Stoker 280t/d (140t/d,2units)	JFE HYPER Stoker 510t/d (170t/d,3units)
Power Generation	5.7 MW	16.7 MW

and others

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Cost Structure of Yangon WTE

JFE

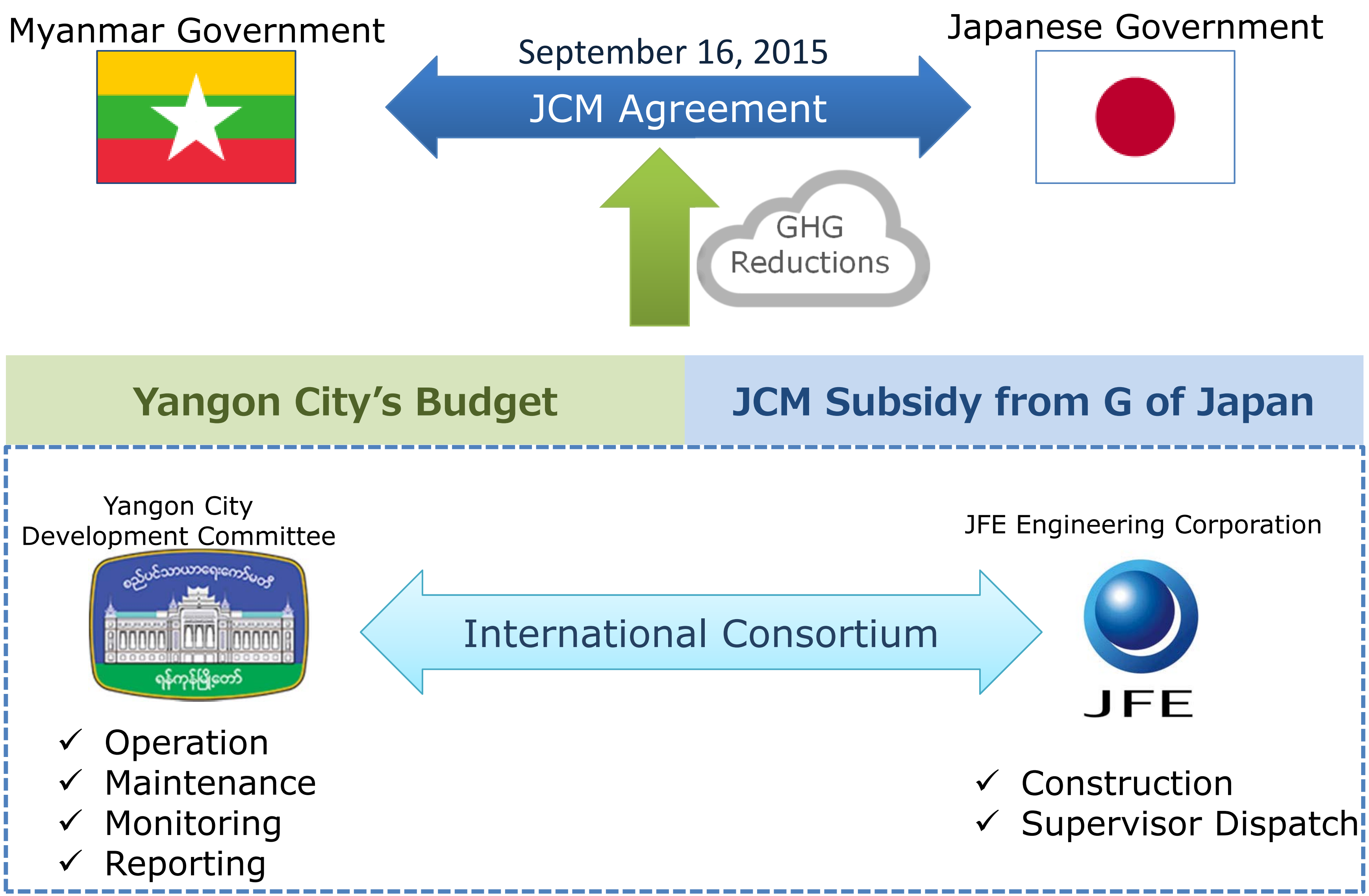
Outline of the Project	
Owner	Yangon City
Scope	Construction: JFE (EPC) O&M: Yangon City
Finance (CAPEX)	50%: Yangon City 50%: JCM Subsidy Scheme
Specification	Waste-to-Energy Plant ➢ Waste: Municipal ➢ Furnace: Stoker ➢ Capacity: 60 tons/ day ➢ Power Gen.: 760kW
Completion	31st May 2017

Budget (mil. USD)		
CAPEX	M & E	16.3
	C & S.	3.7
		20.0
OPEX (15yrs)	Operation	10.5
	Maintenance	7.5
		18.0
Total Budget		**38.0**

Key for Materialization :
JCM Subsidy from Ministry of Environment, Japan

DISCUSSION PURPOSE ONLY

JCM Project Scheme



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Why WTE fail in many countries ?

Planning (pre-FS) → Design (FS) → PQ / Tender → Build → Operation /Maintenance

Stop at Planning Stage

- Weak policy enforcement, public opposition, no financial source, no supporting regulations, etc.

Stop at Designing Stage

- Reject of proposal by a competent authority, opposition from existing stakeholders, lack of budget, gap between proposal and needs, etc.

Stop at PQ/Tender Stage

- Unsuccessful PQ/tender due to conflict of price (tipping fee, etc.), etc.

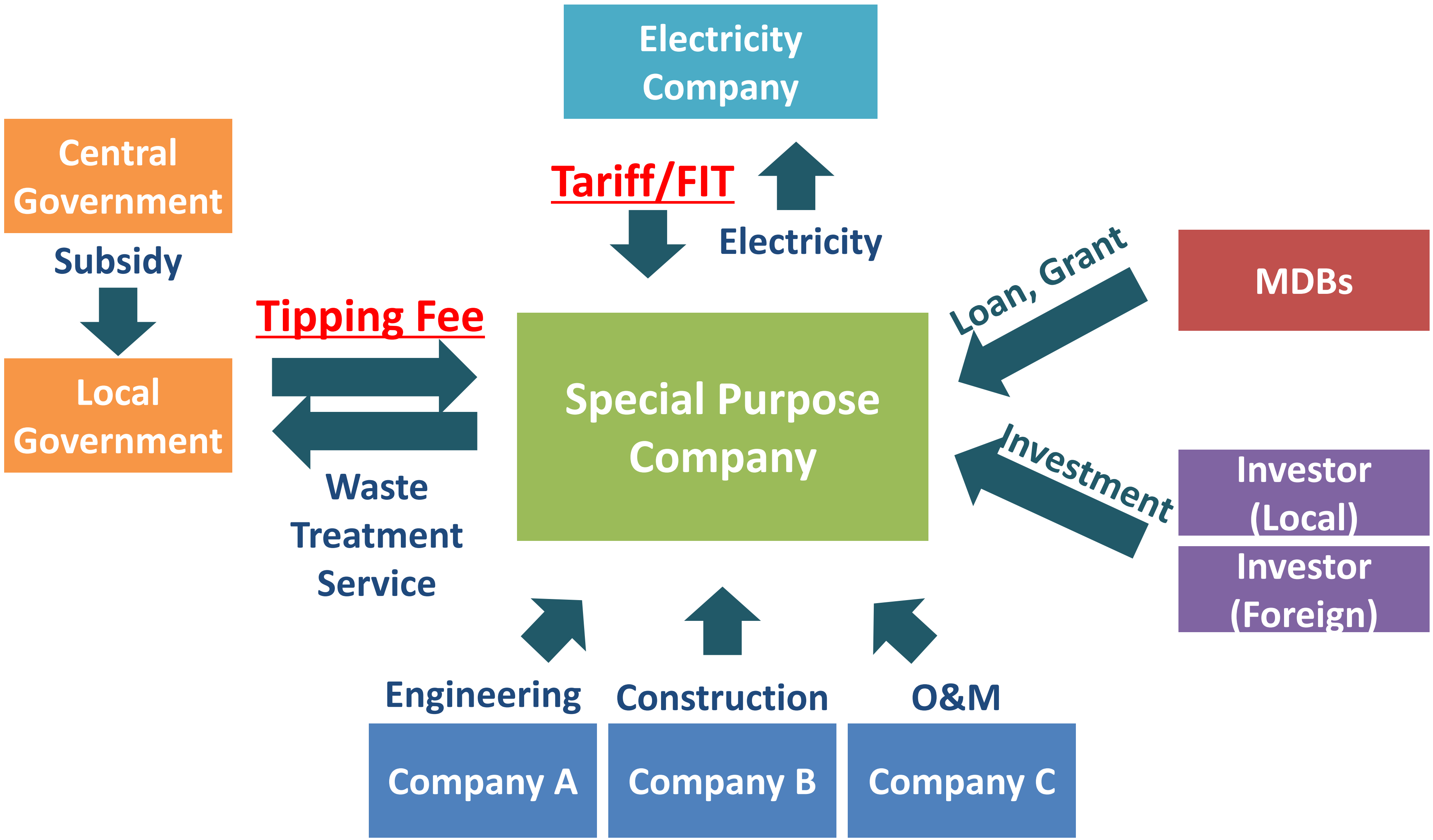
Stop at Operation Stage

- Insufficient performance of facility, critical change of waste management policy, bankruptcy of operation company, etc.

Source : Created based on "Financing issue for a development of recycling and waste treatment facility", Nov. 3rd 2016, Shiko Hayashi, IGES

DISCUSSION PURPOSE ONLY

Basic PPP Scheme of Waste Treatment



DISCUSSION PURPOSE ONLY

Standard Model for Cost Sharing in Japan

JFE

Total cost

Total construction cost of WtE facility (CAPEX)

*** Local gov't can issue bonds maximum 90% of the cost which is not covered by national government.**

Financing construction cost

Subsidy from national government (33%)

Local government bond (60%)

amortized by local allocation tax (30%)

amortized by local government (30%)

City budget (~10%)

*** Local gov't bares only about 10% of the total cost when it is constructed.**

Cost sharing national and local governments

Cost burden on national government (63%)

Cost burden on local government (37%)

Source : Japan's Solid Waste Management Policy, Financing and Implementation, May 2017, World Bank

Public arrangement is Key for successful implementation of project.

DISCUSSION PURPOSE ONLY

Public Finance for WTE (Yokohama Case)

Name of WTE	Total Construction Cost Mil. JPY (%)	Central Government Mil. JPY (%)	Prefectural Government Mil. JPY (%)	City Bond Mil. JPY (%)	City Budget Mil. JPY (%)
TSUZUKI (1,200tpd, 12MW)	28,683 (100.0)	8,044 (28.0)	0 (0.0)	16,428 (57.3)	4,211 (14.7)
TSURUMI (1,200tpd, 22MW)	51,778 (100.0)	12,450 (24.0)	0 (0.0)	27,532 (53.2)	11,797 (22.8)
ASAHI (540tpd, 9MW)	27,289 (100.0)	4,633 (17.0)	96 (0.4)	13,911 (51.0)	8,649 (31.6)
KANAZAWA (1,200tpd, 35MW)	62,594 (100.0)	11,030 (17.6)	47 (0.1)	43,344 (69.2)	8,173 (13.1)

Source：Resources and Waste Recycling Bureau, City of Yokohama

DISCUSSION PURPOSE ONLY

Major Risks and Problems on WTE Project

JFE

	Item	Risk / Problem	Impact / Remarks
1	Waste Volume	No guarantee for Waste Volume (insufficient volume)	Tipping fee will be increased
2	Feed in tariff (PPA: Power Purchase Agreement)	PPA is responsible for the bidder	Project is not financially feasible
3	Tipping Fee	Lower tipping fee	Project is not financially feasible
4	Sovereign Guarantee	No Guarantee from central government providing government guarantees for infrastructure Public-Private Partnership (PPP) projects.	Negative influence on project finance

Guarantees and financial condition for a project are the most important

DISCUSSION PURPOSE ONLY

Appropriate Risk Allocation

JFE

		Public	Private
Preparation and Construction Phase	Land Availability	✔	
	Infrastructure Risk	✔	
	Opposition of the local residents	✔	
	Cost and time over run		✔
	Accident and physical damage of facility and equipment		✔
	Credit risk of sub-contractor		✔
	Completion and Performance of facility		✔
Operation Phase	Quantity of Waste	✔	
	Quality of Waste (LHV, components)	✔	
	Tipping Fee	✔	
	Feed in Tariff (unit price, Period)	✔	
	Ash disposal	✔	
	Waste disposal during planned maintenance of WtE facility	✔	
	Accident and trouble of facility due to prohibited waste	✔	
	Accident and physical damage of facility and equipment		✔
	Cost over run		✔
	Environmental emission risk		✔
Overall Phase	Change in law	✔	
	Political risk /Country risk (e.g. Change in policy of Myanmar/YCDC, Transfer of foreign currency)	✔	
	Force Majeure (e.g. Disaster, Industrial dispute)	✔	
	Market risk (e.g. Escalation, interest-rate, change in tax system)	✔	

Thank you

http://www.jfe-eng.co.jp/en/