Waste-to-energy status in Japan

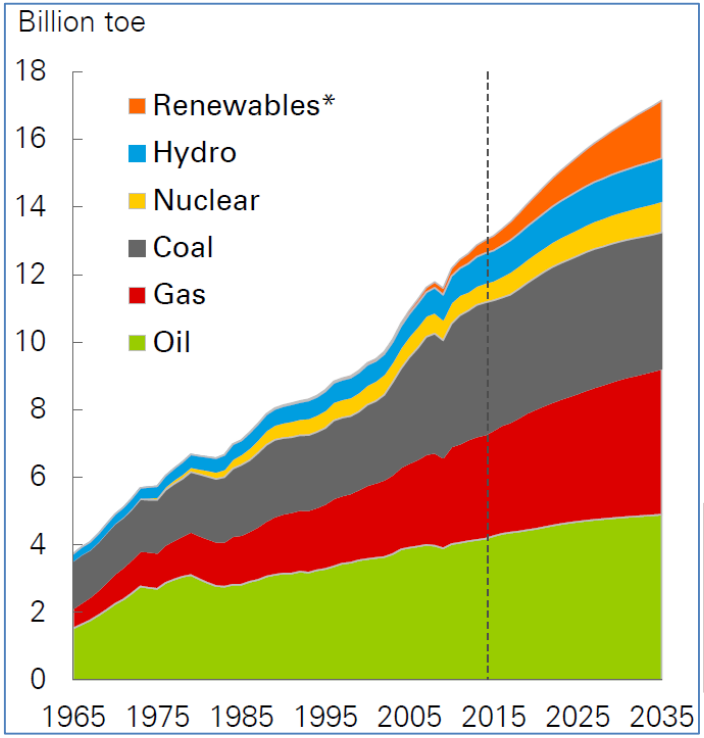
Professor Katsuya Kawamoto, Dr. Eng.
Graduate School of Environmental and Life Science
Okayama University, Japan

Today's outline

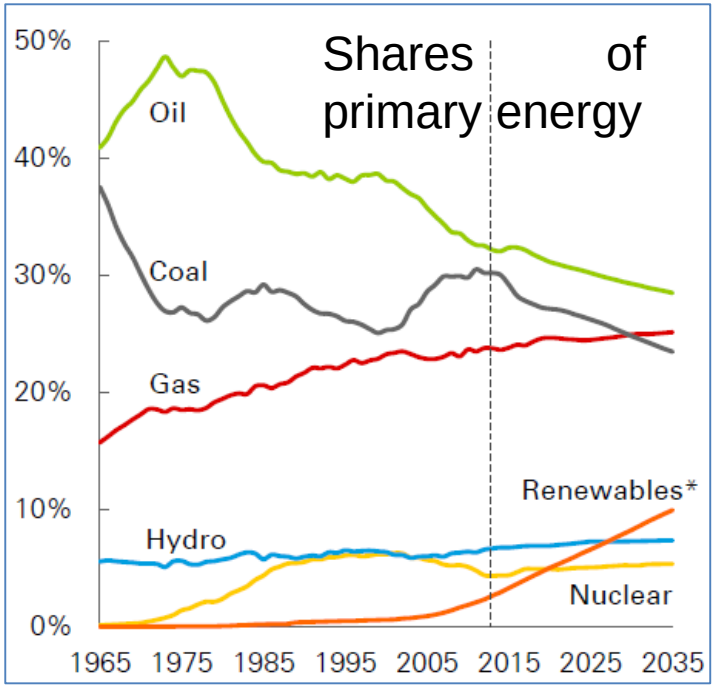
Introduction
Potential of wastes as an energy source
Policies on energy from waste
Technologies for recovering energy from waste
Summary and future remarks

Introduction

- Because of the growth of populations and economies worldwide, we are facing an ever-expanding demand for energy.
- Under the circumstances, renewable energies are justifiably attracting considerable attention.
- In addition, the problem of global warming is increasing the value of extracting energy from waste, because effective use of biomass reduces carbon dioxide emissions.



Primary energy consumption by fuel



Ref.: BP Energy Outlook 2017 edition

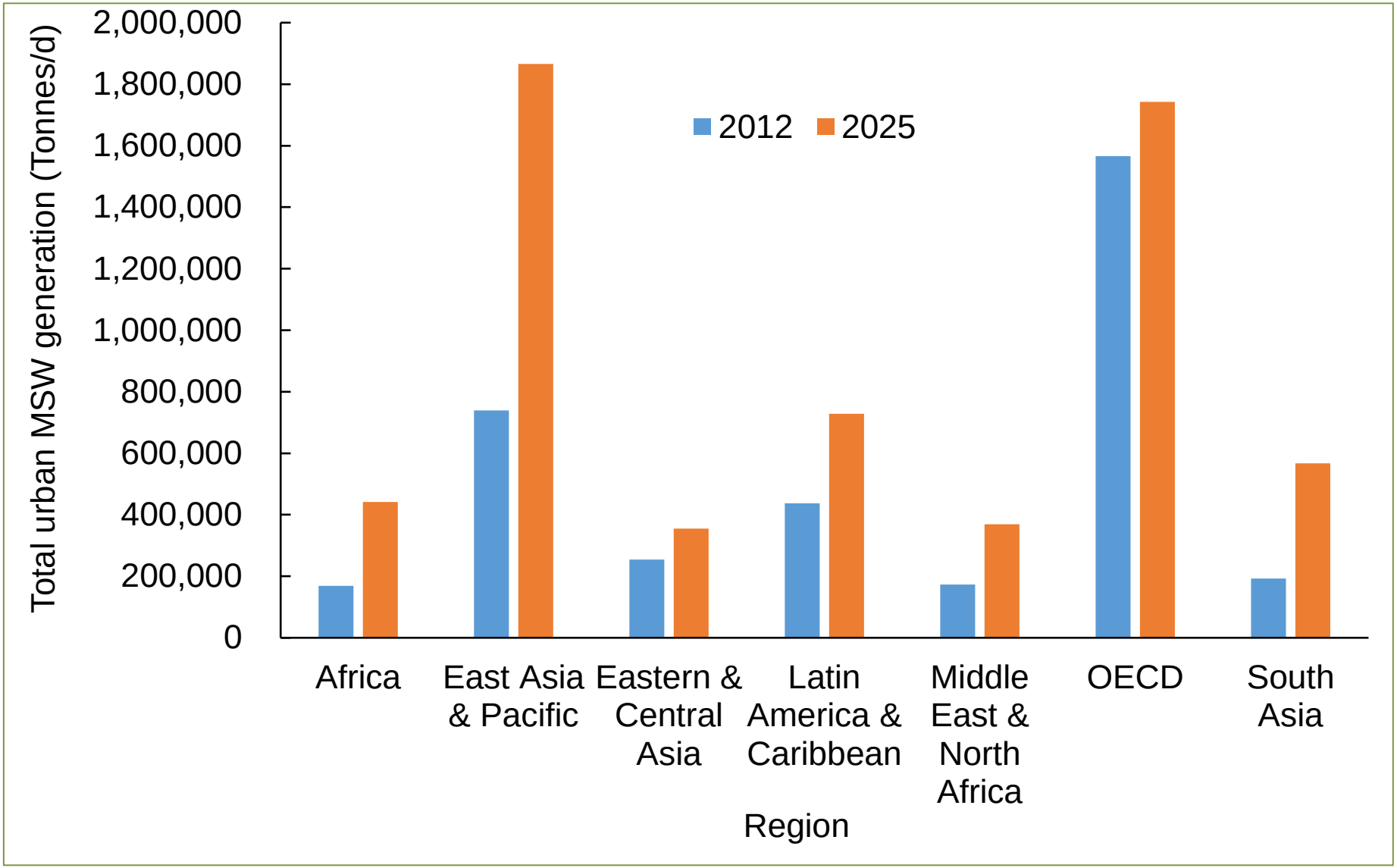
https://www.bp.com/content/dam/bp/pdf/energy-economics/energy-outlook-2017/bp-energy-outlook-2017.pdf

Worldwide waste generation data with urban population in 2012

Region	Total urban population (millions)	Total urban MSW generation (tonnes/d)	Urban MSW generation per capita (kg/d)
Africa	261	169,120	0.65
East Asia & Pacific	777	738,959	0.95
Eastern & Central Asia	227	254,389	1.12
Latin America & Caribbean	400	437,545	1.09
Middle East & North Africa	162	173,545	1.07
OECD	729	1,566,286	2.15
South Asia	426	192,411	0.45

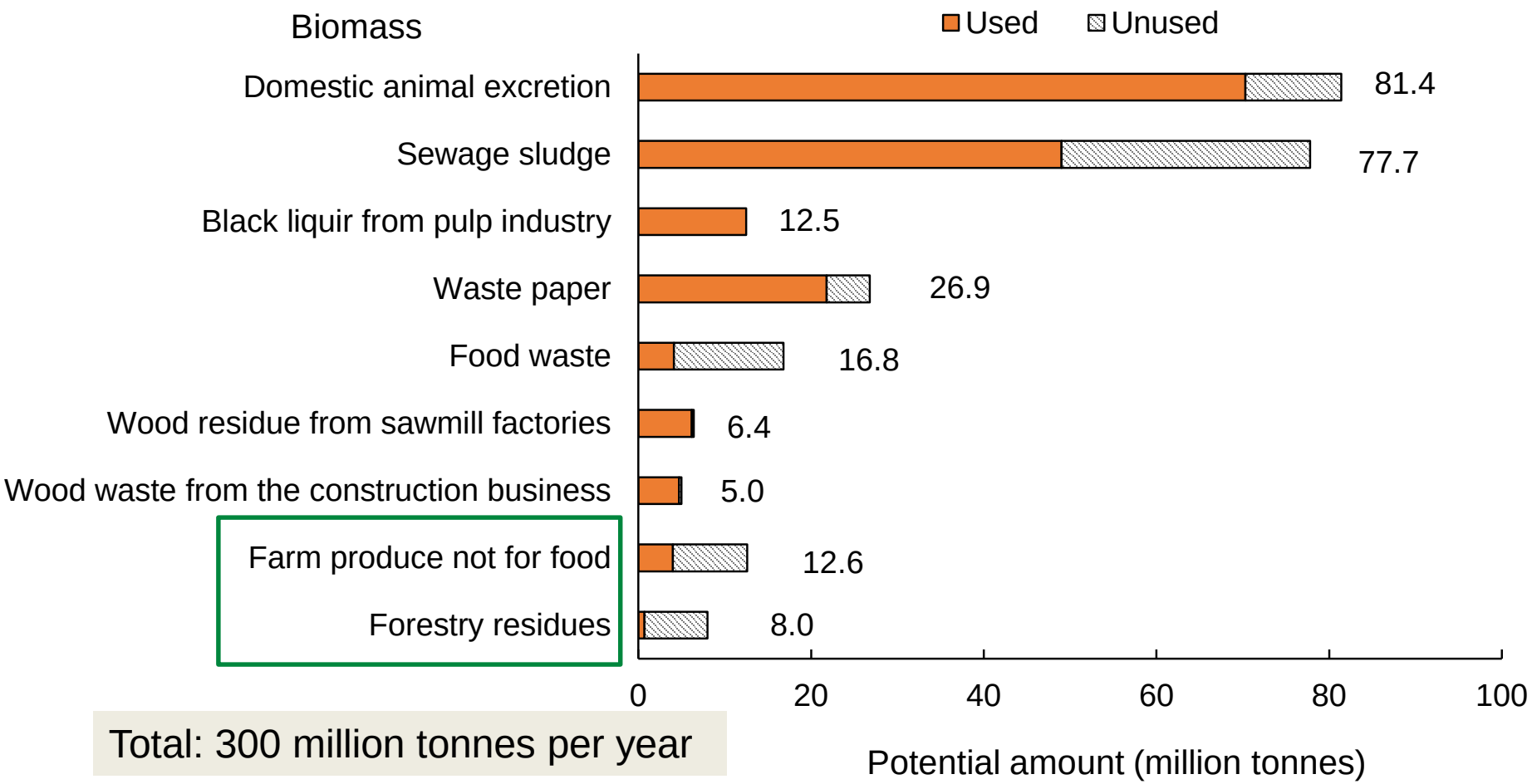
The fact that urban MSW (Municipal Solid Waste) generation per capita is around 1 kg/d has been well known.

Growth of MSW generation, by region



The generation amount in East Asia & Pacific will significantly increase, and also MSW of south Asia and Africa increase even if the current amounts are not so large.

Biomass waste amount in Japan

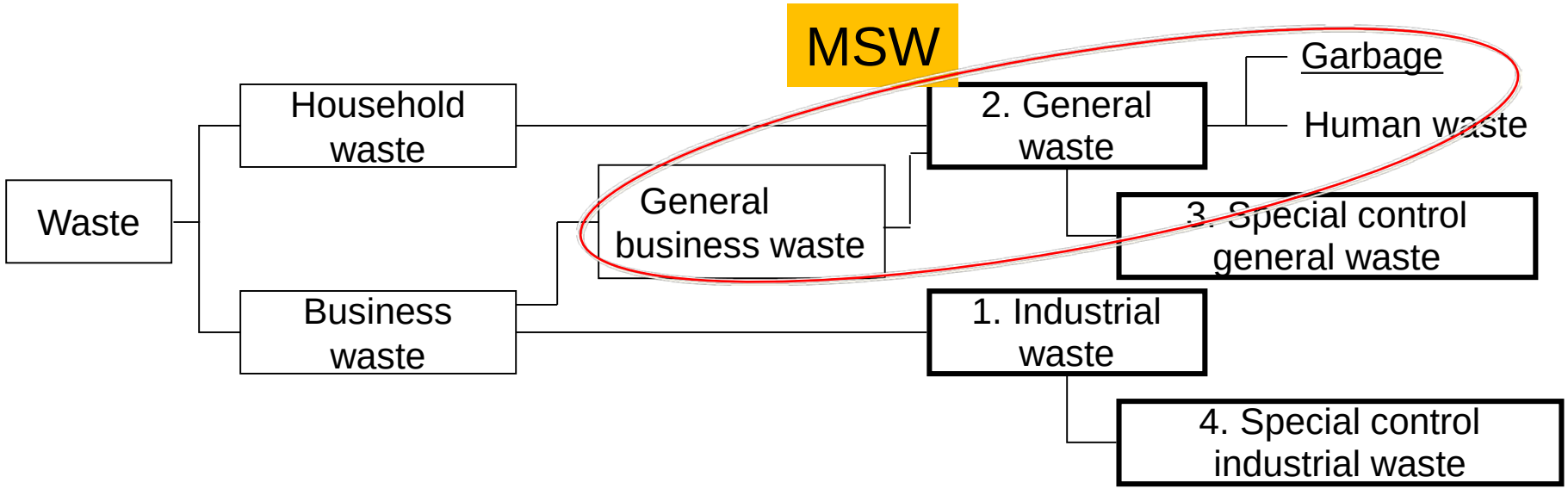


Total: 300 million tonnes per year

Estimated annual amount of potential biomass with used or unused in Japan (at the end of March in 2016)

The total amount of biomass potential corresponds to roughly 5 % of the amount of fossil fuels in the primary energy sector.

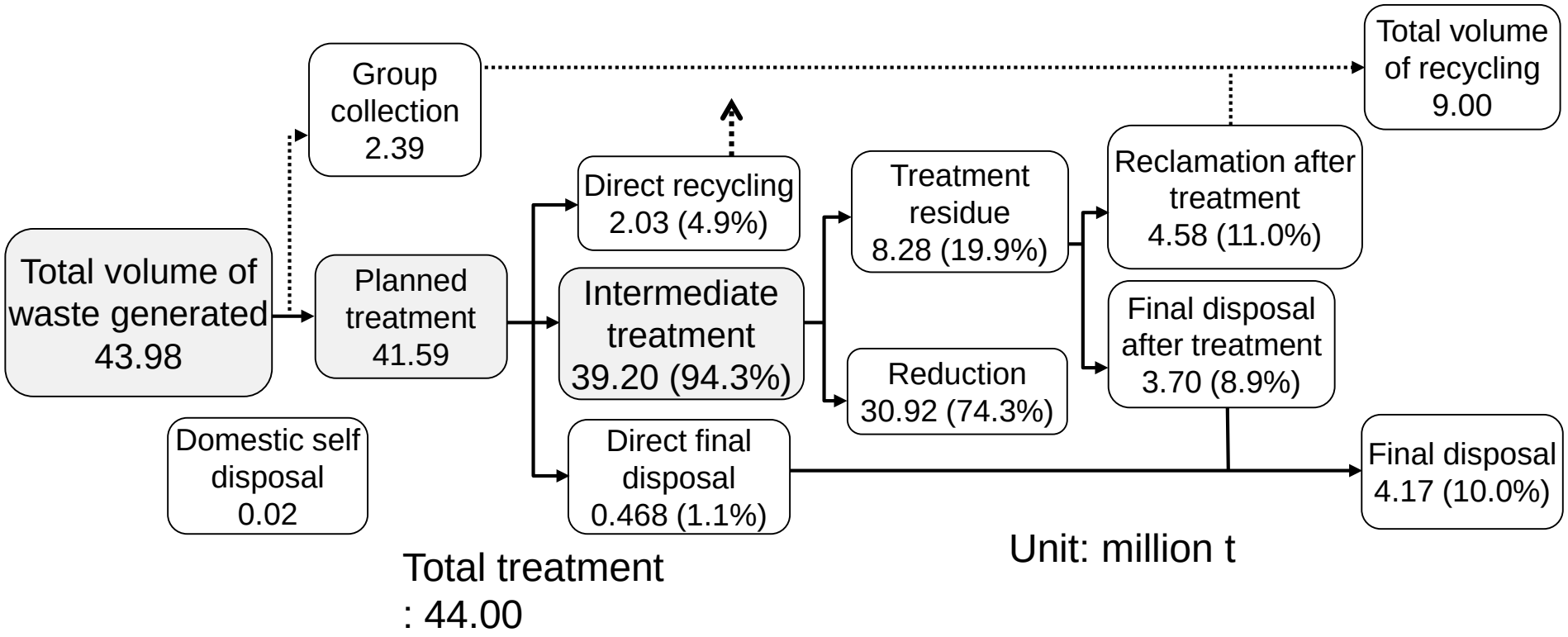
Classification of waste in Japan



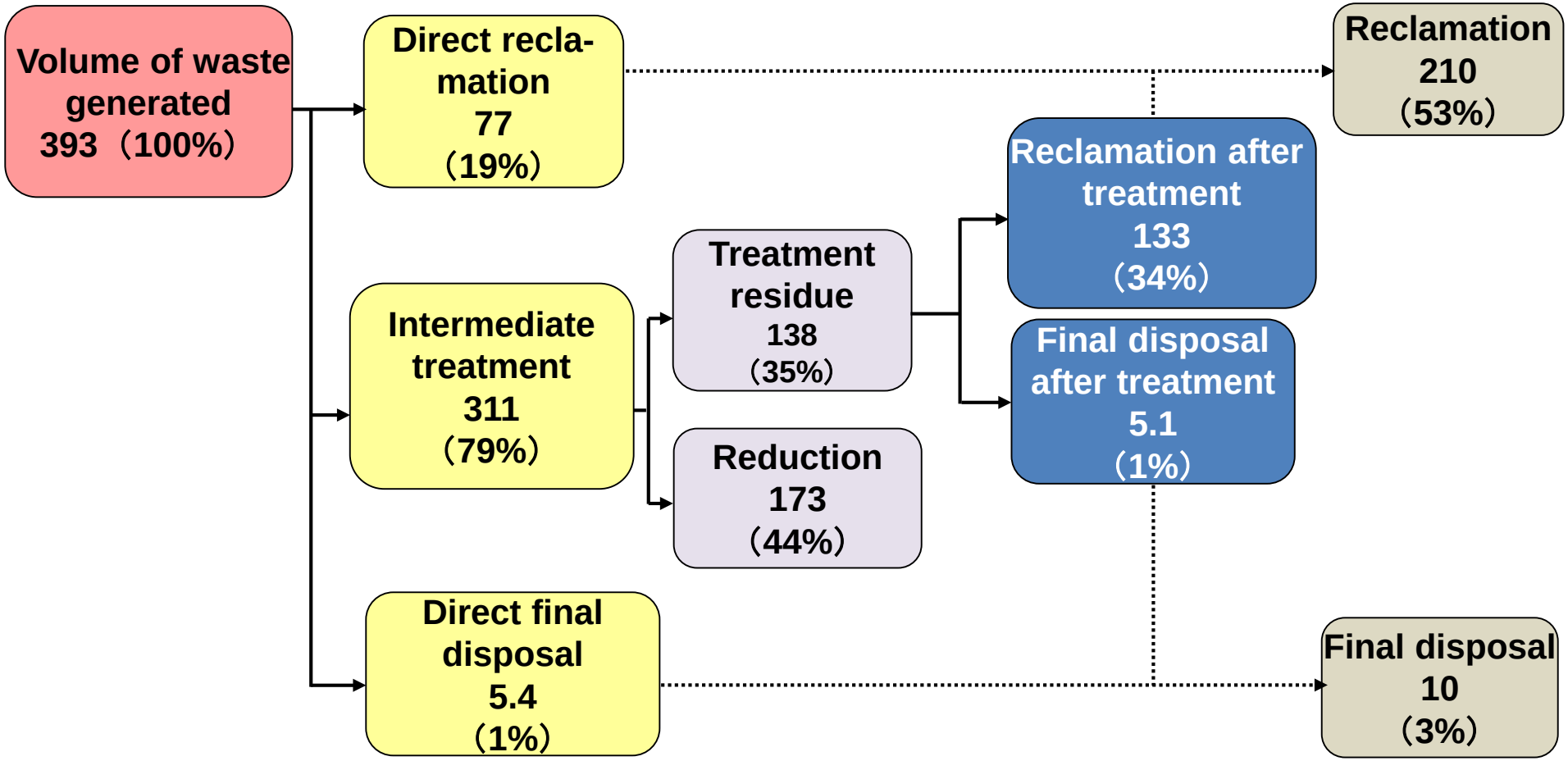
1. **Industrial waste**：Waste products (20 items) generated as part of business activities, and imported waste are defined industrial waste.
2. **General waste**：Non-industrial waste

3. **Special control general waste:**
   Within general waste: explosive, toxic and infectious waste, and other items designated by government ordinance as being harmful to human health and the living environment
4. **Special control industrial waste:**
   The same definition is made within industrial waste

Municipal waste treatment and disposal flow in FY2015



Industrial waste treatment flow in FY2014



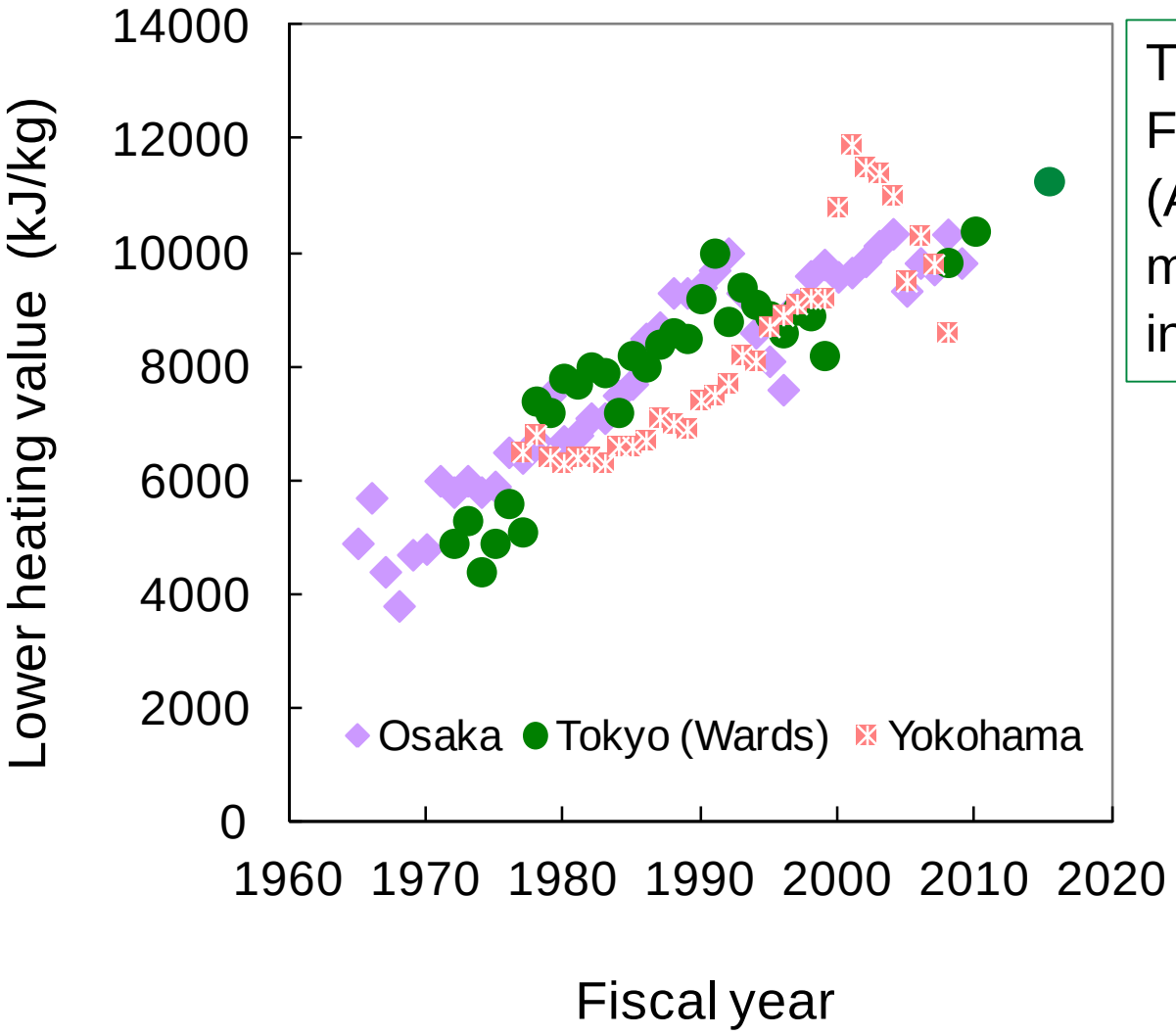
Unit: million t

Thermal process : Incineration

Change of social role of incineration facility and background

	Function and nature	Background
~1950s	Appropriate treatment for sanitation	Basic matter
1950s~	Weight and volume reduction	Weight reduction : 1/10 Volume reduction : 1/20
1980s~	Reduction of pollutant emission and environment impacts	HCl, Dioxins, NOx…
2000s~	Thermal and resources recovery	Energy from waste
	Withstanding disasters	Large-scale disasters

Changes over time in lower heating value of waste (Big cities of Japan)



The data of Tokyo in FY2016 : 11,223 kJ/kg (Averaged number measured in 19 MSW incineration plants)

Data of WtE from MSW incineration

Electric power generation data from MSW incineration in Japan in FS 2015

Number of plants supplying power-generation facilities	**348**
Total performance of power generation	**1,934 MW**
Averaged efficiency of generation*	**12.6 %**
Electric potential energy	**8,175GWh**

* Defined as 100 × (860kcal/kWh × [Electric potential energy]) / (1,000kg/t × [Amount incinerated] × [Calorific value kcal/kg])

- Japan has a large number of MSW incineration facilities and the number is over 1,100 from small scale plants to large scale plants.
  - the maximum capacity is 1,200 tonnes per day, but the average is 100~200 tonnes per day.

Problems: Japan has still many small scale facilities where heat recovery is not so effective.

The efficiency of power generation has a limitation due to the composition of acidic nature of flue gas. The latest number is only 12.6%.

The Feed-in Tariff scheme

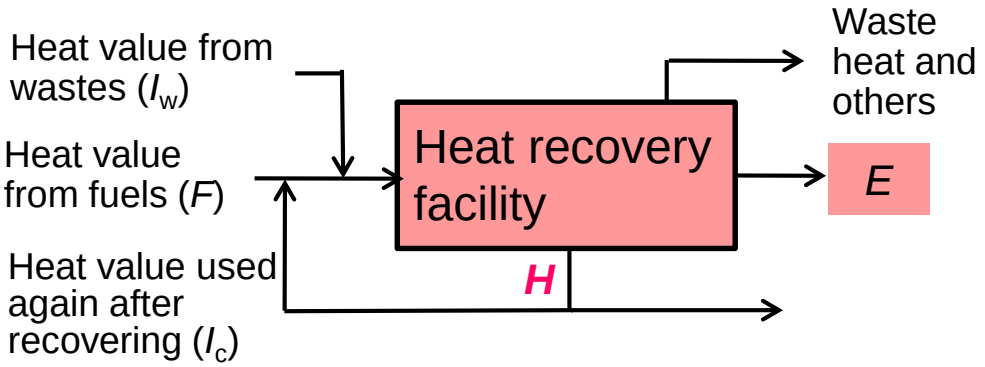
Heat recovery has been encouraged through various measures.

Japanese standard with regard to heat recovery in incineration plants

- The regulations introduced in Japan in 2011 dictate that the founder of the heat recovery facility (that is, the incineration plant) should meet the standard below.

$$A = \frac{E \cdot 3600 + H - F}{I} \times 100$$

The value *A*, annually averaged, should be **10 or more**.



A: Heat recovery ratio (%)
E: Value of power generation obtained from conversion of heat value (MWh)
H: Heat value obtained, excluding power generation (MJ)
F: Heat value from fuel (excluding waste materials) (MJ)
I: Total of thrown heat values from wastes and fuel (MJ)

- The energy *I* is a summation of the heat value from waste, fuel and other media such as high-temperature air obtained in an air preheater.
- The ratio of fuel is restricted to less than 30% of the total of waste and fuel, because this standard targets waste treatment facilities.

Policy matters and others

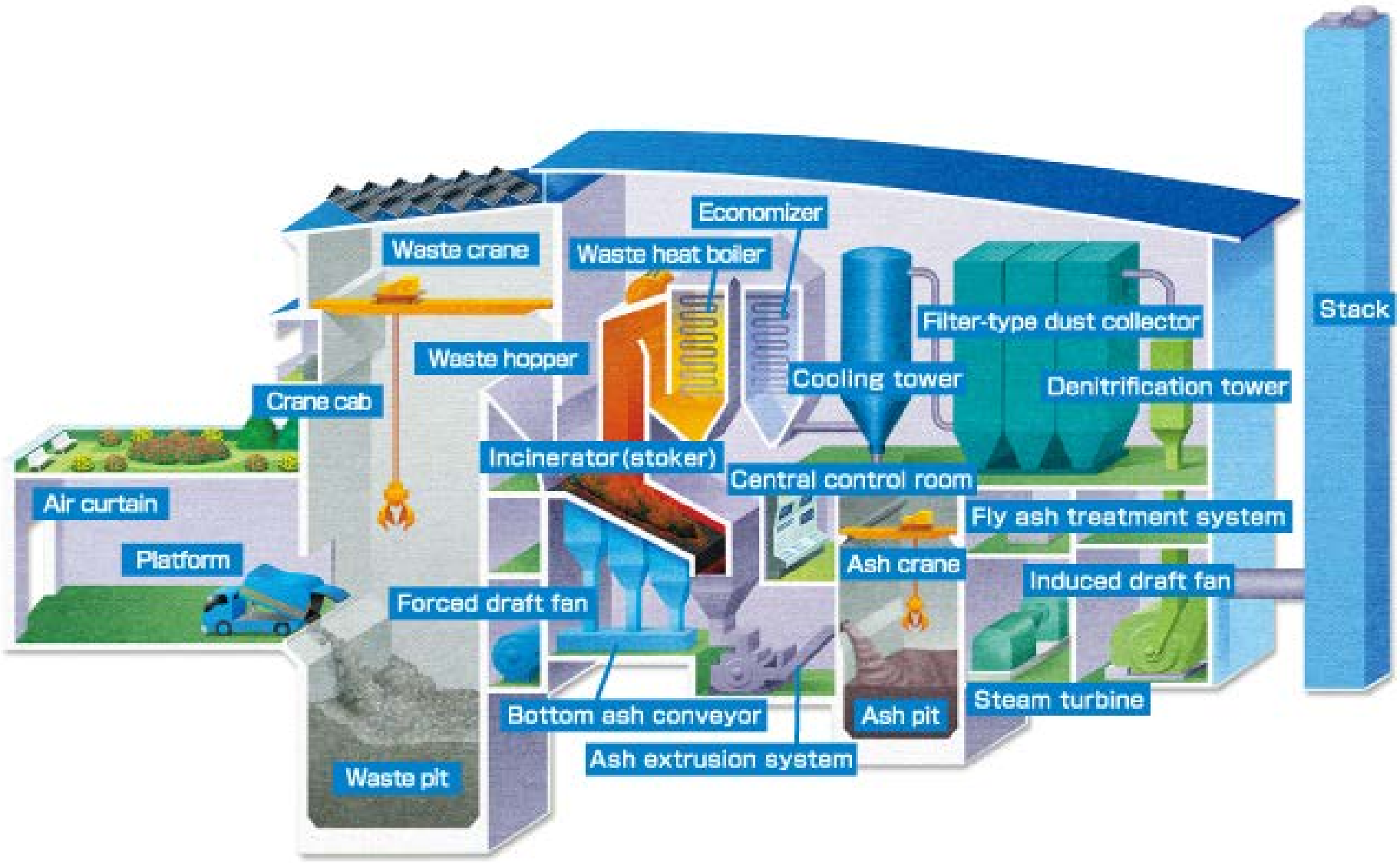
- Japan: the targets for introduction of renewable energy, the ratio of renewable energy to the primary energy source is set to be 6 % by 2020. The Feed-in Tariff scheme was used for this promotion.

- EU: the ratio of renewable energy to the final energy demand is set to be 20 % by 2020 and especially in Germany, the ratio is set to be 18 % by 2020 and 30 % by 2030.

World Energy Council: Publications-World Energy resources
:https://www.worldenergy.org/publications/

- US: most MSW is disposed in a landfill, and only about 13% is incinerated with energy recovery. There are about 90 waste-to-energy plants, and these are unevenly distributed, with a disproportionately large number in Florida, New York and Minnesota. There is a growing tendency toward increasing the number of such plants, against the social background of environmental concerns.

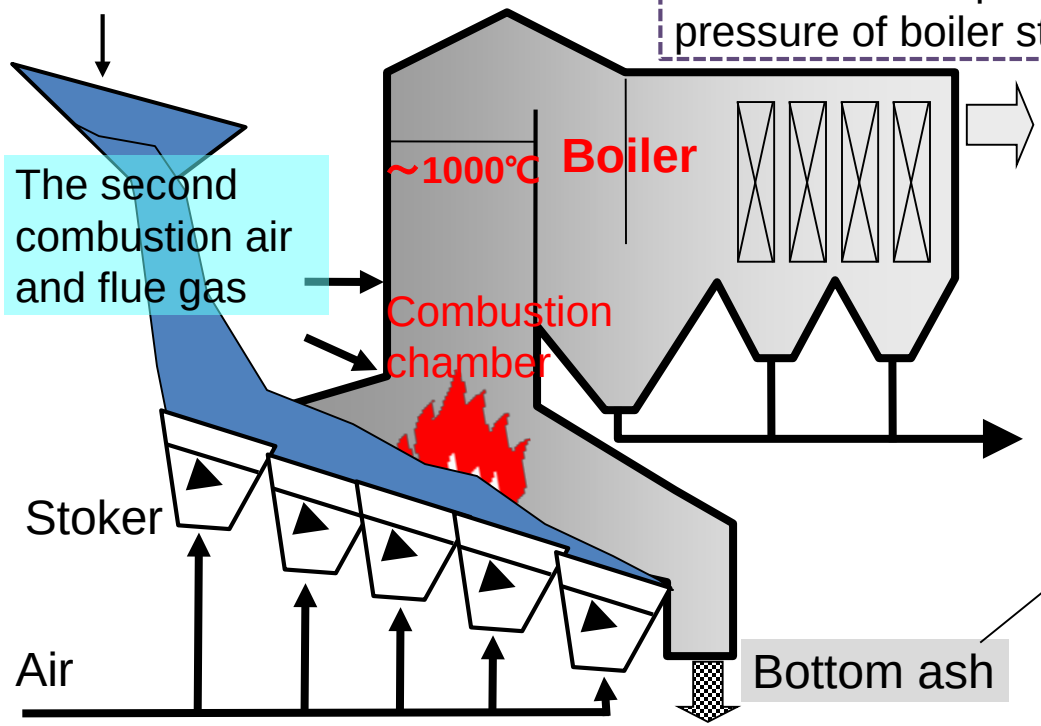
Stoker type incineration plant



Ref, http://www.takuma.co.jp/english/product/msw/stoker_msw.html

Improvements in the stoker furnace

Improvement of heat recovery ability



To increase temperature and pressure of boiler steam

Recent data: 400 ºC, 4 MPa

Flue gas cleaning equipment

Development of advanced flue gas treatment

Fly ash

Enhancement of effective use of residues

Use of ashes as a cement raw material

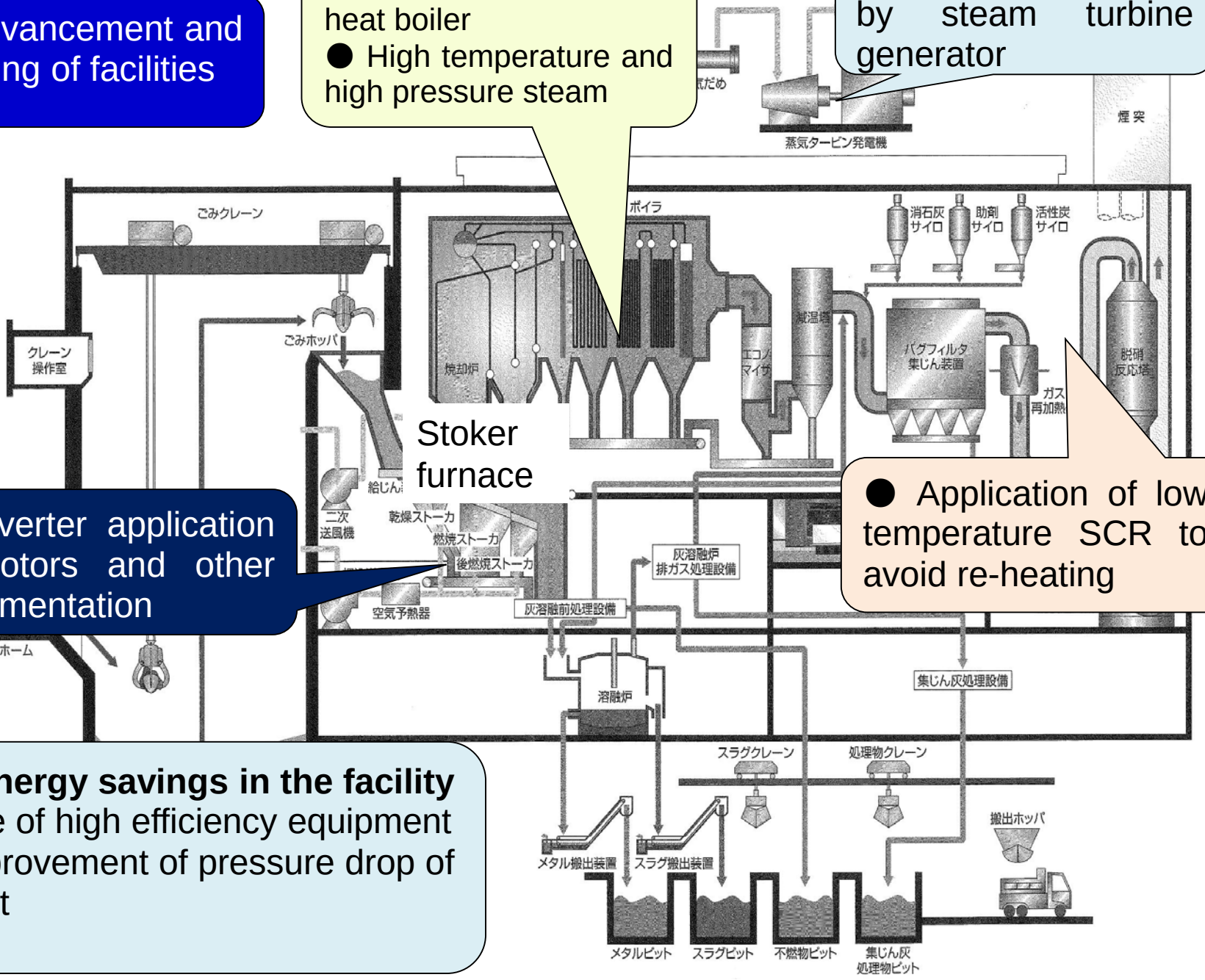
Improvement of combustion technology

- Control of combustion temperature
- Control (Reduction) of excess air ratio: from about 1.8 to about 1.2
- Recirculation of flue gas into the combustion zone
- Improvement of combustion control by artificial intelligence technology

● Advancement and upsizing of facilities

● Introduction of waste heat boiler
● High temperature and high pressure steam

● Power generation by steam turbine generator

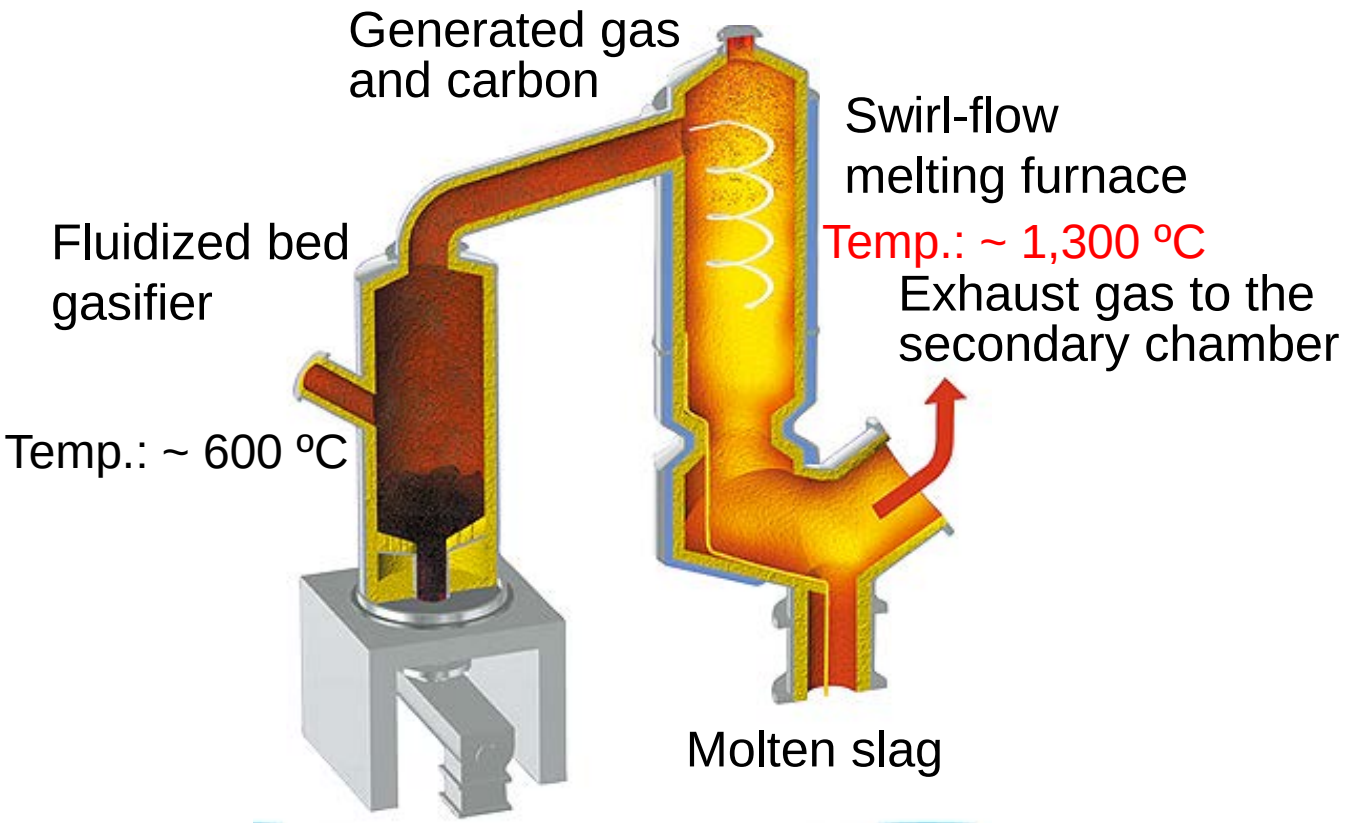


● Inverter application to motors and other instrumentation

● Application of low temperature SCR to avoid re-heating

●**Energy savings in the facility**
Use of high efficiency equipment
Improvement of pressure drop of duct
etc.

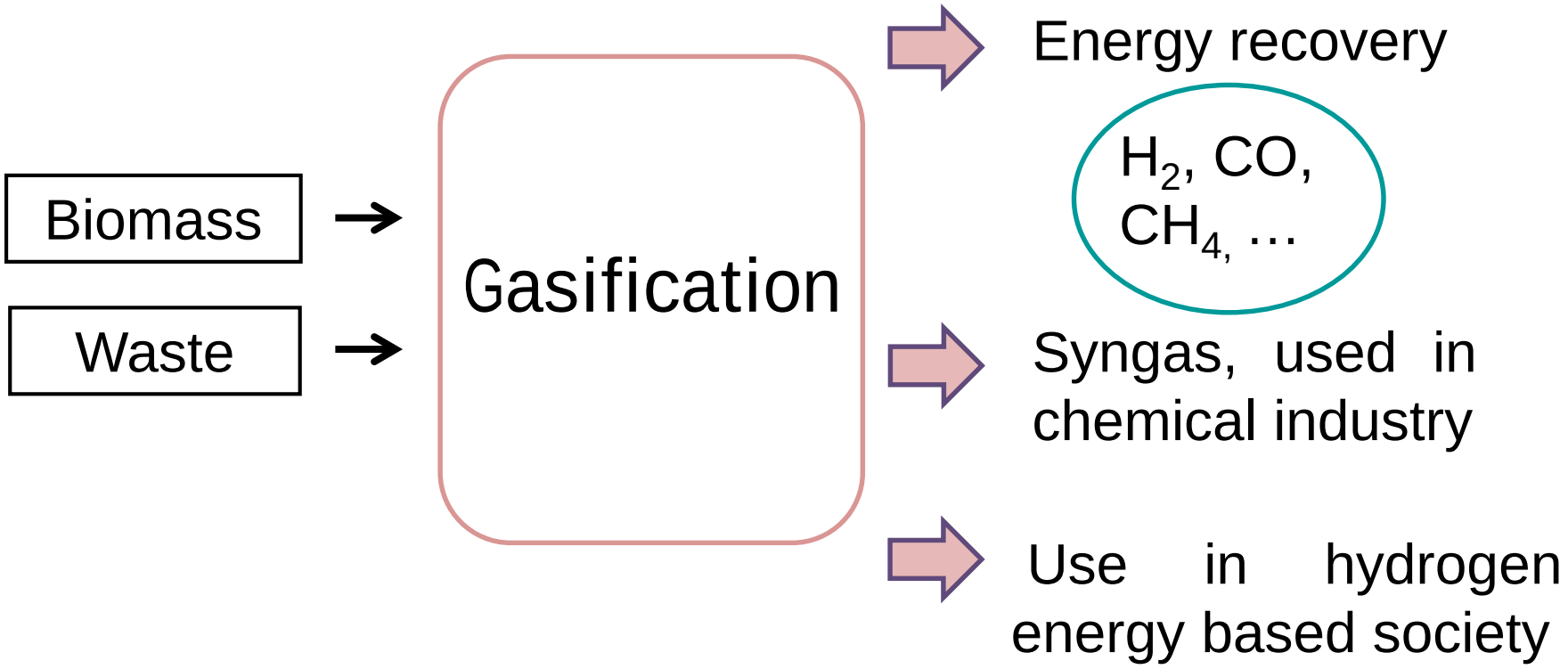
Gasification and melting process



Fluidized bed type

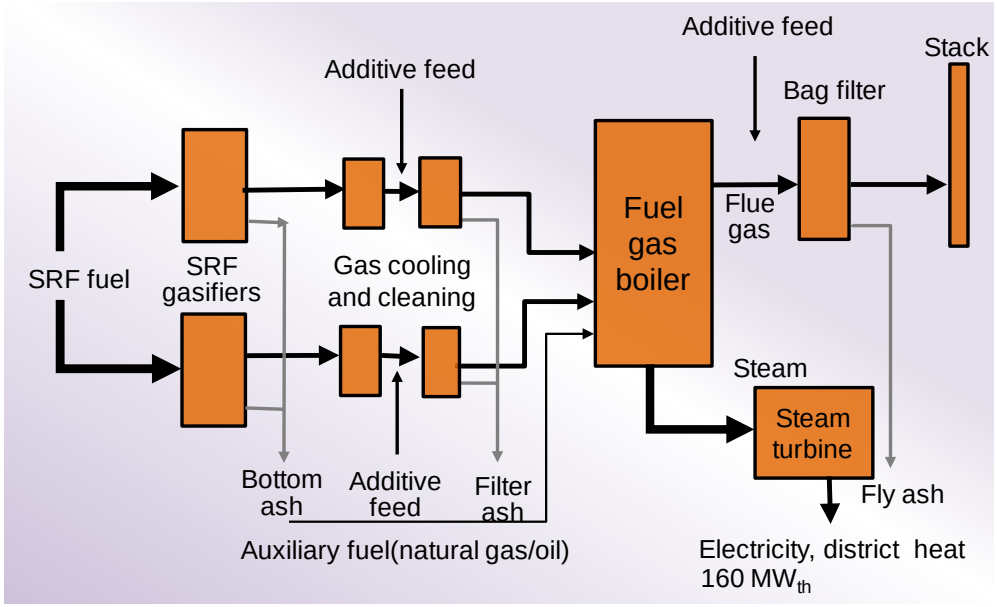
- Gasification takes place in the gasifier at very low O_2 level.
- Generated gas and carbon are then combusted at high temperature (~1300 ºC), which can produce molten slag.
- The ratio in number to whole incineration plants reaches about 10%.

Gasification - based technology and future prospects



Example of WtE plant based on fluidized-bed gasification of solid recovered fuel (SRF)

Lahti stand-alone gasification plant in Finland



Lahti Energy's Kymijärvi II power plant

This is planned to efficiently generate electricity and district heat from SRF.

Ref.
https://www.lahtigasification.com/

Technical data

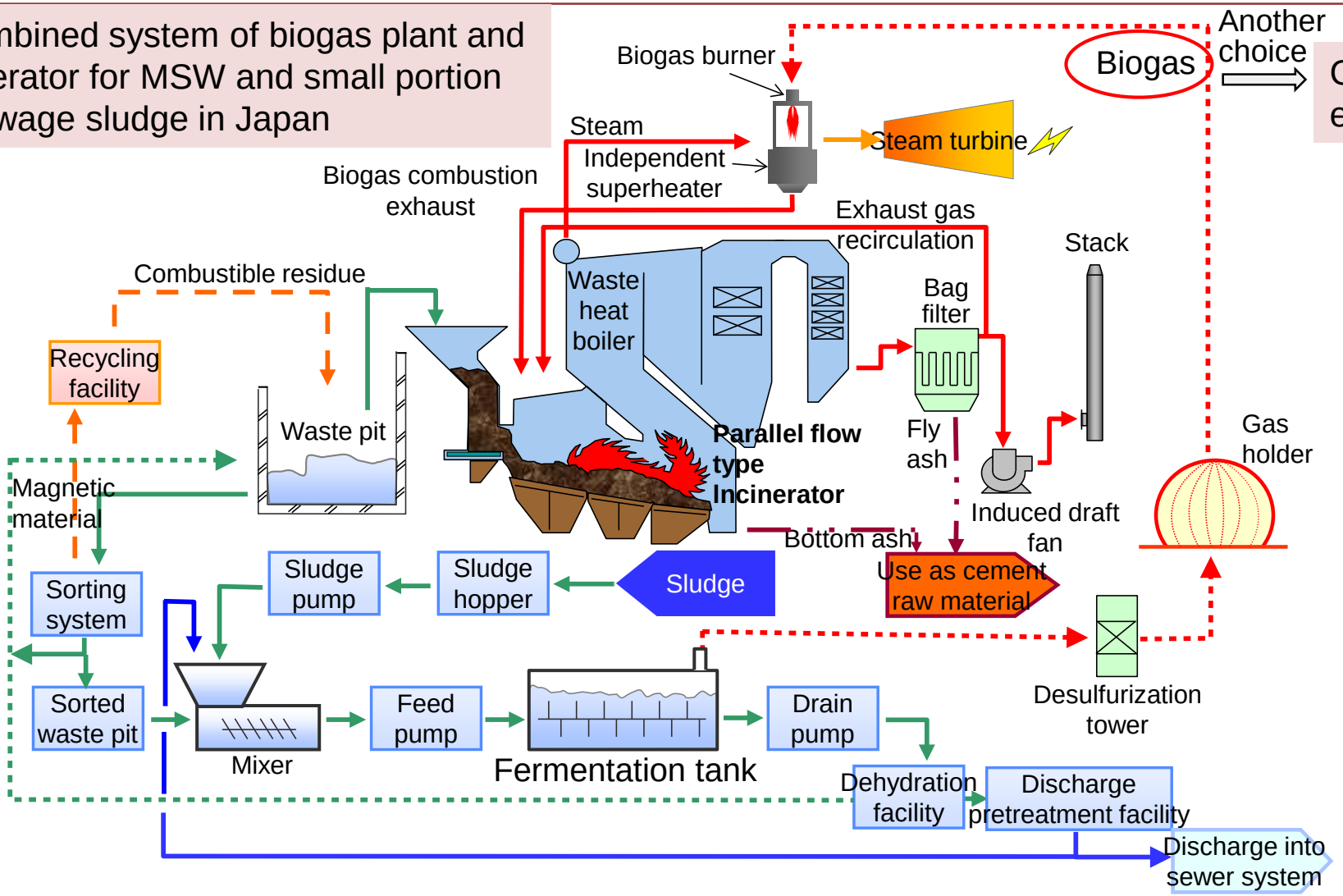
Capacity, fuel	2 x 80 MW
Capacity, electricity	50 MW
Capacity, district heat	90 MW
Fuels	RDF, REF and recycled wood
Start-up	2012

http://www.valmet.com/about-us/references/energy-references/lahti-energia-produces-energy-from-waste-efficiently-and-environmentally-friendly/

Combined system in Japan

The combination of biogas plants and incineration plants are a good choice for the recovery of energy and the reduction of CO_2 emissions. The residues from the fermentation process can be incinerated in an adjacent facility in the same area. Electric power is generated by gas engine that runs on biogas from the biogas plant.

A combined system of biogas plant and incinerator for MSW and small portion of sewage sludge in Japan



Concluding remarks for the future

1) In biomass waste treatment in the context of WtE, it is important to consider and well design a separation and collection process before the main process in a series of total system. The disposal must also be conducted with good sanitation and minimal environmental impact.

2) The recovery of electric power and also heat in incineration plant has been promoting. However, it is a big problem to raise the recovery rates.

3) The combined system is one choice that should be thought about to avoid risk of the raw materials procurement. Biomass, MSW and industrial wastes including sewage sludge could be considered.

4) Innovative thermal processes are needed for WtE. One technical solution is found in gasification process application.