Workshop: Urban Water within a changing Globe, Aachen, Oct.31, 2013

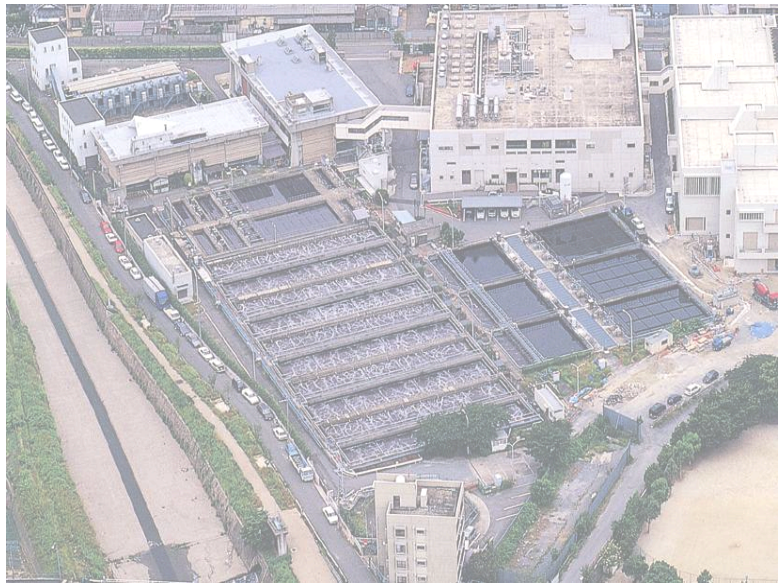
Global Warming and Wastewater Treatment System in Japan

Hiroki ITOKAWA

Wastewater Treatment R&D Division,
Japan Sewage Works Agency (JS)

Contents

- Current status of sewage system in Japan
- Practical countermeasures against climate change
- Ongoing national projects



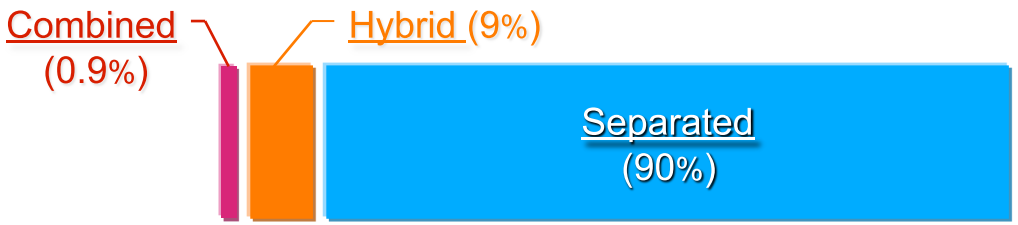
Sewage facilities in Japan

- Current status (as of FY2010)

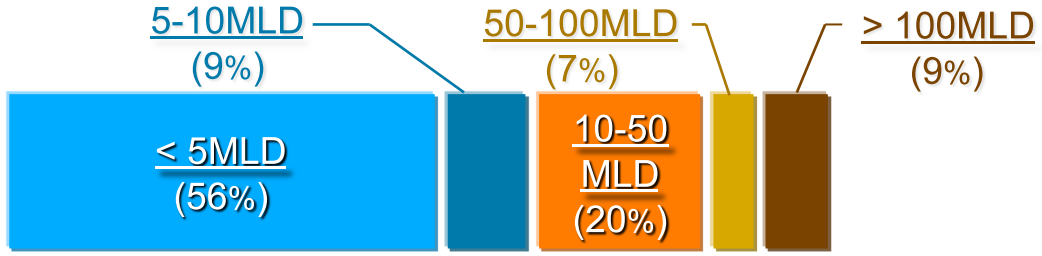
- Population served (FY 2012) : **96.5 million** (**76**% coverage)
  * 88.1% coverage by any kinds of WWT system
- Municipal WWTPs : **2,145** plants
- Length of sewer pipes : **443 x 10^3** km
- Wastewater treated : **14.7 billion** m^3/yr (40.3 million m^3/d)
- Waste sludge : **2.21 x 10^6** t-DS/yr generated, while **0.48 x 10^6** t-DS/yr disposed

Sewage facilities in Japan

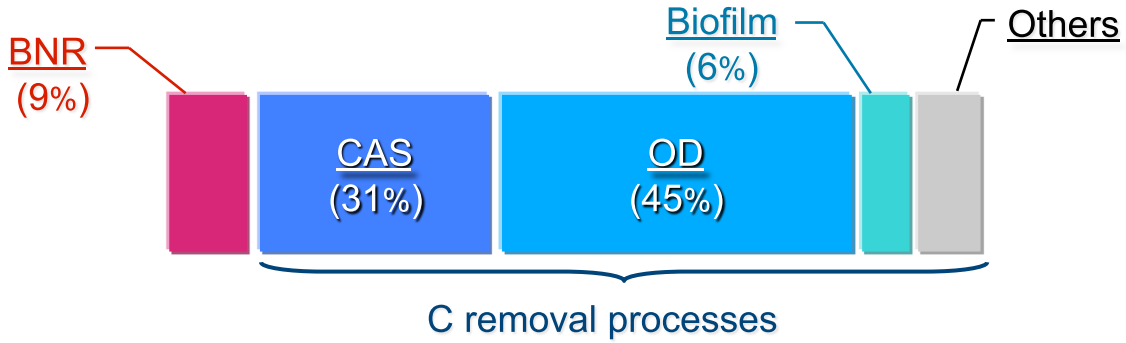
- Sewer system



- WWTP capacity

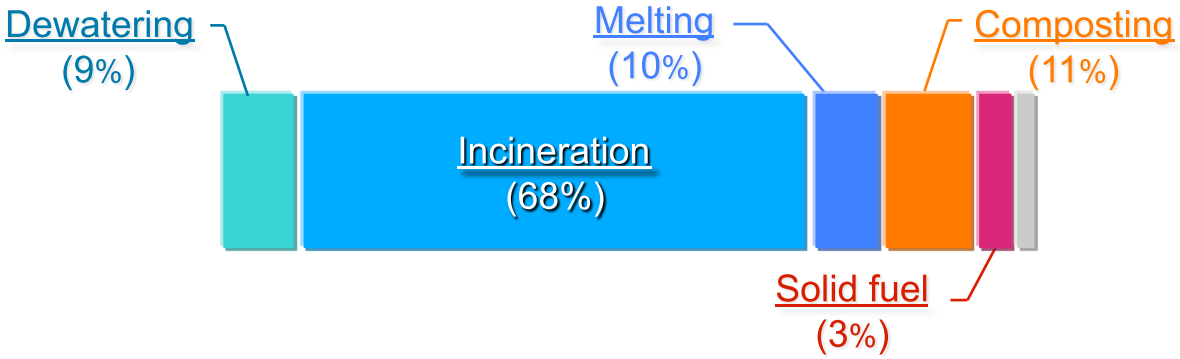


- WWT processes

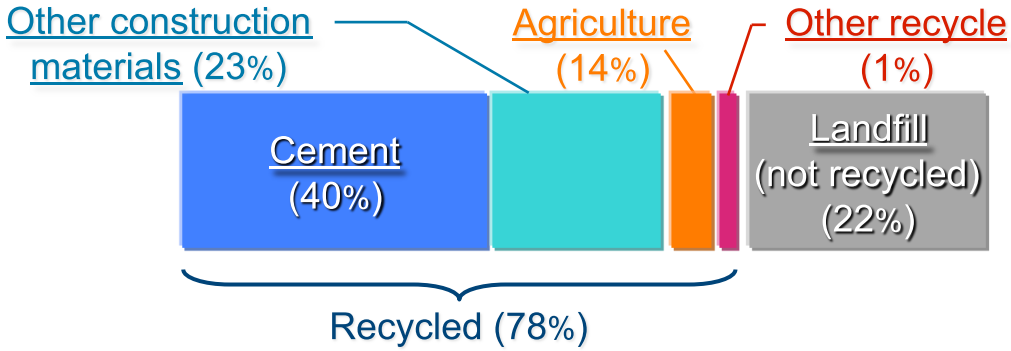


Sewage facilities in Japan

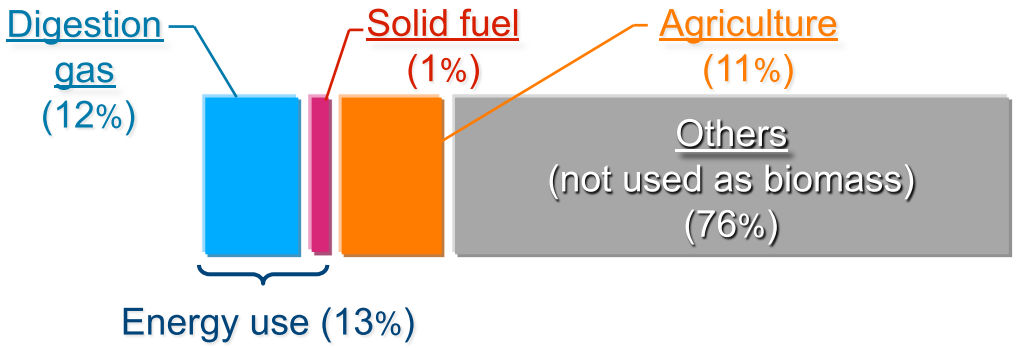
- Sludge processing (DS-based)



- Sludge recycle (DS-based)



- Sludge recycle (Carbon-based)



Climate change countermeasures

- Measures against global warming in sewage facilities

Mitigation

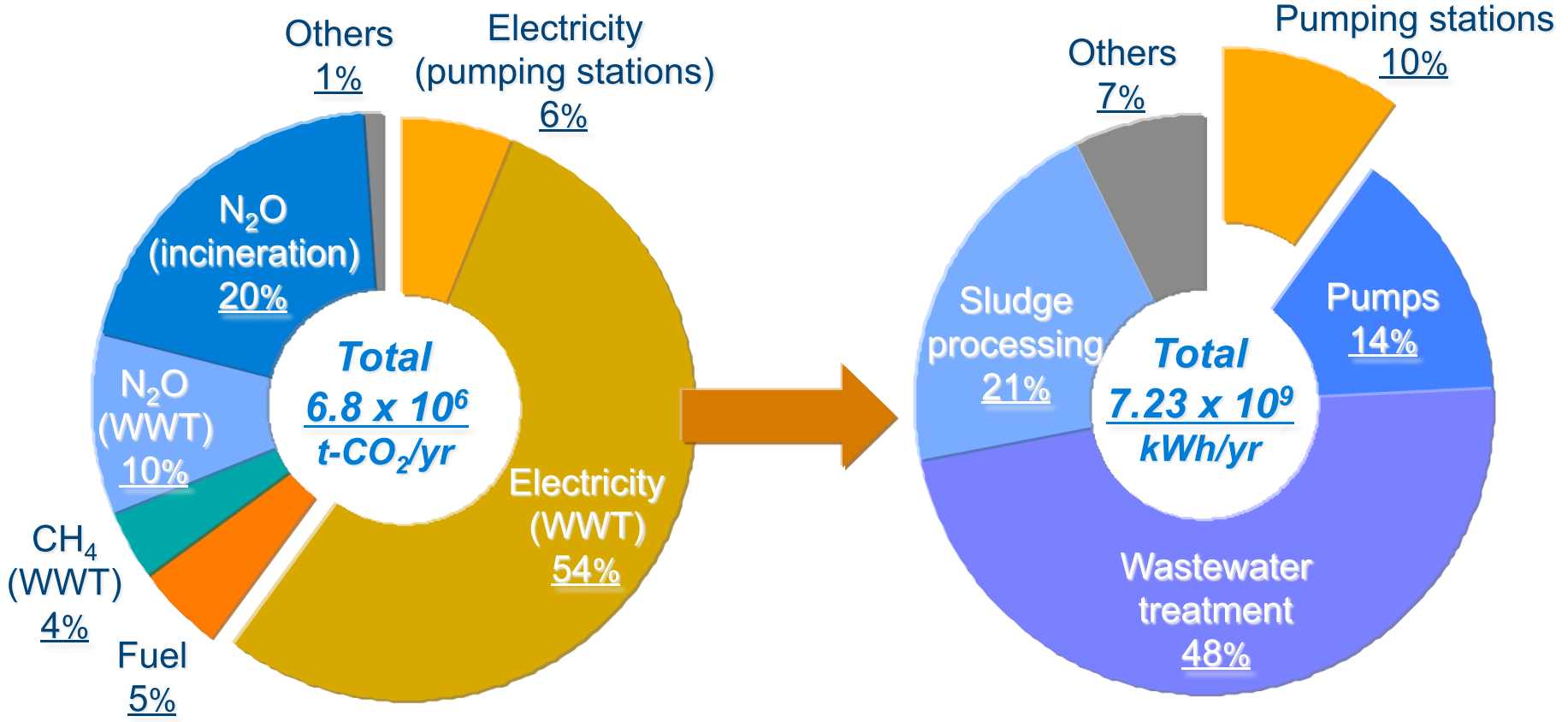
- *Energy reduction*
- *Energy recovery/generation*
- *Reduction of other GHGs (e.g. N_2O from incineration)*

Adaptation

- *Storm water management*
- *Water reuse/recycle (WWTPs effluent, rain water)*
- *Effluent management*

GHG emissions from sewage system

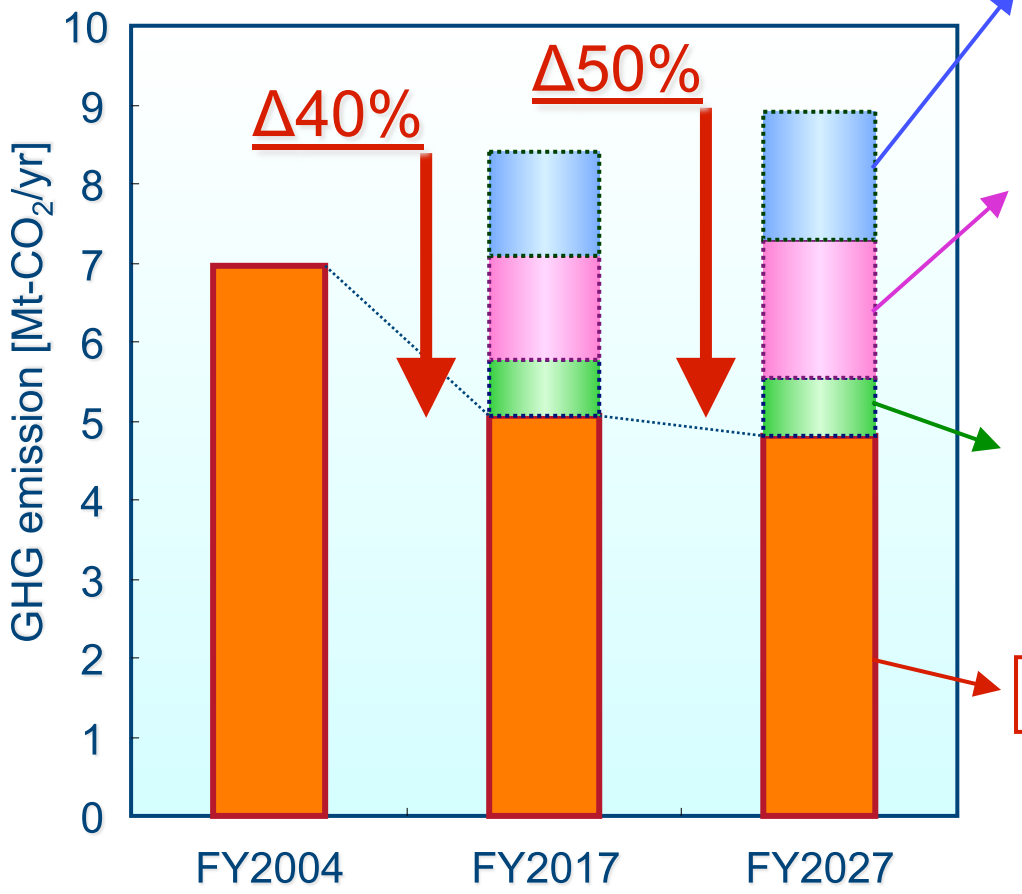
- **GHG emissions** : **6.8** Million t-CO_2/yr (**0.5%** of national total)
  * 50% increase from 1990 to 2010, while the amount of WW increased by 42%.
- **Power consumption**: **7.23** billion kWh/yr (**0.7%** of national total)
  * Average specific value being 0.49 kWh/m^3.



Breakdown of GHG emissions and power consumption at sewage facilities in Japan (FY2010)

GHG emissions from sewage system

➢ Projected GHG reduction in sewage facilities



Estimated GHG emission and reduction from WWTPs all over Japan

Energy reduction measures
- Low energy equipment
- Optimized operation incl. online control

Energy recovery/generation measures
- Solid fuel production
- Power generation with digestion gas
- Natural power generation

N2O reduction
- Higher temperature incineration
- Solid fuel production

Estimated GHG emission

* Data taken from JSWA(2012) *White Paper on Sewage Works, FY2012* (in Japanese) and other relevant MLIT reports.

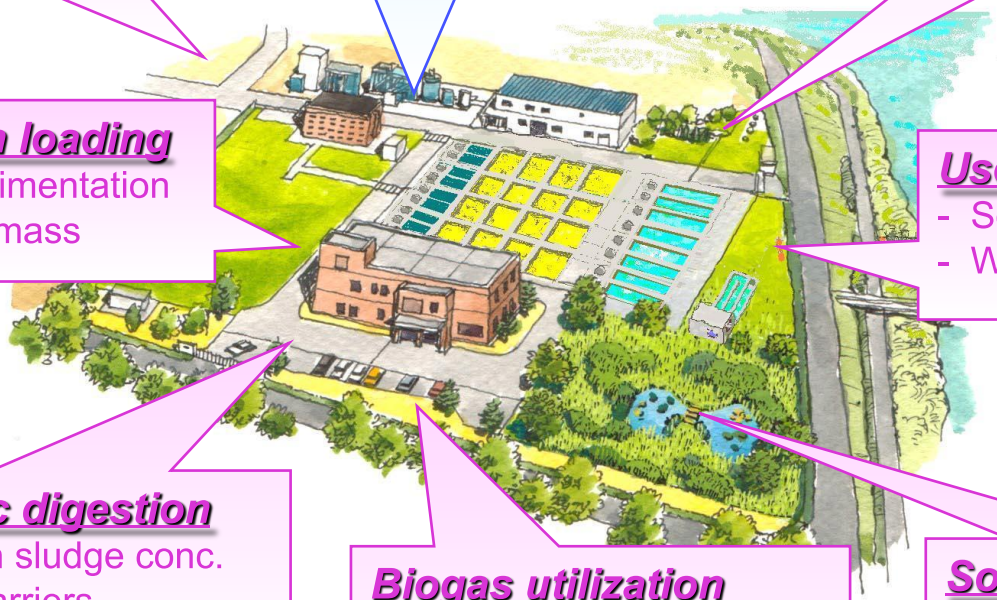
Energy reduction & recovery

➢ Possible energy reduction/recovery measures in practice

Heat recovery from WW
- Off-site heat recovery
- In-pipe heat recovery
- Snow melting

Optimized WWT operation
- Inflow control
- Aeration control
- High efficiency equipment

Small hydropower generation
- Power generation at effluent channels



Increasing digestion loading
- Enhanced primary sedimentation
- Receiving external biomass

Use of land area
- Solar power generation
- Wind power generation

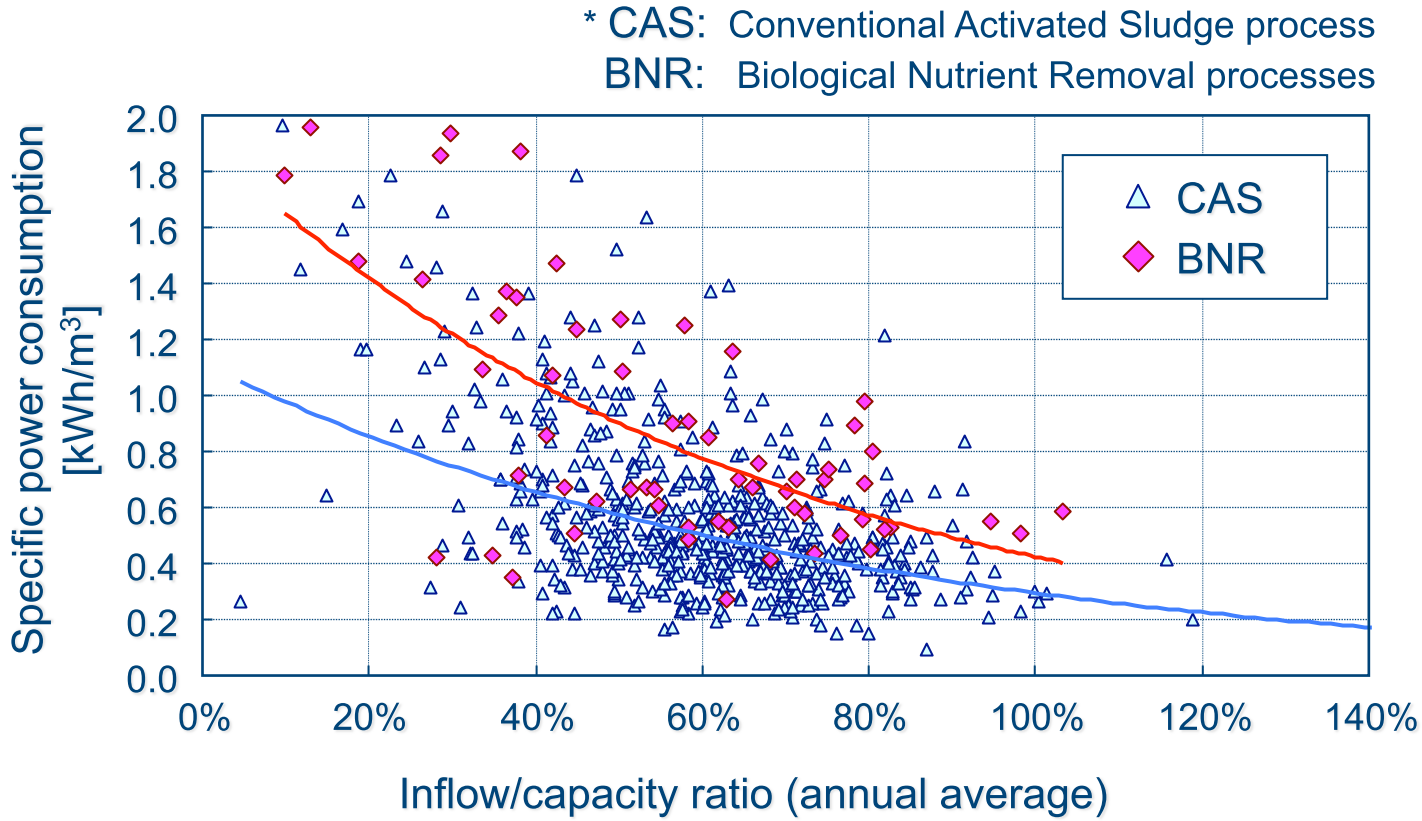
Enhanced anaerobic digestion
- High temperature, high sludge conc.
- Hybrid with biomass carriers
- Sludge disintegration

Biogas utilization
- Power generation
- Fuel cell
- Car fuel
- Injection to gas pipes

Solid fuel production
- Sludge drying
- Sludge carbonizing

Energy reduction measures

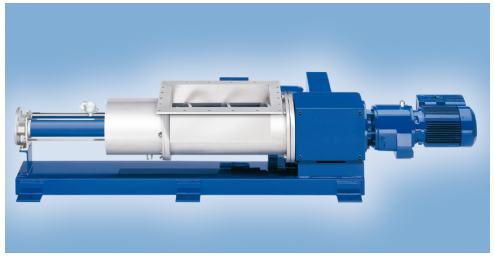
- Specific power consumption at municipal WWTPs

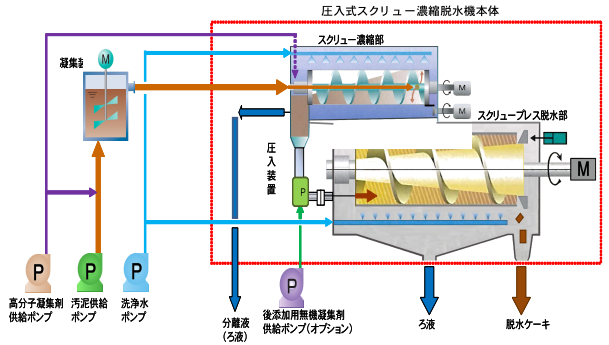


Relationship between inflow/capacity ration and power consumption at municipal WWTPs in Japan (FY2010)

Energy reduction measures

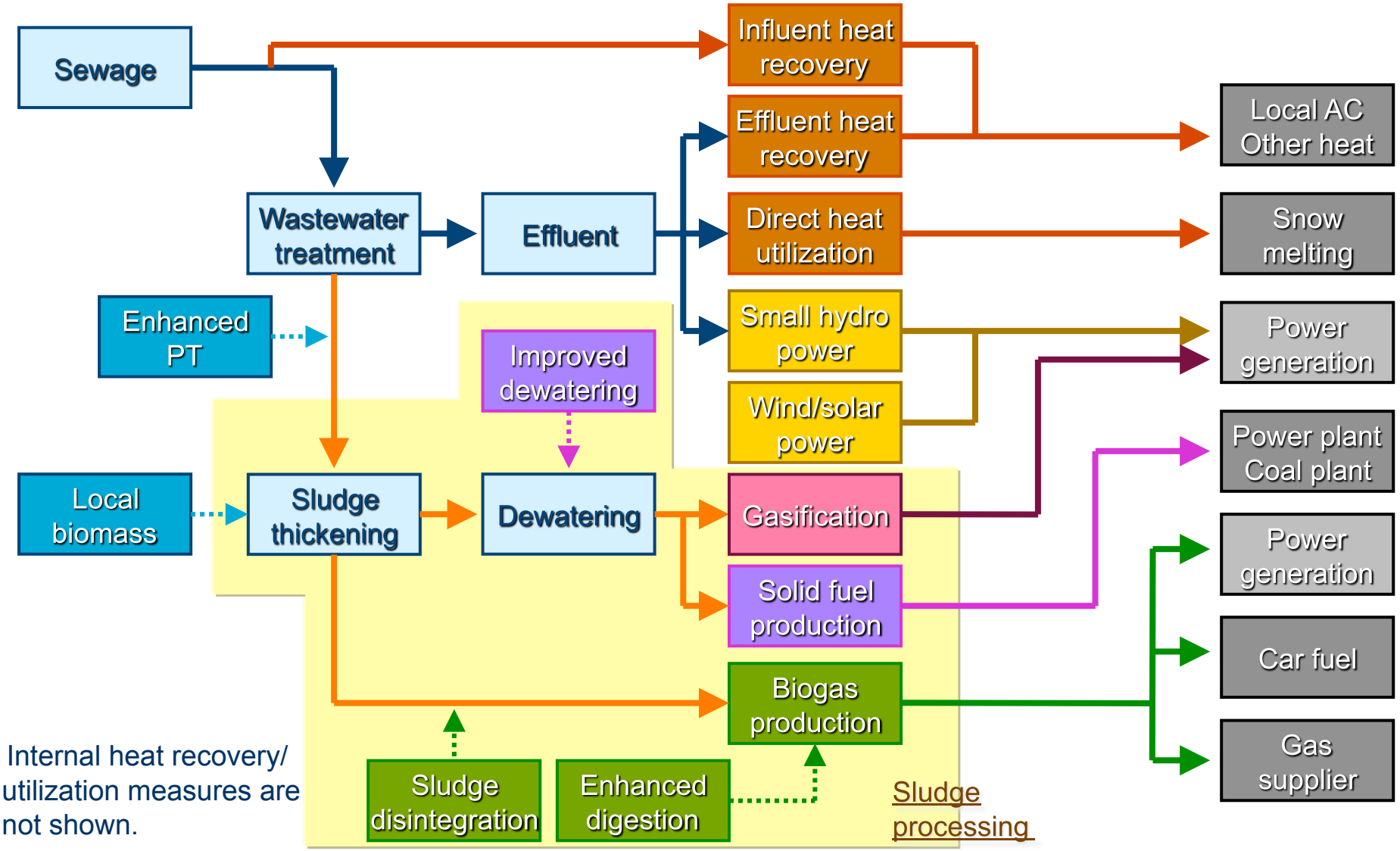
- Energy reduction measures in WWTPs
  - Aeration energy reduction
    - Improved diffusers
    - Optimized operation including online control
    - Optimized number and capacity of blowers
    - Inflow control (*e.g.* peak loading equalization)
  - Low energy equipment
    - WWT: pumps, mixers, etc., together with optimized operation
    - Sludge: mechanical thickening, dewatering, incinerator, etc.
    - Electrical: transformer, controller, etc.
  - Any other measures including building equipment (light, AC...)





Energy recovery/generation measures

➢ Energy recovery/generation measures in sewage facilities



Energy recovery/generation measures

- Potential energy of sewage/sludge/WWTPs

Resource	Potential amount of energy	Present utilization
Heat recovery from raw sewage	**7,800 Gcal/hr** * Equivalent to annual AC heat for 15 million houses.	**Just 3 sites**
Energy recovery from waste sludge	**3.6 billion kWh/yr** * Equivalent to annual power consumption of 670,000 houses.	**10%**
Other power generation measures * Incl. solar, wind, and small hydropower.	**2.3 billion kWh/yr** * Equivalent to annual power consumption of 430,000 houses	**0.4%**

* Data taken from *"White Paper on Sewage Works, FY2012" (in Japanese)* .

Energy recovery/generation measures

➢ Solid fuel production

- Sludge carbonizing: low temperature carbonizing, installed in 2 plants, 6 more plants under construction/design
- Sludge drying: pelletization-drying or oil-temperature drying, installed in 3 plants, 1 more plant under design
- To be used as alternative coal at nearby thermal power plants and other industries

➢ Gasification

- Sludge drying – gasification: installed in 1 plant
- Produced combustible gas can be used for power generation

Energy recovery/generation measures

➢ Biogas production and utilization

- Biogas production by anaerobic digestion
- Measures for improving digestion rate/efficiency
  - High temperature, high concentration
  - Biomass carriers
  - Sludge disintegration (*e.g.* heat treatment, ozonation)
  - Co-digestion with local waste (*e.g.* kitchen/food production waste)
  - Enhanced primary treatment (*e.g.* high rate filtration)

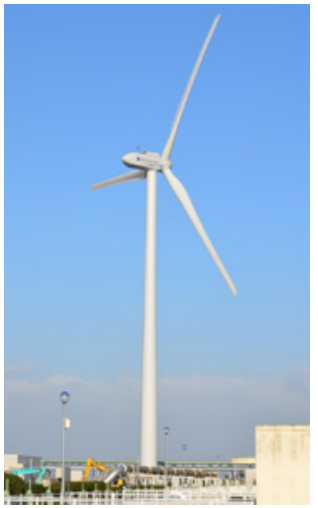
- Use of biogas
  - Power generation (gas engine, micro gas turbine, fuel cell) at 31 plants
  - Fuel for natural gas vehicles at 2 plants
  - Supply to local gas company (to gas production, direct injection) at 3 plants

- Sludge liquor treatment
  - Nitrogen removal: anammox
  - Phosphorus removal: MAP, adsorption

Energy recovery/generation measures

➢ Heat recovery

- Heat recovery from raw wastewater or effluent water
  - Typical case: effluent heat for building/district-scale air conditioning
  - Heat recovery from raw WW is conducted just at 3 sites, “In-pipe” heat recovery is just at demonstration stage
  - In northern area, influent/effluent heat is used directly for snow melting



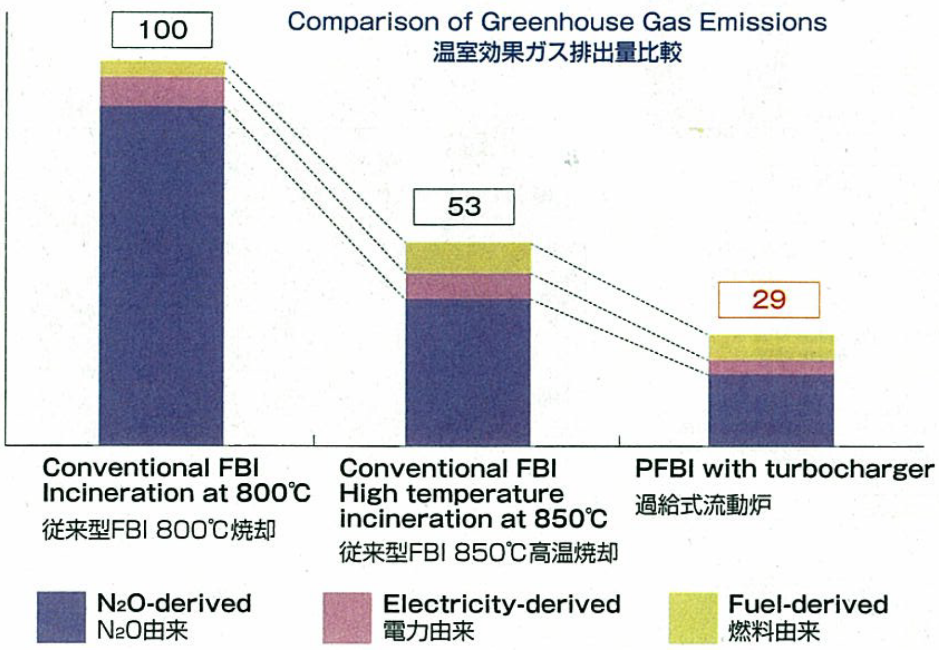
- Use of exhaust heat from sludge incinerators/furnaces
  - For both internal and external use

➢ Renewable energy generation

- Using effluent: hydraulic energy
  - Small-scale hydropower generation (10 installations)
- Using land area/space: solar/wind energy
  - Solar power generation (34 installations)
  - Wind power generation (5 installations)

N_2O reduction measures

- Controlling N_2O emission from sludge incineration
  - 60% reduction by increasing temperature from 800 ºC to 850 ºC
  - Possible further reduction by improved incinerator
  - Secondary effect of replacing incineration (*e.g.* to solid fuel technologies)
- Controlling N_2O emission from wastewater treatment
  - At a stage of “rule of thumb” (*e.g.* enhancing nitrification)



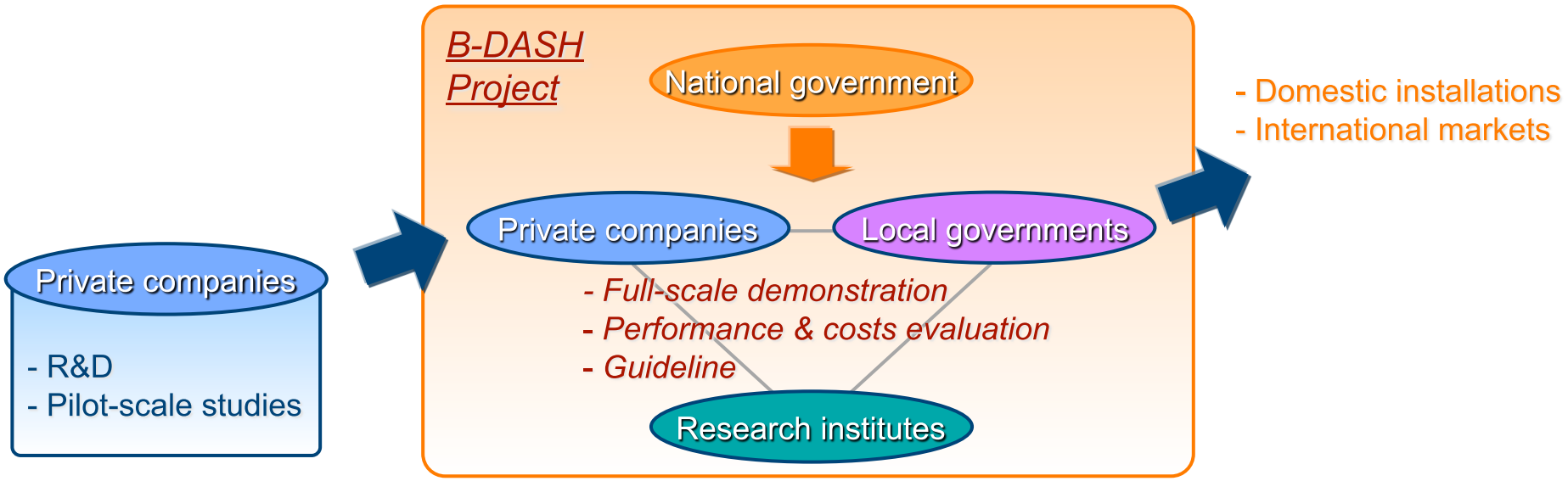
* JSWA(2010) Sewage Works in Japan 2010.

Legislative measures

- Act on the Rational Use of Energy (2010 amendment)
  - Any business operators with energy consumption larger than 1,500 kL/yr are encouraged to reduce their energy consumption by 1%/yr.
- Act on Special Measures concerning Procurement of Renewable energy by Power Companies (2011)
  - Introduction of feed-in tariff mechanism for renewable energy (solar, wind, small-scale hydropower, geothermal and biomass).
- Act on Special Measures concerning Urban Regeneration (2011 amendment) and Act on the Facilitation of Low-Carbon Cities (2012 amendment)
  - Utilization of raw wastewater for heat recovery was opened to private sector.
- Relevant target values by national government
  - GHGs reduction target in municipal WWTPs: 0.90 Mt-CO_2 by energy reduction/recovery and 1.26 Mt-CO_2 by N_2O reduction measures in FY2010.
  - Overall sludge recycle ratio at municipal WWTPs is to increased to 85% by 2020.
  - Each power company is to increase the renewable energy ratio to 50% by 2020.
  - Each gas companies are to utilize 80% of biogas generated in their area by 2015.

B-DASH Project

- B-DASH (Breakthrough by Dynamic Approach in Sewage High technology) Project
  - R&D project since FY2011, funded and managed by national government (MLIT and NILIM).
    * MLIT : Ministry of Land, Infrastructure, transport and tourism
    * NILIM : National Institute for Land and Infrastructure Management
  - Full-scale demonstration and evaluation of "*innovative*" technology which will achieve smaller carbon footprint and resources recycling in WWTPs.
  - Results are to be published as "*guidelines*".

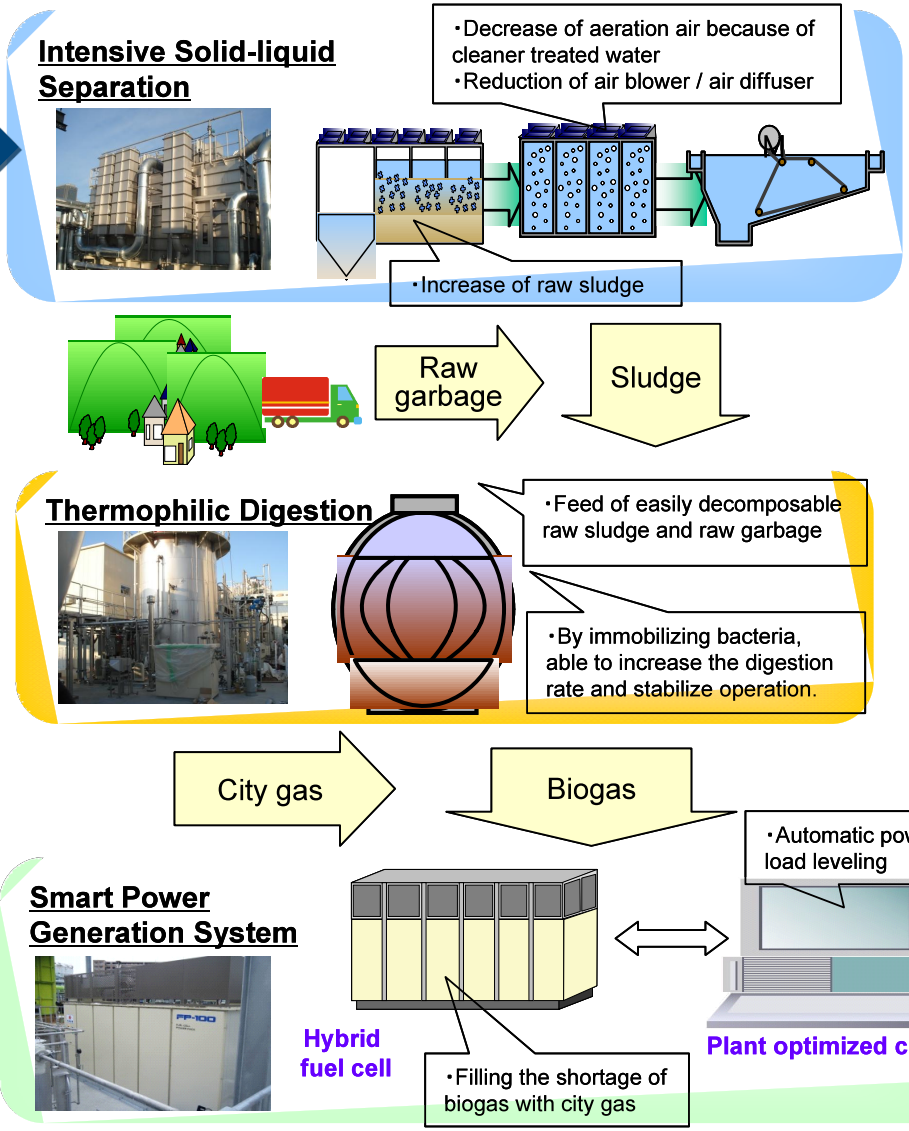


B-DASH Project

➢ Enhanced biogas production and utilization (FY2011-2012)

(1) Enhanced primary treatment
+ high rate digestion with local biomass
+ power generation with fuel cell

(2) Low cost digester
+ mixed digestion with local biomass
+ packaged biogas purification



Outline of enhanced biogas production and power generation system combined with enhanced primary treatment
(B-DASH Project by Metawater and JS)

B-DASH Project

➢ Solid fuel production (FY2012-2013)

(1) Hydrothermal treatment + high rate digestion + drying

(2) Low cost sludge drying with external excess heat utilization

➢ Heat recovery from sewage (FY2012-2013)

(1) In-pipe heat recovery combined with sewer rehabilitation

➢ Nutrient removal and recovery from sludge liquor (FY2012-2013)

(1) Nitrogen removal from sludge liquor by fixed-bed anammox process

(2) Phosphorus removal and recovery from digester sludge by MAP process

➢ Power generation from sludge biomass (FY2013-)

(1) High efficiency centrifugal dewatering + low energy fluidized bed incinerator + power generation from exhaust heat

(2) High efficiency centrifugal dewatering + improved step grade stoker incinerator + steam power generation

Conclusions

- Regarding climate change, reducing GHGs emissions is of primary concern in sewage facilities in Japan.
- Many technologies for recovering heat and energy from wastewater/ sludge are available in practice, although there is still significant amount of unused potential.
- New technologies are being demonstrated under the government-aided R&D projects. Spread of these systems is to be the major concern in the coming years.

Thank you
for your kind attention !