

# Biosolids Gasification A Technology Review

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# Gasification - Outline

- Background
- Process
  - Reactions/Equations
- Technologies
- What's Been or Being Done for Biosolids

# Gasification Background

- Charcoal Formation
  - (Pyrolysis – first stage of gasification)
  - Several thousand years old
- Gasification
  - Large scale use on coal
  - 19<sup>th</sup> century
  - Used today for coal, wood, ag waste and many other materials

# Gasification - Process

## Steps in Gasification Process

- **Pyrolysis (Volatilization)**
  - Release volatile compounds produce char (carbon solids)
  - Occurs at about 400°C to 700°C
- **Combustion (Oxidation)**
  - Combust char to create heat for process
  - Can be skipped if and external heat source used
- **Gasification (Reduction)**
  - Produce Synthesis gas
  - Occurs at about 850°C to 1,200°C

# Gasification - Reactions

## Combustion (Oxidation) Reactions



## Boudouard Reaction



## Water Gas Reaction



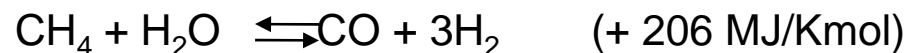
## Methane Formation



## CO Shift Reaction



## Steam Methane Reforming Reaction



# Gasification - Technologies

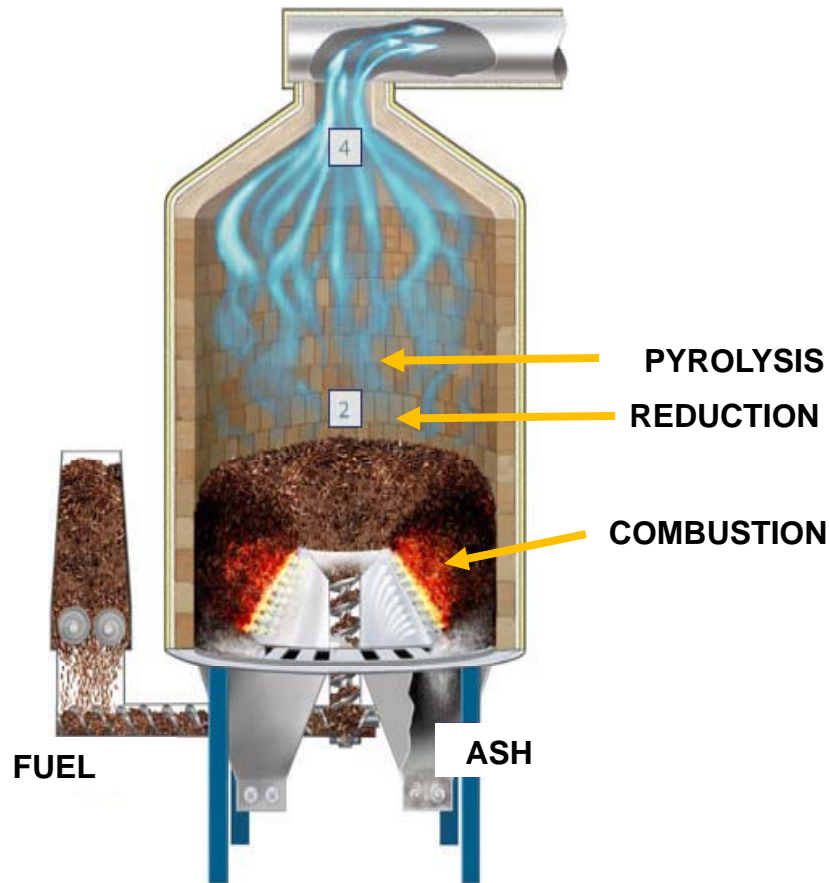
## Reactor Types

- Fixed Bed Updraft (Countercurrent)
- Fixed Bed Downdraft (Co-Current)
- Fluidized Bed
- Entrained Flow

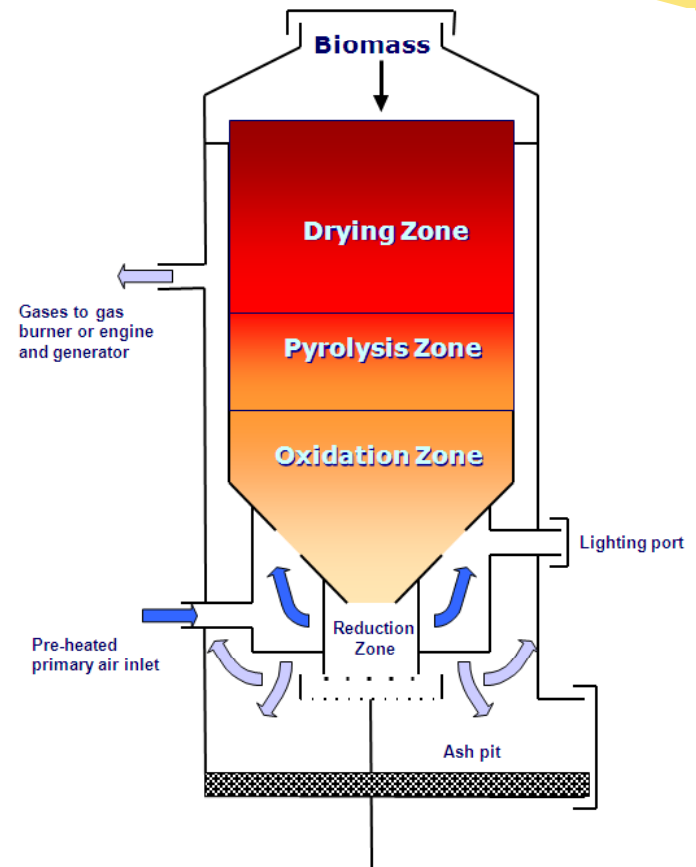
## Heating Methods

- Fuel/Char (Biomass or Biosolids)
- Plasma Torch
- Induction Heater

# Technologies – Fixed Bed Gasifiers

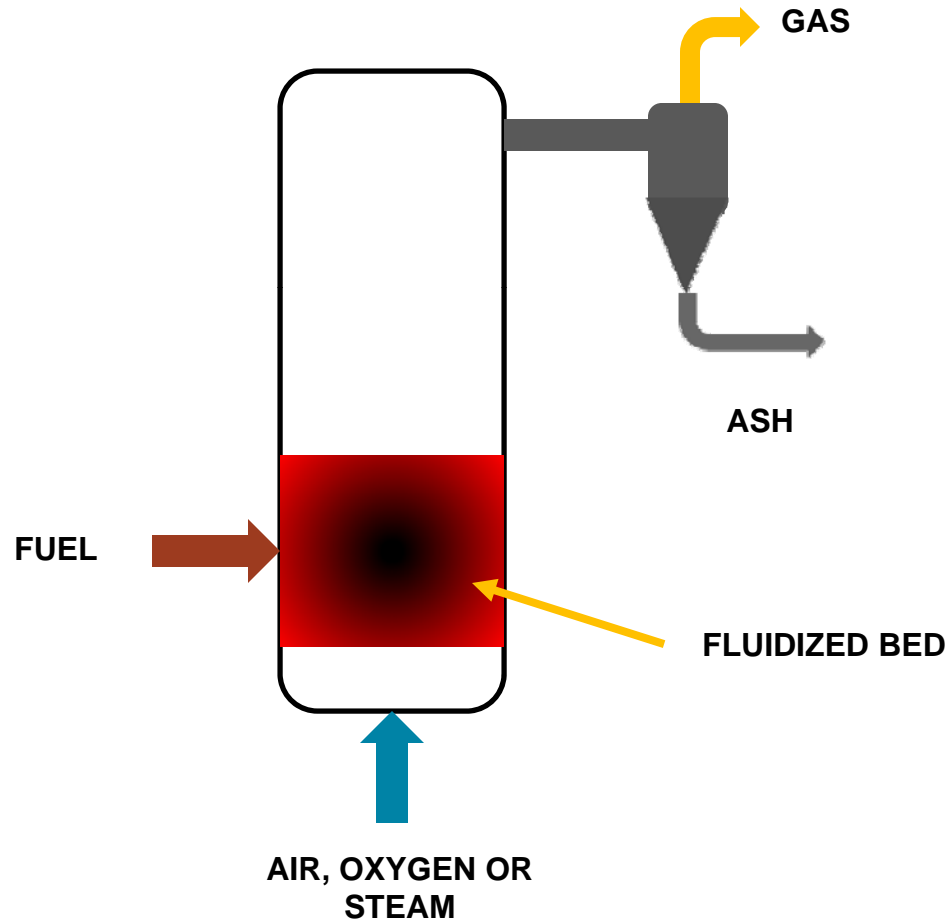


**NEXTERRA UPDRAFT  
GASIFIER**



**NEWCASTLE UNIVERSITY  
DOWNDRAFT GASIFIER**

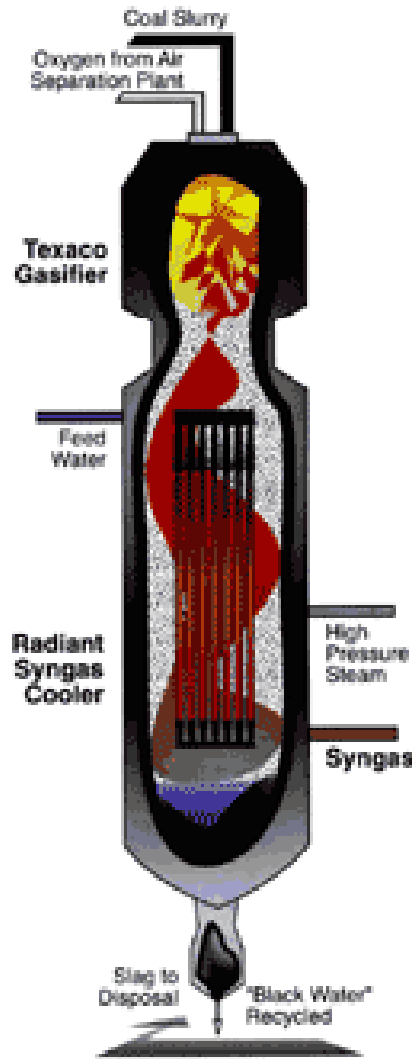
# Technologies - Fluidized Bed Gasifier



Bubbling Fluidized Bed Gasifier



# Technologies - Entrained Flow Gasifier



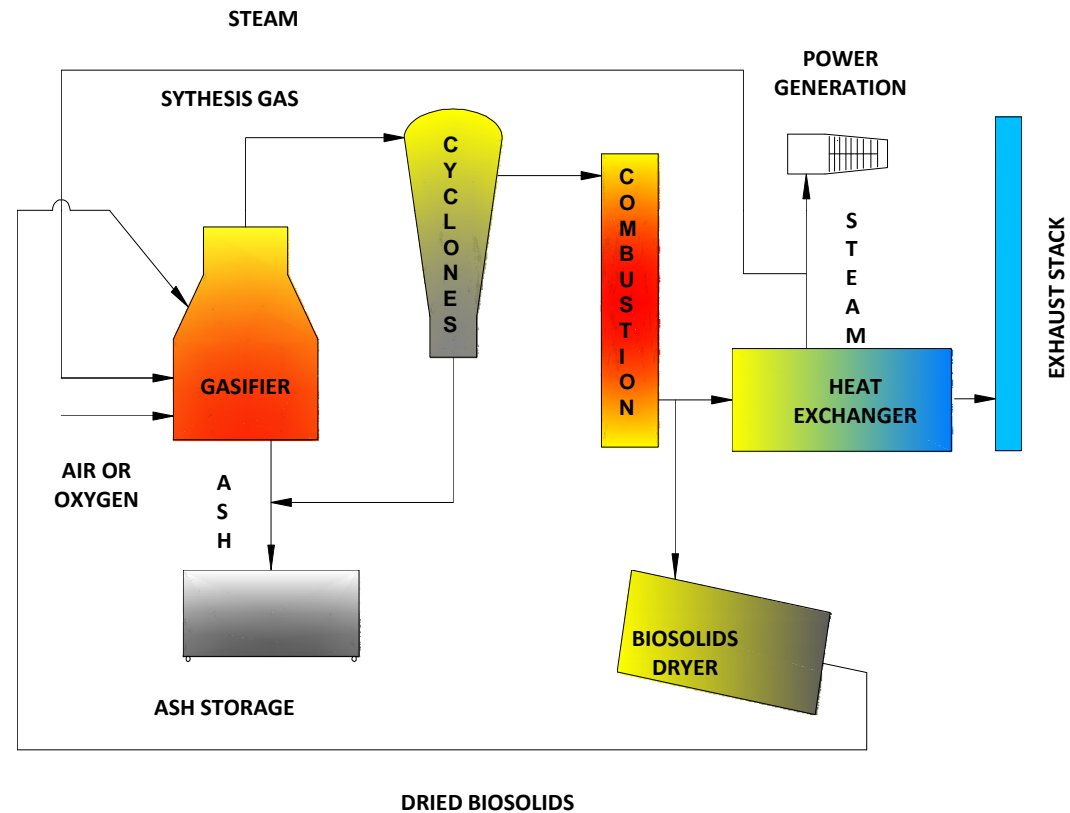
# Biosolids Experience - Ecotech

## EcoTech Gasification

- Location: Philadelphia, PA
- Started Operation: June 2005
- Current Status: Out of operations
- Technology: Downdraft Fixed Bed
- Equipment Supplier: Primenergy
- Size: 10 Wet tons per hour



# Biosolids Experience - Ecotech



# Biosolids Experience - Ecotech

## Issues

- Inconstant energy content
- Both water and wastewater sludge
- Digestion of wastewater sludge reduced btu value
- Ferric Chloride added to particulate and slag production
- Horizontal heat exchanger – slag did not drain well hardened (cleaning every 2 weeks)

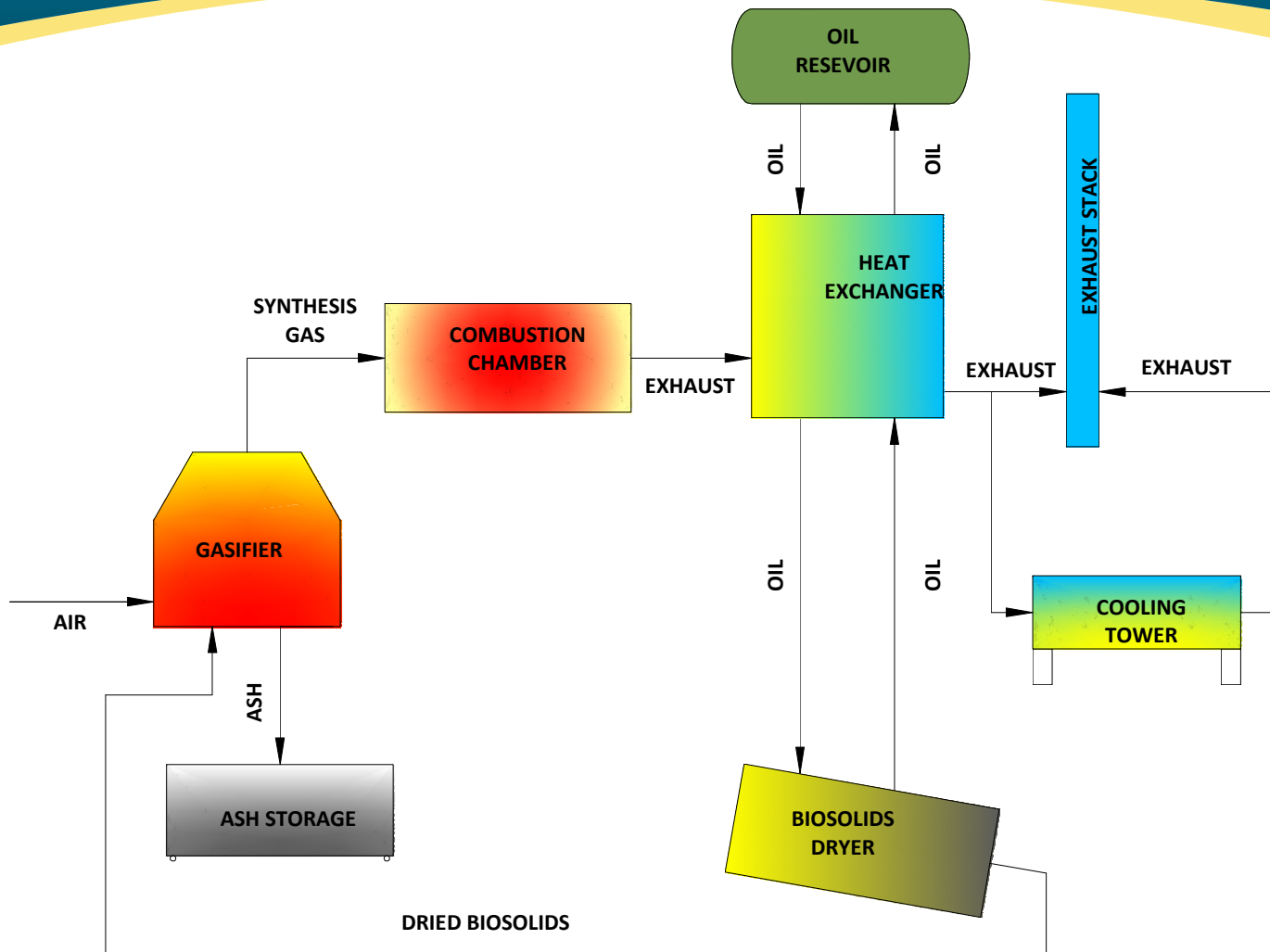
# Biosolids Experience - MaxWest

## MaxWest

- Location: Sanford, FL
- Started operation: Fall 2009
- Current status: Operating
- Technology: Downdraft Fixed Bed
- Size: 720 to 1,140 lbs/hr dried biosolids (85% to 92%)



# Biosolids Experience - MaxWest



# Biosolids Experience - MaxWest

## General

- Product - Hot exhaust – provides heat to run the dryer
- Immediate high temp combustion of gas – *no gas cleaning needed*
- The system is a closed loop disposal technology
- No power production
- Limited emissions information
- Odor from fuel loading and ash unloading - easily solved
- MaxWest operates the dewatering, drying and gasification

# Biosolids Experience - MaxWest

## Economics - Sanford, FL

- Flat fee per month (\$21,572/month)
- 3% annual increase (+\$647/month)
- Minimum required heat value 4,225 btu/lbs delivered
- MaxWest to deliver hot oil to dryer
  - In reality MaxWest is operating dryer and dewatering
- Revenue sharing for outside feedstocks



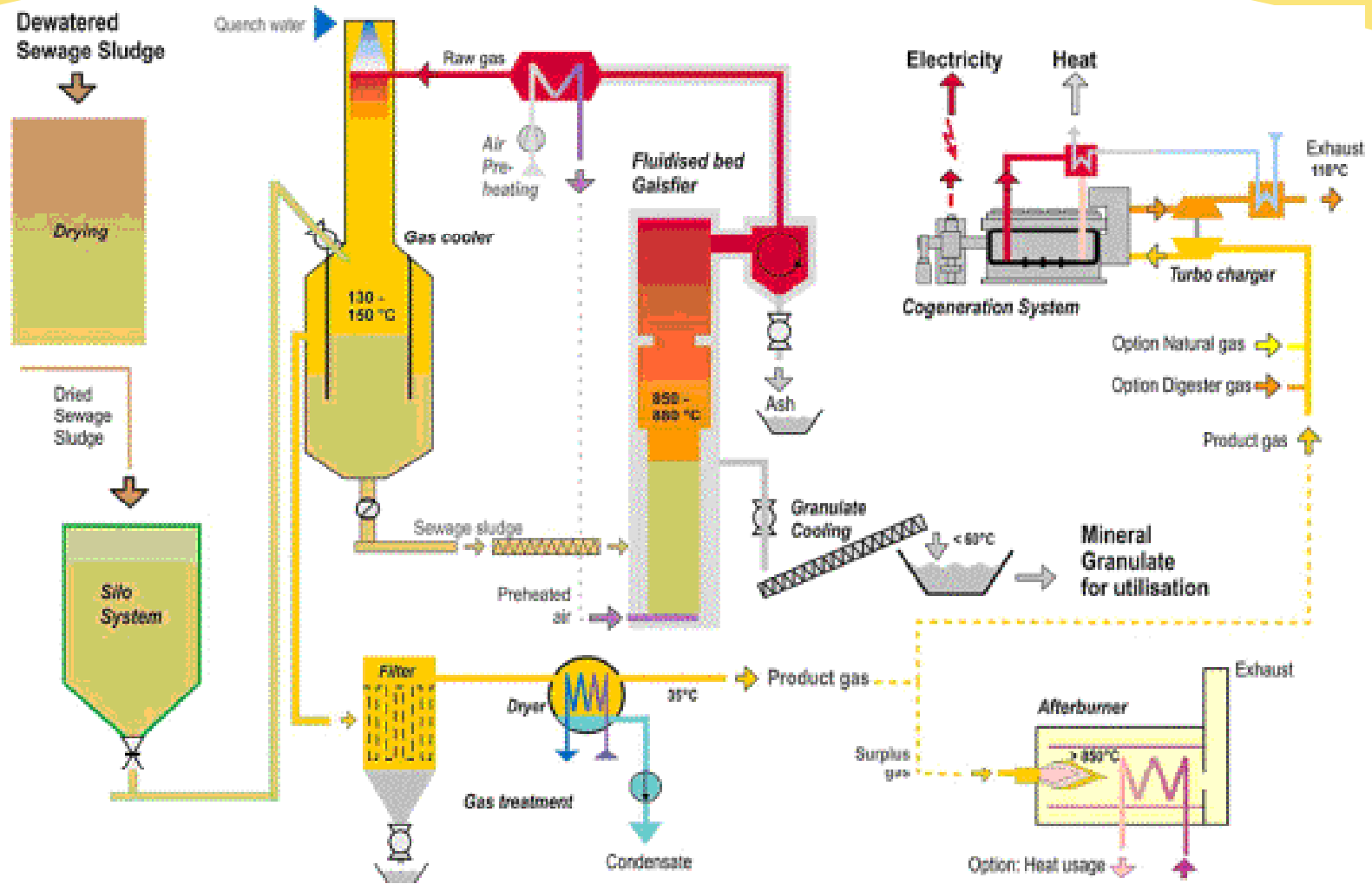
# Biosolids Experience – Kopf Pilot

## Kopf

- Location: Balingen, Germany
- Started Operation: 2006
- Current status: Operating
- Technology: Fluidized Bed Gasifier
- Size: 331 lbs/hr



# Biosolids Experience – Kopf



# Biosolids Experience – Kopf Pilot

## General

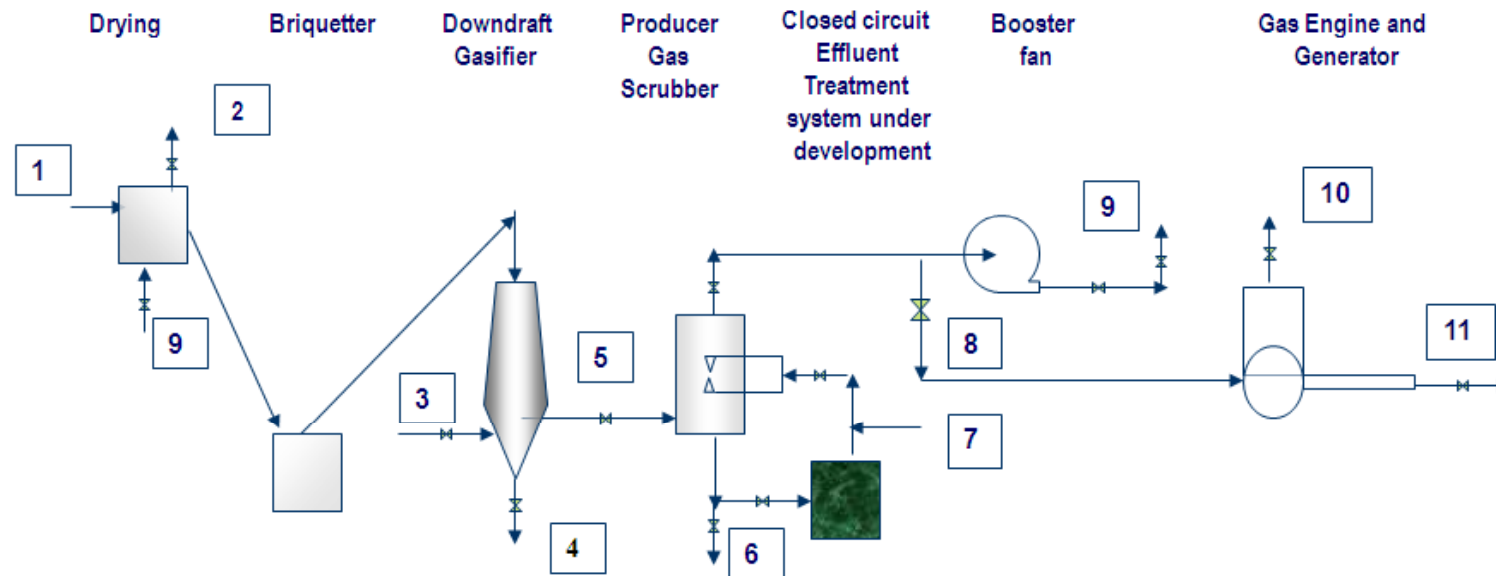
- Biosolids dried separately
  - Dried to 85% solids
- Gas used in CHP
- Reported output 70 kw of electricity
  - 15 kw to run process
  - 55 kw available for power generation

# Biosolids Experience – Waste to Energy Ltd

## Waste to Energy Ltd Pilot

- Location: Anglican Water Wellingborough, England
- Started operation            2005
- Current Status                Unknown
- Technology:                    Downdraft Fixed Bed Gasifier (mobile skid mounted unit)
- Size:                              275 lbs/hr

# Biosolids Experience – Waste to Energy Ltd



1- After centrifuge sludge enters into the dryer at 20-25% ds  
 2- Clean dust free exhaust gases after scrubber  
 3- Air enters the gasifier at about stoichiometric levels  
 4- White ash (low carbon) with leachable metals but when used as road aggregate, produce zero leachate.

5- Hot producer gas at ~400°C exits the reduction zone in the gasifier and enters the scrubber where it is quenched to ~50°C thereby removing dust, acid gases, tars and also eliminate dioxin reformation.  
 6- Scrubber residue - Tars, dust  
 7- Make up water

8- Clean producer gas mainly consisting of H<sub>2</sub>, CO, CH<sub>4</sub>, CO<sub>2</sub>, H<sub>2</sub>O, N<sub>2</sub> to dual fuel compression engine  
 9- Clean gas to dryer or invisible flare

# Biosolids Experience – Tokyo Bureau of Sewerage

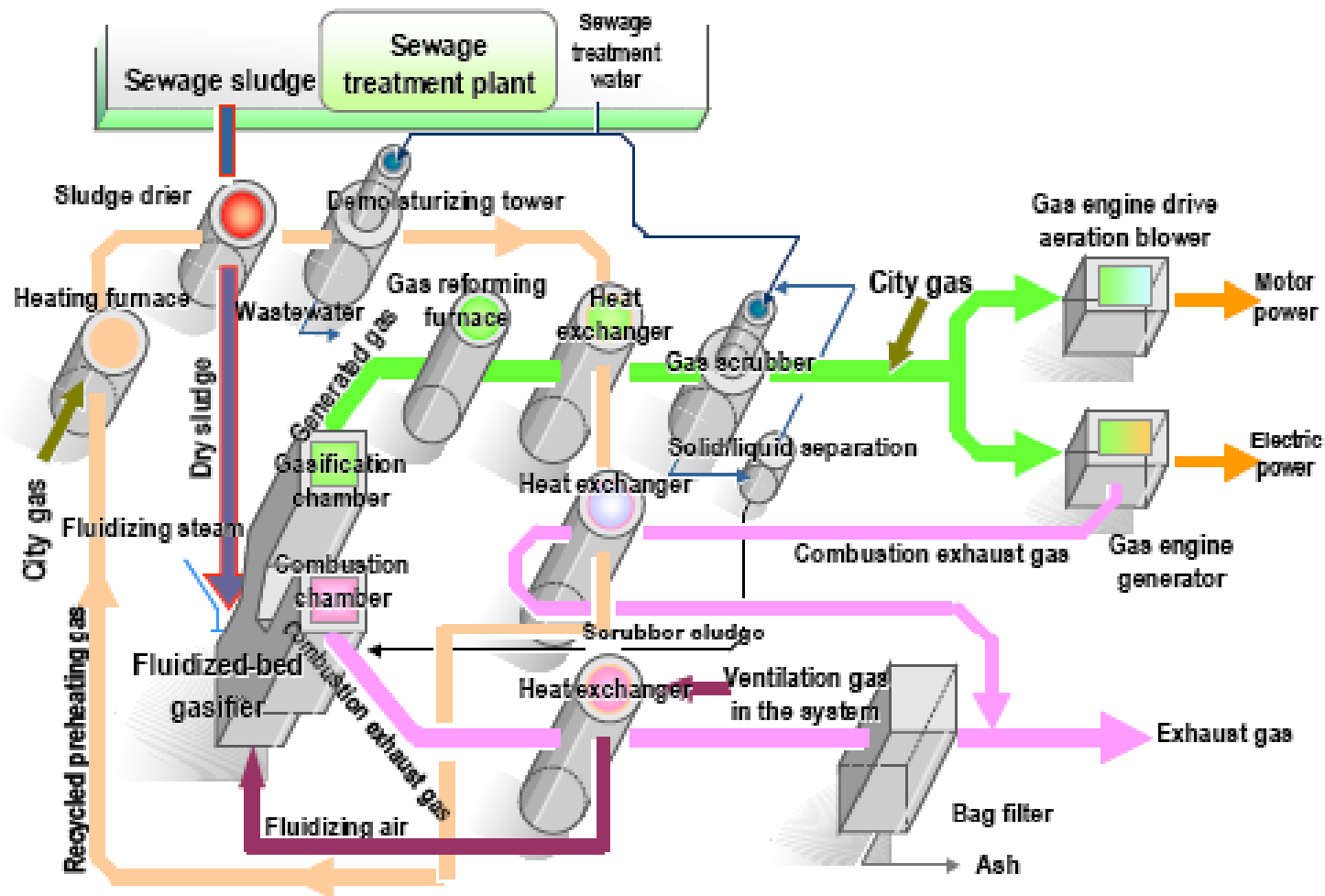
## Tokyo Bureau of Sewerage

- Location: Tokyo
- Started operations: 2005
- Current status: Ceased operation in 2006 (3,400 hours of operation)
- Technology: Internal Circulating Fluidized Bed
- Size: 1,375 lbs per hour

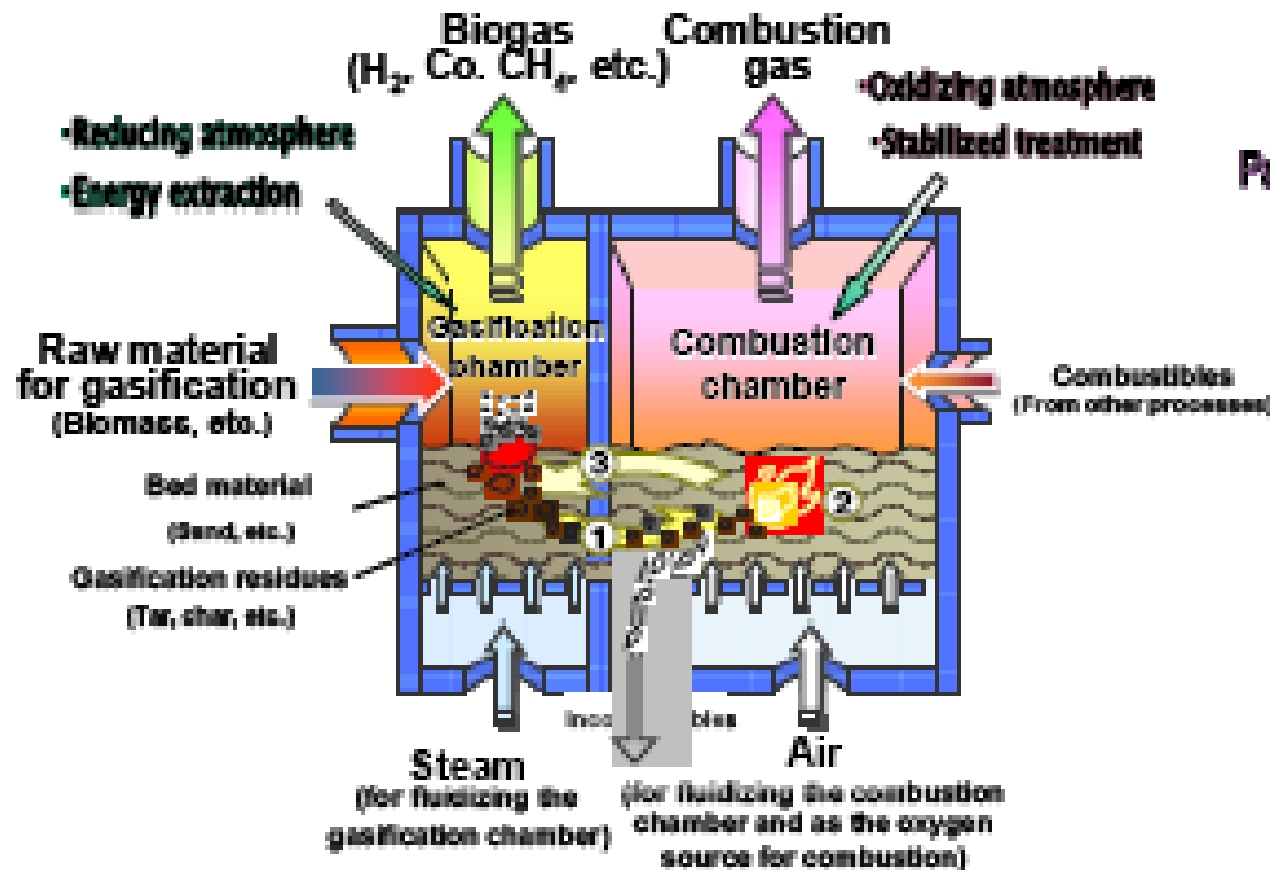
Reference: Takahashi, Hajime, "Study on Sewage Sludge Gasification", Bureau of Sewerage, Tokyo Metropolitan Government



# Biosolids Experience – Tokyo Bureau of Sewerage



# Biosolids Experience – Tokyo Bureau of Sewerage





# Biosolids Experience – Tokyo Bureau of Sewerage

## Results

- Used a blend of 55% syn gas and 45% natural gas
- Power output 200 kw
- Sludge drying included in output
- Steam generation included in output
- 55% reduction in GHG emission over incineration
- 19% reduction in purchased energy over incineration

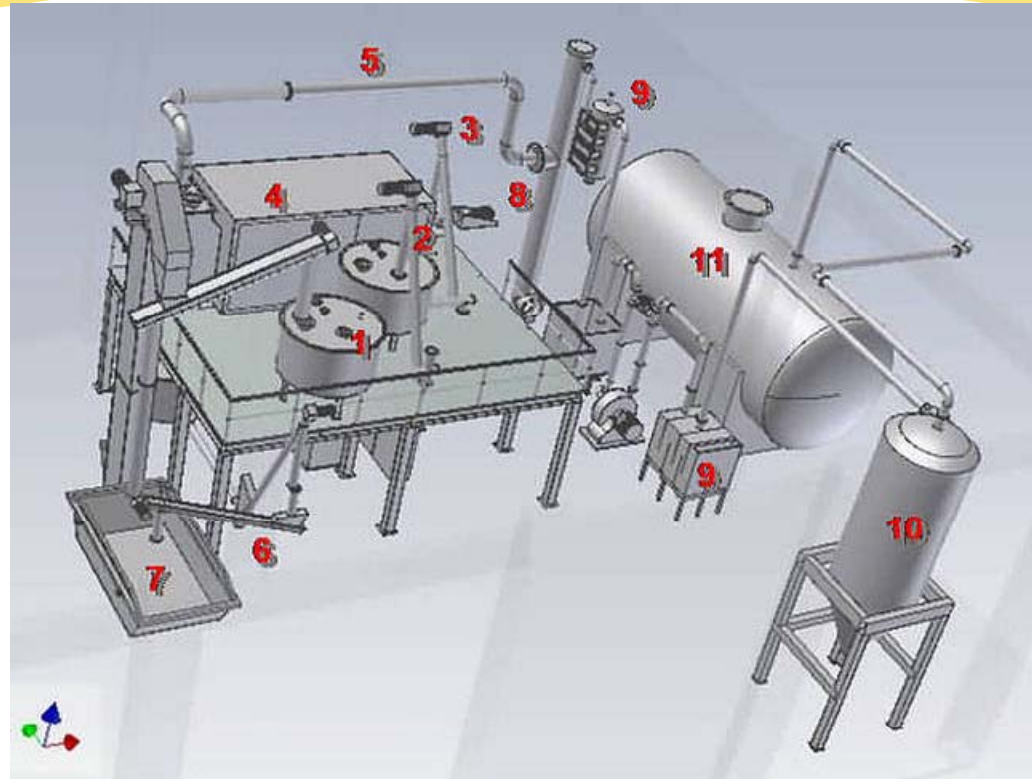
# Biosolids Experience - Pyromex

## Pyromex Pilot

- Location: Emmerich, Germany
- Started operation: 2000
- Current status: Ceased 2003 equipment moved to commercial client
- Technology: Induction heated rotating gasifier
- Size: 2,290 lbs/hr



# Biosolids Experience - Pyromex



- 1 Input material storage tanks
- 2 Rotation valves
- 3 Feed auger
- 4 Reactor

- 5 Syngas pipe
- 6 Inert residue outfeed
- 7 Inert residue silo
- 8 Sedimentation

- 9 Scrubber
- 10 Cyclone
- 11 Cleaned syngas to gas tank

# Biosolids Experience - Pyromex

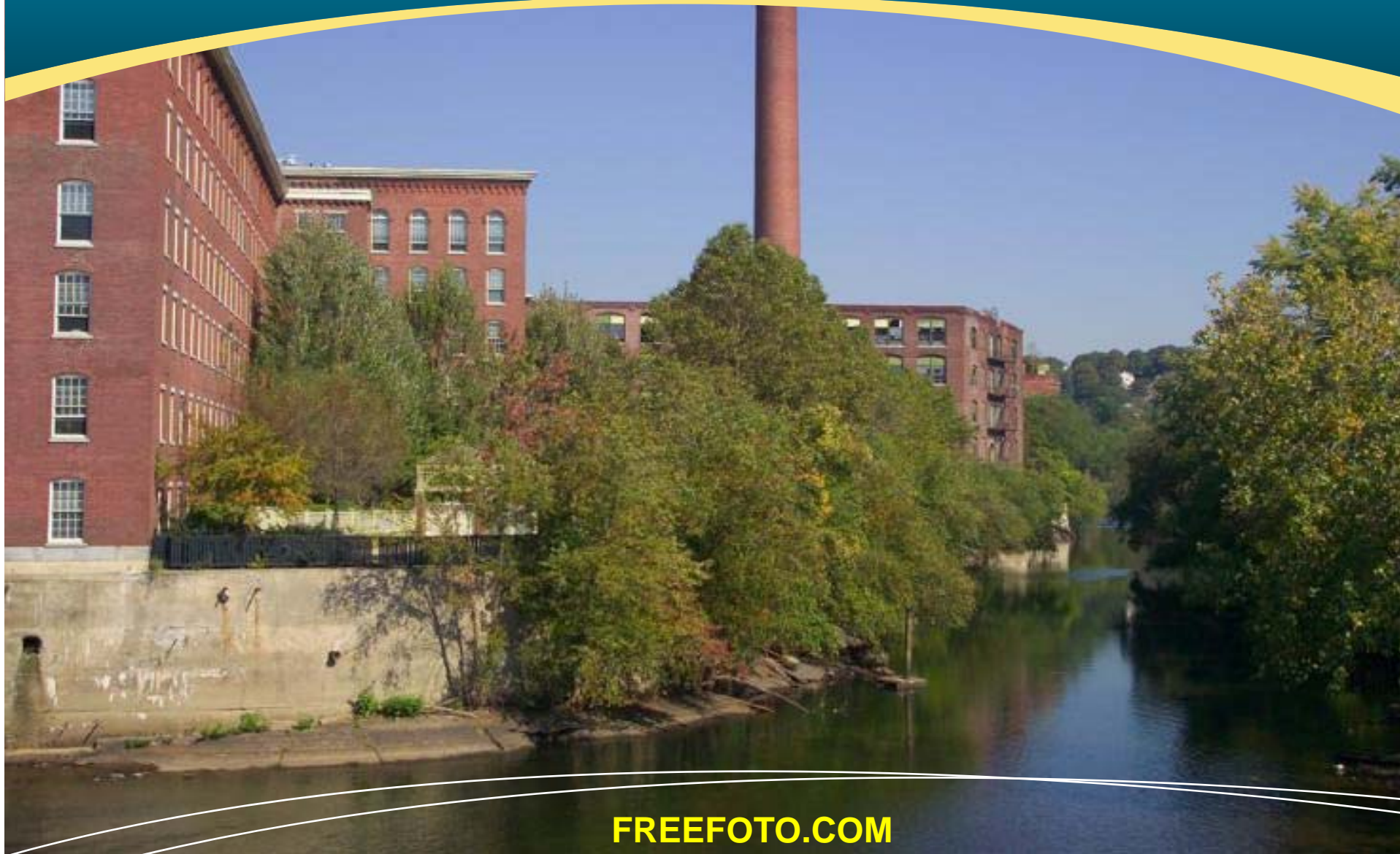
## Results

- Sludge dried to 85% solids
- High temperature process 1,750°C
- Reported Energy Output
  - Energy retrieved 1035 kwh/tonne sludge
  - Gasifier energy consumption 345 kwh/tonne
  - Sludge dryer power demand 540 kwh/tonne
- External heating means no combustion of char/feedstock

# Conclusions

- If drying included - gasification is a closed loop disposal technology
- If digester gas used for drying – energy production is possible
- Avoiding steam simplifies process but reduces energy output
- Direct burning of syn gas avoids gas cleaning, simplifies the process reduces options for end uses

# Questions



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