



# **Energy Production from Waste Using The Anaerobic Membrane Bioreactor (AnMBR) Process**

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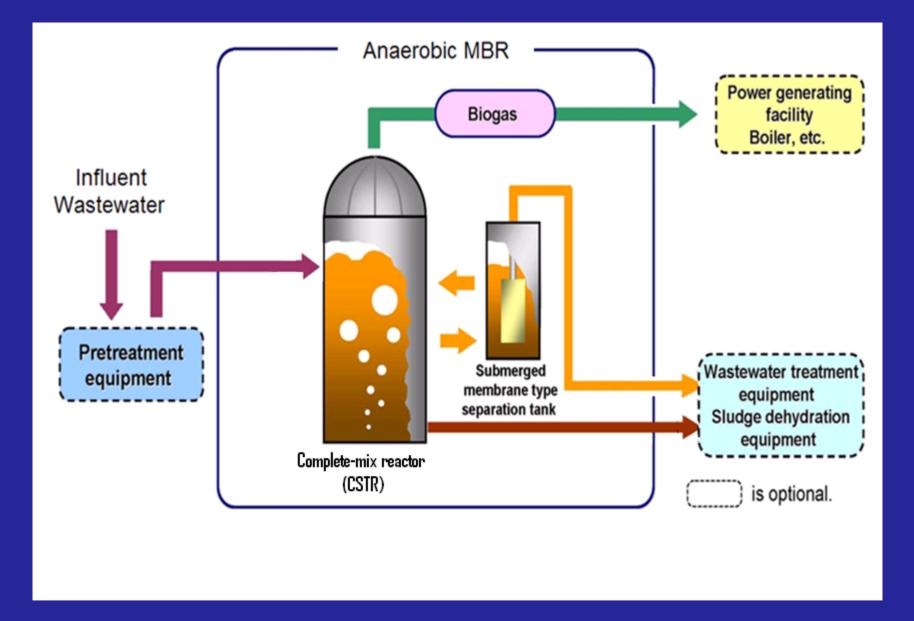
- A form of high-rate anaerobic digestion technology
- Uses physical membrane barrier to retain biomass
- Creates renewable energy source in the form of biogas (methane)
- In full-scale use since 2000, full-scale tests since mid-1990's

- Excellent for low flow, highly-concentrated (high COD/BOD/TSS)
- Compact footprint and simple operation/control

#### **AnMBR Technology**

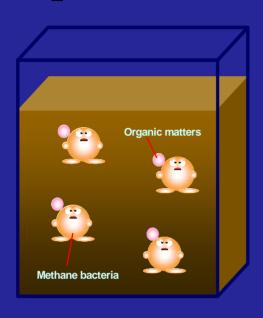
- Membrane barrier allows for high mixing intensities
- Organic loading rates of 15 kg/m<sup>3</sup>·d on high energy substrates
- HRT and SRT are dependant upon waste/wastewater type
- Thermophilic (130°F/55°C) and mesophilic (100°F/35°C) systems
- Thermophilic results in better removals, more biogas and reduced sludge production); membrane overcomes typical thermophilic AD downfall---solids loss
- In-situ cleaning; simple citric acid cleaning procedure every 1-3 months

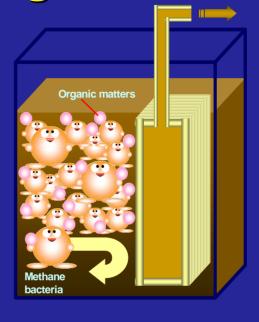
#### **AnMBR Technology**



**Anaerobic MBR (AnMBR)** 

# Comparison of Anaerobic Digestion Processes





#### **Conventional Anaerobic System**



**Anaerobic MBR System** 



# **Applications**

# **Alcohol Stillage**















Parameter	Influent	AnMBR Effluent	MBR Effluent
COD, mg/l	75,000 -110,000	1,000 – 2,500	< 100
BOD, mg/l	63,000 -79,000	500 – 1,500	< 5
TSS, mg/l	25,000 - 35,000	< 5	< 5
TS, mg/l	35,000 – 80,000	2,500 – 5,000	500 – 1,000
TN, mg/l	2,000 – 5,500	500 – 2,500	**
FOG, mg/l	1,600 -	< 50	< 5
TP, mg/l	500 – 1,200	*	**
Temp, °F	180-200	130	

<sup>\*-</sup> less than 20 mg/l can be achieved with chemical addition

Shochu/Awamori Distilleries (barley, sweet potato, rice)

<sup>\*\* -</sup> depends on level of BNR performed

# **Food Production/Processing Wastes**





#### Full-scale energy generation from food processing wastes to date:

- Confectionary (jellies and beverages)
- Bean processing
- Waste dairy (milk processing) products
- Prepared meals / kitchen food waste
- Potato processing
- Salad dressing / BBQ sauce production wastes

Any other strong, concentrated wastes would be applicable.





#### **Food Production/Processing Wastes**

# **Municipal Garbage**

### Nishi-Tenboku Sanitation Center, Hokkaido, Japan



#### **Influent streams to facility:**

1.Night soil and septic tank sludge (5,300 gpd)

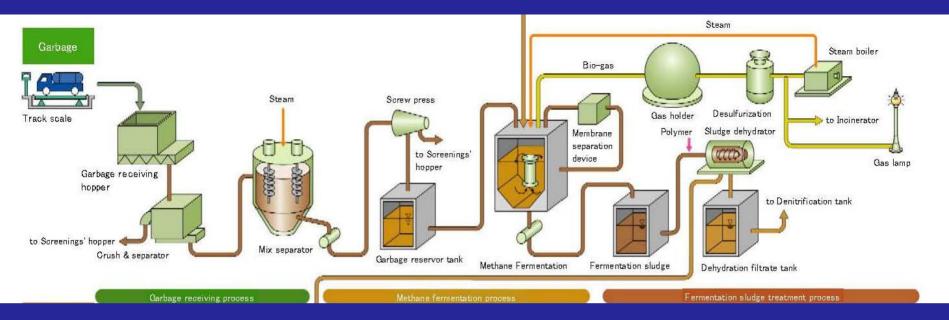
2.Waste activated sludge from nearby POTW (3 ton/d)

3.Municipal garbage (5 ton/d)

Organic municipal garbage is anaerobically digested for energy generation; high energy substrate (250,000mg/l COD; 20% solids)

Garbage to energy

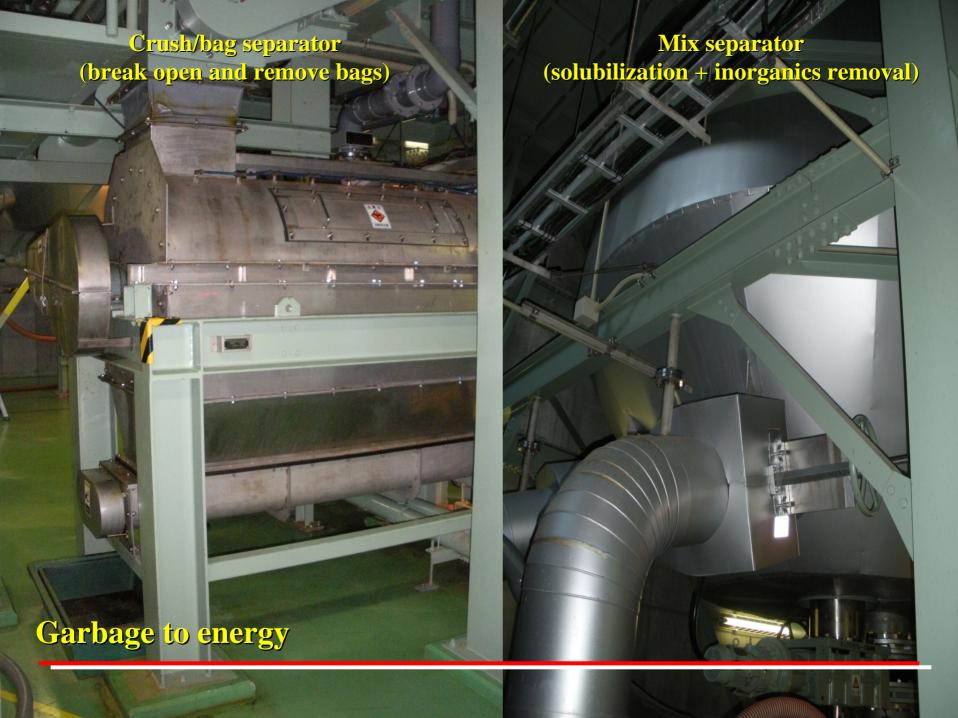




#### **Basic process:**

- 1.Break open bags, separate inorganic material from organic
- 2. Solubilize solid waste to facilitate fast anaerobic digestion; remove remaining inorganic materials
- 3. Anaerobic digestion using AnMBR process
- 4. Collect, scrub, and store biogas
- 5. Polish liquid anaerobic effluent in aerobic MBR and discharge
- 6.Process waste sludge and reclaim as soil additive

#### Garbage to energy



- Anaerobic reactor operates at thermophilic temperatures to maximize solids destruction and biogas production
- Biogas is utilized to heat reactor and buildings at facility
- Permeate is polished in aerobic MBR and discharged
- Aerobic WAS also digested in AnMBR



Garbage to energy





## **Industrial Wastewater**

# Anaerobic Reactor ADI- BVF

### **EQ** Tank



#### **AnMBR**

### **SBR (now SO tank)**



First Full-Scale AnMBR in North America and Largest in the World!

# Membrane Unit Installation



# **Installed Membranes**



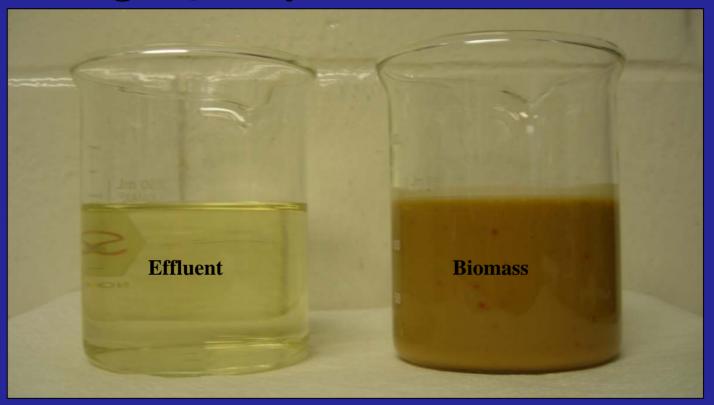
# **Biogas Scour Blowers and SMTs**



# Ken's Foods AnMBR Operating Results (First 12 months)

Parameter	Raw Wastewater	Permit Discharge Limits	Actual AnMBR Effluent	Actual Removals (%)
Flow rate (avg), m <sup>3</sup> /d	475	475		
Flow rate (peak), m <sup>3</sup> /d	530	530		
BOD, mg/L BOD, kg/d	18,000 8,600	 180	16 5	99.9
COD, mg/L COD, kg/d	39,000 18,500		190 62	99.5 99.5
TSS, mg/L TSS, kg/d	12,000 5,700	230	< 1 < 1	100
FOG, mg/L	1,500	100	< 5	100
рН		6-9	7.1	

# High Quality Anaerobic Effluent



#### **AnMBR Effluent**

< 25 mg/L BOD

< 2 mg/L TSS

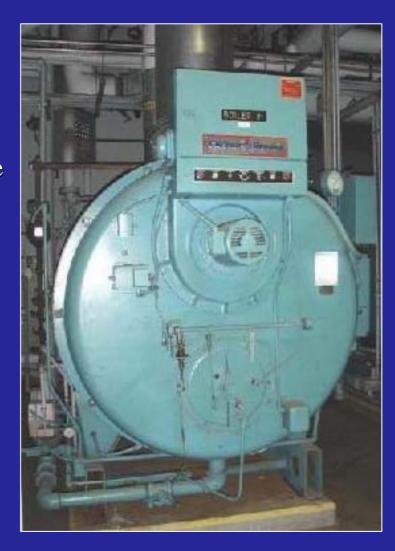
#### **Biomass**

2.0 - 4.5 % solids

75% volatility

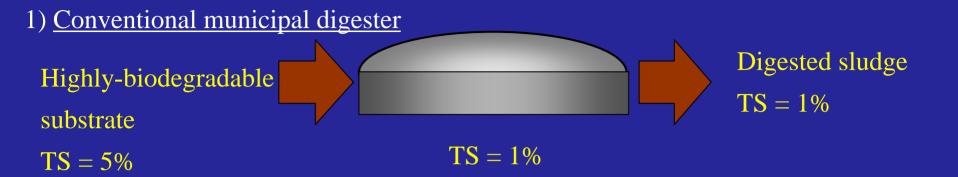
## **Biogas Production and Utilization**

- AnMBR produces biogas (methane) from the anaerobic digestion process
- Biogas is utilized in a dual fuel boiler (natural gas + biogas) to produce hot water supply
  - excess biogas is flared at an enclosed flare
  - hot water used for reactor heating (controlled at 35 °C), as well as building heat, hot water supply for other in-plant uses
- Average biogas production:
  - 5,800 m<sup>3</sup>/d biogas produced
  - CH<sub>4</sub> = 60 %
  - CO<sub>2</sub> = 35%, ~ 1% O<sub>2</sub>, and 50 ppm H<sub>2</sub>S

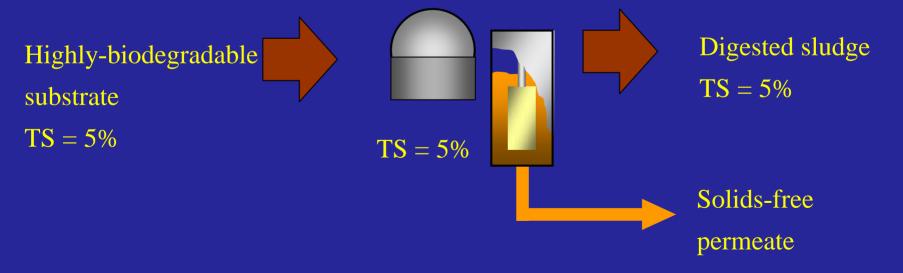


# **Municipal Sewage Sludge**

#### Primary sludge, TS ~ 80% degradable



#### 2) AnMBR system



Much smaller reactor; great advantage

#### AnMBR technology holds great promise for some new applications as well:

- Cellulosic ethanol stillage
  - Stable thermophilic operation allows for digestion of lignins
  - Destruction of designer enzymes before discharge
- Other fuel ethanol production stillages and syrup (corn/wheat/milo/etc.)
- Separated MSW (food and garden wastes)
- Modular, packaged systems (already in use)
- Many others

#### **New Applications**

Kubota received the gold medal "New Energy Award" in 2003, a prize given by the Japanese New Energy Foundation, an extra-departmental body of the Japanese Ministry of Economy, Trade and Industry.

Biomass fuel manufacturing 
"Methane fermentation system using 
submerged membrane"



Kubota AnMBR technology received the Japanese "New Energy Award"

# **Questions or Discussion?**