HARVEST™
Power of We™

Anaerobic Digestion Technologies
Presentation to NEWMOA
January 17, 2011

Outline

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  - Technical Parameters
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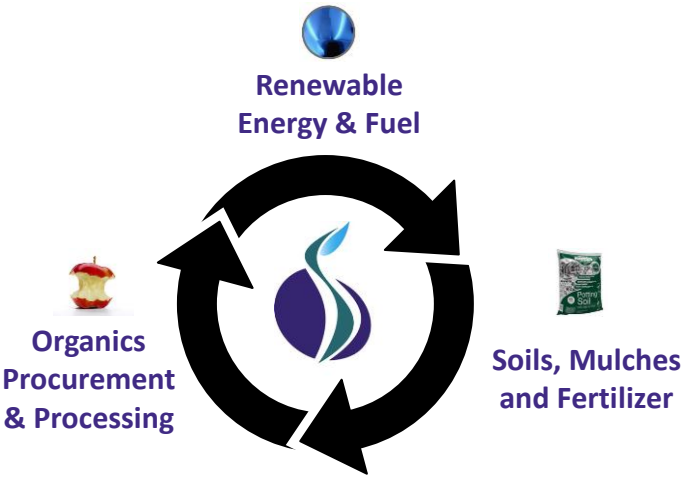
  - Removal of Settleables
- **AD Technologies**
  - Batch High-Solids Anaerobic Digestion
  - Continuous High-Solids Anaerobic Digestion
  - Low-Solids Anaerobic Digestion
- **Digestate Handling**

Harvest Power's Business

Harvest **finances**, **builds**, **owns**, and **operates** state-of-the-art organics recycling centers:

- **Business**: Founded in 2008 as builder, owner and operator of organics processing facilities
- **Investors**: Include Kleiner Perkins, Generation Investment Management, Waste Management, Munich Venture Partners, SAM (part of Rabobank Group)
- **Revenue**: $100 million annualized revenue
- **Capacity**: Handle 1.8 million metric tonnes of waste per year across 15 sites; Sell 29 million bags of soil and mulch and 400,000 cubic yards in bulk
- **Team**: 300 employees; 200+ years experience on management team



Expertise Required in all Three for Success

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Our Vision for Organics

Technology Selection – Practical Considerations

Factors Affecting Technology Choice

- Feedstock Availability
- Feedstock Economics
- Site Characteristics / Existing Infrastructure
- Wastewater Disposal Options
- Digestate Utilization Options
- Market for end-products

Typical Economically-Justified Technology Applications for Organic Waste

Batch High Solids AD	Continuous High Solids AD	Low Solids AD
Combined commercial and residential SSO (food waste and yard waste) are abundantly available year-round, and both feedstocks are associated with favorable tipping fees. This technology is associated with a large amount of solid organic digestate and thus integrates well with composting operations. It generates little or no wastewater. Coarsely shredded MSW can also be used.	Relatively clean commercial food waste is abundantly available (e.g. restaurants, supermarkets and food processing) and associated with a favorable tipping fees. MRF organic residuals are a common feedstock as well. The liquid effluent from this process must be managed, either as an agricultural fertilizer or a high-strength wastewater. Solid digestate can be composted or dried.	Most common digester technology. Wastewater sludge , industrial wastewater (breweries, distilleries, milk processing, etc.) and/or manure is abundantly available. Food waste slurries and FOG may be co-digested. Typically requires some wastewater treatment before final disposal of liquid effluent.

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Digester Selection – Technical Parameters

Characteristic	Batch High Solids AD	Continuous High Solids AD	Low Solids AD
Solids Content of Recipe @ Inlet	25-50%	18-40%	5-15% (any greater would require dilution)
Attractive Feedstocks	Combined commercial and residential SSO (food waste and yard waste) , shredded MSW	Commercial food waste (SSO or commercial food waste), FOG, dewatered biosolids, MRF residual	Diverse mixtures of waste water sludges, food waste, manure, FOG
Feedstock (TPY) to Produce 1 MWe	40,000	25,000 (high energy mix)	25,000 – 60,000 (depending on feedstock)
Contamination Tolerance	Higher due to no moving parts in digester tunnel; contaminants removed post-AD	Medium, pumps are designed for foreign matter	Lower due to conventional pumping and mixing
End Product	Compost	Liquid effluent and solids for drying or composting	Liquid effluent and solids for drying or composting
Quantity of Liquid Effluent	De minimus	Medium	High

The choice is also dependent on the availability of wastewater reuse options (farms, WWTPs, etc.)

Promoting AD – Policy & Economic Considerations

Factors Influencing Developers and Investors to Pursue Large-Scale AD Development in a Particular Jurisdiction

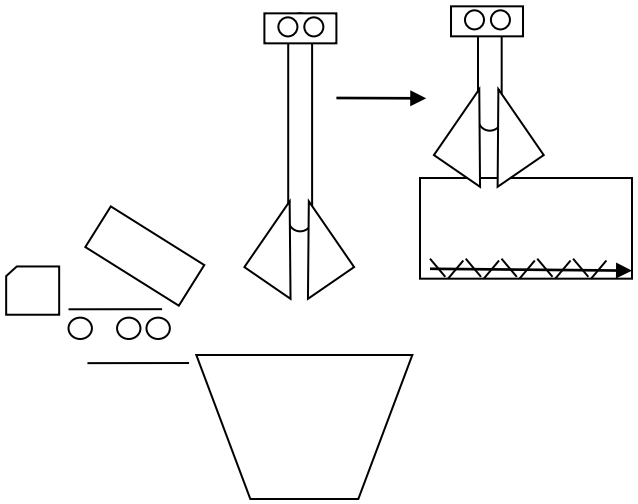
Policy Factors	Economic Factors
Permitting Pathway • **Predictability**: is it clear *how* to proceed and *what* information will be required? • **Speed** • **Cost and complication**: how many different agencies? **Organics Policies** • **Diversion**: encouraged or required (note: commercial & institutional more important than residential) • **Operating Rules**: are standards re: contamination, odor-control, *etc.* up-to-date and realistic?	**Feedstock** • **Availability** • **Price** **Energy Offtake** • **Price** • **Inter-connection:** availability, cost, and timing? • **Contracting:** ease of contracting with off-taker? **Product Markets** • Is there an established market for the solid or liquid residuals? • Pricing?

Contaminant Removal/Feedstock Prep

Feedstock preparation is dependent on the feedstock and the digester technology			
	Batch High Solids AD	**Continuous High Solids AD**	**Low Solids AD**
Contaminant removal	Most contaminants (plastic, glass, metal) removed ***after*** digestion and composting	Contaminants removed from incoming feedstocks ***before*** digestion	
Feedstock Preparation	Mixing with front-end loader – optional coarse shredding	Different types of feedstock are received and handled separately. Contaminated food waste (e.g. supermarkets) is depackaged, macerated and stripped of plastic and metals. Slurry is created for storage and pumping to digester.	Similar to continuous High Solids AD for contaminated feedstocks; Other homogeneous liquid wastes (e.g. FOG) are typically received by direct tanker discharge to storage tanks.

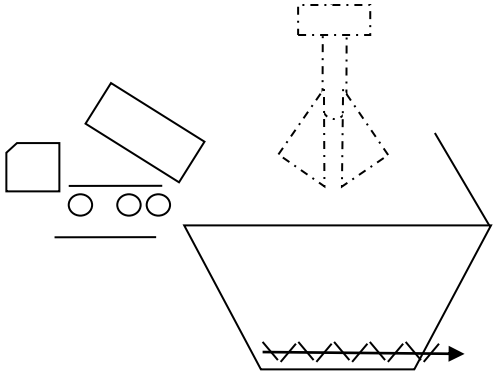
Reception Alternatives

Clamshell Crane



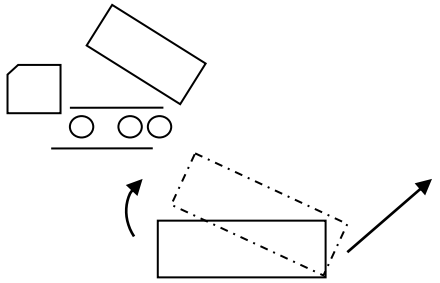
Truck tips into a stainless steel pit, shaped to allow a clamshell crane to pick up all material. Clamshell empties into hopper with screw at the bottom, which opens bags and transports material

Live Floor with Auger



Truck tips into a covered stainless steel pit (opened only when the material is loaded), fitted with a transverse auger. Shear action of the screw does the bag opening. Optional crane removes large items and big contaminants.

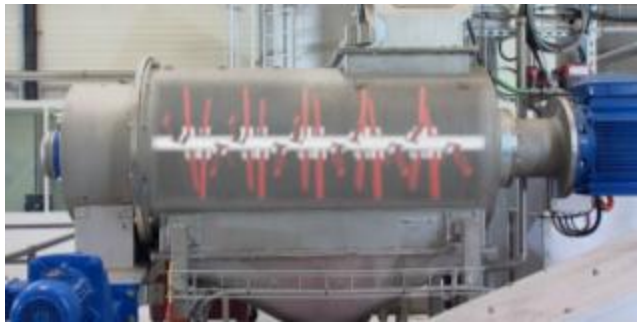
Tipping Trough



Truck tips into a receiving bunker and the entire bucket tips up. A transverse screw conveyor discharges the bunker

Size Reduction & Separation Alternatives

Horizontal separator (Hybag)



Vertical chain mill + Piston press (FITEC)

Vertical Bioseparator (Doda)

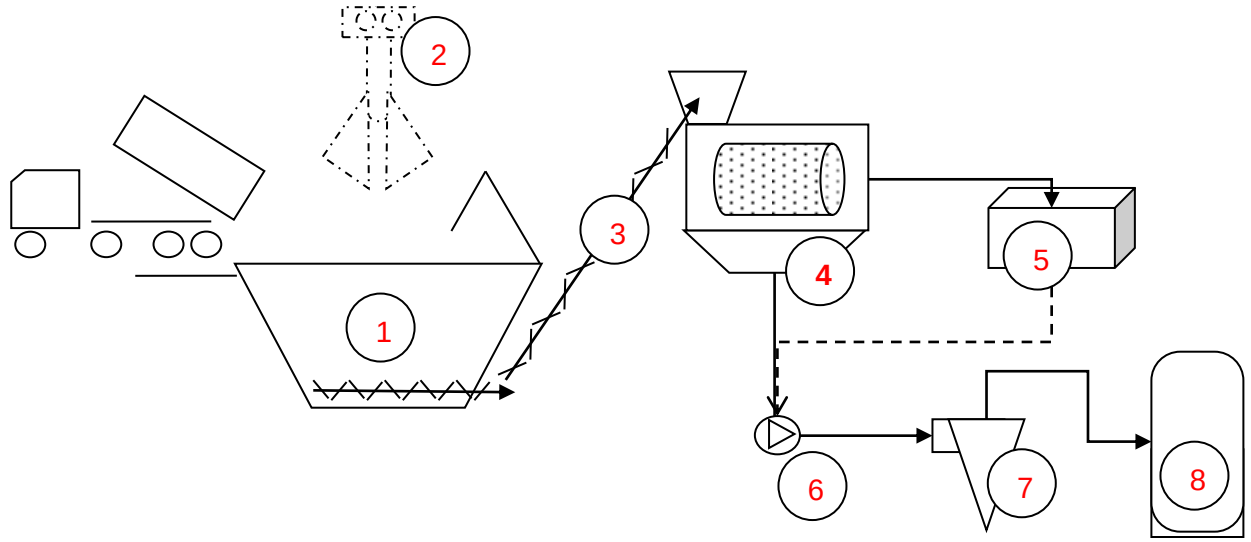
Hammer Mill Separator (Wackerbauer)

Removal of Settleables

Floor Scraper

Hydrocyclone

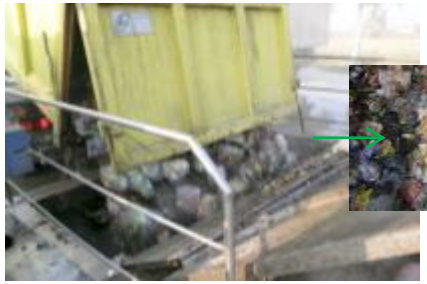
Sample Complete Pre-treatment System for Contaminated Feedstocks in LSAD



Truck tips into a covered stainless steel **pit** (1) (opened only when the material is loaded), fitted with a transverse auger. Shear action of the screw does the bag opening. Optional **crane** (2) removes large items and big contaminants. **Screw conveyor** (3) elevates feedstock into horizontal axis paddle **separator** (4). Paddles and breaker bars create slurry from organics while rejecting metals and plastic (some glass and plastic pass through and are screened post digestion). Rejected plastics and metals are screw conveyed to a **dumpster** (5), while the organic slurry is **pumped** (6) into a **hydrocyclone** (7) to recover the majority of stones, sand, grit and glass (settleables), before being transferred to a **reception tank** (8).

Sample Complete Pre-treatment System for Contaminated Feedstocks

Supermarket Waste
(~10% contamination)



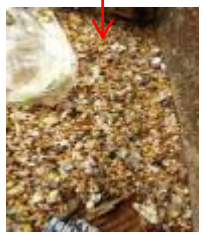
Reception pit

Separator Mill

Shredded
Plastic and metal
rejects

Hydrocyclone

Settleables (metals,
glass, grit, stones, etc.)



Digester

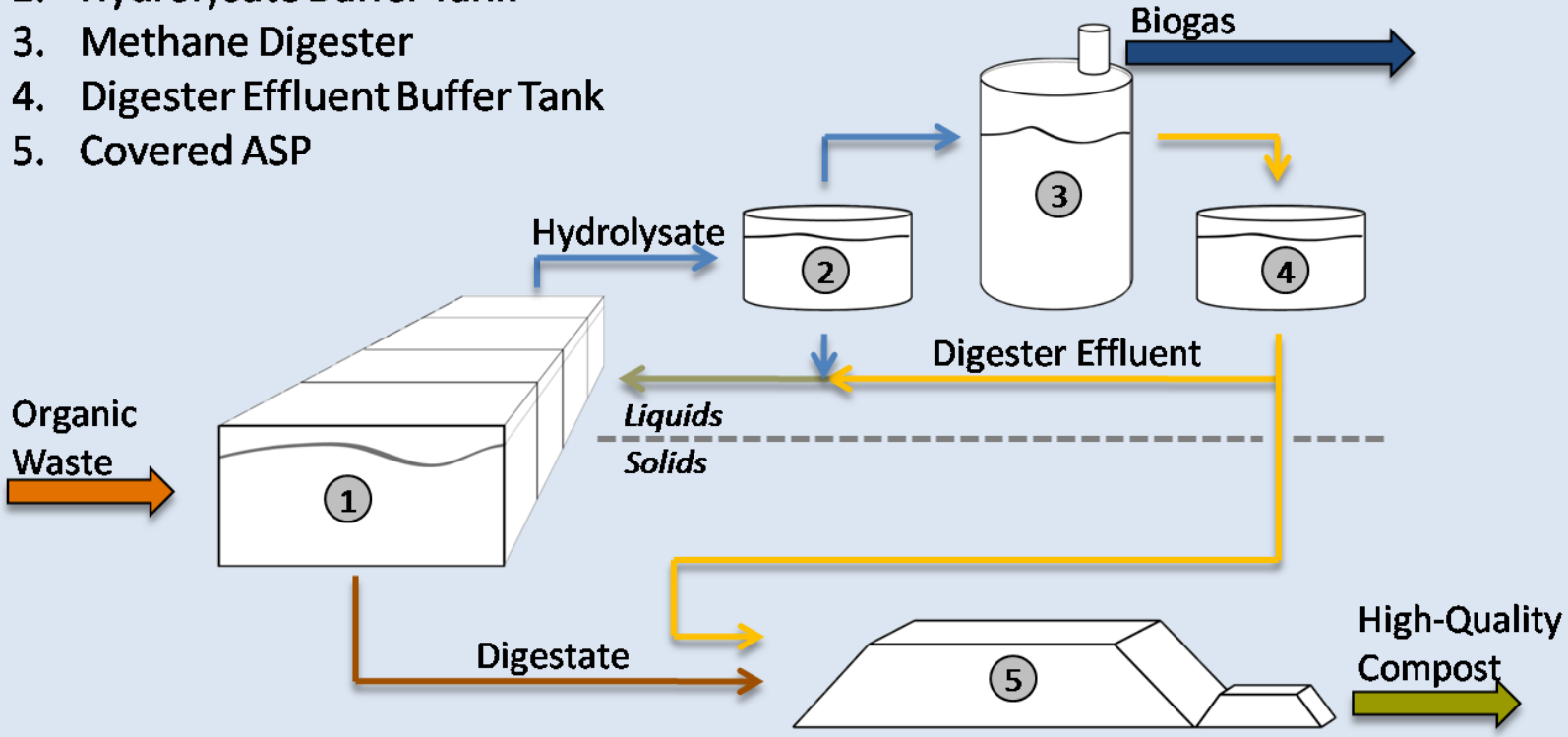
Pre-treatment for Batch HSAD

Optional Shredder/Mixer

Loading Tunnels

Batch High Solids Process Flow

1. Hydrolysis Percolators
2. Hydrolysate Buffer Tank
3. Methane Digester
4. Digester Effluent Buffer Tank
5. Covered ASP



Batch HSAD Facility - Richmond, BC

Feedstock	30,000 tons per year of food and yard waste, including municipal SSO and IC&I waste
Output	1 MWe
Technology	GICON batch , two-stage high solids anaerobic digestion technology
PPA	Long-term agreement with BC Hydro
Compost Product	~20,000 tons/year
Footprint	2 acres

Batch HSAD

- Easily integrates with existing composting operations
- Maximum tolerance for contaminants
- Minimal if any liquid residual
- Requires structural material

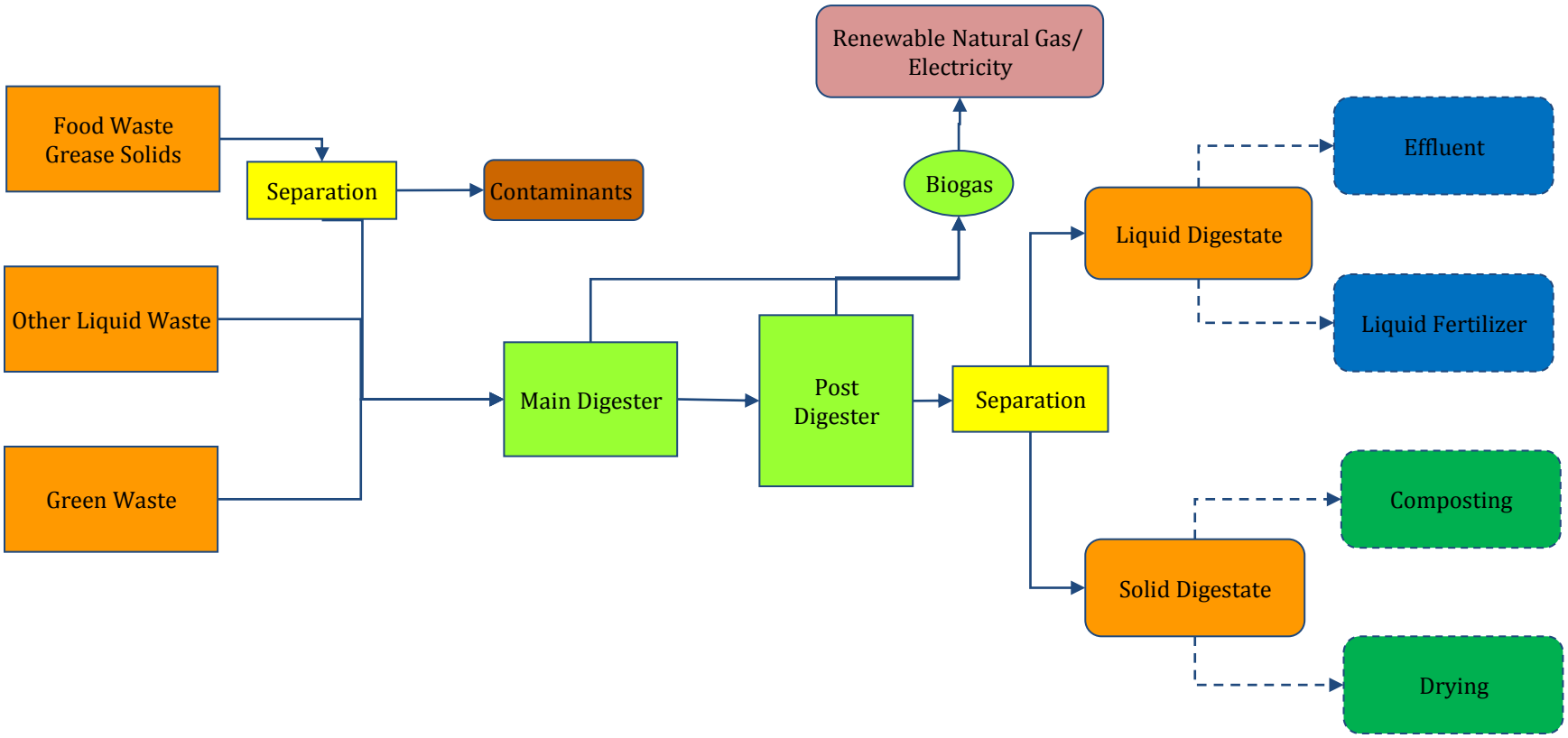
Batch HSAD Reference Facilities

- 50+ fully operational batch HSAD plants in Europe
- 30,000 TPY plant under construction at Harvest's FRSF site

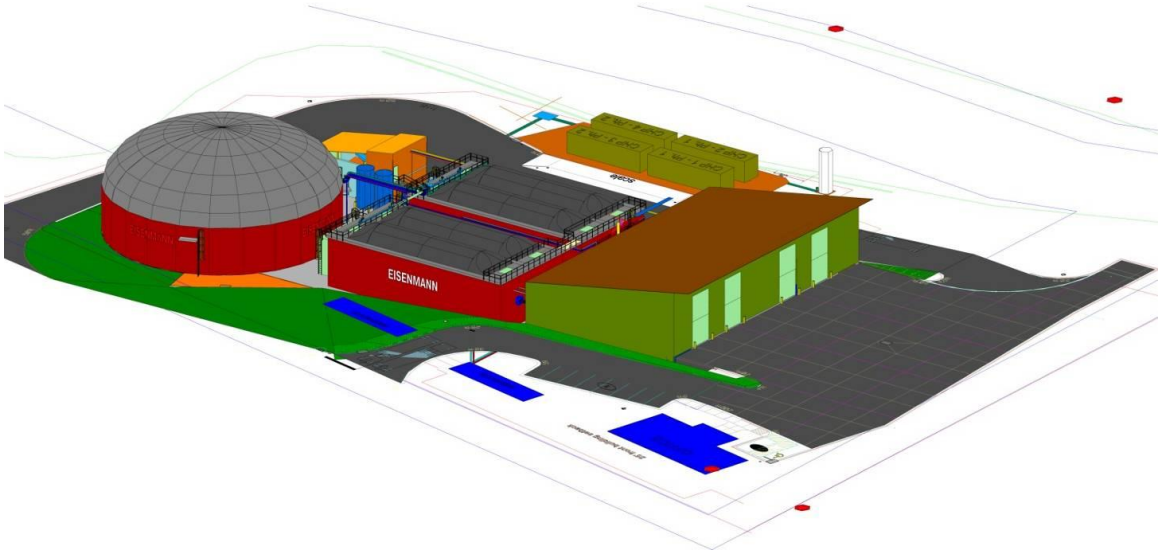




Continuous HSAD Process Flow



Example Continuous HSAD Technology Overview



Feedstock	60,000 tons per year of food waste from supermarkets and dewatered fats, oils and grease (FOG) from grease traps
Output	2.8 MWe
Technology	Eisenmann / OWS (DRANCO) / Biffa / Others
End Product	Granular fertilizer
Footprint	2 acres

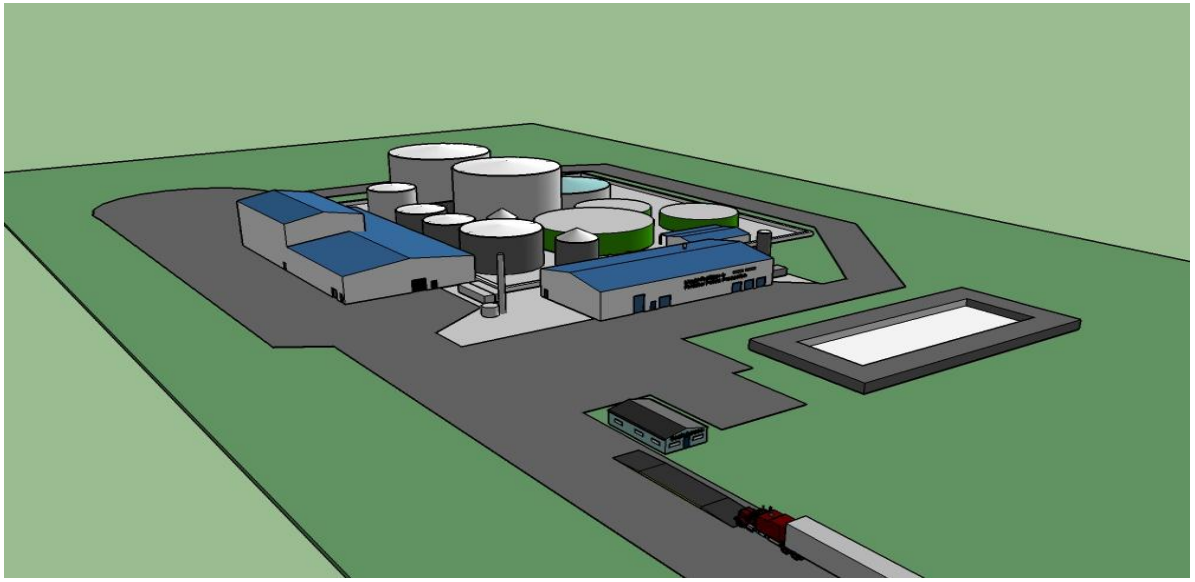
Continuous HSAD

- Can run on food waste alone
- Contaminants must be removed before digestion
- Liquid residual must be managed
- Possibility to integrate dryer and produce granular solid product

Continuous HSAD Reference Facilities

- 200+ fully operational biogas plants in Europe

70,000 TPY Low Solids AD Facility - London, ON



Feedstock	70,000 tons per year of food processing by-products and commercial SSO
Output	2.8 MW of electricity
Technology	OvivoGWE CSTR low solids anaerobic digestion and fertilizer production
PPA	Long term agreement with the Ontario Power Authority
Fertilizer	~5,000 tons/year, granular
Footprint	5 acres

LSAD

- Can operate on a range of liquid wastes
- Contaminants must be removed before digestion
- Digester volumes are large
- Large volumes of liquid residual must be managed
- Preferred configuration is integration with WWTP

LSAD Reference Facilities

- Many around the world

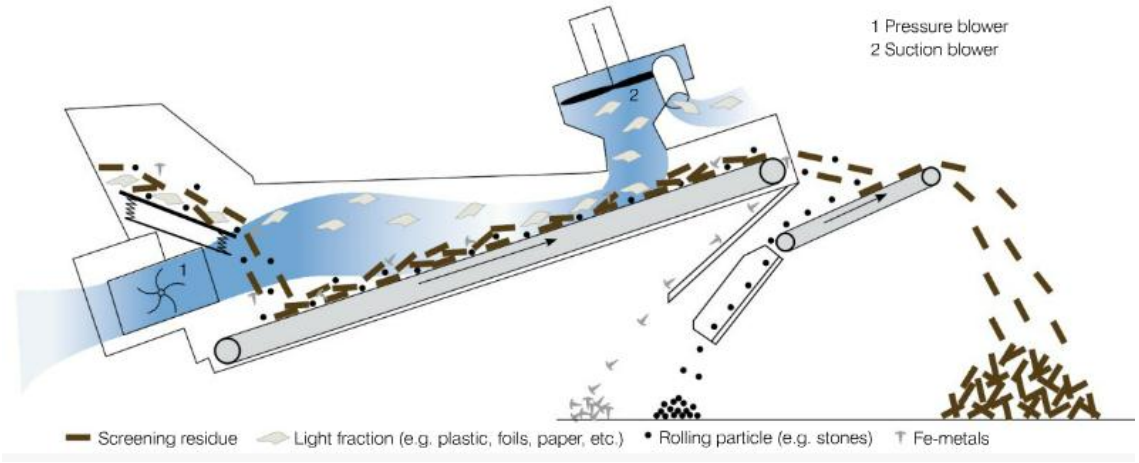
Digestate Management

- Ideally, we would sell unprocessed digestate for direct agricultural land application owing to its high nutrient content
- Minimal market in the Northeast for liquid effluent as fertilizer. Thus, we have to make provisions to manage the digestate
- Digestate management is different for Batch and Continuous systems
  - Batch-HSAD: There is limited pre-treatment before digestion, therefore majority of the contaminants are taken out post-digestion. Processes and equipment are similar to what you would find at a composting operation, involving shredding, screening and sifting.
  - Continuous HSAD / LSAD: Digestate is wet, and requires some combination of the following:
    - Liquid-solid separation: Screw press; belt filter press; rotary press; centrifuge
    - Further processing of solid digestate: drying to produce granular fertilizer; pelletizing; composting in windrows or in piles
    - Treatment of liquid effluent as a high-strength wastewater: Aeration in an MBR or SBR; UF + RO; etc.

Digestate Management – Batch-HSAD

Drumscreen

Wind sifter



Komptech,
Hurrikan, etc.

Liquid-Solid Separation

Screw Press

Vetter, Vincent Corp., etc.

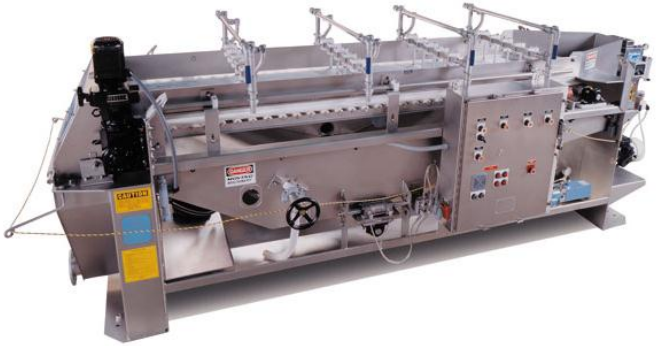
Decanter Centrifuge

Centrysis, Alfa Laval, etc.

Belt Filter Press

Komline, Parkson, Alrick Press Cp., etc.

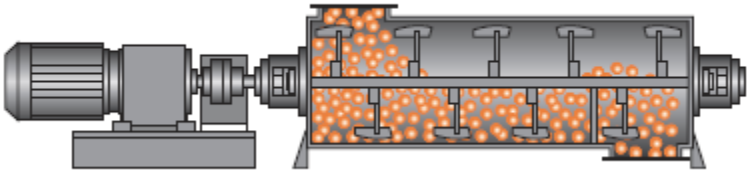
Gravity Belt Thickener



Komline, etc.

Processing Solid Digestate

Dryer



Dorset, Berlie-Falco Technologies, AVA, Aslan, Fenton, Komline, VOMM, Royal GMF-Gouda, Buss-SMS-Canzler, HUBER, etc.

OR

Composting

Harvest's Proprietary CASP system, Existing or new windrow systems

There's a better path for organics — help us get there.

HARVEST

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