



*Recycling Council
of Alberta*

Anaerobic Digestion of Source Separated Organics (SSO) and Municipal Solid Waste (MSW)

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Presentation Overview

- ◆ Technical Aspects of AD
 - How it works
 - Types
 - Issues/variables
- ◆ Current Situation
 - Current use of technology
 - Future



Recycling maximized ✓



Composting maximized ✓



Residuals ?

How Anaerobic Digestion Works

Biological Process

- ◆ Organic materials are broken down in the absence of oxygen in enclosed tanks and produce:
 - “biogas” which is about 60% methane, and
 - digestate, which is generally composted to make more stable (less smelly)
 - Compost is sold for various landscaping uses



Recycling maximized ✓



Composting maximized ✓



Residuals ?

How Anaerobic Digestion Works

- ◆ Breakdown of organic materials in a landfill same process as anaerobic digestion
- ◆ Composting accomplishes breakdown of organic materials in presence of oxygen (aerobic process)
 - Slower than AD
 - Needs more space than AD



Recycling maximized ✓



Composting maximized ✓



Residuals ?

How Anaerobic Digestion Works

Two Phases

- ◆ Acid formers break down complex materials in an acidic environment
- ◆ Methane formers munch up organic material and produce biogas (60% methane)
- ◆ Various vendors control the two processes in different ways:
 - Different retention time in digesters (15 to 25 days)
 - Different temperatures (thermophilic and mesophilic)
 - Two phases in separate tanks or the same tank



Recycling maximized ✓



Composting maximized ✓



Residuals ?

How Anaerobic Digestion Works

Biogas from Digesters

- ◆ 55% to 60% methane (CH_4)
 - Remainder CO_2
- ◆ Water saturated
- ◆ Small amounts of hydrogen sulfide (H_2S)
- ◆ Low pressure (1psi)
- ◆ Needs different levels of upgrading for different uses



Recycling maximized ✓



Composting maximized ✓



Residuals ?

How Anaerobic Digestion Works

Biogas Generation By Material

	Moisture content	Biogas yield- (ft ³ /lb)
Office paper	10%	2.85
Cardboard, mixed paper	10%	1.89
Food	70%	1.82
Brush	40%	1.08
Newspaper	10%	0.98
Grass	60%	0.55
Leaves	60%	0.37



Recycling maximized ✓



Composting maximized ✓



Residuals ?

How Anaerobic Digestion Works

Energy Production By Technology

- ◆ Dry technologies use 20% to 30% of energy created
- ◆ Wet technologies appear to use more (up to 50%) of energy created for in-plant needs
- ◆ Wet technologies more suitable for contaminated waste stream with lots of plastic
- ◆ Dry technologies considered more suitable for green waste



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Composting maximized ✓



Residuals ?

How Anaerobic Digestion Works

Digestion of SSO and MSW

- ◆ Digestion process the same for SSO and MSW
- ◆ Pre-processing more extensive for mixed municipal waste digestion
 - More contaminants need to be removed
- ◆ Gas production different
 - More paper in MSW
- ◆ For same tonnage, digester generally smaller
 - Contaminants removed from MSW at front end of plant



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Composting maximized ✓



Residuals ?

Types of Anaerobic Digesters

- ◆ Wet
- ◆ Dry
- ◆ Thermophilic
- ◆ Mesophilic
- ◆ One Stage
- ◆ Two Stage



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Composting maximized ✓



Residuals ?

Types of Digesters

One vs Two Stage

◆ Single Stage

- ◆ Longer proven track record
- ◆ Simple design
- ◆ Lower capital costs and technical problems
- ◆ Similar biogas yield

◆ Two Stage

- ◆ Robust (not as pH sensitive)
- ◆ Lower retention time because phases optimized
- ◆ Potential for higher gas yield



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Composting maximized ✓



Residuals ?

Types of Digesters

Wet vs Dry

- ◆ Wet
- ◆ Loss of volatile organics during hydropulping
- ◆ Not suitable for garden wastes
- ◆ Less tolerant of contaminants in digester
- ◆ Good where plastic bag contamination
- ◆ Dry
- ◆ Uses less water and less energy
- ◆ More tolerant of contaminants in digester
- ◆ Lower power requirement



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Composting maximized ✓



Residuals ?

Types of Digesters

Mesophilic vs Thermophilic

◆ Mesophilic

- ◆ Bacteria more robust and adaptable
- ◆ Longer retention time (15-30d)
- ◆ Larger footprint
- ◆ Lower gas yield

◆ Thermophilic

- ◆ Higher gas yield
- ◆ Lower retention time (12-14d)
- ◆ Higher energy use
- ◆ Higher maintenance and costs



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Composting maximized ✓



Residuals ?

Main AD Design Variables



Situation Update

Experience With AD Technology

- ◆ Well established for wastewater treatment biosolids (sludge) and industrial food processing operations in US
- ◆ 50-70 digesters for animal manures in US
- ◆ Application of AD to municipal solid waste in Europe and Japan in last 10 years with growing success
- ◆ 2 AD facilities for municipal solid waste in North America (both near Toronto)
 - A third AD facility (Guelph) currently closed
- ◆ No AD facilities for municipal solid waste in US



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Composting maximized ✓



Residuals ?

BTA HYDROPULPER



Situation Update

AD of MSW Growing Rapidly in EU

- ◆ EU Landfill Directive - organic material must be stabilized before landfilling
 - ◆ 75% of 1995 level by 2006
 - ◆ 50% of 1995 level by 2010
 - ◆ 35% of 1995 level by 2016
- ◆ Stabilization accomplished through composting, digestion or incineration
- ◆ Green power incentives
 - Local utility must buy green power at 15 cents/kwhr in Switzerland
- ◆ High cost of landfilling and incineration
 - \$90 to \$140/ton



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Residuals ?

Situation Update

Energy From European AD Plants

- ◆ Engine generator sets on site produce electricity
 - Sold into grid at 15c/kwhr
- ◆ Gas cleaned up and injected into NG pipeline system
- ◆ Convert biogas to fuel for vehicles
- ◆ Sell heat or steam to adjacent industry



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Composting maximized ✓



Residuals ?

Situation Update

Digestate from European Plants

- ◆ Given to farmers who apply on land without further stabilization
- ◆ Given to soil blenders directly
- ◆ Stabilized in open windrow composting sites for use as soil conditioner
- ◆ Compost revenue not a factor in plant economics



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Composting maximized ✓



Residuals ?

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Wir garantieren das beste Preis-Leistungs-Verhältnis, die höchste
Sicherheit und den besten Service für Sie.

ENERGIE-UND
STOFFKREISLAUF



Auch Ihren Küchenabfall
haben wir zum verwerten gern.

Ohne die Umwelt zu belasten, gewinnen wir aus Ihrem
organischen Abfall Energie in Form von Gas, Strom, Wärme
und Aufbereiteter. Zurück bleibt hochwertige Komposte,
die wieder in den Kreislauf zurückgeführt wird.

TANZ AG OTELINGEN









Situation Update

Distribution of 74 Existing AD Facilities

- ◆ 28 in Germany
- ◆ 12 in Switzerland
- ◆ 7 in Spain
- ◆ 5 each in Austria and Italy
- ◆ 4 each in Japan and France
- ◆ 3 each in Belgium and Netherlands
- ◆ 2 in Canada
- ◆ 1 each in Finland, Sweden and Denmark (this may be closed), Libya, Korea and Portugal



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Composting maximized ✓



Residuals ?

Situation Update

Locations of Planned AD Facilities

- ◆ 9 Germany
- ◆ 7 Spain
- ◆ 4 US
- ◆ 3 Switzerland
- ◆ 2 each France and Japan
- ◆ 1 each Martinique, Pusan South Korea, Sydney Australia, Portugal and Italy



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Composting maximized ✓



Residuals ?







Recycling maximized ✓

Composting maximized ✓

Residuals ?



Situation Update

Size of Existing Facilities

- ◆ Many were small (< 20,000 t/y) until about 5 years ago
- ◆ Trend to larger capacity facilities
- ◆ A number of facilities planned to handle 100,000t/y
 - Only one operating facility handling over 100,000t/y
- ◆ Limited operating experience above 50,000t/y



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Composting maximized ✓



Residuals ?

Situation Update

74 full scale AD facilities

- ◆ 57 have <50,000 ton/year capacity
 - 60% of these <20,000 tonne/year capacity
- ◆ 10 have capacities 50, 000 to 100,000 tonness/y
- ◆ 7 are > 100,000 t/y
- ◆ 33 planned or under construction



Recycling maximized ✓



Composting maximized ✓



Residuals ?

Environmental Benefits of AD

- ◆ Supplants use of fossil fuels for electricity and heat generation
- ◆ Diverts waste from landfill
- ◆ Produces green energy
- ◆ Small footprint



Recycling maximized ✓



Composting maximized ✓



Residuals ?

Future of AD

- ◆ Will continue to develop in Europe
- ◆ Increasing interest in US with energy concerns and new focus on “biomass” energy
- ◆ Expensive in Canada, but interest will continue
- ◆ Co-digestion with animal manures or biosolids appropriate in some circumstances



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Composting maximized ✓



Residuals ?

Evaluation of Anaerobic Digestion Cost

Population	20,000	80,000	200,000
Tonnage per year	1,845t SSO 2,470t MSW	7,338t SSO 9,641t MSW	18,453t SSO 24,714t M
Capital Costs	\$3m SSO \$3.3m MSW	\$7m SSO \$7.3mMSW	\$12m SSO \$12.6mMSW
Operating Costs/year	\$225,000 (S) \$257,000 (M)	\$525,000 S \$601,000 M	\$955,000 S \$1,109,000
Cost per tonne	\$257-\$282	\$156-\$172	\$111- \$123



Recycling maximized ✓



Composting maximized ✓



Residuals ?

Evaluation of Anaerobic Digestion

Energy Recovery and Space Requirements

Population	20,000	80,000	200,000
Tonnage per year	1,845t SSO 2,470t MSW	7,338t SSO 9,641t MSW	18,453t SSO 24,714t MSW
Energy Recovery	47kW-65kW	235kW-325kW	470kW-650kW
Staffing	5	7	9
Footprint (ha)	1.2	1.6	2



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Composting maximized ✓



Residuals ?

Evaluation of Anaerobic Digestion GHG as eCO₂

Population	20,000	80,000	200,000
Tonnage per year	1,845t SSO 2,470t MSW	7,338t SSO 9,641t MSW	18,453t SSO 24,714t M
SSO Incl C Seq	(897)	(3,632)	8,972)
SSO Excl C Seq	(1,791)	(7,161)	(17,913)
MSW Incl C Seq	(650)	(2,827)	(6,499)
MSW Excl C Seq	(1,817)	(7,237)	(18,173)

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Residuals ?

