Anaerobic digestion – GHG emissions reductions

Washington CAT: Ag Carbon Market Work Group

Craig Frear and Chad Kruger

WSU Center for Sustaining Ag & Natural Resources

June 23, 2008

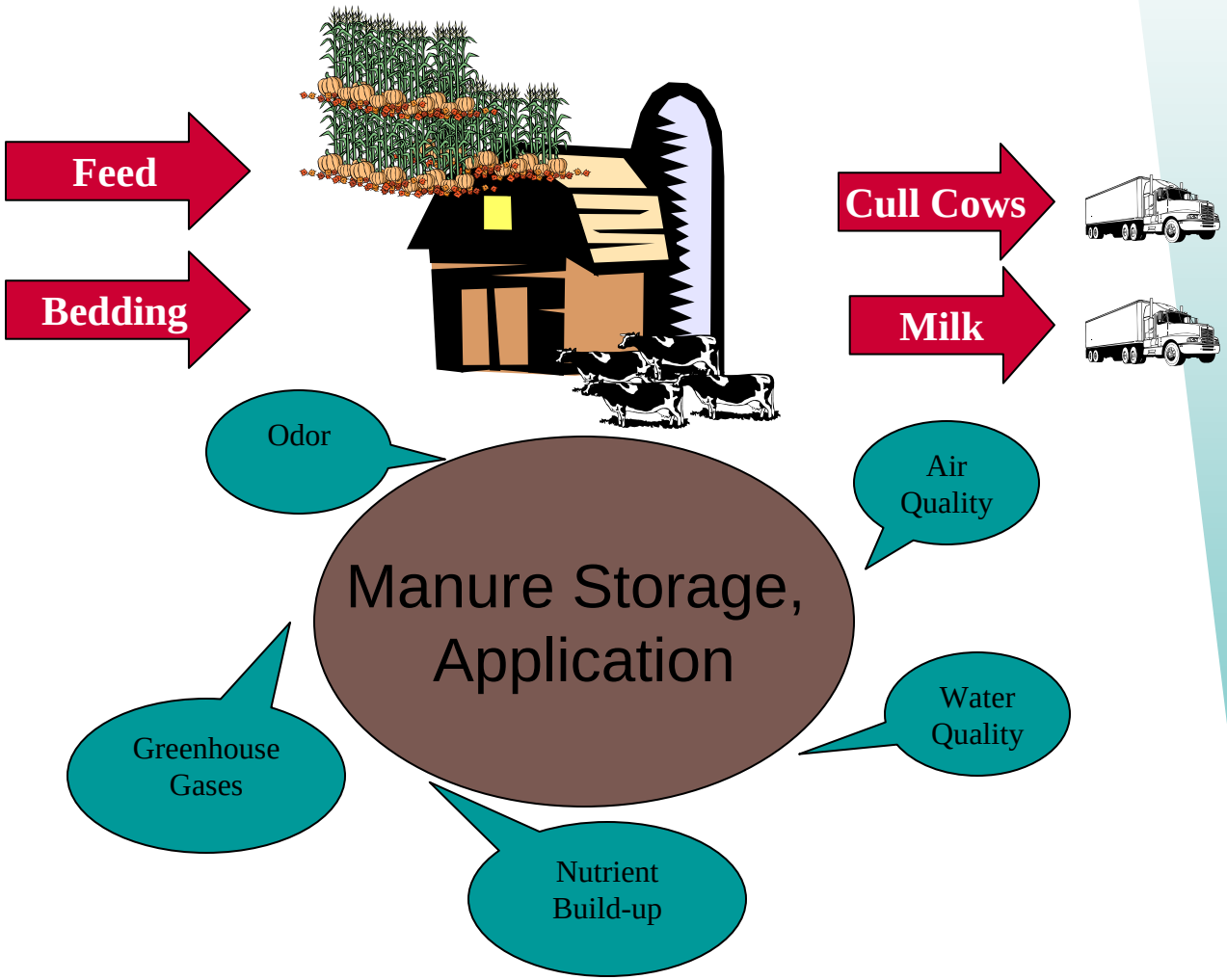
Moses Lake, Washington

WASHINGTON STATE UNIVERSITY

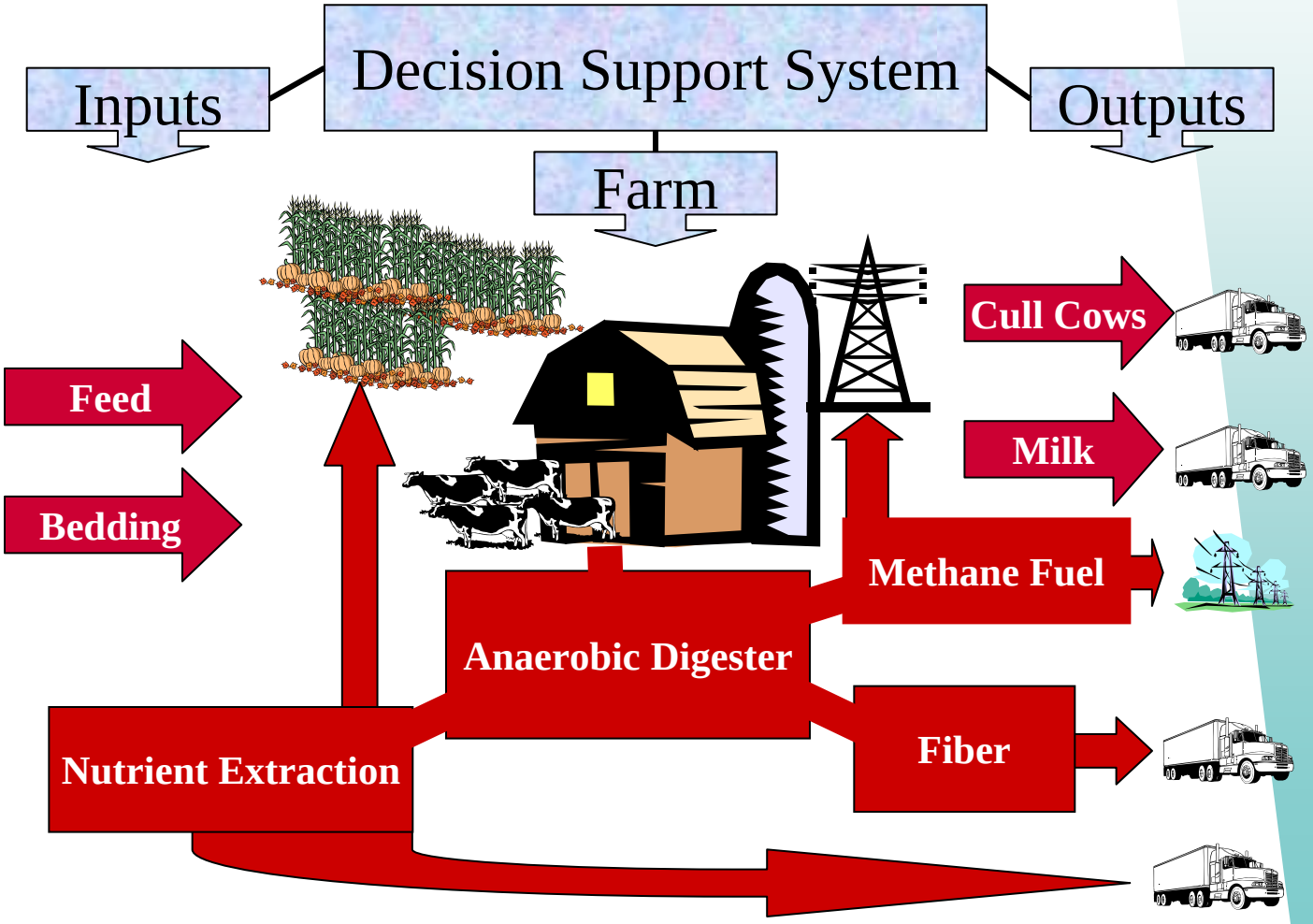
World Class. Face to Face.

CLIMATE FRIENDLY FARMING™

Current Dairy Farm



Next Generation Dairy Farm



Influent and Effluent Parameters and Percentage Reduction Performance

Parameter (g/L)	Influent	Effluent	Mean % Reduction
TS	70.42 ± 12.13	41.82 ± 4.03	**40.61**
VS	59.51 ± 7.49	30.52 ± 3.50	**48.71**
FS	12.54 ± 1.69	11.35 ± 1.93	NA
COD	84.13 ± 15.04	36.58 ± 5.74	**56.62**
VFA	7.71 ± 1.76	0.05 ± 0.02	**99.35**
TKN	4.12 ± 0.93	3.84 ± 0.53	NA
TAN	1.87 ± 0.45	2.65 ± 0.76	**+41.71**
TP	0.51 ± 0.14	0.44 ± 0.10	NA
K	2.31 ± 0.35	2.28 ± 0.27	NA
pH	6.87 ± 0.41	7.88 ± 0.14	+14.37
Alkalinity	8.96 ± 1.00	14.23 ± 1.80	+58.82
FC (cfu/g)	339,031 ± 247,461	3,418 ± 7,060	98.99

NA refers to mean reduction parameters not statistically relevant as determined by General Linear Model (GLM) ANOVA analysis with Statistical Analysis System program 9.0 (SAS Institute Inc. NC) at α=0.05 with n=24 samples. All reductions were with calculated p-values <0.0001 except for FS (0.2531), TKN (0.2355), TP (0.0417), and K (0.4567).

Biogas Production and Reactor Performance

Parameter	Units	Co-Digestion	Manure-Only[a]
Total Biogas	m^3 biogas/day	4,390 ± 511	2,693 ± 992
Total Biogas	m^3 biogas/ AU* day	4.69 ± 0.54	2.87 ± 0.73
Specific Biogas Yield	m^3 biogas/kg VS_{Added}	0.65 ± 0.15	0.57 ± 0.18
Specific Methane Yield	m^3 CH_4/kg VS_{Added}	**0.41 ± 0.10**	**0.32 ± 0.10**
Specific Biogas Yield	m^3 biogas/kg $VS_{Destroyed}$	1.33 ± 0.47	1.44 ± 0.47
Specific Methane Yield	m^3 CH_4 /kg $VS_{Destroyed}$	**0.84 ± 0.30**	**0.80 ± 0.26**
Reactor Performance	m^3 biogas/ m^3 reactor day	1.13 ± 0.13	0.69 ± 0.19
Biogas Composition	%CH_4 ; %/H_2S	63.52 ± 6.89; 0.20 ± 0.12	55.9 ± 2.10; 0.20 ± 0.12

[a] Process model simulation of manure-only production using assumed flow rate of 114.33 m^3/day so that comparison with co-digestion would be at equivalent flow rates

Nutrient load to farm under co-digestion and manure-only scenarios

Nutrient	Manure-Only metric tons/yr	Co-Digestion metric tons/yr	% Change %
Ammonia N	**89.7**	**110.66**	**23.37**
Total N	**102.31**	**160.36**	**56.74**
Total P	16.29	18.37	12.77
Total K	101.89	95.2	-6.57

Co-digestion and manure-only scenario enterprise budgets

	Co-digestion		Manure-Only	
Gross Receipts	$/AU yr	$/yr	$/AU yr	$/yr
Tipping Fees	195.61	183,484		
Electrical Sales	141.57	132,792	75.83	71,128
Carbon Credit	**19.68**	**18,464**	**19.68**	**18,464**
Avoided Bedding Cost	15.25	14,300	15.25	14,300
Tax Credit	56.63	53,117	30.33	28,451
Fiber Sales	10.94	10,265	10.94	10,265
Other Income	4.59	4,306	4.59	4,306
Total Revenue	444.27	416,727	156.62	146,913
Operating Costs				
Delivery	50.68	47,539	50.68	47,539
Maintenance	78.43	73,571	78.43	73,571
Utilities	32.13	30,139	32.13	30,139
Miscellaneous	31.15	29,226	31.15	29,226
Ownership	81.09	76,063	81.09	76,063
Total Operating Costs	273.49	256,538	273.49	256,538
Return to Risk	**170.78**	**160,189**	**-116.87**	**-109,625**

Table 9. Greenhouse credits and revenues from two scenarios at Lynden, WA digester

Production (yr)	Manure Credit		OFMSW Credit		Energy Offset		Total	
	tons C-eq	$	tons C-eq	$	tons C-eq	$	tons C-eq	$
Co-Digestion	1,830	18,466	1,860	18,710	290	2,921	3,980	**40,097**
Manure Only	1,830	18,466	NA	NA	160	1,565	1,990	**20,031**