REFERENCE

Anand, C. and Apul, D.S. (2011) Economic and environmental analysis of standard, high efficiency, rainwater flushed, and composting toilets. Journal of Environmental Management, 92, 419-428

Ann, C.W. (2005) Anaerobic Digestion of Dairy Manure: Design and Process Considerations. Ithaca, NY: Natural Resource, Agriculture and Engineering Service.

Annex X Energy Efficient Drying and Dewatering Technologies Technical report 4 (2010) Superheated Steam Drying for Sludge and Related Applications. International Energy Agency Industrial Energy-related Technologies and Systems (IETS), NTNU, Norway.

BFE. (2011) Life Cycle Assessment of Biogas Production from Different Substrates; Bundesamtfür Energie BFE Forschungs Program Biomass, Switzerland, [N/A]. 15 July 2013. <http://www.esu-services.ch/ fileadmin/ download/ stucki-2011 LCA_Biogas_v1.0.pdf.>

Cavinato, C., Fatone, F., Bolzonella, D., and Pavan, P., (2010) Thermophilic anaerobic co-digestion of cattle manure with agro-wastes and energy crops: Comparison of pilot and full scale experiences. Bioresource Technology, 101, 545–550.

Chang, A. and Harter, T., Eds. (2005) Managing Diary Manure in the Central valley of California; Division of Agriculture and Natural Resources Committee of Experts on Dairy Manure Management, University of California: California.

D Cuellar, A. and E Webber, M. (2008) Cow power: the energy and emissions benefits of converting manure to biogas. IOP Science, 3, 1-8.

Delaval (2013) Type of manure. [N/A]. 18 February 2014. <http://www.delaval.com/en/-/Product-Information1/Manure/Manure-solutions/Types-of-manure/>

De Mes, T.Z.D., Stams, A.J.M., Reith, J.H., and Zeeman, G. (2003) Bio-methane and Bio-hydrogen: Methane production by anaerobic digestion of wastewater and solid wastes. The Netherlands Agency for Energy and the Environment (Novem), Netherlands.

Dennis, A.B. (2001) Diary Waste Anaerobic Digestion Handbook : Option for Recovering Beneficial Products from Dairy Manure. Olympia, WA.: Environmental Energy Company.

Department of Natural Resources, 4.0 Manure Handling And Storage, [N/A]. 15 May 2013. <http://www.nr.gov.nl.ca/nr/agrifoods/land_resources/envseries/ slm027.pdf >

De Vries, J.W., Corre, W.J., and Van Dooren, H.J.C. (2010) Environmental assessment of untreated manure use, manure digestion and co-digestion with siliage maize. Nertherland: Wageningen UR Livestock Research, part of Stichting Dienst Landbouwkundig Onderzoek (DLO Foundation).

Donald J, E., Kevin, E., Jay, J., William F, L., Karen, M, M., and Gary, S. (2006) Ohio Livestock Manure Management Guide. Ohio: Ohio State University.

GEA. (2005) Superheated dryer and processor. G EA Process Engineering Division, [N/A]. 10 February 2014. <http://www.barr-rosin.com/english/pdf/super_heated_steam_dryer_processor.pdf>

Hamed, M., El, M., and Ruihong, Z. (2010). Biogas production from co-digestion of dairy manure and food waste. Bioresource Technology, 101, 4021–4028.

Harrigan, T. M. (2010) Liquid manure hauling capacity of custom applications using tank spreader systems. American Society of Agricultural and Biological Engineers Journal, 26, 729-741.

Henry, F. (2004). "Factory Farms Cause Big "Stink"." Organic Consumers Association. [N/A]. 5 May 2013 <http://www.organicconsumers.org/corp/stink081104.cfm>

Hishinuma, T., Kurishima, H., Yang, C., and Cenchi, Y. (2008) Using a life cycle assessment method to determine the environmental impacts of manure utilization: biogas plant and composting systems. Australian Journal of Experimental Agriculture, 48, 89-92.

IPCC. (2006) Emissions from Livestock and Manure Management; 2006 IPCC Guidelines for National Greenhouse Gas Inventories. [N/A]. 15 July 2013 <http://www.ipccnggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_10_Ch1 0_Livestock.pdf.>

IPCC (2013) Working Group I Contribution to the IPCC fifth Assessment ReportClimate Change 2013. Final Draft Underlying Scientific-Technical Assessment, Intergovermental Panel on Climate Change (IPCC), Stockholm, Sweden. [N/A]. 11 October 2013 <http://www.climatechange2013.org/ images/uploads/WGIAR5_WGI-12Doc2b_FinalDraft_All.pdf>

International Organization for Standardization (1997) Environmental Management Life Cycle assessment-Principals and Framework. MI: ISO.

International Organization for Standardization (2006) Environmental Management Life Cycle Assessment-Requirements and guidelines. MI: ISO.

John, H.M.Jr. (2003) A Comparison of Dairy Cattle Manure Management with and without Anaerobic Digestion and Biogas Utilization., Boston, MA. : U.S. Environmental Protection Agency.

Jean-Claude, F., and Serge, R.G. (2010) Biomethane production from starch and lignocellulosic crops: a comparative review. Biofuels Bioproduct. Bioresources Journal, 4, 447–458.

Jensen A.A., Hoffman L., Moller T.B., and Schmidt A. (1997) Life Cycle Assessment : A guide to approaches, experiences and information sources, The European Environment Agency (EEA).

Karen, A., Beauchemin, H., Janzen, H., Shannan, M., Tim, A., and Sean M. (2010) Life cycle assessment of greenhouse gas emissions from beef production in western Canada: A case study. Agricultural Systems Journal, 103, 371–379.

Kirk, K. (2010) "Renewable Energy Resources: Banking on Biosolids." The National Association of Clean Water Agencies. The National Association of Clean Water Agencies, [N/A], 5 May 2013. <http://www.cityofpaloalto.org/civica/filebank/blobdload.asp?BlobID=2306>

Lorimor, J., Powers, W., and Sutton, A. (2000) Manure Characteristics. Ames, Iowa: Iowa State University.

Lyngso, H. (2012) Livestock Manure to Energy Status, Technologies and Innovation in Denmark; Agro Business Park A/S, Denmark.

Mezzullo, W. G., Mcmanus, M. C., and Hammond, G. P. (2013) Life cycle assessment of a small-scale anaerobic digestion plant from cattle waste. Applied Energy, 102, 657-664.

Miettinen, P., Raimo P. Hamalainen (1997) How to benefit from decision analysis in environmental life cycle assessment (LCA). European Journal of Operational Research, 102, 279-294.

Mujumdar, A.S. (2007) Handbook of Industrial Drying. 3rd eds, Boca Raton, FL.: Taylor & Francis.

Nallathambi, V. (1997). Anaerobic digestion of biomass for methane production : A review. Biomass and Bioenergy, 13, 83-114.

Ogejo, J.A., Wen, Z., Ignosh, J. Bendfeldt, E., and Collin, E.R. (2007) Biomethane Technology, Virginia: Verginia State University.

Society of Environmental Toxicology and Chemistry (SETAC) (1993) Guidelines for Life-Cycle Assessment, Brussels: SETAC.

OSU (2006) Ohio Livestock Manure Management Guide. OSU Extension Bulletin 604, Ohio: Ohio State University.

PE. International “New room A brief history of Life Cycle Assessment (LCA)”. [N/A]. 24 January 2014. <http://www.peinternational.com/company/newsroom/news-detail/article/a-brief-history-of-life-cycle-assessment-lca/>

PE International (2010) Handbook for Life Cycle Assessment (LCA) Using the Gabi Education Software Package. Leinfelden-Echterdingen, Germany.

Peter W. (2001) Overview of Anaerobic Digestion Systems for Dairy Farms, Natural Resource, Agriculture and Engineering Service (NRAES-143), NY: Cornell University.

Ratkowsky, D. A., Olley, J., Mcmeekin, T.A., and Ball, A. (1981) Relationship between temperature andgrowth rate of bacterial cultures. Journal of Bacterioloy 149(1), 1-5.

Robert G., William E. (1996) LCA- How it Came About Personal Reflections on the Origin and LCA in the USA, International Journal of. LCA 1 (1), 4-7.

Solomon S, D.Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor, and H.L. Miller (eds.) 2007 IPCC (2007): Summary for Policymakers. In Climate Change 2007: The Physical Science Basis.Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, Cambridge University Press.

Tao, J. and Mancl, K. (2008) Estimating Manure Production, Storage Size, and Land Application area. [Fact sheet: Agriculture and Natural Resources, No. AEX-715-08]. Ohio: Ohio State University.

Turnbull, J.H., Kamthunzi, W. (2002) Greenhouse gas emission reduction associated with livestock waste management system : A case study for the Langerwerf dairy waste management system. Austria, Greenhouse Gas Balances of Biomass and Bioenergy Systems, IEA Bioenergy task 38. [N/A]. 22 May 2013. <http://www.ieabioenergytask38.org/projects/ task38casestudies/usa-fullreport.pdf>

US.EPA (2001) Effect of acid rain forest. [N/A]. 10 February 2014. <http://www.epa.gov/ acidrain/effects/forests.html.>

US.EPA (2001) Emissions from Animal Feeding Operation.Emission. Standards DivisionOffice of Air Quality Planning and Standards Research Triangle Park. [N/A]. 17 April 2013. <http://www.epa.gov/ttnchie1/ap42/ch09/draft/ draftanimalfeed.pdf>

U.S.EIA (2011) Electricity Explained Basics. [N/A]. 15 May 2013. < http://www.eia.gov/forecasts/ieo/electricity.cfm>

US.EPA (2011) National Greenhouse Gas Emissions Data. [N/A]. 10 May 2013. <http://www.epa.gov/climatechange/ghgemissions/usinventoryreport.html>

US.EPA (2011) Market Opportunities for Biogas Recovery Systems at U.S. Livestock Facilities. [N/A]. 10 May 2013. <http://www.epa.gov/agstar/documents/biogas_recovery_systems_screenres.pdf>

US.EPA (2011) Source of Greenhouse gas emissions: Agriculture Sector Emissions. [N/A]. 15 August 2013. <http://www.epa.gov/climatechange/ghgemissions/sources/agriculture.html>

US.EPA (2011) Source of Greenhouse gas emissions: Commercial and Residential Sector Emissions, [N/A]. 15 August 2013. <http://www.epa.gov/climatechange/ghgemissions/sources/commercialresidential.html>

US.EPA (2011) Source of Greenhouse gas emissions: Industry Sector Emissions. [N/A]. 15 August 2013. <http://www.epa.gov/climatechange/ghgemissions/sources/industry.html>.

UW-Extension. (2001) Anaerobic Digestion and Methane Production. [N/A]. 10 April 2013. <http://bio.uwex.edu/library/documents/ methanepubbw.pdf>

Volbeda, D. (2009) Dairy Manure Anaerobic Digester Feasibility Study Report. Eugene, OR: Essential Consulting Oregon.

Yoo-Sung, P., Chun-Youl, B., Kun-Mo, L., Kyu-Hyun, P. (2011) Life cycle assessment of dairy cow in Korea. Paper presented at Proceedings of EcoDesign 2011: 7th International Symposium on Environmentally Conscious Design and Inverse Manufacturing, 977-978.

APPENDICES

Appendix A Ohio State Farm Dairy

Table A1 The Ohio state farms dairy in 2013

County	Number of farms	Number of cows	Average Cows
Adams	24	3,100	129
Allen	3	700	233
Ashland	147	6,000	41
Ashtabula	64	6,500	102
Athens	9	1,100	122
Auglaize	48	5,200	108
Belmont	21	900	43
Brown	15	800	53
Butler	7	1,400	200
Carroll	57	3,600	63
Champaign	19	1,900	100
Clark	5	2,400	480
Clermont	3	200	67
Clinton	6	100	17
Columbiana	93	9,500	102
Coshocton	78	3,800	49
Crawford	12	1,300	108
Darke	57	7,900	139
Defiance	12	3,800	317
Delaware	9	400	44
Erie	7	500	71
Fairfield	21	1,000	48
Fayette	9	300	33
Franklin	2	300	150
Fulton	9	3,100	344
Gallia	11	600	55
Geauga	65	3,000	46
Greene	8	200	25

County	Number of farms	Number of cows	Average Cows
Guernsey	29	1,500	52
Hamilton	2	300	150
Hancock	7	1,200	171
Hardin	94	6,000	64
Harrison	6	800	133
Henry	12	1,800	150
Highland	24	1,300	54
Holmes	479	17,000	35
Huron	37	3,400	92
Jackson	10	300	30
Jefferson	8	1,800	225
Knox	81	3,500	43
Lawrence	2	200	100
Licking	26	3,500	135
Logan	65	2,300	35
Lorain	23	4,600	200
Madison	13	2,900	223
Mahoning	49	5,200	106
Marion	13	3,300	254
Medina	53	2,700	51
Meigs	12	2,000	167
Mercer	127	20,500	161
Miami	13	1,400	108
Monroe	22	1,400	64
Montgomery	4	500	125
Morgan	12	1,100	92
Morrow	26	1,700	65
Muskingum	19	1,600	84
Noble	3	200	67
Ottawa	1	300	300
Paulding	11	7,800	709
Perry	4	500	125
Pickaway	10	1,400	140
Pike	15	400	27
Portage	18	1,800	100

County	Number of farms	Number of cows	Average Cows
Preble	13	1,700	131
Putnam	21	4,500	214
Richland	139	6,100	44
Ross	9	1,100	122
Sandusky	13	800	62
Seneca	6	700	117
Shelby	63	6,700	106
Stark	89	9,400	106
Trumbull	57	2,900	51
Tuscarawas	97	10,100	104
Union	12	1,200	100
Van Wert	10	3,200	320
Warren	3	100	33
Washington	23	2,400	104
Wayne	415	32,500	78
Williams	6	7,300	1217
Wood	5	1,800	360
Wyandot	11	1,400	127

Table A2 The Northwest Ohio farms dairy in 2013

County	Number of farms	Number of cows	Average Cows
Allen	3	700	233
Defiance	12	3,800	317
Fulton	9	3,100	344
Hancock	7	1,200	171
Henry	12	1,800	150
Ottawa	1	300	300
Paulding	11	7,800	709
Putnam	21	4,500	214
Sandusky	13	800	62
Seneca	6	700	117
Van Wert	10	3,200	320
Williams	6	7,300	1217
Wood	5	1,800	360

Appendix B Life Cycle Impact Assessment

B1 Global warming potential

The result from Gabi 5 simulation from all of five scenarios showed in these figure.

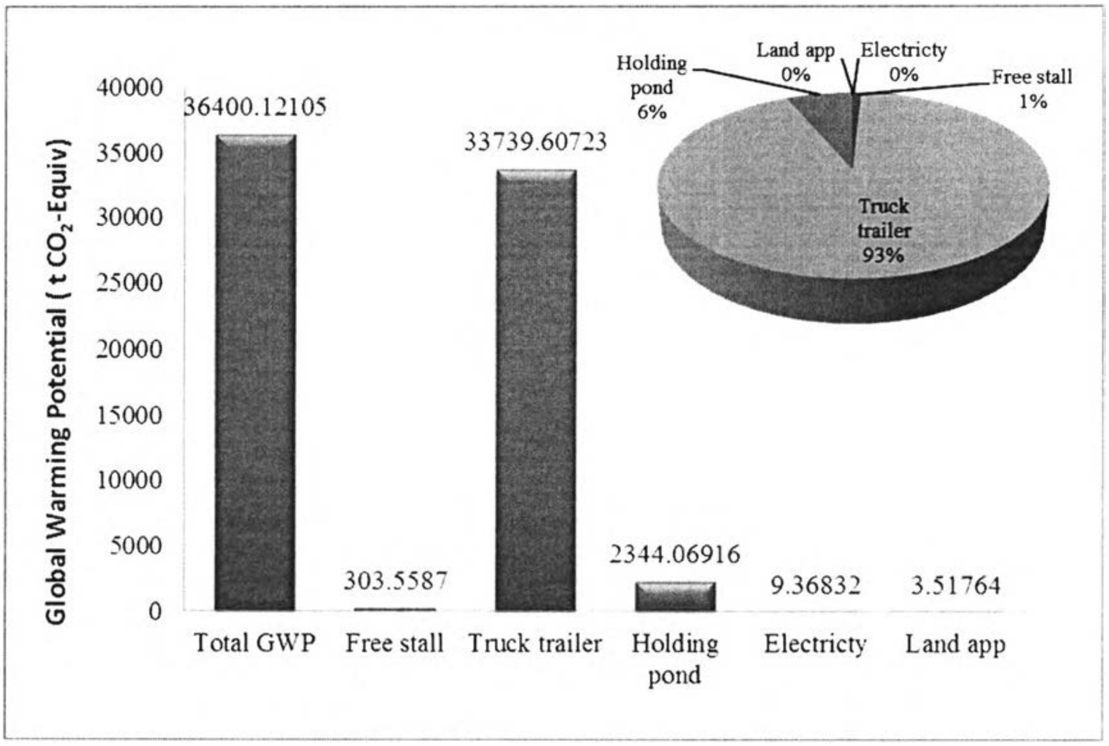

Figure B1.1 Global warming potential for scenario 1A.

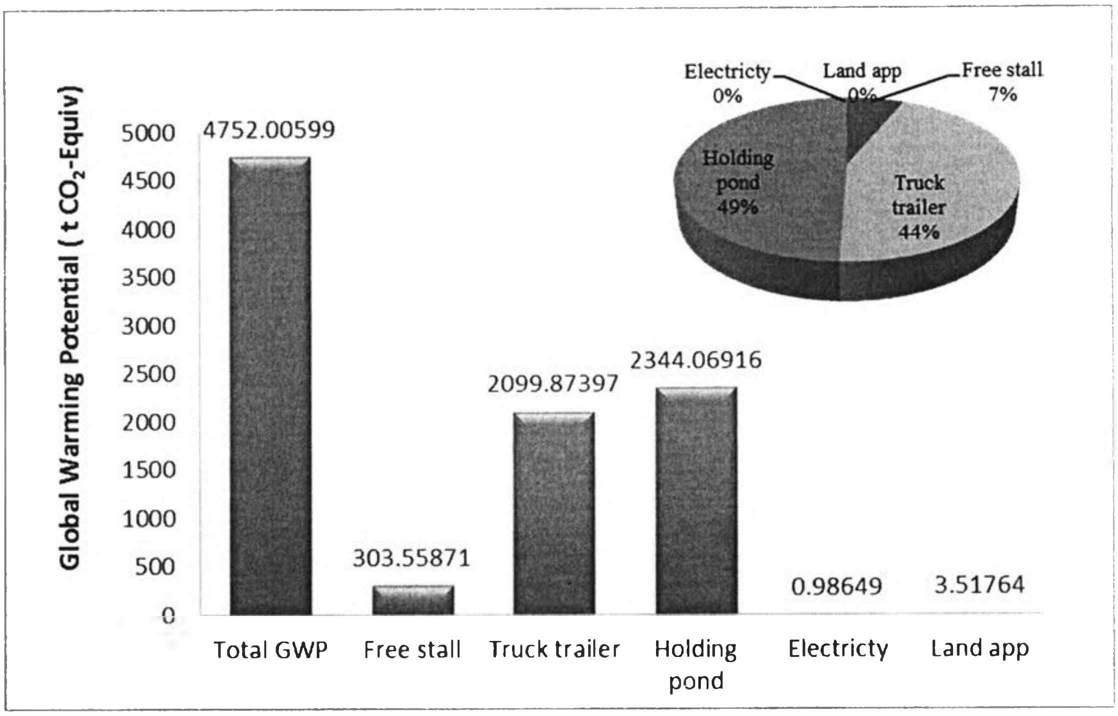

Figure B1.2 Global warming potential for scenario 1B.

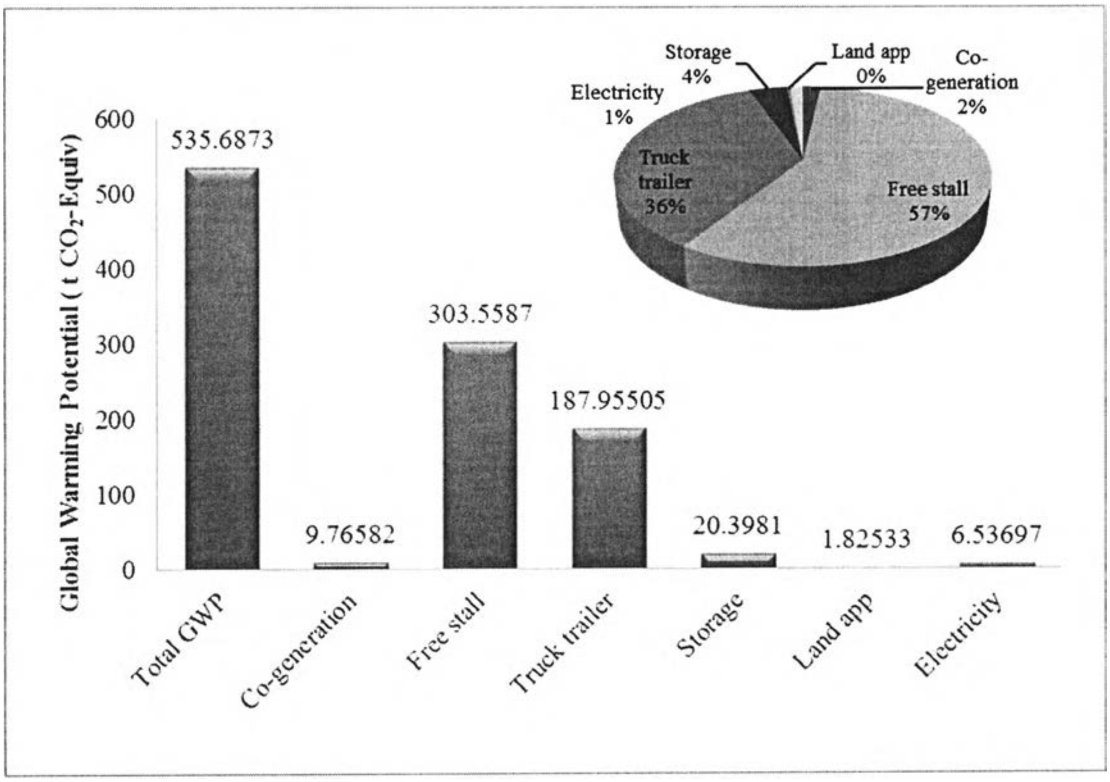

Figure B1.3 Global warming potential for scenario 2.

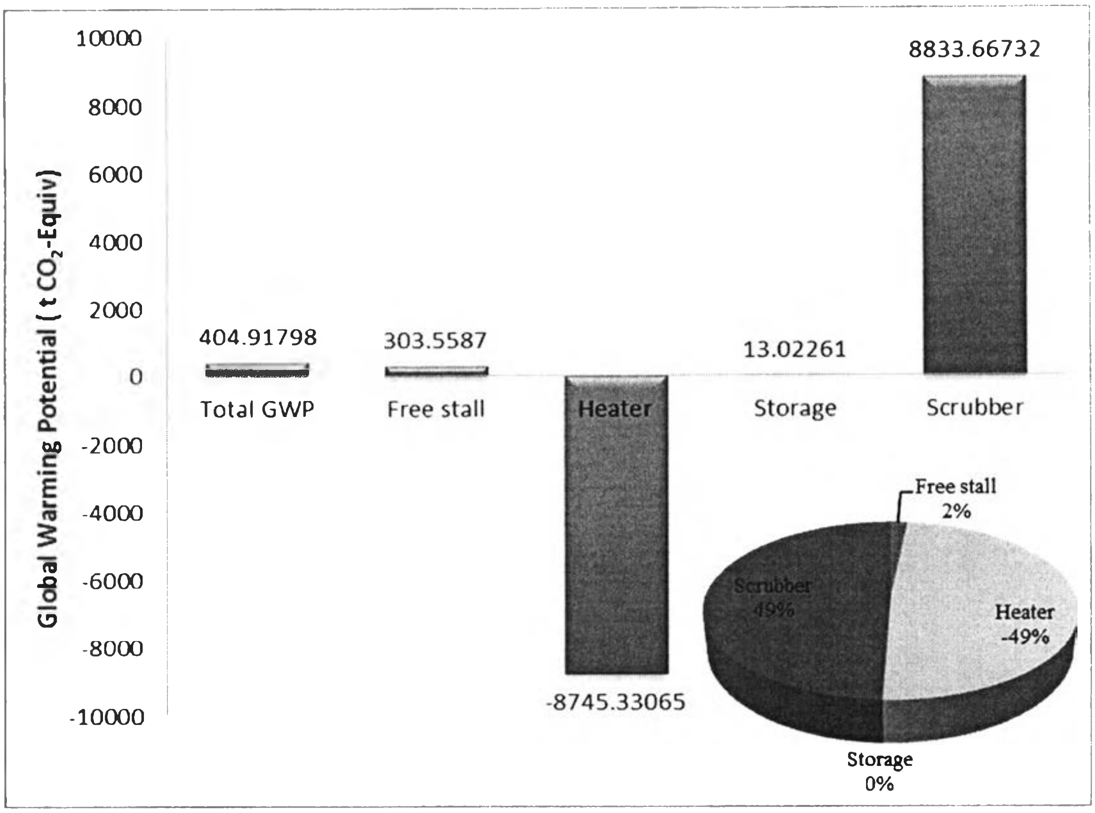

Figure B1.4 Global warming potential for scenario 3A.

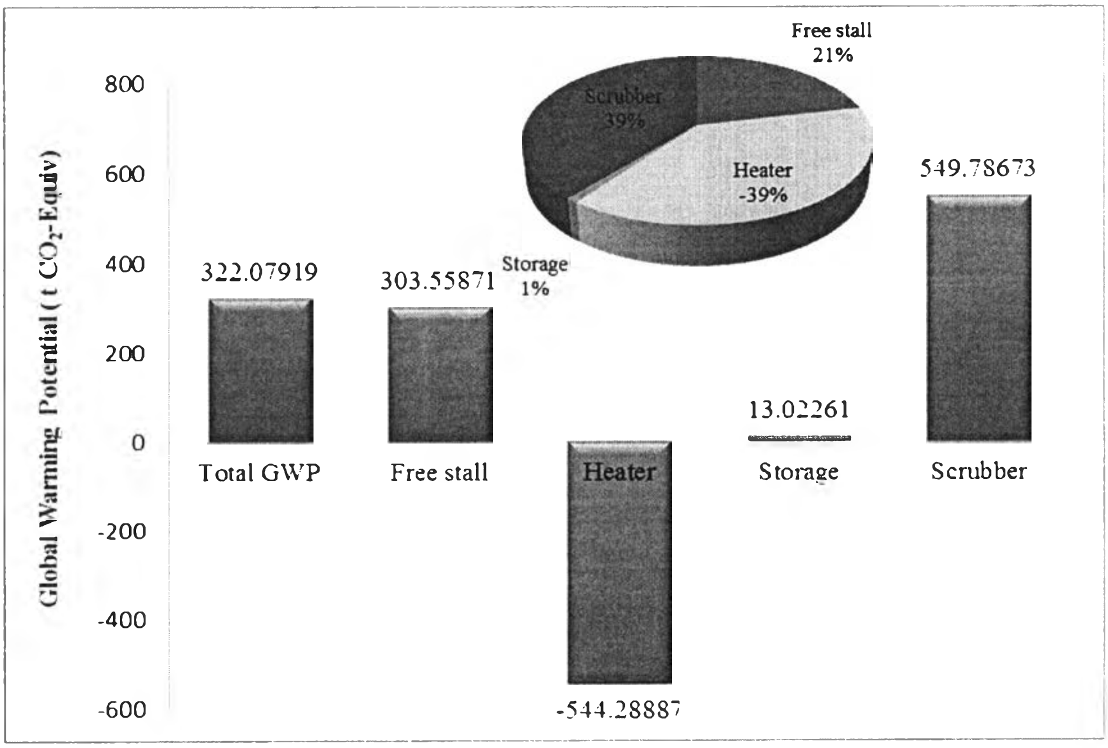

Figure B1.5 Global warming potential for scenario 3B.

B2 Acidification potential

The result from Gabi 5 simulation from all of five scenarios showed in these figure.

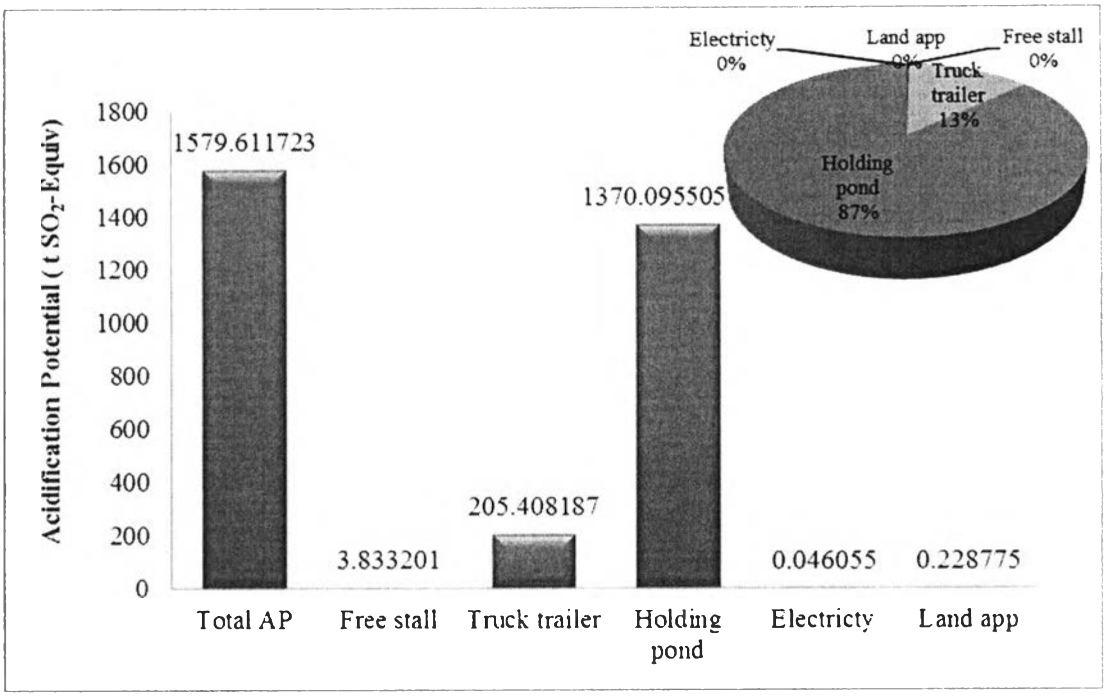

Figure B2.1 Acidification potential for scenario 1A.

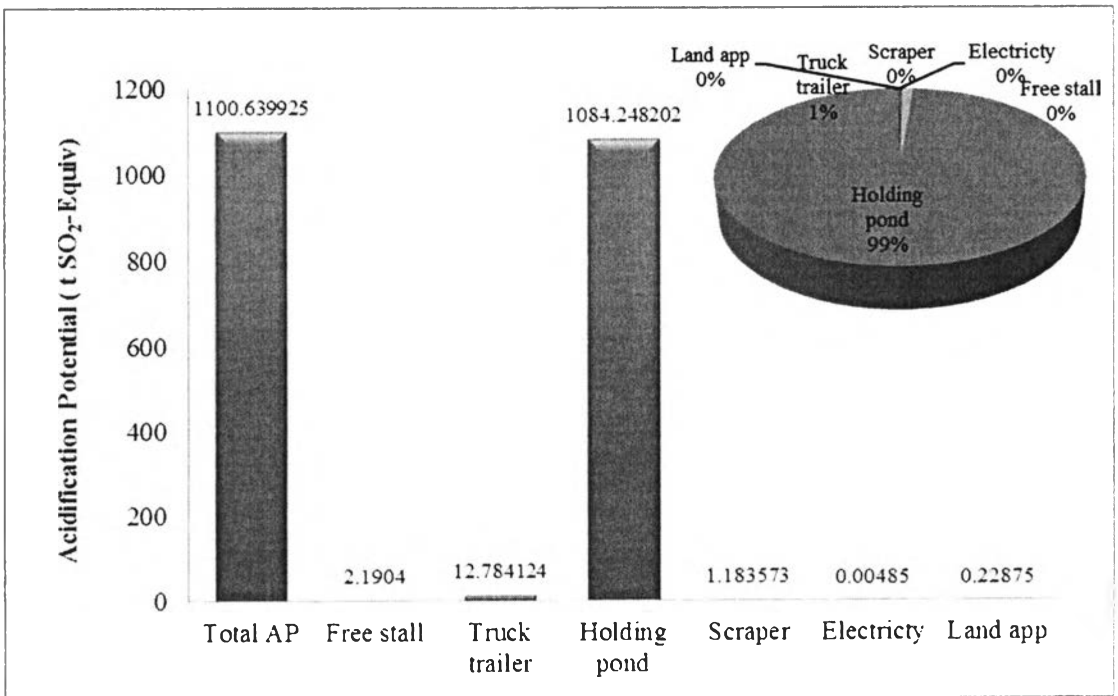

Figure B2.2 Acidification potential for scenario 1B.

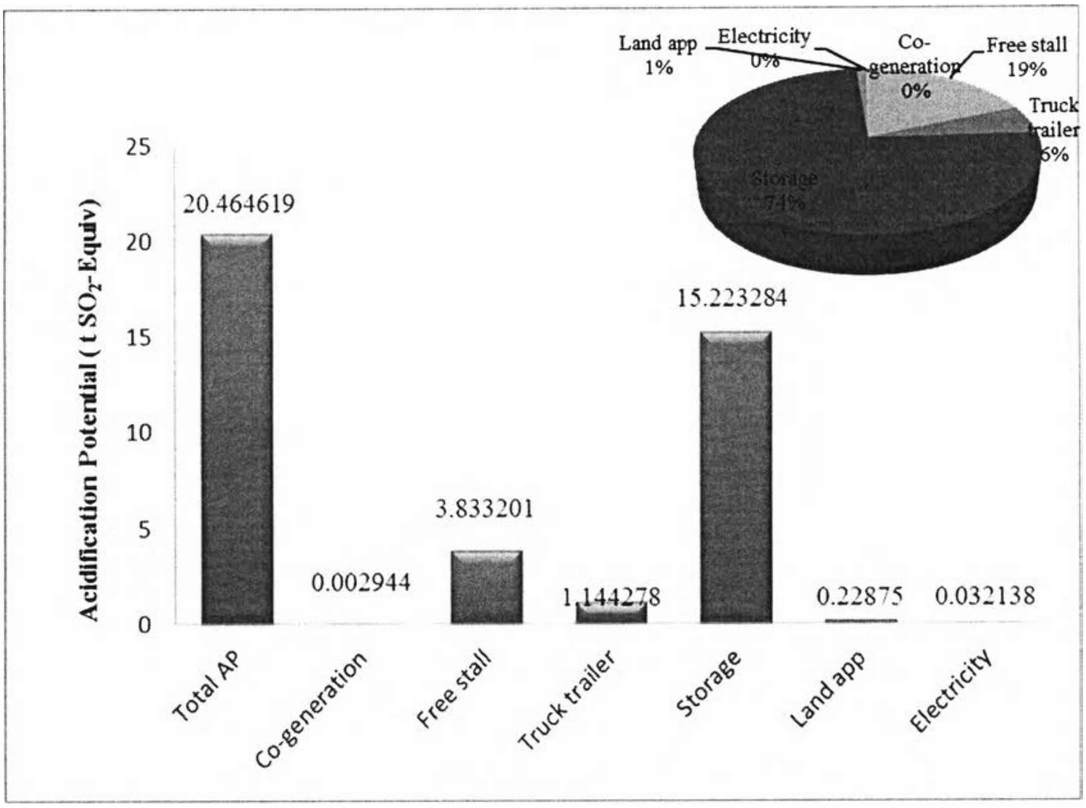

Figure B2.3 Acidification potential for scenario 2.

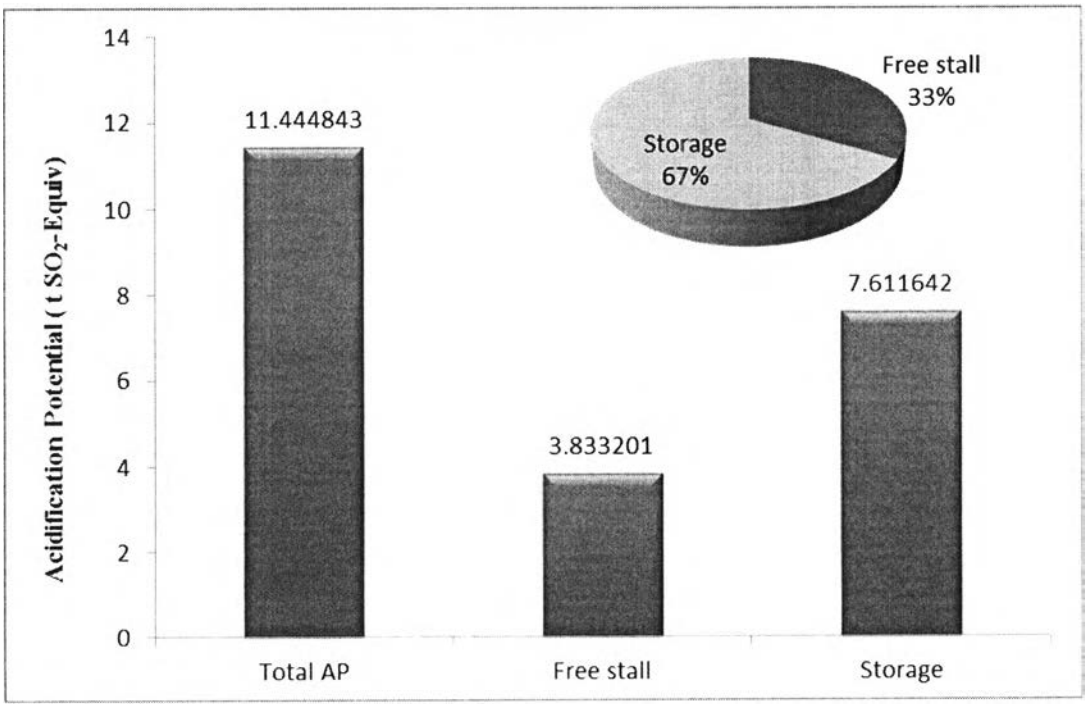

Figure B2.4 Acidification potential for scenario 3A.

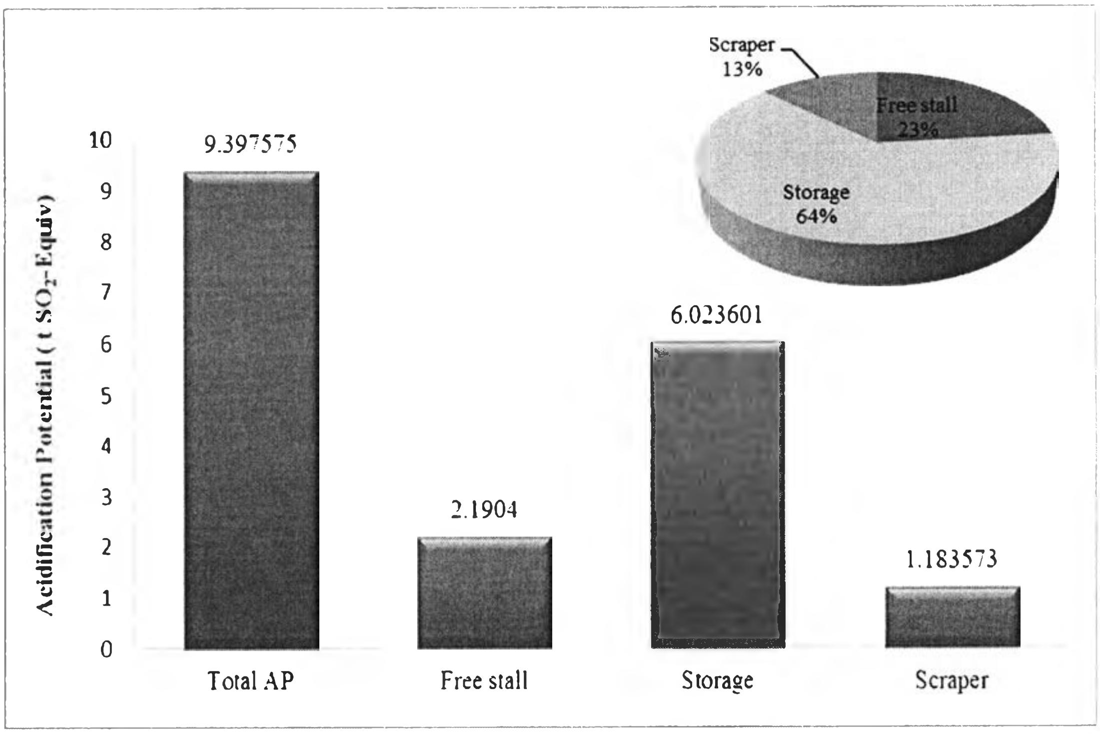

Figure B2.5 Acidification potential for scenario 3B.

Appendix C Calculation

C1 Energy required for the pumps.

$$P = (Q*\gamma*(h_e+h_p)(1+\alpha))/\eta$$

Where : P = Energy delivered to pump [W]

η = combined mechanical and hydraulic efficiency of the pump

Q = flow rate [m^3/s]

γ = specific weight of water [N/m^3]

α = percentage of energy lost to friction

h_e = elevation head provided by pump [m]

hp = pressure head provided by pump [m]

Assumption

$\alpha = 0.3$, $\eta = 0.65$, $h_p = 0$ m, $h_e = 1$ m.

Example flush system free stall 24 hr/day.

$$P = \frac{\left(0.003041\frac{m^3}{s}\right)*\left(9807\frac{N}{m^3}\right)*(1+0\text{ m})*(0.3)}{0.65}$$

P = 59.6383 W

C2 Consumption of gasoline from holding pond to land application.

Assumption of general truck:

Average speed = 66 mph, average consumption (full capacity) = 8 mpg, average consumption (empty capacity) = 11 mpg, load of full capacity = 40 m^3, distance from farm to land application = 5 mile, rate of land application = 500 gal/acere

Example

Load capacity 40 m^3 is equal to $\frac{(40\text{ m}^3)*(5000\text{ gal})}{18.9271\text{ m}^3}$ = 10,566.88 gals

Therefore, 10,566.88 gals is equal 2.11 acres. (use rate of land application ratio 500 gal : 1 acere)

Thus, one truck used 74.93 mile to land application and 5 mile for empty capacity.

Also, to calculate fuel consumption,

For load capacity is equal to $\frac{74.93\ mile}{8\ mile/gal} = 9.3663$ gal

Empty capacity is equal to $\frac{5\ mile}{11\ mile/gal} = 0.4545$ gal

Therefore, total fuel consumption for 1 truck = 9.8208 gal.

C3 Biogas production from anaerobic digester.

Using the ratio; 1000 kg of waste can convert to 102.5 kg of biogas (10.25%) from De Mes, (2003); 72,721.9954 gal/day is equal to 7,454.0045 gal/day or 28.2165 m^3/day. The conversion of energy content of biogas is about 23 MJ/m^3.

From anaerobic digestion can generate 28.2165 m3/day of biogas.

Therefore,total energy content is (28.2165 m^3/day)*(23 MJ/m^3) = 648.9790 MJ

Co-generation system.

Assumption : 1) overall efficiency of gas engine is 70 %
2) 35% results from electric power generation
3) 45% from waste heat recovery
4) 20% heat radiation and others

Thus, total energy content is (648.9790 MJ)*(70%) = 454.2853 MJ/day

Table C3.1 The energy content from co-generation system.

Total Energy from biogas (MJ/day)	35% electric power (MJ/day)	45% heat (MJ/day)	20% heat loss (MJ/day)
454.2853	158.9998	204.4284	90.8571

Energy allocation: Total energy = 454.2853 MJ

$$\text{Electric power} = \frac{158.9998}{454.2853} = 35\%$$

$$\text{Heat} = \frac{204.4284}{454.2853} = 45\%$$

$$\text{Heat loss} = \frac{90.8571}{454.2853} = 20\%$$

C4 Calculated methane emission from land application.

From IPCC 2006 method (Eq 22) :

$$CH_4 \text{ Manure} = \sum T\ E_F(T) * N(T) / 106$$

Where :

CH_4 Manure = CH4 emissions from manure management, for a defined population.

E_F (T) = Emission factor for the defined livestock population, kg CH4/ head year.

N (T) = The number of head of livestock speicies/category T in the country.

T = Species/category of livestock.

From the annual temperature in Ohio State is 10 °C

From Table 10.14 (IPCC 2006); E_F(T) = 48 kg CH_4/ head year

N (T) = 347 head

Thus, CH_4 Manure = [(48 kg CH_4/ head year)*(347 head)]/ 106 = 16,656 kg CH_4/ year

From Table 10A-4 = (Liquid/slurry = 17 % (scenario 1A-1B)) and (Anaerobic digester = 10% (Scenario 2)

So, CH_4 Manure at land application = (16,656 kg CH_4/ year)*(17/100) = 2,831.52 kg CH_4/ year (scenario 1A)

C5 Calculated nitrous oxide emission from land application.

Using IPCC 2006 method Tier 1. Eq 25 Direct N_2O Emissions from Manure Management.

$$N_2O_D(mm)= [Ss[ST(N(T)*Nex(T)*MS(T,s)]*EF3(s)]*(44/28)$$

Where :

N_2O_D (mm) = direct N_2O emissions from manure management in the country, kg N_2O yr^{-1}

$N_{(T)}$ = number of head of livestock species/category T in the country

$Nex_{(T)}$ = annual average N excretion per head of species/category T in the country, kg N $animal^{-1}$ yr^{-1}

$MS_{(T,s)}$ = Fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country, dimensionless.

$EF_3(s)$ = emission factor for direct N_2O emissions from manure management system S in the country, kg N_2O-N/kg N in manure management system S.

S = manure management system.

T = species/category of livestock.

44/28 = conversion of (N_2O-N)(mm) emissions to N_2O(mm) emissions.

From Eq 30 IPCC 2006 method: Annual N excretion rates

$$Nex_{(T)} = Nrate_{(T)}*(TAM/1000)*365$$

Where :

$Nex_{(T)}$ = annual N excretion for livestock category T, kg N $animal^{-1}$ yr^{-1}

$Nrate_{(T)}$ = default N excretion rate, kg N (1000 kg animal $mass)^{-1}$ day^{-1} (see Table 10.19)

$TAM_{(T)}$ = typical animal mass for livestock category T, kg animal^{-1} (see Table 10A-4 to 10A-9 in Annex 10A.2)

From Table 10.19 ; $Nrate_{(T)}$ = 0.44 kg N (1000 kg animal mass)$^{-1}$ day^{-1}
From Table 10A-4 ; $TAM_{(T)}$ = 604 kg animal^{-1}
So, Eq 30
$Nex_{(T)}$ = (0.44 kg N (1000 kg animal mass)$^{-1}$ day^{-1})*(604 kg animal^{-1}/1000)*365
= 97.0024 kg N animal^{-1} yr^{-1}
For eq 25; $N_{(T)}$ = 347
$Nex_{(T)}$ = 97.0024 kg N animal^{-1} yr^{-1}
MS(T,s) = 0.15 (untreated holiding pond (Liquid/slurry)
= 0 (anaerobic digester)
$EF_{3(s)}$ = 0 (uncovered anaerobic lagoon/ liquid slurry)
= 0 (anaerobic digester)
Therefore, eq 25: N_2O_D(mm) = [[(347)*(97.0024)*(0.15)]*0]*(44/28)
= 0 kg N_2O yr^{-1} (untreated holding pond)
= 0 kg N_2O yr^{-1} (anaerobic digester)

For Eq 26 IPCC 2006 method: N Losses due to volatilisation from manure management

$$N_{volatilization\text{-}MMS} = S_s[S_T[(N_{(T)}*Nex_{(T)}*MS_{(T,S)}*(Frac_{GasMS}/100)_{(T,S)}]]$$

Where :
$N_{volatilization\text{-}MMS}$ = amount of manure nitrogen that is lost due to volatilisation of NH_3 and NOx, kg N yr^{-1}
$N_{(T)}$ = number of head of livestock species/category T in the country
$Nex_{(T)}$ = annual average N excretion per head of species/category T in the country, kg N animal^{-1} yr^{-1}

$MS_{(T,s)}$ = fraction of total annual nitrogen excretion for each livestock species/category T that is managed in manure management system S in the country, dimensionless

$Frac_{GasMS}$ = percent of managed manure nitrogen for livestock category T that volatilise as NH3 and NOx in the manure managemennt system S,%

From Table 10.22 (IPCC 2006), $Frac_{GasMS}$ for anaerobic lagoon = 35 %

FracGas$_{MS}$ liquid slurry = 40 %

Daily spread = 7 %

So, $N_{volatilization\text{-}MMS} = (347)*(94.0024\ \text{kg N animal}^{-1}\ \text{yr}^{-1})*(0.125)*(40/100)$

$= 2{,}019.59\ \text{kg N yr}^{-1}$ (untreated holding pond)

$= 0\ \text{kg N yr}^{-1}$ (anaerobic digester)

For Eq 27 IPCC 2006 method: Indirect N_2O emissions due to volatilization of N from Manure Management in the country, kg N_2O yr^{-1}

$$N_2O_{G(mm)} = (N_{volatilization\text{-}MMS}*EF_4)*44/28$$

Where :

$N_2O_{G(mm)}$ = indirect N_2O emissions due to volatilization of N from Manure Management in the country, kg N_2O yr^{-1}

EF_4 = emission factor for N2O emissions from atmospheric deposition of nitrogen on soils and water surface, kg N_2O-N (kg NH_3-N+NO_x-N volatilised)$^{-1}$; default value is 0.01 kg N_2O-N (kg NH_3-N + NO_x-N volatilised)$^{-1}$ = 0.01

Thus, $N_2O_{G(mm)} = (2{,}019.59\ \text{kg N yr}^{-1})*(0.01)$

$= 31.7364\ \text{kg } N_2O\ \text{yr}^{-1}$ (untreated holding pond)

$= 0\ \text{kg } N_2O\ \text{yr}^{-1}$ (anaerobic digester)

Total N_2O emission = Direct N_2O + Indirect N_2O

For untreated holding pond = 0+31.7364 = 31.7364 kg N_2O yr^{-1}

For anaerobic digester = 0+0 = 0 kg N_2O yr^{-1}

CURRICULUM VITAE

Name: Mr. Pairote Longka

Date of Birth: July 4, 1991

Nationality: Thai

University Education:

2008–2012 Bachelor Degree of Chemical Engineering, Faculty of Engineering, King Mongkut's Institute of Tecnology Ladkrabang, Bangkok, Thailand

Work Experience:

April 2010-May 2010

Position: Summer Intern

Company name: Thaiplastic and Chemicals public company limited

February 28-May 31 2013

Position: Summer Intern

Company name: Department of Chemical & Environmental Engineering, University of Toledo, OH, USA

Proceedings:

1. Longka, P.; Malakul, P.; Apul, D.; and Kim, D. (2014, April 22) Optimization and Sustainability of Converting Agricultural Animal Wastes into Biofuels. Proceedings of the 5th Research Symposium on Petrochemical and Materials Technology and the 20th PPC Symposium on Petroleum, Petrochemicals, and Polymers, Bangkok, Thailand.