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POTENTIAL CLIMATE CHANGE MITIGATION OPPORTUNITIES IN WASTE MANAGEMENT SECTOR IN VIETNAM

Background Paper

Prepared by:

RCEE Energy and Environment JSC (Vietnam), and Full Advantage Co., Ltd. (Thailand)

Submitted to the World Bank Carbon Finance Assist Program – Vietnam

May 2009

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Abbreviations and Acronyms

BOD	Biochemical Oxygen Demand
CCM	Climate Change Mitigation
CDM	Clean Development Mechanism
CEETIA	Center for Environmental Engineering in Towns and Industrial Areas
CH_4	Methane
CIDA	Canadian International Development Agency
CMESRC	Center for Marine Environment Survey Research and Consultation
CO_2	Carbon dioxide
COD	Chemical Oxygen Demand
DOC	Degradable Organic Carbon
DONRE	Department of Natural Resources and Environment (city or provincial)
DONRE&H	Department of Natural Resources, Environment and Housing (Hanoi)
DS	Domestic Sewage
DWW	Domestic Wastewater
GHG	Greenhouse Gases
HCMC	Ho Chi Minh City
HEPA	HoChiMinh City Environmental Protection Agency
HSW	Healthcare Solid Waste
ISW	Industrial Solid Waste
IWW	Industrial Wastewater
LFG	Landfill gas
MARD	Ministry of Agriculture and Rural Development
MONRE	Ministry of Natural Resources and Environment
MSW	Municipal Solid Waste
N_2O	Nitrous oxide
NOCCOP	[Vietnam] National Office for Climate Change and Ozone Protection
PDD	Project Design Document
PIN	Project Idea Note
SEV	The State of the Environment in Vietnam
SME	Small and Medium Enterprises
WB	World Bank
WWTP	Wastewater Treatment Plant
URENCO	Urban Environment Company
VEM	Vietnam Environment Monitor
VEPA	Vietnam Environment Protection Agency

1. Brief Description of the Sector

Along with economic growth and improved living standards, waste from households, industries, and commercial/service establishments is expected to increase rapidly over the next years. Managing this waste is a hard challenge for the Government of Vietnam because of its substantial cost and lack of awareness and participation of people and businesses.

Wastes can be classified according to:

- their form (wastewater, solid waste,…),
- their origin (industrial wastes, agricultural wastes, urban (municipal) wastes, …),
- their hazardous nature (non-hazardous, hazardous,…).

The actual and forecasted amounts of waste generated in Vietnam and their sources are presented in Table 1.

Table 1: Waste generation in Vietnam

Type of waste	Source	Amount generated	
		2006	2010
Wastewater (billion m^3)			
Domestic wastewater	Residential, commercial, service	0.97	1.66
Industrial wastewater	Industries	0.40 (2004)	N/A
Solid wastes (million tons)			
Municipal solid waste	Residential, commercial, markets, etc.	15.8	21.0
Industrial solid waste	Industries	2.9	3.2
Healthcare solid waste	Hospitals	0.11	0.13
Agricultural solid waste		68.0	72.0
Livestock waste (million tons)	Animal	56.5	60.7

1.1 Wastewater

Wastewater originates from a variety of domestic, commercial and industrial sources. Domestic wastewater (DWW) is the used water from households, commercial or service establishments, while industrial wastewater (IWW) is from industrial practices only. The main factors causing GHG emissions from wastewater are organic and biodegradable substances.

Table 2: Estimated DWW and IWW generation in Vietnam (in million m3/day)

Year	DWW[1]			IWW
	Total	Urban	Rural	Total
2000	1.45	1.07	0.38	N/A
2006	2.66	2.01	0.65	1.10 (2004)
2010	4.56	3.58	0.98	N/A

Urban centers and industries are largest producers of wastewater. Currently, for the whole country, the total amount of untreated wastewater discharged into the environment is about 1.5 billion m^3 per year (4.1 million m^3/day), of which over 3 million m^3/day are from urban centers and industries[2]. Ho Chi Minh city and Hanoi city are the highest producers of wastewater.

1.1.1 Domestic Wastewater

Domestic Wastewater Generation:

[1] The estimation was based on Vietnam experience that 80-85% of fresh water use returns as wastewater; and domestic wastewater accounts for 60-90% of this amount.

[2] MONRE's website: http://www.monre.gov.vn

Domestic wastewater generation in Vietnam increased from about 1.45 million m^3/day in 2000 to 2.66 million m^3/day in 2006. It is expected to reach 4.56 million m^3/day by 2010.

In 2006, urban domestic wastewater accounted for about 75% of total domestic wastewater generation. It is equivalent to over 2.0 million m^3/day of domestic wastewater, of which Ho Chi Minh City produced more than 0.8 million m^3/day (40% of total) and Hanoi produced 0.38 million m^3/day (19%). The urban domestic wastewater volume is expected to be over 3.5 million m^3/day by 2010 and will account for over 78% of total domestic wastewater in Vietnam.

Organic Content of Domestic Wastewater:

The organic content is the major pollution-related factor of the domestic wastewater. It reduces oxygen content in natural waters and can produce methane under anaerobic conditions.

The forecasted domestic wastewater generation and its BOD loadings by city in 2010 are presented in Table 3.

Table 3: Domestic wastewater generation and BOD loadings by city in Vietnam in 2010

City	City class	Population (thousand person)	Wastewater generation (km3/day)	BOD loadings (ton/day)
HCMC	Special	7,200	1,152.0	288.0
Hanoi	Special	4,100	656.0	164.0
Hai Phong	Class I	2,060	309.0	72.1
Da Nang	Class I	1,000	150.0	35.0
Hue	Class I	400	56.0	14.0
Nam Dinh	Class II	511	51.1	15.3
Thai Nguyen	Class II	480	72.0	14.4
Ha Long	Class II	650	84.5	19.5
Viet Tri	Class II	280	28.0	8.4
Thanh Hoa	Class II	350	35.0	10.5
Vinh	Class II	300	30.0	9.0
Quy Nhon	Class II	350	35.0	10.5
Nha Trang	Class II	550	66.0	16.5
Buon Me Thuot	Class II	400	40.0	12.0
Da Lat	Class II	490	49.0	14.7
Bien Hoa	Class II	645	96.8	19.4
Vung Tau	Class II	350	52.5	10.5
My Tho	Class II	350	35.0	10.5
Can Tho	Class II	1,210	181.5	36.3
36 prov. cities/towns	Class III	3,960	277.2	99.0
674 dist. towns/townlets	Class IV&V	1,968	118.1	39.4
Total		**27,604**	**3,575**	**919.0**

Notes: Estimated BOD generation rates: 40 g/pers/day for special cities; 35 g/person/day for cities of Class I, 30 g/pers/day for cities of Class II; 25 g/pers/day for provincial cities and towns; and 20 g/pers/day for district towns and townlets (The average BOD generation rate is 33 g/pers/day for urban areas).

Domestic Wastewater Treatment and Disposal:

Currently, in urban areas, about 30% of the total domestic wastewater is being treated. In rural areas, the amount of treated domestic wastewater is smaller. The untreated domestic wastewater is directly discharged into sewer systems, rivers and lakes. This causes heavy pollution and environmental degradation in many canals and rivers in the country.

In urban areas, septic tanks, latrines, and the centralized wastewater treatment plants are common technologies used for treatment of the domestic wastewater. In 2004, about 89.6%[3] of urban

[3] World Bank,2008. Economic Impacts of Sanitation in Vietnam. A five-country study conducted in Cambodia, Indonesia, Lao PDR, the Philippines and Vietnam under the Economics of Sanitation Initiative (ESI).

households have access to hygienic septic tanks and latrines. This percentage is expected to reach 99.2% by 2010[4].

Septic tanks (or semi-septic tanks) are mostly used for human waste treatment in urban areas. Most septic tanks are single-chamber type made from brick. Human waste enters the tank, allowing solids to settle and scum to float. The settled solids are anaerobically digested in the tank while scum and liquid component flow directly to the urban sewer system. This type of septic tanks and latrines has low removal efficiency for COD and BOD (20-30% for BOD removal)[5].

In rural areas, the domestic wastewater is treated through open defecation, septic tanks/latrines or direct discharge into the rivers or open ponds. The number of the people having access to hygienic latrines reached 50% in 2004[3]. The target is to achieve 59.8% of rural households having hygienic latrines by 2010[4].

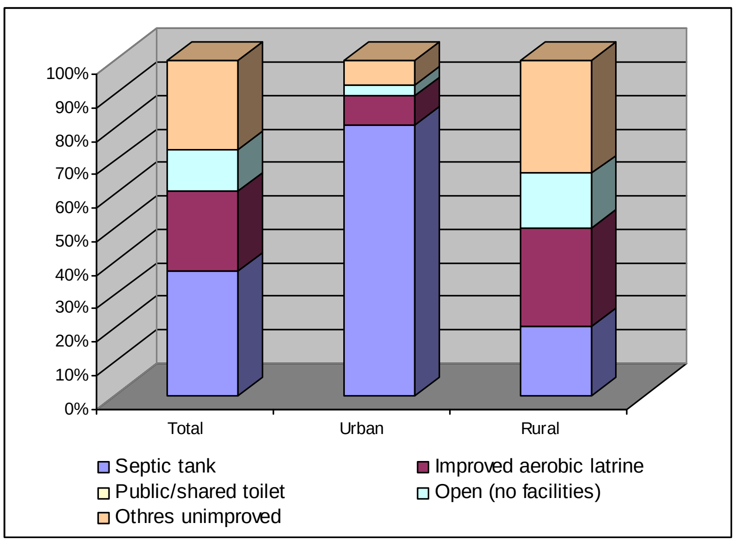
The sanitation types and coverage values (%) in urban and rural areas of Vietnam are showed in Table 4 and Figure 1.

Table 4: Sanitation types and coverage values (in %) in Vietnam (2004)

	Septic tank (Flush/Pour-flush)	Ventilated improved pit latrine, latrine with slab, composting toilet	Public or shared toilet, Pit latrine without slab	Open (no facilities)	Others unimproved	Total
Urban	80.8	8.8	N/A	3.2	7.2	100
Rural	20.5	29.5	N/A	16.3	33.7	100
Total	37.2	23.8	N/A	12.6	26.4	100

N/A: Not Available

Figure 1: Sanitation types used in Vietnam (% of population)



At present, about 10% (i.e. 200,000 m3/day) of urban domestic wastewater is treated in centralized wastewater treatment plants (WWTPs). Hanoi city has three centralized WWTPs with a total capacity of 48,000 m3/day, and Da Nang city has four WWTPs of a total capacity of 89,200 m3/day. Large cities such as Hanoi, Ho Chi Minh City, Hai Phong, Can Tho and Danang have ongoing projects to collect domestic wastewater for treatment. Several other small and medium cities within the country are also planning to build centralized wastewater treatment plants. It is expected that 20% of urban

[4] World Bank, 2006. Water supply and sanitation strategy – Building on a solid foundation.
[5] Nguyen Viet Anh et al. Decentralized wastewater treatment – new concept and technologies for Vietnamese conditions. Proceedings of 5th Specialised Conference on Small Water and Wastewater Treatment Systems. Istanbul, Turkey, 24-26 September 2002.

domestic wastewater (i.e. 720,000 m3/day) will be treated in centralized WWTPs in 2010. Table 5 lists down the centralized wastewater treatment plants (existing, under construction or being developed) in large cities/towns of Vietnam.

Table 5: Existing and underway centralized WWTPs in large cities/towns in Vietnam

City/Town	Name of plant	Capacity (m3/day)	Owner/Developer/Sponsor	Status
Hanoi	Van Tri	42,000	Hanoi URENCO	In operation
Hanoi	Truc Bach	2,300	Hanoi URENCO	In operation
Hanoi	Kim Lien	3,700	Hanoi URENCO	In operation
Hanoi	Yen So[6]	200,000	Gamuda Corporation (Malaysia)	Under construction (completion 2010)
Hanoi	Yen Xa, Phu Do	346,000	Nippon Koei and VIWASE (VN)	Feasibility study
Ho Chi Minh[7]	Binh Hung	141,000 (Phase 1) 371,000 (Phase 2)	Ho Chi Minh city URENCO	Under construction (phase 1 completed Jan 2009)
Ho Chi Minh	-	-	Wijaya Baru Global Bhd (Malaysia)	Feasibility study
Ho Chi Minh	-	-	SFC Umwelttechnik Gmbh (Austria) and Phu Dien and Hoang Gia Co., Ltd. (VN)[8]	Feasibility study
Da Nang[9]	4 plants	89,200	Da Nang city/World Bank	In operation
Ha Long	1 plant (Hon Gai)	7,000	Ha Long city/World Bank	In operation
Nha Trang[10]	2 plants	22,890 (Phase 1) 77,340 (Phase 2)	Nha Trang city/World Bank	2010 (Phase 1) 2020 (Phase 2)
Quy Nhon	3 plants	10,470 (Phase 1) 44,560 (Phase 2)	Quy Nhon city/World Bank	2010 (Phase 1) 2020 (Phase 2)
Dong Hoi	1 plant	4,340 (Phase 1) 8,570 (Phase 2)	Dong Hoi city/World Bank	2010 (Phase 1) 2020 (Phase 2)
Hoi An[11]	-	6,700	Quang Nam province	Feasibility study

The technology currently used in domestic wastewater treatment plants (Truc Bach and Kim Lien WWTPs in Hanoi) is activated sludge (aerobic fluidized bed). The process flow diagram of this technology is shown in Figure 2.

[6] Website: http://tmmt.gov.vn
[7] This project will be implemented in two phases. The capacity of phase 1 is 141,000 m3/day completed in January 2009. Phase 2 will increase to 512,000 m3/day completed after 2010.
[8] HEPA's website: http://www.hepa.gov.vn
[9] World Bank, 1999. Project Appraisal Document of Three Cities Sanitation Project
[10] World Bank,2006. Project Appraisal Document of Coastal Cities Environmental Sanitation Project
[11] Website: http://www.mientrung.com

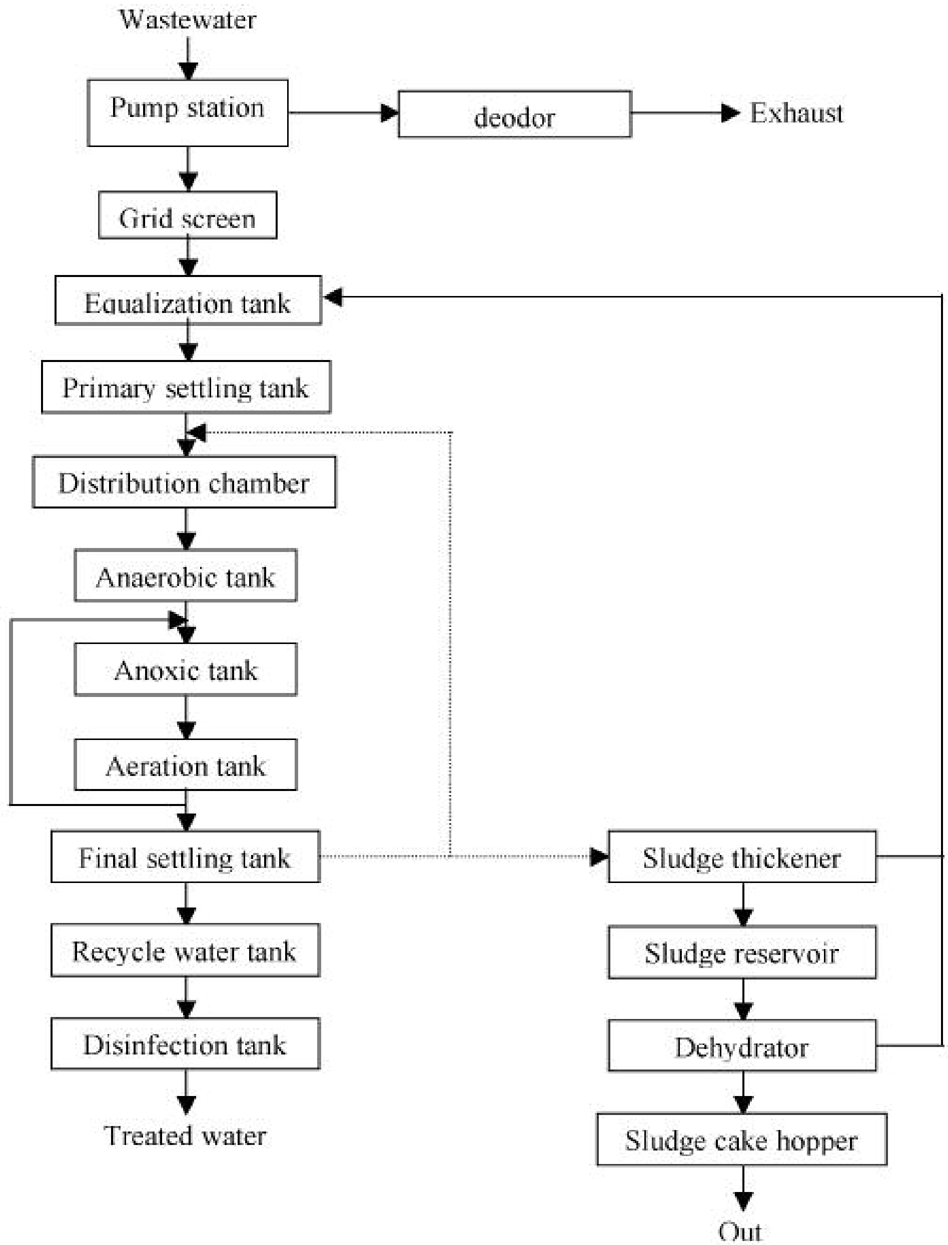


Figure 2: Process flow diagram of Truc Bach and Kim Lien WWTPs in Hanoi

1.1.2 Industrial wastewater

Industrial wastewater generation:

The surveys conducted by MONRE and World Bank showed that the total industrial wastewater generated in three largest river basins in Vietnam was 910,000 m3/day in 2004 (Table 6). As these surveys cover only 23 cities and provinces, the industrial wastewater generated in the whole of Vietnam should be higher. However, as the largest producers of industrial wastewater were included in the surveys, it is estimated that the surveyed areas represented 80-90% of Vietnam's industrial wastewater generation. Thus, the total industrial wastewater generation would be estimated at about 1,100,000 m3/day.

Table 6: Industrial wastewater generation in 2004[12]

River basin	Cities/provinces included	Main IWW sources	Amount generated (m3/day)
Cau river basin (6 provinces)	Bac Kan, Thai Nguyen, Vinh Phuc, Bac Giang, Bac Ninh and Hai Duong	Paper production; mining and ore exploitation; metallurgy and steel industry; craft villages.	109,000
Nhue-Day river basin (6 provinces)	Hoa Binh, Hanoi, Ha Tay, Ha Nam, Nam Dinh and Ninh Binh	Food & beverage; chemical & chemical products; textile industry, craft villages.	321,000
Dong Nai-Sai Gon river basin (11 provinces)	Lam Dong, Binh Phuoc, Binh Duong, Tay Ninh, Dong Nai, Ho Chi Minh city, Ba Ria-Vung Tau, Ninh Thuan, Binh Thuan, Dak Lak and Long An	Industrial zones and craft villages	480,000
Total			910,000

The industrial wastewater generation varies from one province to another, depending on the level of industry development. The industry-intensive cities and provinces in the South Eastern region (HCMC, Binh Duong, Dong Nai, Ba Ria-Vung Tau, etc.) and in the Red River Delta region (Ha Noi, Vinh Phuc, Ha Tay, Hai Phong, etc.) share the majority of industrial wastewater generated in Vietnam. A recent study conducted by the World Bank[13] showed that the top 10 BOD-intensive industries in Vietnam are:

- Food and beverages (FOO);
- Paper and paper products (PAP);
- Publishing, printing & recording (PUB);
- Tanning & dressing of leather; manufacture of leather products (LEA);
- Basic metal (BMT);
- Wood & wood products;
- Chemical & chemical products (CHE);
- Non-metallic mineral products (NMT);
- Fabricated metal products, except machinery & equipment (FMT);
- Coke & refined petroleum products (CAP).

The total BOD emissions from industries was estimated at 66,700 tons in 2004. With an annual growth of 3.1-6.0%, it is projected that the total BOD emissions from industries will reach 158,500 tons by 2015. The BOD emissions from the top 10 BOD-intensive industries are presented in Table 7.

Table 7: BOD emissions by industry (WB data)

Industry type	BOD emissions (ton/yr)		
	2004	2010[14]	2015
FOO	39,000	62,460	82,000
PAP	15,000	25,910	35,000
PUB	6,000	16,360	25,000
LEA	2,000	3,640	5,000
BMT	2,000	3,640	5,000
WOD	1,000	1,820	2,500
CHE	1,000	1,270	1,500
NMT	500	770	1,000
FMT	100	590	1,000
CAP	100	320	500
Total	**66,700**	**116,780**	**158,500**

[12] The State of Environment in Vietnam 2005 (MONRE), and Vietnam Environment Monitor 2006 (World Bank, MONRE and DANIDA) .
[13] World Bank,2008. Industrial Development and Environmental Management in Vietnam.
[14] Estimated by interpolation

The data presented in Table 7 were calculated based on the experience from South Korea. As these values are rather low[15], the emissions of organic matter from industries will be calculated based on their annual production, wastewater generation per unit of industrial product and the organic content in wastewater. Table 8 presents the estimated COD emissions from 15 COD-intensive industries in Vietnam.

Table 8: COD emissions by industry (calculated)

Industry type	Output of industry[16] (ton/yr)		COD[17] content (mg/l)	COD[18] emission rate (kg/ton of output)	COD emissions (ton/yr)	
	2006	2010			2006	2010
Liquor	290,000	380,000	11,000	264.0	76,560	100,320
Beverage	800,000	1,100,000	5,000	100.0	80,000	110,000
Beer	1,548,000	2,500,000	2,900	18.3	28,328	45,750
Canned milk	100,860	150,000	2,700	18.9	1,906	2,835
Fish processing	2,604,350	3,150,000	2,500	25.0	65,109	78,750
Meat processing	2,800,000	6,500,000	4,100	53.3	149,240	346,450
Petroleum refinery	0	6,500,000	1,000	0.6	0	3,900
Plastics and resins	2,271,700	3,561,800	3,700	2.2	4,998	7,836
Paper	997,400	1,450,000	1,500	75.0	74,805	108,750
Paper pulp	399,000	1,000,000	2,000	140.0	55,860	140,000
Soap	531,100	700,000	1,000	9.0	4,780	6,300
Tapioca starch	1,000,000	1,200,000	10,000	90.0	90,000	120,000
Sugar mill	1,032,000	1,400,000	3,200	14.4[19]	14,861	20,160
Vegetable oil refinery	415,000	500,000	1,000	3.1	1,287	1,550
Bioethanol production	0	240,000		807.5	0	193,800
Total					**647,734**	**1,286,401**

Industrial wastewater treatment and disposal:

Currently, only 30-40% of the total national industrial wastewater is being treated. In HCMC, a largest producer of industrial wastewater, about 40% of generated industrial wastewater is being treated. Among 183 export processing zones and industrial parks operating in Vietnam, only 55 (30%) have wastewater treatment systems[20]. Untreated industrial wastewater is being discharged directly in the rivers that are already highly polluted.

The chemical and aerobic technologies are mostly being used for treatment of industrial wastewater of the industrial zone. The anaerobic treatment technology is used in some industries such as sugar mills and tapioca factories. Typical technology used for wastewater treatment in the industrial zones is shown in Figure 3.

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[15] If the total BOD emissions from the top 10 BOD-intensive industries in 2004 were 66,700 ton/yr (as in Table 7) and the wastewater generation was 1,100,000 m3/day (i.e. 401,500,000 m3/yr), the average BOD concentration of industrial wastewater would be 166.1 mg/l only, which seems abnormally low.

[16] The data on outputs of industries in 2006 are mainly from the 2007 Vietnam Statistical Yearbook. The data for 2010 are from various sector development plans.

[17] The data on COD content of industrial wastewater are from 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Volume 5: Waste). Some of these IPCC defaults were cross-checked with the some respective ones published in Vietnam.

[18] These value are calculated based on default values of wastewater generation (m3/ton of product) given in 2006 IPCC Guidelines.

[19] Not included molasses

[20] “Tuoi Tre” Newspaper, October 9, 2008.

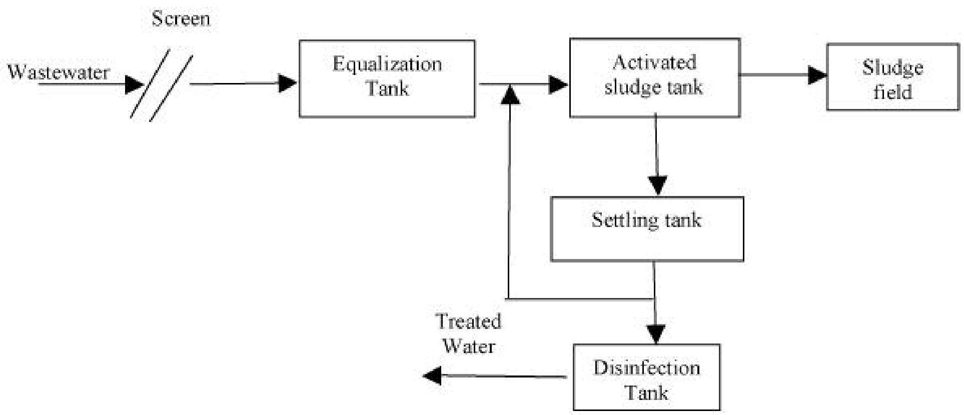

Figure 3: Process flow diagram of typical wastewater treatment plant at an industrial zone

1.2 Solid wastes

Solid wastes in Vietnam are commonly grouped into four categories:

- Municipal waste;
- Industrial waste;
- Healthcare waste;
- Agricultural waste.

The actual amounts of solid wastes generated in Vietnam are summarized in Table 9.

Table 9: Solid waste generation in 2006

Type	Amount (million tons/yr)
Municipal solid waste	15.8
Industrial solid waste	2.9
Healthcare solid waste	0.11
Agricultural solid waste	68.0

1.2.1 Municipal solid waste

Municipal solid waste (MSW) in general includes waste generated in households, commercial establishments, institutions, and market waste.

MSW generation:

Vietnam's MSW production was estimated at about 5.9 million tons (19,300 ton/day) in 1997[21], and 12.8 million tons (35,000 ton/day) in 2003[22]. Cities are the major generators of municipal waste. Urban areas contain only 26% of the country population but produced about 50% of the total municipal waste in 2003. MSW is expected to reach 21 million tons (57,500 ton/day) by 2010, of which 63% would be generated in urban areas[(8)].

In 2006, HCMC generated about 6,100 ton of MSW per day, accounting for 25.5% of total MSW production in Vietnam, while Hanoi produced a total of 3,220 ton of MSW per day, or 13.5% of total country MSW generation. MSW generation in HCMC increases at a rate of about 10-11% per year. It is expected to reach 9,360 ton/day by 2010. The MSW generation in Hanoi increases at a rate of 15% per year. It would reach 5,740 ton/day by 2010.

The per-capita MSW generation rates are presented in Table 10. The growth rate in MSW generation is high, especially in urban areas due to urbanization, increased per-capita income/consumption, and population growth.

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[21] SEV, 2001. VEPA website: http://www.nea.gov.vn
[22] World Bank, MONRE and CIDA. Vietnam Environment Monitor, 2004

Table 10: The per-capita MSW generation rates in Vietnam (kg/person/day)

	1997	2003	2010
Whole Vietnam	0.25	0.43	0.65
Urban areas	0.52	0.84	1.26
Rural areas	0.16	0.29	0.38

Table 11 presents the estimated MSW generation by city in Vietnam for years 2006 and 2010. The estimation was based on population growth and expected MSW generation rates in different cities/towns according to their urban class.

Table 11: MSW generation by city, town and townlet in Vietnam

Name of city	City class[23(1)]	Population (thousand person)		MSW generation (ton/day)	
		2006	2010	2006	2010
HCM City	Special	6,106	7,200	6,720	9,360
Hanoi City	Special	3,217	4,100	3,220	5,740
Hai Phong City	Class I	1,803	2,060	1,800	2,680
Da Nang City	Class I	788	1,000	790	1,300
Hue City	Class I	346	400	310	480
Nam Dinh City	Class II	295	511	240	610
Thai Nguyen City	Class II	290	480	230	580
Ha Long City	Class II	498	650	450	780
Viet Tri City	Class II	168	280	140	340
Thanh Hoa City	Class II	200	350	160	420
Vinh City	Class II	260	300	210	360
Quy Nhon City	Class II	260	350	210	420
Nha Trang City	Class II	400	550	360	660
Buon Me Thuot City	Class II	340	400	270	480
Da Lat City	Class II	200	490	160	590
Bien Hoa City	Class II	549	645	490	770
Vung Tau	Class II	290	350	230	420
My Tho	Class II	234	350	190	420
Can Tho City	Class II	1,140	1,210	1,030	1,450
36 cities and towns	Class III	3,600	3,960	2,880	4,360
674 towns and townlets	Class IV&V	1,806	1,968	1,260	1,770
Total		**22,790**	**27,604**	**21,350**	**33,990**

Nineteen special, national and regional cities generated 81.0% of total country MSW in 2006. This figure is expected to decrease to 76.8% in 2010.

By 2010, five cities (HCMC, Hanoi, Hai Phong, Da Nang and Can Tho) will generate more than 1,000 ton/day, six (Nam Dinh, Thai Nguyen, Ha Long, Nha Trang, Da Lat and Bien Hoa) cities will generate 500 to 1,000 ton/day, eight cities will generate 300 to 500 ton/day, and 36 provincial cities will generate 100 to 150 ton/day. The dumping sites for these 19 cities with a MSW generation of 300 ton/day and above are potential sites for LFG recovery projects while 36 provincial cities with a MSW generation of 100-150 ton/day may be potential sites for composting projects that may also qualify as CDM projects.

MSW Composition:

Municipal waste from households, markets, and business in rural areas contains a large proportion (60-75%) of easily degradable organic waste. In urban areas, such biodegradable waste is produced in lower quantities (approximately 50% of MSW). The change in consumption patterns and products is accompanied by a larger proportion of hazardous waste and non-degradable waste, such as plastic, metals, and glass.

[23] Urban/city classification in accordance with the Government's Decree No. 72/2001/ND-CP of October 5, 2001 on the classification of urban centers and urban management levels

MSW Collection and Transportation:

MSW management falls under the jurisdiction of several governmental bodies at national, provincial and municipal levels. There is no unified or standardized system for waste collection, thus waste collection rates and efficiency vary from one city to the other, depending on adequacy of waste management, facility and human resource availability, etc.

Average MSW collection rates are improving, but remain low in many cities. The national average collection rate of MSW in urban areas rose from 65% to 72% between 2000 and 2004. Collection rates are typically higher in larger cities than in smaller cities.

The method of waste collection and transportation varies from one place to another. In urban areas, citizens usually collect their waste in the plastic bag and place it in front of their dwelling for URENCO employees to pick up a few times daily. The trash is transported by handcarts or small motored trucks that the URENCO collectors move from one house to another. When the handcarts or small trucks are full, they are moved to a designated transfer station where bigger waste trucks take the waste to the nearest dumpsite of landfill. In places, where there are no transfer points, residents are provided with the communal containers and are responsible for disposing their waste into these containers. The URENCO trucks will come daily to unload the communal containers and transport the waste to the dumpsites.

In general, most MSW is not sorted at the source or at the transfer points. Regardless of the type of waste being collected (domestic, industrial, healthcare, hazardous or non-hazardous,…), it is all disposed of in the same landfill.

MSW Disposal:

Some part of MSW is recovered and recycled. No information is available on the amount of MSW recycled at the national level. However, it seems like approximately 20% of Hanoi MSW was recycled in 2003.

MSW handling (collection, treatment and disposal) in Vietnam is mainly carried out by public URENCOs, which are responsible for the collection and disposal of municipal waste, including domestic, institutional, and in most cases also industrial and healthcare wastes.

There are 91 landfills located throughout Vietnam, but only 17 are engineered and sanitary landfills (VEM 2004). The largest engineered and sanitary landfills in Vietnam are listed in Table 12. Open and controlled dumping areas are the dominant form of MSW disposal in Vietnam. Only 12 out of 64 cities and provincial capitals have engineered or sanitary landfills. Most of them do not have the necessary ground linings or adequate top covers; many of them are located within 200-500 meters of residential areas. Many landfills and dumpsites are poorly operated, posing an enormous health threat to local populations due to ground and surface water contamination from untreated leachate. These also result in increased GHG emissions to the atmosphere.

Table 12: Largest engineered and sanitary landfills in Vietnam

No.	Name of landfill	Location	Area (ha)	Designed Capacity (mil. tons)	Actual receivability (ton/day)	Status
1.	Dong Thanh	HCMC	40	8.0	-	Closed (2001)
2.	Phuoc Hiep 1	HCMC	20	3.0	-	Closed (2006)
3.	Go Cat	HCMC	25	4.9	-	Closed (2007)
5.	Phuoc Hiep 2	HCMC	98	-	3,000	Operating
6.	Da Phuoc	HCMC	128	-	3,000	Operating
7.	Me Tri	Hanoi	N/A		-	Closed (2001)
8.	Tay Mo	Hanoi	N/A		-	Closed
9.	Nam Son	Hanoi	83	15.0	2,500	Operating
10.	Lam Du	Hanoi	14	-	1,000	Operating
10.	Thuong Ly	Hai Phong	N/A		-	Closed
11.	Gia Minh	Hai Phong	N/A		-	Closed
12.	Trang Cat	Hai Phong	60		800	Operating

13.	Khanh Son 1	Da Nang	N/A			Closed (2006)
14.	Khanh Son 2	Da Nang	50	6.0	700	Operating
15.	Dong Thanh	Can Tho	4.7	0.27	-	Closed (2005)
16.	Tan Long	Can Tho	20		350	Operating

Source: websites of different public media in Vietnam

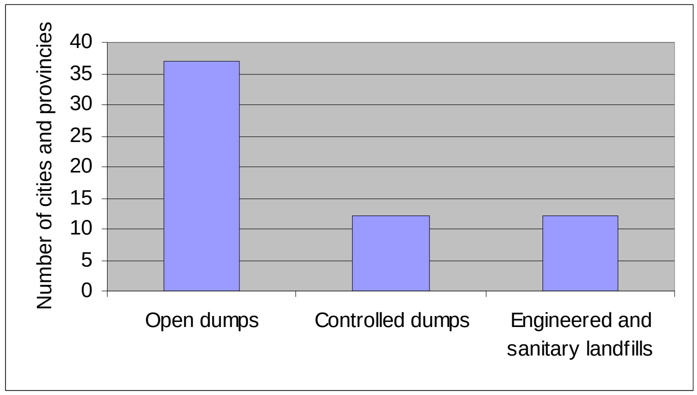

Figure 4: Number of Waste Disposal Facilities by type (VEM, 2004)

Self-disposal is common in areas with no collection and disposal services (VEM 2004). Households (usually, the poor) that do not have access to collection and disposal services use their own means of waste disposal. The waste is often dumped in nearby rivers or lakes, or discarded at sites near houses. Other methods of self-disposal include burning or burying waste. All of these methods cause serious environmental damage, endanger human health and increase GHG emissions due to uncontrolled decay of waste in open air.

In recent years, modern technologies are employed for MSW treatment.

- **LFG recovery:** This technology is currently used for only one sanitary landfill, Go Cat, located outside of HCMC. The landfill covers 25 hectares with a total amount of waste of 4.9 million tons accumulated in place until its closing in 2007. It also includes a system for collecting and treating leachate. The LFG recovered is used for powering 3 gas engines with a total capacity of 2.43 MW.
- **MSW composting:** A few centralized composting facilities are currently operated in Vietnam. However, the combined capacity of these composting facilities is less than 1,000 ton/day that accounts for less than 5% of current amount of MSW generated in the whole of Vietnam.
- **Incinerating MSW** is not a common practice in Vietnam. This technology is being used for treatment of healthcare solid waste only.

According to Vietnam's strategy for solid waste management until 2020[24], the MSW disposal practices will be improved with sanitary landfill, biological treatment and incineration becoming the main methods for MSW treatment. The percentages of MSW treated by each method in 2010 and 2020 are presented in Table 13.

Table 13: Strategic objectives to 2020 for MSW management in Vietnam (in % of generated MSW)

Used technology	Special and Class I cities		Class II & Class III cities		Class IV & Class V cities and towns	
	2010	**2020**	**2010**	**2020**	**2010**	**2020**
Controlled Sanitary landfills	40-50	40-50	60-65	60-65	55-60	55-60
Biological treatment	10-15	20-25	20-25	20-25	25-30	25-30
Incineration	10-15	15-20	2-4	4-8	2	4-5
Other	2-5	5-10	2	4	2	4

[24] N.T.K. Thai, 2005.

1.2.2 Industrial solid waste

Industrial solid waste generation:

Industrial solid waste is generated by manufacturing or industrial processes such as construction, fabrication, light and heavy manufacturing, refineries, chemical plants, demolition plants, power plants, , etc. In Vietnam, industrial solid waste is classified into two groups: (i) industrial non-hazardous waste (e.g. paper, cardboard, plastics, metal, wood, glass, etc.); and (ii) industrial hazardous waste (e.g. consumer electronics, batteries, oil, tires, chemicals, etc.).

In 1997, Vietnam's industrial solid waste amounted to about 1.48 million tons. This figure was 2.64 million tons in 2003, of which industrial non-hazardous waste accounted for 95.1%, industrial hazardous waste for 4.9%. The total industrial solid waste is projected to be 3.2 million tons by 2010 (8,770 ton/day)[25].

Industrial solid waste is mainly concentrated in the South. Nearly half of the Vietnam industrial solid waste is produced in the South East region. In 2007, HCMC, the main city in this region, generated 1,800 ton/day accounting for 23% of the total industrial solid waste generated in Vietnam[26]. Hanoi produced about 1,100 ton/day of industrial solid waste that accounts for 14% of the whole country's production[27].

Industrial solid waste composition:

The average composition of industrial solid waste is very different from the average composition of municipal solid waste. It also varies by type of industry. However, many types of waste can be included in both industrial and municipal solid wastes.

No data is available on the composition of ISW generated in Vietnam.

ISW Disposal:

At least 80% of industrial non-hazardous waste is recycled and reused. The remaining part (about 20%) is mixed and dumped along with municipal solid waste[28].

Most industrial hazardous wastes generated from larger industries are either treated on-site by simple furnaces or industrial boilers, or by specialized small private enterprises, which recycle part of the waste and use cheap, locally made furnaces. As a result, the risk of posing an additional environmental threat from air emissions and ash is quite high. For SMEs, there are even fewer options for proper treatment of industrial hazardous waste. The lack of combined treatment facilities has led industries, especially SMEs, to practice a variety of unsafe methods of treatment and disposal, including co-disposal with municipal solid waste, storage onsite, or sale to recyclers.

1.2.3 Healthcare solid waste (HSW)

The total amount of healthcare solid waste generated in Vietnam is rather small. It was 107,500 tons in 2003, of which about 20% (21,500 tons) were considered hazardous. The hazardous healthcare waste is expected to reach 25,000 tons (68.5 ton/day) by 2010[(12)].

Healthcare solid waste is mainly generated from hospitals and clinics. It includes non-hazardous (paper, foods, plastic bags, etc.) and hazardous (tissue samples, blood, used syringes, etc). There is limited data on the HSW composition. The organic content of HSW is around 52.9%, with an average bulk density of 150 kg/m3; a moisture content of 42% and a calorific value of 2,150 kcal/kg.

The major part of healthcare solid waste is currently burned in modern waste incinerators. The remaining part, including paper, wasted foods, plastics, is disposed in landfills.

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[25] Vietnam Environment Monitor 2004. World Bank, MONRE and CIDA
[26] DONRE of HCMC. Website: http://www.donre.hochiminhcity.gov.vn
[27] DONRE&H of Hanoi city. Website: http://tnmtnd.hanoi.gov.vn
[28] World Bank, MONRE, CIDA. Vietnam Environment Monitor 2004.

1.2.4 Agricultural solid waste

Agricultural solid wastes consist of unusable materials, that result from agricultural practices. Agricultural wastes include both natural (organic) and non-natural wastes. Main non-natural waste arises from packaging and non-packaging plastics, agrochemicals (e.g. fertilizers and pesticides), animal health products (e.g. used syringes), waste from agricultural machinery (e.g. oil, tyres, batteries), etc. Natural agricultural waste includes mainly crop residues and animal wastes.

As the GHG emissions from agricultural activities are mainly caused by inappropriate management of natural agricultural waste, this report therefore focuses on this type of wastes. Table 14 presents the main crop residues and their related energy content for 2006.

Table 14: Production (ktons) and heat input (kTOE) of main crop residues in 2006

	Crop production	**Crop residues generated**		**Crop residues used**[29]	
	(ktons)	**(ktons)**	**(kTOE)**[30]	**(ktons)**	**(kTOE)**
Main Agricultural wastes:		**48,167**	**14,830**	**12,920**	**3,505**
Paddy straw	35,827	35,827	11,990	5,830	1,950
Rice (paddy) husk	35,827	7,170	1,950	3,360	915
Sugarcane bagasse	15,679	5,170	890	3,730	640
Others:		**19,800**	**6,730**	**4,900**	**1,690**
Cane trash	15,679	1,570	470		
Maize trash	3,819	9,550	2,850		
Cassava stem	7,714	2,310	690		
Coconut shells and leaves	982	5,890	2,540		
Peanut shell	465	140	40		
Coffee husk	854	340	140		
Total		**67,967**	**21,560**	**17,820**	**5,195**

The total crop residues generated in 2006 was about 68 million tons (21,560 kTOE) in which the largest are paddy straw, maize trash, coconut shell, rice husk and bagasse.

Current use of biomass:

<u>Rice husk:</u>

Currently, rice husk is collected and used by the inhabitants in rural areas as cooking fuel. It is also used as “shock absorber” for fruit transportation, and as fuel in brick kilns, paddy dryers, etc. However, in the Mekong Delta provinces where rice husk residue is abundant during the milling season, a large amount of surplus rice husk is thrown into rivers that cause a serious threat to the environment.

<u>Bagasse:</u>

All bagasse generated in the sugar mills is being used for heat and electricity generation to supply to the sugar mills. However it is used in a very inefficient way in old low pressure boilers. Much more energy could be produced from bagasse if it is used in higher efficiency cogen plants.

<u>Other biomass:</u>

Other biomass such as paddy straw, cane and maize trash are mainly used as fuels for cooking in rural households, production of building material (e.g. in brick kilns, pottery furnaces) as well as for other non-fuel applications (material for house roofing, raw material for cultivating mushroom, cattle food, etc.).

[29] Pham Khanh Toan, 2008.
[30] 1 TOE equals 41.84 GJ

1.3 Livestock waste

In 2006, the livestock population in Vietnam included about 26.9 million pig-heads, 6.5 million cattle-heads, 2.9 million buffalo-heads and 214.6 million poultry-heads. The total number for other animals (horse, goat, sheep, etc.) is around 1.6 million heads[31].

Livestock in Vietnam is concentrated in small, individual household farms (5-20 animal heads) that account for close to 99% of the total livestock population in Vietnam[32]. The number of larger-scale livestock farms accounting for just over 1% of livestock population, was estimated at be over 16,700 in 2006[15]. In the recent years, there was a tendency to move from small household-scale to larger livestock farms. However, this trend was slow, as larger farms are unable to compete with small household-scale farms.

Animal waste includes livestock and poultry manure, bedding and litter, plus such things as dairy parlor waste water, feedlot runoff, silage juices from trench silos and even wasted feed. Table 15 shows the manure generation from main livestock types in 2006.

Table 15: Manure generation from main livestock types in 2006 (million tons)

Livestock type	Livestock population (million heads)	Manure generation[33] (million tons)
Pig	26.9	26.9
Cattle	6.5	16.3
Buffalo	2.9	13.3
Total		56.5

Limited data is available on the composition of animal waste. Table 16 presents the typical composition of cattle and pig manure in Vietnam.

Table 16: Composition of animal manure in Vietnam

Component	Cattle manure	Pig manure
Dry matter (DM), %	15.3	29.1
Organic matter, %	83.6	76.5
pH	7.19	-
Total N, mg/kg	3,730	4,350
NH_3-N, mg/kg	640	654
NH_3-N in total N, %	17.2	15.0

A major part of animal manure is discharged into streams or rivers. This causes a serious threat to the environment. Only a small part of animal manure is reused, mainly for feeding fish and fertilizing fields and gardens. Another part is used for biogas production. Currently, about 60,000 biogas digesters (40,000 brick and 20,000 plastic digesters) have been installed. These digesters can produce about 110 million m^3 of biogas per year, which accounts for more than 3% of the biogas potential[34]. Most of installed biogas digesters are family-sized (1-10 m^3). The number of large biogas digesters for livestock farms is low.

An ongoing “Biogas Program for the Animal Husbandry Sector in Vietnam” plans to install 140,000 family-sized biogas plants in 58 provinces of Vietnam by 2010[35]. With this program implemented, the biogas production could reach about 10% of the identified potential.

[31] Vietnam Statistical Yearbook 2006

[32] ENERTEAM, 2001.

[33] The amount of pig manure is 1.0 ton/year/head, cattle 2.5 ton/year/head, and buffalo 4.6 ton/year/head.

[34] The potential for biogas production is estimated at about 3,400 million m3/yr,based on the data of the year 2006.

[35] Biogas program website: http://www.biogas.org.vn

2. GHG Emissions from the Sector

The main GHG emissions arising from inappropriate waste management are carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4).

The major source of GHG emissions from **industrial and municipal wastewater** is CH_4. The latter is mainly produced when the wastewater degrades in open anaerobic systems such as polluted waterways (rivers, lakes), septic tanks, open pit latrines, or open anaerobic treatment systems without biogas capture. The sludge generated from wastewater treatment plants will also produce methane if it is directed to and degraded in the open sludge pits that are clearly under anaerobic conditions. N_2O and CO_2 emissions from wastewater decay in open anaerobic systems or sludge pits are not significant..

Municipal solid waste is usually collected and transported to landfills. The major source of GHG emissions from municipal solid waste is methane generated by organic decomposition of waste at the landfill site. Methane is also emitted from the uncontrolled decay of a part of municipal solid waste that can not be collected and delivered to the landfill. N_2O and CO_2 emissions from decomposition of municipal solid waste are usually small compared to CH_4 emission. In case of uncontrolled burning of municipal solid waste, the main emission will be CO_2.

GHG emissions from **agricultural residues** occur from uncontrolled burning or decay of surplus crop residues and animal wastes. Carbon dioxide emissions are primarily related to burning of wastes, nitrous oxide emissions are linked to using of manure and synthetic fertilizers for crop cultivation, while methane emissions are generally related to animal manure.

The GHG emissions from the waste sector are presented in Table 17. The total GHG emissions in 1994 were 5,273,600 tCO-e. They increased to 25,248,305 tCO-e in 2006 and are expected to reach 33,891,044 tCO-e in 2010.

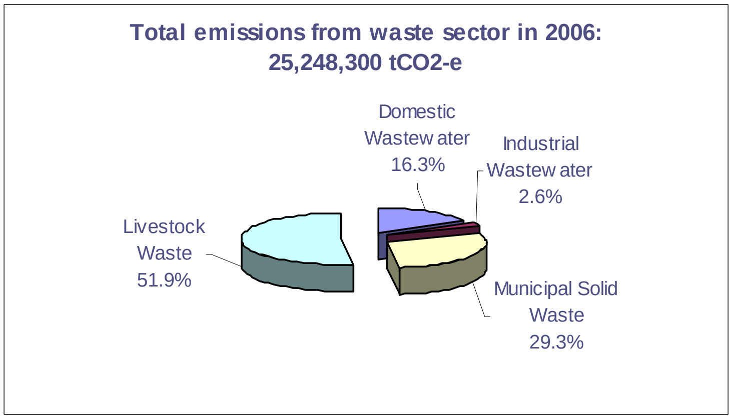
Table 17: GHG emissions from waste sector (in tCO_2-e/year)

Waste stream	Urban	Rural	Total	%
1994(1):				
DWW(2)			1,156,167	21.9
IWW(3)			16,590	0.3
MSW(4)			1,392,258	26.4
ISW			NA	-
HSW			NA	-
Animal waste(1)			2,708,580	51.4
Total for 1994			**5,273,595**	**100.0**
2006(5):				
DWW(6)	1,244,865	2,867,845	4,112,710	16.3
IWW(7)			646,115	2.6
MSW	5,933,480	1,456,000	7,389,480	29.3
ISW(10)			NA	-
HSW(11)			NA	-
Animal waste(10)			13,100,000	51.9
Total for 2006			**25,248,305**	**100.0**
2010(5):				
DWW(6)	1,643,716	2,976,470	4,620,186	13.6
IWW(7)			1,812,338	5.3
MSW	10,844,120	2,114,400	12,958,520	38.2
ISW(8)			NA	-
HSW(9)			NA	-
Animal waste(10)			14,500,000	42.8
Total for 2010			**33,891,044**	**100.0**

Notes: (1)- 1994 National GHG Inventory for Vietnam; (2)- estimated for DDW generated in urban areas only; (3)- estimated for 8 selected industries (liquor, beer, tinned milk, sugar, fish processing, refined vegetable oils, pulp & paper, and rubber industry); (4)- for urban areas only; (5)- The calculations based on 2006 IPCC

Guidelines for National GHG Inventories; (6)- estimated for 100% DDW generated in Vietnam; (7)- estimated for 15 selected industries presented in Table 8; (8)- the GHG emissions from 20% of IWW that is dumped along with MSW, is included in MSW; (9)- GHG emissions from HSW are negligible as its generation is too small; (10)- these figures are from MONRE (The proceedings of the final workshop of the project "Vietnam National Strategy Study on Clean Development Mechanism", Hanoi, 2003).

The distribution of emission sources is shown in Figure 5.



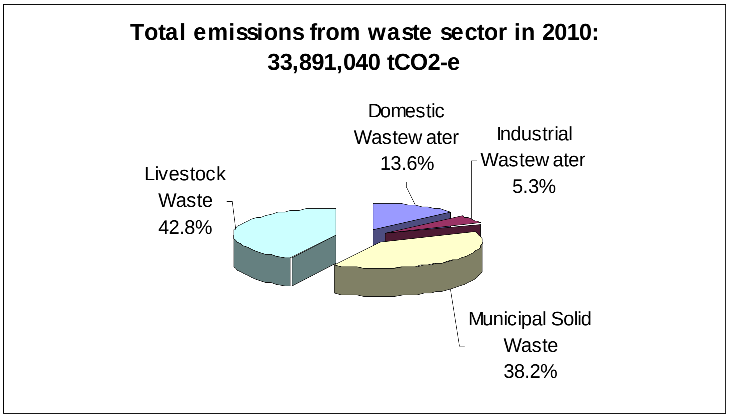


Figure 5: Emission sources from waste sector

Key factors affecting emissions from the waste sector:

<u>Wastewater</u>

(i) Untreated wastewater is concentrated geographically:

- Methane is produced by untreated wastewater disposed in highly polluted waterways.
- Less than 10% of urban domestic wastewater is treated.
- Roughly 30-40% of industrial wastewater is treated.

(ii) Use of anaerobic systems in septic tanks and latrines in urban and rural areas:

- In urban areas, 90% are anaerobic or semi-anaerobic septic tanks and latrines.
- In rural areas, 50% are anaerobic or semi-anaerobic septic tanks and latrines.

(iii) Inappropriate methods of sludge disposal:

- Sludge from septic tank maintenance is disposed to unknown areas, a portion of which is discharged into the rivers and treated in other anaerobic systems.
- Sludge from centralized wastewater treatment plants goes to landfills and open disposal sites.

Solid wastes:

(i) High proportion of organic matter (50-70%) in municipal solid wastes

(ii) Methane produced from dump sites is not mitigated through collection of gas (except for one in HCMC) or large scale composting (<5% composted).

(iii) The low quality of the disposal sites (81% of disposal sites are open dump) and lack of collection and formal disposal in rural areas reduces emissions relative to modern sanitary landfill disposal.

Trends in emissions from waste sector:

The trends in emissions from waste sector are shown in Figure 6. The main reasons for growth in emissions from waste sector are:

Domestic wastewater:

- Population growth (1.4% annually)
- Growth in urban population due to rapid urbanization (4.4% annually)
- Installation of centralized aerobic/anaerobic treatment systems in urban areas (will grow from 10% in 2006 to 20% in 2010)
- Continued use of landfills as wastewater sludge disposal practices
- Continued use of anaerobic/semi-anaerobic septic tanks and latrines in rural and urban areas.

Industrial wastewater:

- Industry growth (5-30% annually depending the sector)
- Installation of aerobic/anaerobic systems without methane capture (will grow from 40% to 65% in 2010).
- Establishment of new high BOD-emitted industry such as bioethanol production.

Municipal solid waste:

- Population growth
- Growth in urban population
- Increase in consumption but with a lower proportion of organic matter in municipal solid waste
- Establishment of sanitary landfills without methane capture or composting will increase emissions.

Livestock waste:

- Growth in livestock population (1.0-2.5% annually for the 2006-2010 period)
- Continued use of open manure management practices in livestock industry

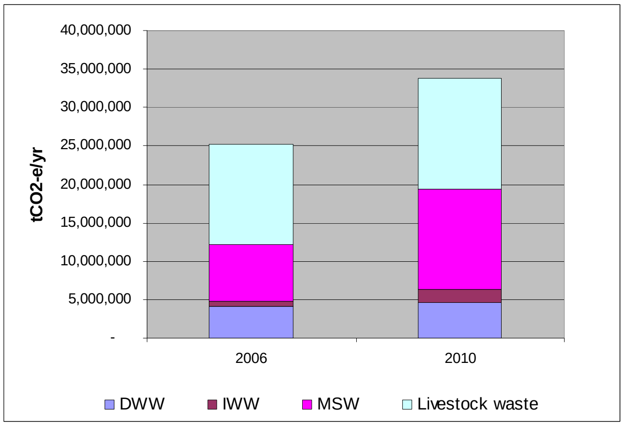


Figure 6: Trends in emissions from waste sector

3. Key Potential Climate Change Mitigation Opportunities in the Sector

A list of potential typologies of interventions were evaluated to understand their potential for sector wide reductions in emissions of GHGs. Based on the sector potential and the relative challenges of implementing the typology in a portion of the sector, potentially feasible interventions were characterized based a set of criteria important to their implementation potential including estimates of potential emission reductions, in-roads institutionally, and methodology and additionality issues. While all interventions are believed to have potential as “win-win” or “no-regrets” interventions under the CDM, considerations on the related co-benefits and financial cost (if any) related to the intervention was also included in the evaluation and as summarized in the Annexes. All calculations of the emission reduction potentials were based on the sector structure over the time span of 2010 and 2015 and used CDM and IPCC methodologies where available and local emission factors where available.

3.1 Overview of the potential

There are several waste management practices and technologies whose use can create opportunities to reduce the GHG emissions. These practices and technologies can be grouped according to the type of waste being managed:

- Wastewater management (including industrial and municipal wastewater);
- Organic solid waste management (including organic parts of industrial and municipal solid wastes and crop residues); and
- Animal waste management.

Wastewater management:

As mentioned in Section 2, untreated wastewater or sludge generated from an existing wastewater treatment plant will produce significant methane emission if they are directed to the open anaerobic systems, such as polluted waterways, lagoons, septic tanks, latrines, open anaerobic treatment systems, etc.

Anaerobic digestion of untreated wastewater can reduce methane emission if the biogas (methane) is extracted from the anaerobic digester in a controlled way. This biogas can be used for electricity and/or heat production that reduce the on-site electricity use and/or on-site fossil fuel consumption.

Methane recovery in an existing wastewater treatment system is applicable if the sludge generated from an existing wastewater treatment system is not treated, but discharged into open lagoons or sludge pits where sludge will be naturally decayed. The methane emission reduction can be achieved if the sludge is treated in a new anaerobic digester or under aerobic conditions (e.g. dewatering and land application). Methane (biogas) recovery from sludge treatment can be used for energy production.

Organic solid waste management:

There are three opportunities for mitigating GHG emission from organic solid wastes.

The first opportunity is the composting of organic solid wastes. This project type includes construction and/or expansion of compost production facilities as well as activities that increase capacity utilization at an existing composting production plant. These measures can help to avoid the production of methane from organic wastes that would have otherwise been left to decay anaerobically in a solid waste disposal site without methane recovery. This project type is also applicable for co-composting wastewater and organic solid wastes.

The second opportunity is landfill gas capture and its use. This measure avoids the partial or even total release of the GHG emissions from a landfill to the atmosphere. The captured gas is flared (if generated in small amount) or is used to produce energy (e.g. electricity and/or thermal energy).

Incineration of organic solid wastes for energy generation (electricity and/or thermal energy) is another opportunity for climate change mitigation. Electricity generated is either consumed on-site, exported to the grid or to a nearby facility. The thermal energy generated is either consumed on-site and/or sold to a nearby facility. This type of project can avoid GHG emissions (mainly methane) caused by uncontrolled anaerobic processes in open air through controlled combustion of organic solid wastes in an incinerator/furnace and by utilizing combustion heat generated for electricity and/or thermal energy production. This type of project also includes gasification (i.e. combustion taking place in a low/insufficient oxygen environment) of organic solid wastes to produce syngas/producer gas which is used for electricity and/or thermal energy generation.

Animal waste management:

The technology/measure used to mitigate the GHG emissions (mainly, methane) in this area is recovery and destruction of methane from animal manure and waste that would be otherwise left to decay anaerobically with methane is released to the atmosphere. The recovered methane is flared or gainfully used as fuel for cooking and lighting (in household/small livestock farms) and for thermal or electrical energy generation (in large-scale livestock farms).

3.2 Typologies of potential CCM projects in the sector

Below is the list of possible project interventions

W1: Methane recovery and avoidance through treatment of urban domestic wastewater

W2: Methane recovery and avoidance through treatment of rural domestic wastewater
W3: Methane recovery and avoidance through treatment of industrial wastewater
W4: Composting of municipal solid waste
W5: Landfill gas capture and its use
W6: Use of agricultural solid wastes for energy generation
W7: Methane recovery at livestock farms

3.2.1 Methane recovery and avoidance through treatment of domestic wastewater

(i) Project technologies/activities

This project type comprises the technologies/activities that recover and avoid methane emissions from biogenic organic matter in domestic wastewater by means of the following options:

- **Option 1:** Desludging and treatment of sludge from septic tanks and latrines by using aerobic (land farming) and/or anaerobic (biogas) systems;
- **Option 2:** Increase in treatment of wastewater in centralized wastewater treatment plants by using aerobic and/or biogas (with methane recovery) systems;
- **Option 3:** Treatment of sludge from centralized wastewater treatment plants by using biogas (with methane recovery) and/or land farming.
- **Option 4:** Increase in use of aerobic/semi aerobic sanitation systems (composting toilets, ventilated improved pit latrines) and/or biogas systems.

(ii) Baseline Practices and Additionality

Figure 7 shows the conceptual diagram of the baseline practices of domestic wastewater disposal.

<u>For urban domestic wastewater:</u>

At present, a majority part of organic degradable material in urban domestic wastewater (from human manure) generated in the cities is being treated in on-site septic tanks and latrines. The remaining part is discharged into the sewer system or to the polluted urban waterways (rivers or lakes). Only small amount (less than 10%) of wastewater is sewered to and treated in centralized wastewater treatment plants. The remains are untreated and discharged into the polluted urban waterways.

The sludge from septic tanks and latrines is disposed in unknown areas, a portion of which is discharged into the polluted urban waterways and other anaerobic systems. The sludge from wastewater treatment plants goes to landfill/disposal sites.

All existing domestic wastewater treatments in Hanoi, Da Nang, etc., and the new plants under development in large cities (Hanoi, Ho Chi Minh city) use aerobic technology. The anaerobic methane recovery systems are not common practice and not being adopted for treatment of domestic wastewater.

The lack of financial sources is a main barrier to these projects.

For rural domestic wastewater:

In case of rural domestic wastewater, a larger portion of organic degradable material is being treated in septic tanks, improved latrines and other unimproved systems. The smaller part is discharged to ground and into the rivers and lakes. Sewer systems do not exist in rural areas.

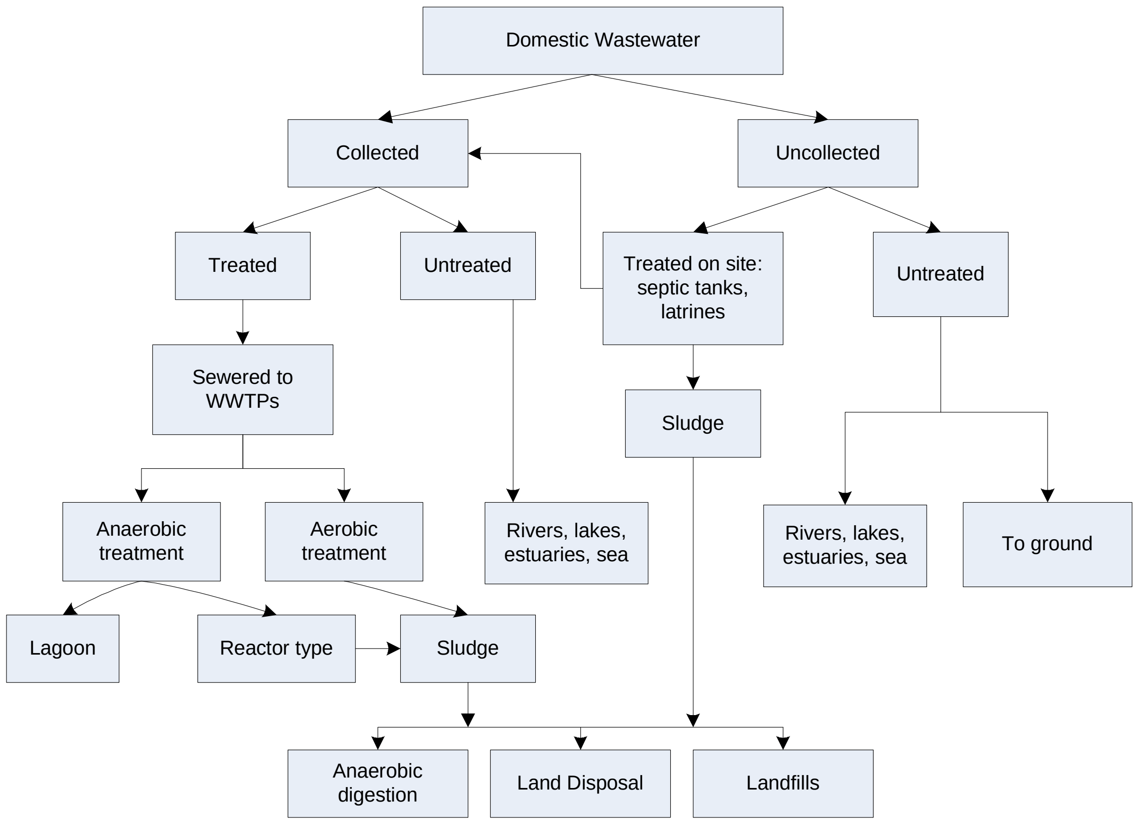


Figure 7: Domestic Wastewater Baseline
(Based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories)

(iii) Assessment of Applicable CDM methodologies

Some approved CDM methodologies and tools do exist. They can be used for the demonstration and assessment of additionality of this type of CDM projects:

- AMS-III.H (Small scale projects): Methane recovery in wastewater treatment;
- AMS-III.I (Small scale projects): Avoidance of methane production in wastewater treatment through replacement of anaerobic lagoons by aerobic systems;
- EB 36 (Annex 13): Tool for the demonstration and assessment of additionality;
- EB 28 (Annex 13): Tool to determine project emissions from flaring gases containing methane.

These methodologies and tools can be downloaded from UNFCCC website[(18)].

[(18)] http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html

(iv) GHG emission reduction potential

For calculation of emission reduction (ER) potential, the selected baseline scenario will be as follows:

For urban domestic wastewater:

- 40% of total organic degradable material (BOD) in urban domestic wastewater generated in 2010 is treated in on-site sanitation systems. The remaining is discharged into sewer system (50%) and to the polluted rivers or lakes (10%).
- The urban sanitation systems include anaerobic/semi-anaerobic septic tanks (81%), improved aerobic septic tanks (12%), public/shared toilets (1%), open systems, i.e. no facility (1%), and other unimproved systems (5%).
- The wastewater from septic tanks and latrines is discharged into sewer system. The sludge is disposed in unknown areas.
- 20% of wastewater from sewer system is treated in open anaerobic centralized aerobic wastewater treatment plants. The remaining 80% wastewater from sewer system is discharged into rivers and lakes.
- The sludge from treatment plants goes to landfills.

For rural domestic wastewater:

- 60% total organic degradable material (BOD) in rural domestic wastewater is treated in on-site sanitation systems. The remaining is discharged into sewer system (10%) and to ground or into waterways (30%).
- The rural sanitation systems consist of anaerobic/semi-anaerobic septic tanks (30%), improved aerobic septic tanks (30%), open systems (10%), and others unimproved systems (30%).
- The wastewater from septic tanks and latrines is disposed to ground or discharged into rivers and lakes. The sludge is disposed in unknown areas.
- No centralized wastewater treatment plants in rural areas.

The GHG emission reduction potential is calculated by using the methodology AMS-III.H and AMS-III.I with some simplification.

For urban domestic wastewater:

The results of ER estimation by intervention typology for domestic wastewater generated in all urban areas in Vietnam in 2010 are presented in Table 18 and Figure 8.

Table 18: Estimated ER potential from treatment of domestic wastewater in all urban areas in Vietnam (in tCO2-e/yr)

% of sewage/sludge treated or sanitation technology changed	Intervention typology:				
	Typology 1: Adoption of aerobic systems for new centralized WWTPs alone	Typology 2: Land farming of sludge from centralized WWTPs	Typology 3: Desludging and treatment of sludge from septic tanks	Typology 4a: Switching from anaerobic septic tanks to aerobic sanitation systems	Typology 4b: Switching from unimproved to improved aerobic sanitation systems
0%	0	0	0	0	0
10%	12,771	6,771	8,226	58,336	5,756
20%	25,542	13,542	16,452	116,671	11,513
30%	38,313	20,314	24,678	175,007	17,269
40%	51,084	27,085	32,903	233,342	23,026
50%	63,854	33,856	41,129	291,678	28,782
60%	76,625	40,627	49,355	350,013	34,539
70%	89,396	47,399	57,581	408,349	40,295
80%	102,167	54,170	65,807	466,685	46,052
90%	114,938	60,941	74,033	525,020	51,808
100%	127,709	67,712	82,258	583,356	57,565

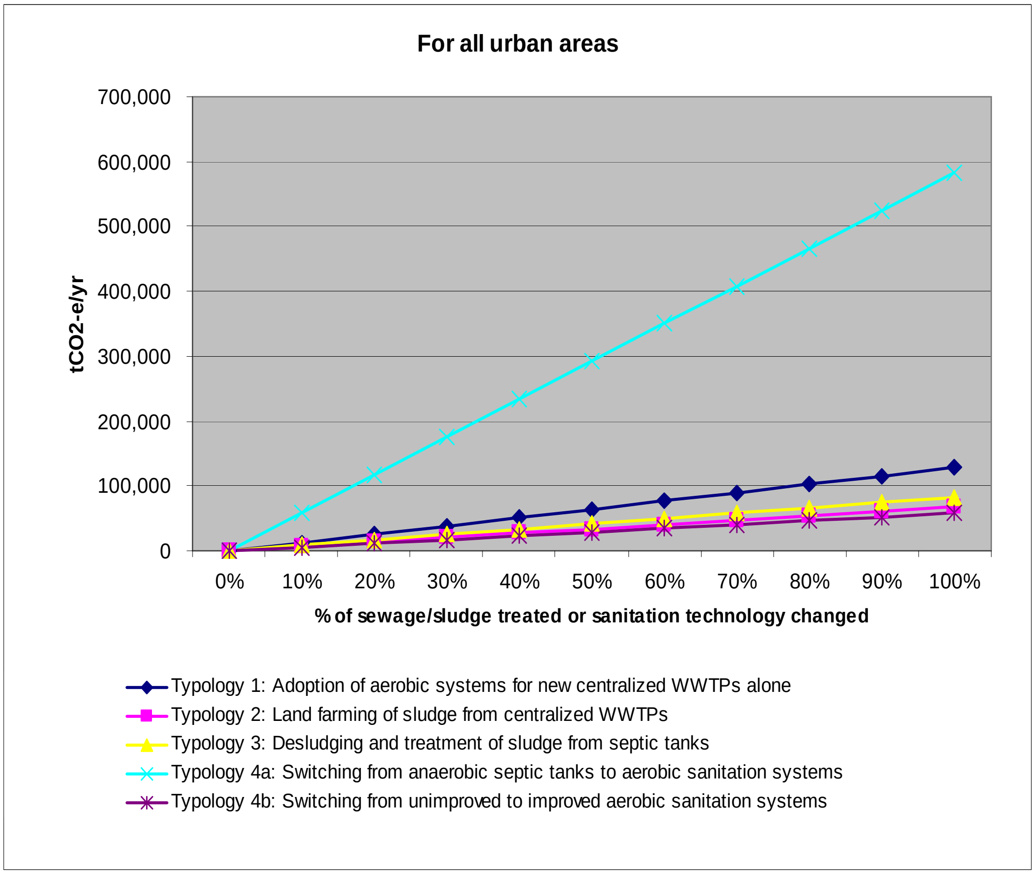


Figure 8: ER vs urban wastewater treatment level and technology changes in sanitation systems

The total estimated ER potential from treatment of domestic wastewater in the five largest cities in Vietnam is presented in Table 20. The calculations are performed for 7 combinations of interventions as shown in Table 19. It can be seen from Table 20 that the emission reduction potential from the treatment of domestic wastewater in the five largest cities (Ho Chi Minh city, Hanoi, Hai Phong, Da Nang and Can Tho) accounts for 64-65% of the total emission reduction potential that could result from the treatment of domestic wastewater in all urban cities.

The cumulative emission reduction vs technology changes in sanitation systems these five cities are shown in Figure 9.

Table 19: Seven combinations of interventions considered
(shown as a % of sewage/wastewater treatment and sanitation technology conversion by city)

Combination of Interventions	New aerobic centralized WWTPs only	Land farming of sludge from centralized WWTPs	Desludging and treatment of sludge from septic tanks	Switching from anaerobic septic tanks to aerobic sanitation systems	Switching from unimproved to improved aerobic sanitation systems
1	50%	50%	50%	0%	0%
2	50%	100%	50%	0%	0%
3	50%	50%	50%	50%	50%
4	100%	100%	100%	0%	0%
5	50%	100%	50%	50%	50%
6	100%	100%	100%	50%	50%
7	100%	100%	100%	100%	100%

Table 20: Estimated ER potential from treatment of domestic wastewater generated in five largest cities of Vietnam (in tCO2-e/yr)

Combination of Interventions	HCMC	Hanoi (HN)	Hai Phong (HP)	Da Nang (DN)	Can Tho (CT)	**Total for five cities**	Total for all urban areas	share of five cities
1	63,382	36,093	16,107	7,819	9,461	**132,862**	206,552	64.3%
2	94,066	53,565	23,715	11,512	13,930	**196,789**	308,121	63.9%
3	158,401	90,201	39,895	19,366	23,433	**331,296**	509,755	65.0%
4	167,676	95,482	42,358	20,562	24,880	**350,960**	548,529	64.0%
5	189,085	107,673	47,503	23,060	27,902	**395,223**	611,323	64.7%
6	257,287	146,511	64,792	31,452	38,057	**538,100**	834,474	64.5%
7	346,898	197,539	87,226	42,343	51,235	**725,240**	1,120,419	64.7%

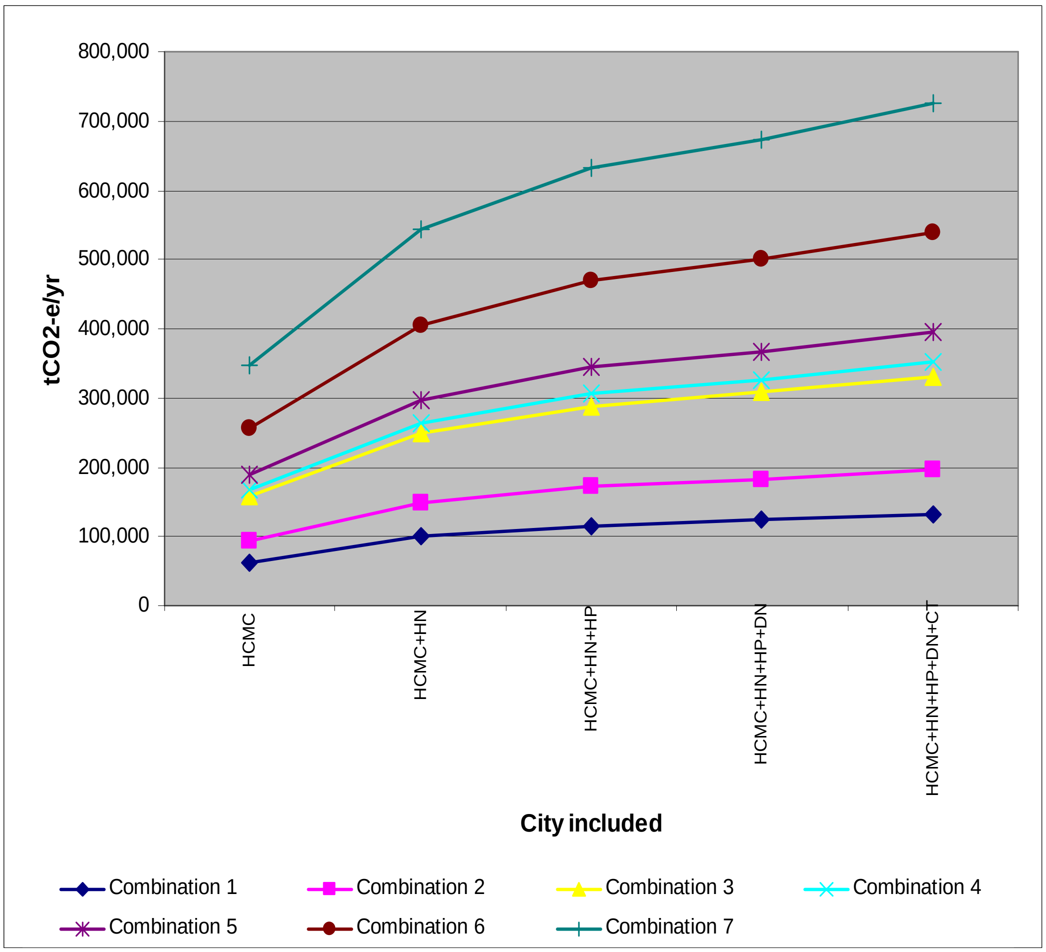


Figure 9: Cumulative emission reduction by combination of interventions

<u>For rural domestic wastewater</u>

For rural domestic wastewater, two intervention typologies are considered. The results of emission reductions for these intervention typologies are presented in Table 21 and Figure 10. The emission reduction potentials estimated for the combination of interventions are shown in Table 22.

Table 21: Estimated ER potential from treatment of domestic wastewater in all rural areas in Vietnam (in tCO2-e/yr)

% of sanitation technology changed	Intervention typology:	
	Typology 1: Switching from anaerobic septic tanks to aerobic sanitation systems	Typology 2: Switching from unimproved to improved aerobic sanitation systems
0%	0	0
10%	59,508	105,284
20%	119,016	210,568
30%	178,525	315,851
40%	238,033	421,135
50%	297,541	526,419
60%	357,049	631,703
70%	416,557	736,986
80%	476,066	842,270
90%	535,574	947,554
100%	595,082	1,052,838

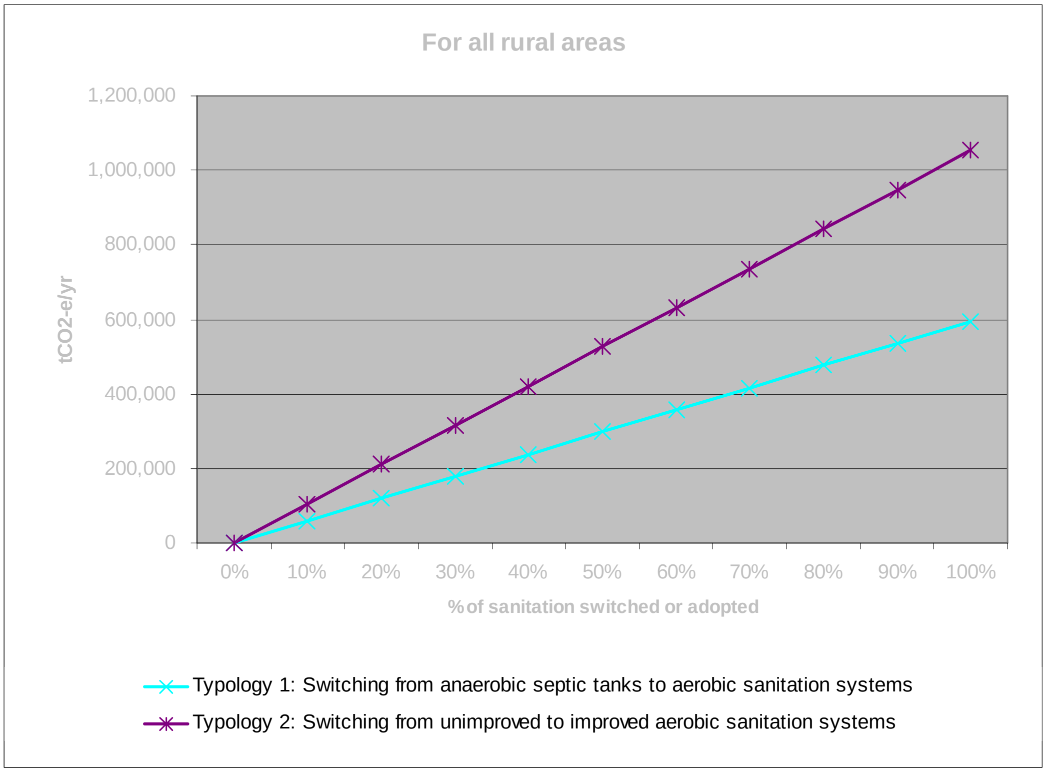


Figure 10:Emission reduction vs technology changes in sanitation systems in rural areas

Table 22: Emission reduction potentials for rural domestic wastewater by combination of interventions (tCO2-e/yr)

Combination of interventions	Switching from anaerobic septic tanks to aerobic sanitation systems	Switching from unimproved to improved aerobic sanitation systems	Emission Reduction Potential (tCO2-e/yr)
1	10%	10%	164,792
2	50%	50%	823,960
3	100%	100%	1,647,920

(v) Potentially feasible sector-wide interventions

Intervention	Potential structure and in-roads	Estimated GHG reduction	Estimated CDM Revenues
Increasing centralized wastewater treatment to 50% with aerobic sludge treatment; land farming of 100% sludge from centralized wastewater treatment plants; and desludging and aerobic treatment of 50% of septic tanks for five major cities	Through participating cities	198,000 tCO2-e per year	$1.98 million per year
Rural domestic wastewater: (1) Methane avoidance through switching 50% of septic tanks to aerobic sanitation and (2) 50% adoption of aerobic sanitation systems for those without sanitation	Through national sanitation program.	820,000 tCO2-e per year	$8.2 million per year

3.2.2 Methane recovery and avoidance through treatment of industrial wastewater

(i) Project technologies/activities

This project type includes the technologies/activities that recover and/or avoid methane emission from biogenic organic matter in industrial wastewater. As the high BOD/COD-intensive industries have better potential for GHG emission reduction, the project will focus in six industries:

- Bioethanol production
- Meat processing
- Liquor, beverage and beer
- Pulp and paper
- Tapioca starch
- Fish processing

(ii) Baseline Practices and Additionality

The use of open anaerobic lagoons is common practice for treatment of wastewater in these six industries. The wastewater from industrial process will be directed to open lagoons for settling, then it is discharged to rivers or lakes. For the industries, where wastewater is being treated, the aerobic process is used. The anaerobic treatment of industrial wastewater with methane recovery is being used in some industries.

The main barriers to this type of project are:

- High investment and operation cost of the anaerobic wastewater treatment plant;
- The industries like to maintain the open lagoons if they would work well;

- More complicated technology for methane recovery is not know.

(iii) Assessment of Applicable CDM methodologies

Several approved CDM methodologies and tools can be used for calculation of the emission reduction potential for this type of CDM projects.

- ACM0014: Mitigation of greenhouse gas emissions from treatment of industrial wastewater;
- EB 36 (Annex 13): Tool for the demonstration and assessment of additionality.

(iv) GHG emission reduction potential

The GHG emission reduction potential is estimated for some selected industries that generate the wastewater with high organic matter.

The selected baseline scenario is the situation in 2010 where, in the absence of the CCM project activity, 50% of industrial wastewater will be treated in aerobic treatment plants (but not well managed and overloaded), 15% will be treated in anaerobic systems with and without methane recovery, and 35% is not treated, but discharged to sewer system, river or lake.

The project activity includes:

- Upgrading and rehabilitation of existing overloaded aerobic systems and improvement of the way they are managed;
- Introduction of anaerobic wastewater treatment with methane recovery and combustion to existing WWTPs without methane recovery;
- Introduction of aerobic or anaerobic treatment systems with methane recovery to untreated wastewater streams.

The GHG emission reduction potential is calculated by using methodology AMS-III.H with some simplification. The total estimated ER potential for industrial wastewater is 1,170,746 tCO2-e/yr for all of 15 industries listed in Table 8, and 1,137,212 tCO2-e/yr for six highest COD-intensive industries (This estimation does not include the emission avoidance resulting from the use of recovered methane to substitute the diesel or fuel oil currently burned in the several industries).

Table 23: GHG emission reduction potential from treatment of industrial wastewater in six selected industries

Industry sector	tCO2-e/yr	%
Bioethanol production	310,322	27.3
Meat processing	272,829	24.0
Liquor, beverage & beer	201,665	17.7
Pulp and Paper	195,891	17.2
Tapioca starch	94,500	8.3
Fish processing	62,015	5.5
Total	**1,137,212**	**100.0**

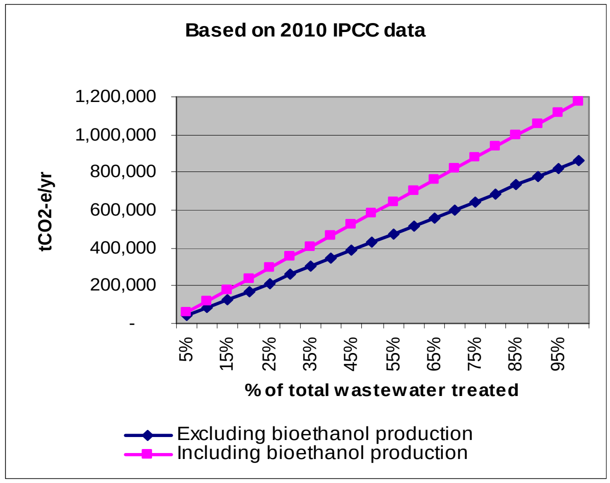


Figure 11: Emission Reduction vs % of industrial wastewater treated (for 15 subsectors)

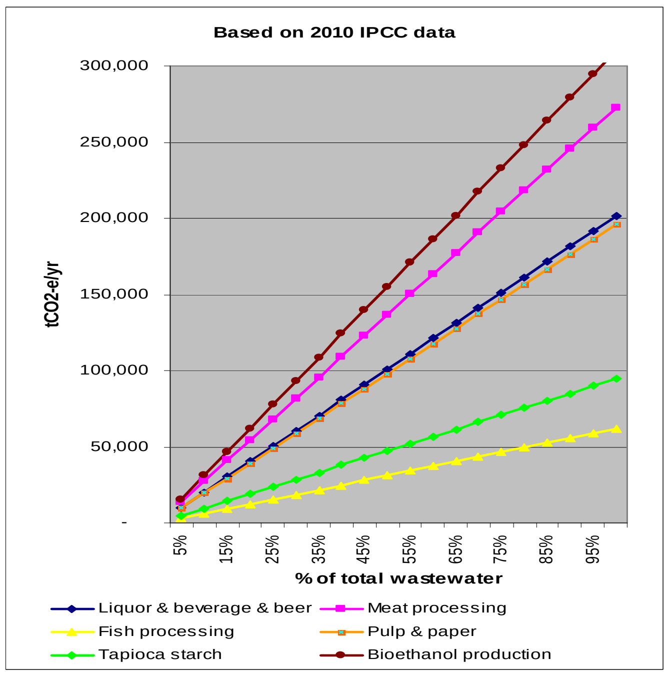


Figure 12: Emission Reduction vs % of industrial wastewater treated (for each of six main sub-sectors)

(v) Potentially feasible sector wide interventions

Intervention	Potential structure and in-roads	Estimated GHG reduction	Estimated CDM Revenues
Industrial wastewater: Methane recovery (biogas) and avoidance (aerobic systems) for 75% wastewater of bioethanol, meat & poultry, pulp &	Through industries or bank intermediary	520,000 tCO2-e per year	$11 million per year

paper, liquor & beer, tapioca starch, and fishing processing industries			

3.2.3 Composting of municipal solid waste

(i) Project technologies/activities

This project type comprises measures to avoid the production of methane from MSW that would have otherwise been left to decay anaerobically in a solid waste disposal site without methane recovery. This project would be recommended for small cities.

The project activities include construction and expansion of compost production facilities as well as activities that increase capacity utilization at an existing composting production facility. Due to the project activities, the uncontrolled anaerobically decay is prevented through aerobic treatment by composting of MSW and proper soil application of the compost.

(ii) Baseline Practices and Additionality

The baseline scenario of this project type is the situation where, in the absence of the project activity, MSW containing biodegradable organic matter is left to decay anaerobically within the project boundary and methane is emitted to the atmosphere.

The project boundary of this project type is the physical, geographical site where (i) the solid wastes would have been disposed and the methane emission occurs in absence of the proposed project activity; (ii) the treatment of MSW through composting takes place; (iii) the soil application of the produced compost takes place; and (iv) the itineraries between them (i, ii, and iii) where the transportation of MSW or compost occurs.

(iii) Assessment of Applicable CDM methodologies

Several approved methodologies and tools do exist. They can be used for the demonstration and assessment of additionality of CDM projects related to the composting of municipal solid waste:

- AM0025: Avoided emissions from organic waste through alternative waste treatment processes;
- AM0039: Methane emissions reduction from organic waste water and bio-organic solid waste using co-composting;
- AMS-III.F (Small scale projects): Avoidance of methane production from decay of biomass through composting;
- EB 39: Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site.

(iv) GHG emission reduction potential

The emission reduction achieved by the project activity will be estimated as the difference between the baseline emission and the sum of the project emission and leakage.

The selected baseline scenario is the situation where, in the absence of the project activity, MSW is left to decay at the site of the landfill and methane is emitted to the atmosphere. Baseline emissions shall exclude methane emissions that would have to be removed to comply with national or local safety requirement or legal regulations. The project activity includes construction of new composting facility or expansion of capacity of existing facilities.

The GHG emission reduction potential is calculated by using the AM0025 with some simplification. It was assumed that 40% of the organic matter of MSW will be composted in the landfills. The total estimated ER potential through composting of MSW collected in 36 small cities and 674 townlets is 898,752 tCO_2-e for year 2010 (Table 24).

Table 24: Estimated ER potential from MSW composting in small cities of Vietnam in 2010

Name of city	City class	Daily MSW disposal rate (ton/day)	ER potential (tCO_2-e)
36 small cities/towns	Class III	4,360	512,755
674 towns/townlets	Class IV&V	1,770	208,160
Total (urban)		**6,130**	**720,915**

The estimated emission reductions potential from composting MSW in the cities the World Bank has an ongoing dialogue with are presented in Table 25. The cumulative emission reduction from MSW composting in these cities is shown in Figure 13.

Table 25: Estimated ER potential from MSW composting in selected cities

City	Daily MSW disposal rate (ton/day)	Emission Reduction (tCO2-e/yr) (Average for 7 years)
Hanoi	6,000	705,627
Lao Cai	120	14,113
Phu Ly	110	12,936
Nam Dinh	610	71,739
Vinh	360	42,338
Hue	480	56,450
Quy Nhon	420	49,394
Vung Tau	420	49,394
Total	8,520	1,001,991

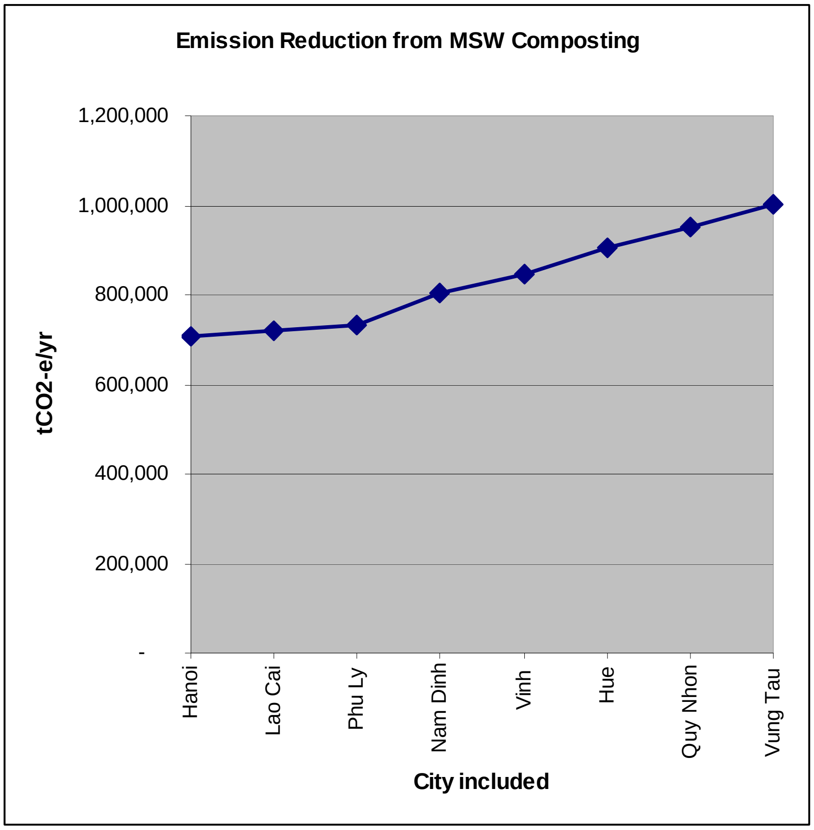


Figure 13: Cumulative Emission Reduction from MSW Composting in 8 selected cities

(v) Potentially feasible sector wide interventions

Intervention	Potential structure and in-roads	Estimated GHG reduction	Estimated CDM Revenues
Urban solid waste: Methane avoidance through solid waste composting in 8 selected cities	Through participating cities.	1,000,000 tCO2-e per year	$10 million per year

3.2.4 Landfill gas capture and its use

(i) Project technologies/activities

The project technologies/activities of this project type include the closing of landfills, capture and combustion of methane from landfills (i.e. solid waste disposal sites) used for disposal solid residues from municipal, industrial, and other solid wastes containing biodegradable organic matter.

The recovered methane from the above project activities will be flared or utilized for electrical energy generation.

The landfill gas recovery technology is most suitable for the landfills with the following conditions[20]:

- A landfill should receive at least 200 tons of waste per day;

[20] VEM, 2004.

- It must be designed for a minimum total capacity of 500,000 tons of waste;
- The waste should be compacted and the surface covered with an impermeable or low permeability top-cover;
- The climate must be sufficiently wet to promote biological activity;
- The filling height should be minimum 10 meters high.

Notwithstanding the "basic requirements" mentioned above and in consideration of the different generation rates in different climatic conditions, a feasibility study should be conducted to determine the technical and economic viability in installing a LFGTE system. For technical viability, parameters such as the waste characteristics (% biodegradable), amount in place, age, moisture, leachate levels, soil cover, etc. should be observed. Ideally, the waste should be more than 10 meters in height, leachate levels are beyond 5 m from the surface of the garbage and the waste not more than 5-10 years in place.

Considering a minimum of one to two years for planning and construction of a new sanitary landfill and a minimum of six months to two years operational time until it is worthwhile to collect and utilize methane it is rather unlikely that a new sanitary landfill project can produce enough emission reductions until 2012 to be economically attractive. Of course, factors like amount of waste disposed and waste characteristics should also be considered as these factors may make the project viable.

Therefore, existing large sanitary landfills that can be covered and where gas collection can be installed should be chosen for CDM projects, because gas production is higher from the start of the project.

(ii) Baseline Practices and Additionality

The baseline scenario of this type of CCM projects is the situation where, in the absence of the project activity, solid wastes containing biodegradable organic matter are left to decay anaerobically within the project boundary (i.e. the physical, geographical site of the landfill where the gas is captured and destroyed/used) and methane is emitted to the atmosphere.

Several CDM projects in this area have been submitted to Vietnam DNA. So far, there is one project with its PDD having been approved, and four projects with their PINs having been endorsed. There are also other projects in the pipeline.

However, the implementation of these projects is progressing slowly. The major barriers are the difficult access to available financing sources and the complexity of legal procedures.

(iii) Assessment of Applicable CDM methodologies

Several approved methodologies and tools do exist. They can be used for the demonstration and assessment of additionality of this type of CDM projects:

- ACM0001: Consolidated baseline and monitoring methodology for landfill gas project activities;
- AMS-III.G (Small scale projects): Landfill methane recovery.
- EB 39: The tool to determine methane emissions avoided from dumping waste at a solid waste disposal site.

(iv) GHG emission reduction potential

The GHG emission reduction potential is calculated by using the methodological tools EB 39. Table 26 presents the results of calculation of potential emission reduction from landfill gas (LFG) capture at all existing and new landfills with capacity of more than 200 ton/day.

Table 26: Potential emission reduction from landfill gas capture at landfills

No.	City/landfill	Daily waste disposal	Emission Reduction (tCO_2-e/yr) (Average for 7 years)

		rate (ton/day)	ER from LFG capture & flaring	ER from LFG capture & electricity generation
1.	Ho Chi Minh city			
	Phuoc Hiep 2	3,000	176,407	200,831
	Da Phuoc	3,000	176,407	200,831
	New landfill(s)	4,000	235,209	267,774
2.	Hanoi city			
	Nam Son	2,500	147,006	167,359
	Lam Du	1,000	58,802	66,944
	New landfill(s)	2,500	147,006	167,359
3.	Hai Phong city			
	Trang Cat	800	47,042	53,555
	New landfill(s)	2,000	117,604	133,887
4.	Da Nang city			
	Khanh Son 2	700	41,162	46,860
	New landfill	1,000	58,802	66,944
5.	Can Tho city			
	Dong Thanh	300	17,641	20,083
	Tan Long	350	20,581	23,430
	New landfill(s)	1,500	88,203	100,415
6.	Hue city	480	28,225	32,133
7.	Nam Dinh city	610	35,869	40,836
8.	Thai Nguyen city	580	34,105	38,827
9.	Ha Long city	780	45,866	52,216
10.	Viet Tri city	340	19,993	22,761
11.	Thanh Hoa city	420	24,697	28,116
12.	Vinh city	360	21,169	24,100
13.	Quy Nhon city	420	24,697	28,116
14.	Nha Trang city	660	38,809	44,183
15.	Buon Me Thuot	480	28,225	32,133
16.	Da Lat city	590	34,693	39,497
17.	Bien Hoa city	770	45,278	51,547
18.	Vung Tau city	420	24,697	28,116
19.	My Tho city	420	24,697	28,116
	Total	**29,980**	**1,762,892**	**2,006,969**

There will be 27 landfills in 19 cities, for which the LFG capture projects could be implemented. The classification of the landfills by their potential emission reduction is shown in Table 27.

Table 27: Classification of the landfills by their potential emission reduction

ER level (tCO2-e/yr)	Existing landfills		New landfills		Total	
	No. of landfills	Total ER (tCO2-e/yr)	No. of landfills	Total ER (tCO2-e/yr)	No. of landfills	Total ER (tCO2-e/yr)
LFG capture and flaring						
> 100,000	3	499,820	3	499,819	6	999,639
50-100,000	1	58,802	2	147,005	3	205,807
< 50,000	18	557,446	0	0	18	557,446
Total	**22**	**1,116,068**	**5**	**646,824**	**27**	**1,762,892**
LFG capture and electricity generation						
> 100,000	3	569,021	4	669,435	7	1,238,456
50-100,000	4	224,262	1	66,944	5	291,206
< 50,000	15	477,307	0	0	15	477,307
Total	**22**	**1,270,590**	**5**	**736,379**	**27**	**2,006,969**

The cumulative emission reduction potential from landfill gas capture at landfills in the cities the World Bank has an ongoing dialogue with is shown in Figure 14.

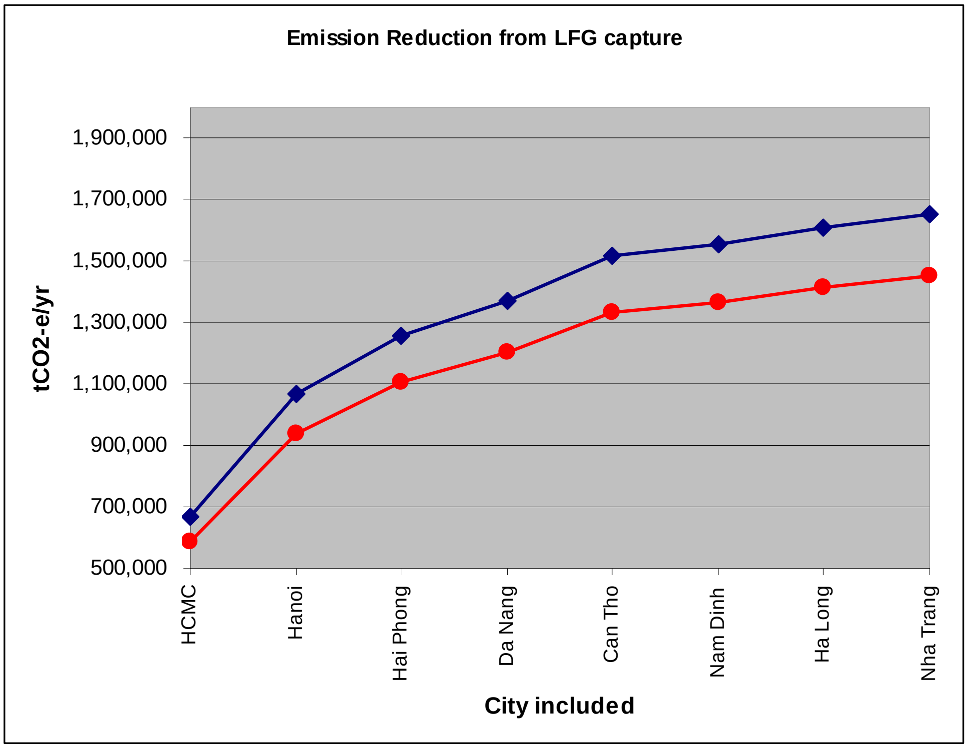


Figure 14: Cumulative emission reduction from LFG capture at landfills in 8 selected cities

(v) Potentially feasible sector wide interventions

Intervention	Potential structure and in-roads	Estimated GHG reduction	Estimated CDM Revenues
Urban solid waste: Methane recovery through landfill gas to energy projects in urban disposal sites for 8 selected cities	Through participating cities.	1,650,000 tCO2-e per year	$16.5 million per year

3.2.5 Use of agricultural solid wastes for energy generation

(i) Project technologies/activities

This project technology/activity is a small grid-connected zero-emissions biomass electricity generation plant. The generated electricity is either consumed on-site to displace electricity supplied from an electricity distribution grid, exported to the grid and/or exported to a nearby facility. The thermal energy generated is either consumed on-site and/or exported to a nearby facility. As biomass has low bulk density, its transport is costly. Therefore, this project will focus in rice husk and bagasse because these types of biomass can be collected and used at the site, where they are generated, i.e. in or very near the sugar mills and rice mills.

The project activities involve both the construction of new facility and upgrading/modification of an existing facility using agricultural solid wastes for energy generation.

In Vietnam, this technology is most suitable for rice husk and bagasse that are generated in rice mills and sugar mills. The use of other types of agricultural solid wastes such as paddy straw, maize trash, coconut husks, etc. for energy generation is complicated by problems related to their collection and transportation from the fields to the energy plants.

(ii) Baseline Practices and Additionality

The baseline scenario is the situation where, in the absence of the project activity, the power grid generates electricity by operation of the planned power plants as usual and/or adjust power development plant to compensate the generated electricity by the project..

Recent statistics showed that about 1.4 million ton/yr of rice husk can be used for electricity generation. However, there is no any rice husk-fired power plant having been built up to now. This may be an argument for justification of the project additionality. The main barrier is that the electricity generation cost of the rice husk power plant is high while the tariff of selling electricity to the grid is too low. At present, the cost of electricity generation by rice husk power plant is around 1,400 VND/kWh (US$0.084/kWh) while the maximum selling tariff of electricity to the grid is only 750 VND/kWh (US$0.045/kWh). Even the Government of Vietnam is planning to increase the selling tariff of electricity to the grid to 1,000 VND/kWh (US$0.06/kWh),non of rice husk power projects appear to be economic. The economical and financial analysis of the rice husk-fired power projects showed that they may become feasible if the ash produced from rice husk combustion can be sold at reasonable prices, and the sales of CER are taken into account.

At present, the total amount of bagasse produced at all sugar mills in Vietnam is estimated at 3.1 million ton/yr. It is being used for generation of electricity and heat (steam) to supply the energy demand of the sugar mills. The total installed power capacity of existing cogeneration systems in the sugar mills is around 150 MW. However, due to the age and low efficiency of the cogeneration systems, the generated electricity is about 440,000 MWh/yr only (generation of 1 kWh of electricity requires 7 kg of bagasse). In case, the existing old and low-efficiency cogeneration systems in sugar mills are upgraded or replaced by high-efficiency cogeneration technologies, the electricity generated would be up to 775,000 MWh/yr. The surplus electricity of 335,000 MWh/yr could be sold to the grid. However, the current electricity generation cost of the cogeneration system is 800-950 VND/kWh, which is still higher than the tariff of electricity sold to the grid. It makes less attractive for the sugar millers to invest in the upgrading their existing cogeneration plants or in the construction of new projects. It was estimated that if the tariff of electricity sale to the grid could be increased up to 1000 VND/kWh, and the CER could be sold at about US$15/tCO2-e, the bagasse-fired cogeneration projects would be feasible.

In addition to the above barriers, other problems of the implementation of the grid-connected biomass power project are:

- The difficult access to finacing sources for the project;
- The regulations and procedures for selling electricity to the grid is still complicated.
- The high cost of rice husk collection and transport.

(iii) Assessment of Applicable CDM methodologies

Several approved methodologies and tools do exist. They can be used for the demonstration and assessment of additionality of this type of CCM projects:

- AM0007: Analysis of the least-cost fuel options for seasonally-operating biomass cogeneration plants;
- AM005: Baseline methodology (barrier analysis, baseline scenario development and baseline emission rate, using combined margin) for small grid connected zero-emissions renewable electricity generation;
- ACM0006: Consolidated methodology for electricity generation from biomass residues;
- AMS-I.D (Small scale projects): Grid connected renewable electricity generation

(iv) GHG emission reduction potential

The GHG emission reduction potential is estimated for two agricultural solid residues: rice husk and bagasse.

The selected baseline scenario is the situation where, in the absence of the CCM project activity, the electricity would have been supplied by the national power grid.

The project activity includes:

- the construction of new rice husk fired power plants.
- the replacing or upgrading of the existing old and low-efficient cogeneration systems in sugar mills by using high-efficient cogeneration technologies.

According to the Draft Master Plan of Renewable Energy Development in Vietnam up to 2015 with an orientation until 2025, about 1.5 million tons of rice husk and 4.4 million tons of bagasse could be used for energy generation since 2010. 33 rice husk-fired power plants and 27 bagasse-fired cogeneration plants are planned to be built until 2025.

The total installed capacity of 33 rice husk-fired power plants could be 169 MW. The total annual electricity generation would be 1,000,000 MWh. It is planned that all amount of electricity generated by rice husk-fired power plants will be sold to the grid.

The total installed capacity of 27 bagasse-fired cogeneration plants could be 250 MW. The total annual electricity generation would be 800,000 MWh. However, 420,000 MWh (53%) of this amount of electricity will be used by the sugar mills to cover their own electricity demand. The remaining 380,000 MWh of electricity could be sold to the grid.

The estimation of emission reduction potential from the use of rice husk and bagasse for energy generation is shown in Table 28.

Table 28: Potential emission reduction from the use of rice husk and bagasse for energy generation

Type of waste	No. of projects	Range of capacity (MW)	Total installed capacity (MW)	Total electricity sold to grid (MWh/yr)	Emission factor of Vietnam power grid (tCO2-e/MWh)	Potential emission reduction (tCO2-e/yr)
Rice husk	33	1-15	169	1,000,000	0.656	656,000
Bagasse	27	5-16	250	380,000	0.656	249,280
Total	**60**		**419**	**1,38,000**	**0.656**	**905,280**

(v) Value-added to the World Bank and their funds

Intervention	Potential structure and in-roads	Estimated GHG reduction	Estimated CDM Revenues
Utilization of 20% of rice husk production and 40% of bagasse production for power generation	Through intermediary bank.	150,000 tCO2-e per year	$1.5 million per year

3.2.6 Methane recovery at livestock farms

(i) Project technologies/activities

The technologies/activities of this type of projects involve the construction of a new biogas digester system, replacement and/or modification of an existing biogas digester to achieve methane recovery and its use for electricity and/or thermal energy generation. This project type is recommended to apply for the large-scale livestock farms.

The project activities shall satisfy the following conditions: (i) the final sludge must be handled aerobically. In case of soil application of final sludge, the proper conditions and procedures (not resulting in methane emissions) must be ensured; (ii) technical measures shall be used to ensure that all biogas produced by the digester is used or flared.

The recovered methane from the above project activities will be utilized for electricity and/or thermal energy generation. The generated energy will be used to supply the energy demand of the farm, that in baseline case should be supplied from the grid or by fossil fuels.

(ii) Baseline Practices and Additionality

At present, the open anaerobic lagoons are commonly used for treatment of animal manure generated in large-scale livestock farms. These lagoons are usually poorly maintained. The effluents from lagoons, which obviously still contain high organic matter are discharged into the rivers or canals. Up to now, there is no project that use the biogas for energy generation in livestock farms in Vietnam.

The main barriers to implementation of this project type are:

- The investment costs of the systems are high, that the farms usually can not bear.
- The price of electricity purchased from the grid is still low that do not stimulate interest of the farm in recovery of biogas for electricity generation.

(iii) Assessment of Applicable CDM methodologies

There are some approved methodologies and tools that can be applicable for the demonstration and assessment of additionality of CCM projects in animal waste management sub-sector:

- ACM0010: Consolidated methodology for GHG emission reductions from manure management systems;
- AMS-III.D (Small scale projects): Methane recovery in animal manure management systems;
- AMS-III.R (Small scale projects): Methane recovery in agricultural activities at household/small farm level.

(iv) GHG emission reduction potential

The GHG emission reduction potential is estimated for three types of livestock: pig, cattle, and buffalo.

The estimated emission reduction potential from methane recovery and electricity generation in large-scale livestock farms in Vietnam is presented in Table 29. The total GHG emission reduction potential could be 1,317,215 tCO2-e/yr. The GHG emission reduction potential per each farm is as follows:

- Pig farm: 3,840 tCO_2-e/yr per farm.
- Cattle farm: 383 tCO_2-e/yr per farm.
- Buffalo farm: 166 tCO_2-e/yr per farm.

Table 29: Estimated emission reduction potential from methane recovery from livestock farms

Farm	No. of farm	Animal heads	Manure generation (ton/yr)	Emission reduction potential (tCO2-e/yr)		
				From methane recovery	From electricity generation	Total
Pig	200	1,000,000	1,000,000	673,986	93,480	767,466
Cattle	1,000	500,000	1,250,000	336,993	46,740	383,733
Buffalo	1,000	100,000	460,000	148,816	17,200	166,016
Total				**1,159,795**	**157,420**	**1,317,215**

The emission reduction according to the percentage of manure digested in large-scale livestock farms in Vietnam is shown in Figures 15 and 16 and Figure 17 includes household and large scale piggeries.

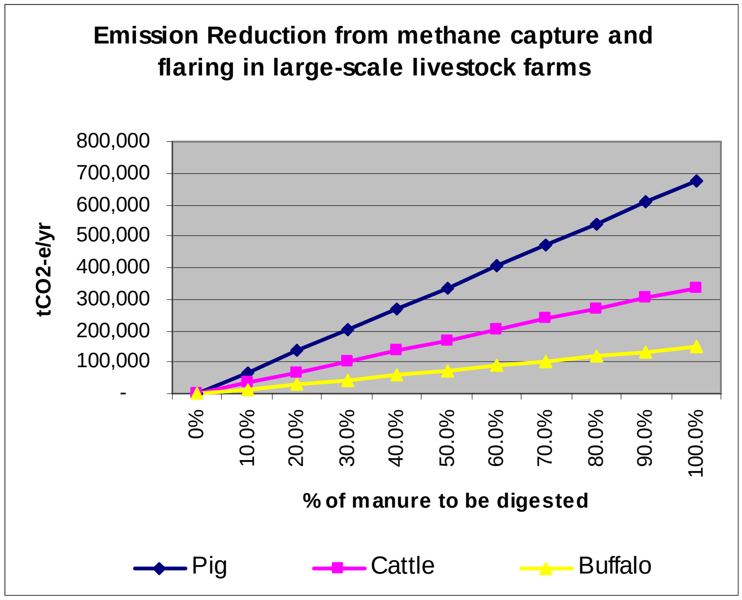


Figure 15: Emission reduction from methane capture and flaring vs % of manure to be digested (commercial farms)

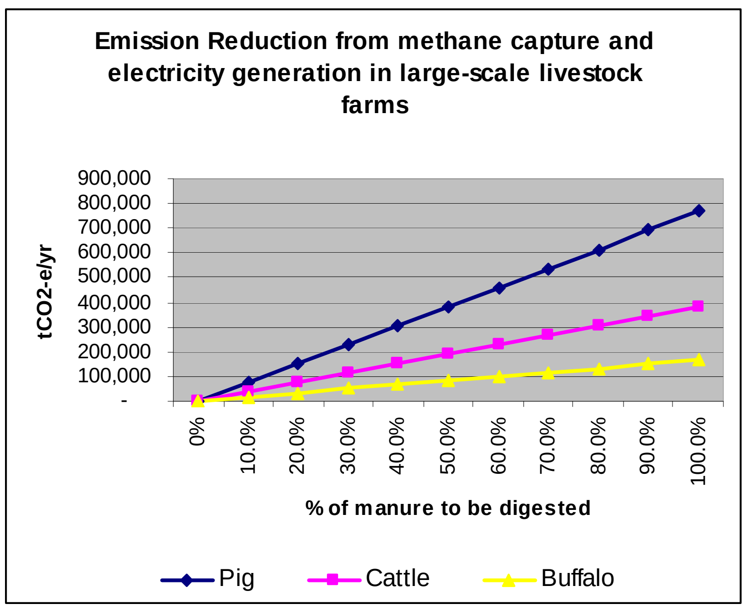
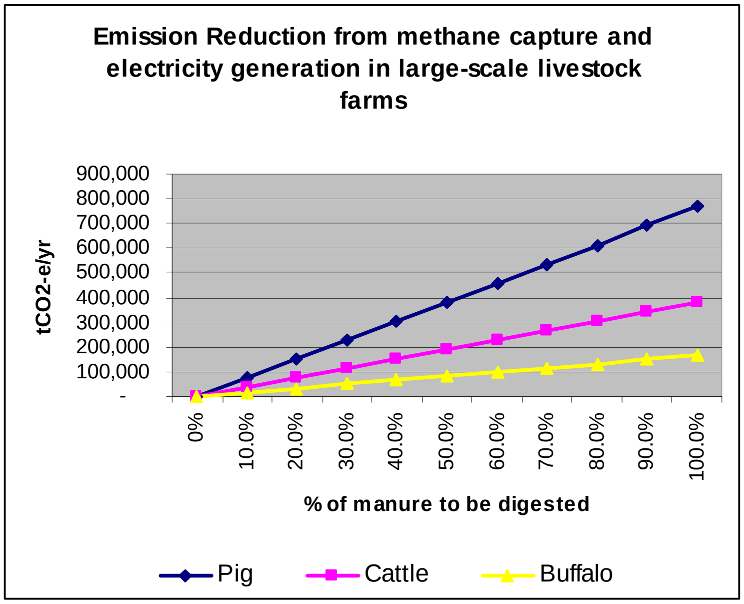


Figure 16: Emission reduction from methane capture and electricity generation vs % of manure to be treated (commercial farms)



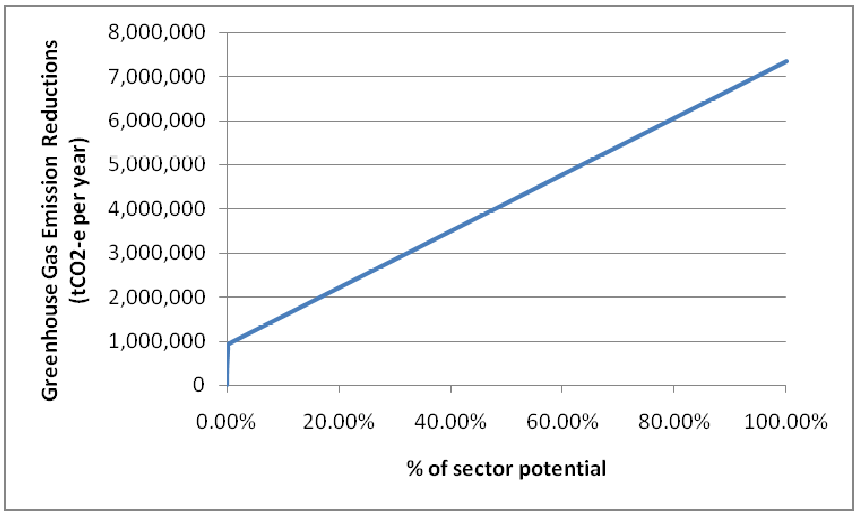


Figure 17: Emission reduction from methane capture and electricity generation vs % of manure to be treated (household and commercial piggeries)

(v) Potentially feasible sector-wide intervention

Intervention	Potential structure and in-roads	Estimated GHG reduction	Estimated CDM Revenues
Methane capture and electricity generation in large-scale livestock farms (200 pig farms with 1,000,000 heads; 1,000 cattle farms with 500,000 heads; and 1,000 buffalo farms with 100,000 heads)	Through MARD	1,320,000 tCO2-e per year	$13.2 million per year

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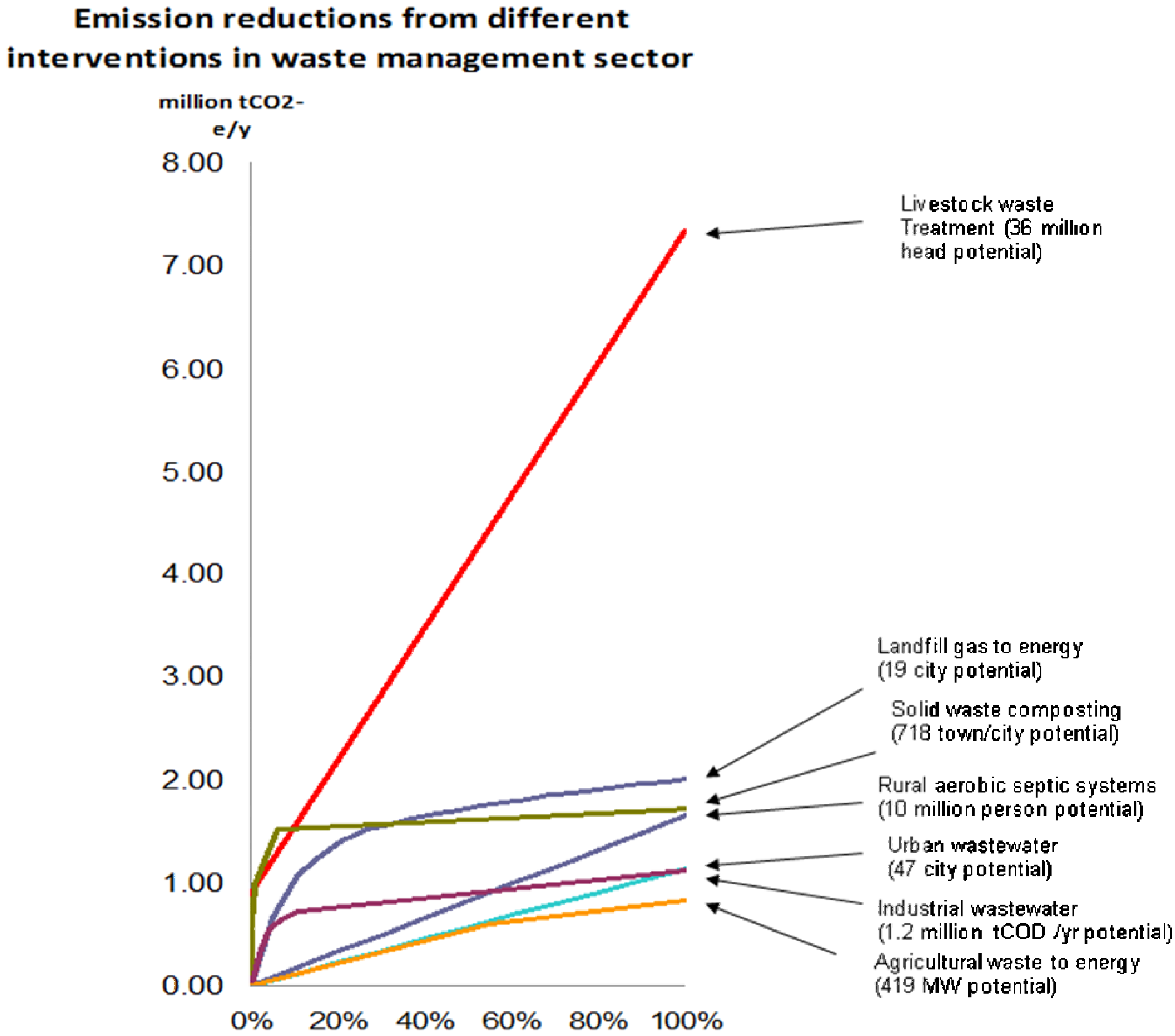
Annex 2: Greenhouse gas emission reduction potential of interventions



Note: Estimates based on annual reductions during 2010-2015

Annex 3: Potentially feasible sector-wide interventions

No.	Sector	Feasible Intervention	GHG emissions in 2010 (million tCO2-e)	GHG reduction potential (2010 to 2015)		Methodology and additionality issues	Co-benefits and Financial costs
				Total Potential (million tCO2-e/y)	For proposed intervention (million tCO2-e/y)		
6	**Waste**		**33.9**	**19.8**	**5.7**		
W1	Urban wastewater	Urban domestic wastewater: Increasing centralized wastewater treatment to 50% with aerobic sludge treatment; land farming of 100% sludge from centralized wastewater treatment plants; and desludging and aerobic treatment of 50% of septic tanks for five major cities		1.12	0.198 0.094 (HCMC) 0.054 (Hanoi) 0.024 (Hai Phong) 0.012 (Da Nang) 0.014 (Can Tho)	(1) Domestic wastewater treatment systems planned to be adopted in cities, it appears to be partially aerobic at least - additionality not clear; (2) Aerobic sludge management is not common practice; (3) Methodologies exist.	Reduced water pollution, improved health; energy savings; Can be profitable with right institutions
W2	Rural wastewater	Rural domestic wastewater: (1) Methane avoidance through switching 50% of septic tanks to aerobic sanitation and (2) 50% adoption of aerobic sanitation systems for those without sanitation		1.65	0.82 0.300 for (1) 0.530 for (2)	(1) It needs to check are the technologies new?; (2) No methodology; (3) May be very difficult to monitor.	Reduced water pollution, improved health; energy savings; Normally not profitable
W3	Industrial waste	Industrial wastewater: Methane recovery (biogas) and avoidance (aerobic systems) for 75% wastewater of bioethanol, meat & poultry, pulp & paper, liquor & beer, tapioca starch, and fishing processing industries		1.10	0.52 0.183 (bioethanol) 0.116 (meat & poultry) 0.076 (pulp & paper) 0.063 (liquor & beer) 0.056 (tapioca starch) 0.026 (fishing process)	(1) Use of biogas and aerobic systems in industries are not common pratice; (2) Approved methodologies exist.	Reduced water pollution; energy savings; Sometimes profitable with CDM

No.	Sector	Feasible Intervention	GHG emissions in 2010 (million tCO2-e)	GHG reduction potential (2010 to 2015) Total Potential (million tCO2-e/y)	For proposed intervention (million tCO2-e/y)	Methodology and additionality issues	Co-benefits and Financial costs
W4	Urban waste	Urban solid waste: Methane avoidance through solid waste composting in 8 selected cities		4.30	1.00 0.705 (Hanoi) 0.072 (Nam Dinh) 0.056 (Hue) 0.049 (Quy Nhon) 0.049 (Vung Tau) 0.042 (Vinh) 0.014 (Lao Cai) 0.013 (Phu Ly)	(1) Only one existing project/some planned; (2) No government plan or legislation; (3) Methodology approved but Methodology Panel is scrutinizing methodology.	Savings on disposal costs, use for farming; Sometimes profitable with CDM
W5	Urban waste	Urban solid waste: Methane recovery through landfill gas to energy projects in urban disposal sites for 8 selected cities		2.00	1.65 0.669 (HCMC) 0.400 (Hanoi) 0.187 (Hai Phong) 0.143 (Can Tho) 0.114 (Da Nang) 0.052 (Ha Long) 0.044 (Nha Trang) 0.041 (Nam Dinh)	(1) Applied in some small cities but not common practice; (2) Lack of skills/knowledge; (3) Lack of policy; (4) Methodology approved.	Reduced odor, energy savings; Typically profitable with CDM
W6	Renewable energy/Agricultural waste	Agricultural solid residues: Utilization of 20% of rice husk production and 40% of bagasse production for power generation		0.91	0.15 0.06 (20% rice husk) 0.09 (40% bagasse)	(1) Rice husk power plants are not common pratice in country; (2) 42 sugar mills using bagasse for power generation but only 3 sold electricity to the grid; (3) Many financial obstacles found (mainly purchasing price by EVN); (4) Approved methodologies exist.	Electrification, reduced pollution in rivers and of air; Typically profitable with CDM

No.	Sector	Feasible Intervention	GHG emissions in 2010 (million tCO2-e)	GHG reduction potential (2010 to 2015)		Methodology and additionality issues	Co-benefits and Financial costs
				Total Potential (million tCO2-e/y)	For proposed intervention (million tCO2-e/y)		
W7	livestock waste	Livestock waste: Methane capture and electricity generation in large-scale livestock farms (200 pig farms with 1,000,000 heads; 1,000 cattle farms with 500,000 heads; and 1,000 buffalo farms with 100,000 heads)		7.80	1.32 0.767 (pig farms) 0.384 (cattle farms) 0.166 (buffalo farms)	(1) Is not common pratice in country and adoption is not widespread; (2) Investment costs are high for the farmers; (3) Some approved methodologies exist.	Power savings for farmers; reduced water pollution; Typically profitable with CDM