Orientation of the Training Programme

13th May 2011

Climate Change Division, Ministry of Environment
JICA Expert Team

Review of the 1st CDM Training Programme

- Period: 24.6.2010 ~ 8.2010 (13 sessions)
- Goal: Train practitioners of emission reduction project in Sri Lankan organization to maximize project/environmental value.
- Lectures on:
  - Functional background of CDM
  - Carbon Credit Market
  - CDM Typology
  - Institutional Background of CDM
  - Post Kyoto
  - Stepwise Consideration of CDM
  - Documentation: PDD
  - CDM development in Sri Lanka
  - Policy and CDM (Energy, Forest)

Objective of 1st Training
- ➢ To acquire the basic knowledge of CDM
- ➢ To apprehend the discussion and important issues related to CDM
- ➢ To network with other practitioners for promoting CDM

Objective of 2nd Training
- ➢ To understand basic rules and emission reduction calculation formula for each project type
- ➢ To acquire the skills of calculating emission reduction through hands-on exercises

Outline of the 2nd CDM Training Programme

- **Period:** **13.5.2011~27.5.2011 (8 sessions)**
- **Goal:** **Build Hands-on Knowledge about Various CDM Categories**

Date	Time	Lecture Title	Lecturer
13 May	09:00~10:00	Renewable Energy Project (Non-Biomass & Biomass)	Kawamura
	10:00~10:15	Break	-
	10:15~11:15	Renewable Energy Project (Exercise)	Kawamura
	11:15~12:15	Waste Management / Handling Project	Sugimoto
20 May	09:00~10:00	Fuel Switch Project	Negishi
	10:00~10:15	Break	-
	10:15~11:15	Energy – saving / Demand Side Management project	Chikamatsu
	11:15~12:15	Afforestation / Reforestation	Chikamatsu
27 May	09:00~09:50	Achievement Test	-
	09:50~10:10	Tea Break	-
	10:10~10:55	Trend of Carbon Markets	Negishi
	10:55~11:40	Policy Measures for Climate Change Mitigation in Other Countries	Sugimoto
	11:40~12:00	Closing session	-

The Goal of the Series of the CDM Training Programme by JICA Expert Team

- **The Seminar is followed by a supplement seminar by Mr. Satoshi Iemoto for updated report about Post-Kyoto Discussions in international arena.**

Date	Lecture Title
To be announced	Current discussions over post-Kyoto Mechanism and Bilateral Credit Mechanism (Tentative)

- **The overall seminar program is designed to build hands-on knowledge about emission reduction projects.**
- **Lectures are mostly based on current Kyoto Mechanisms but are applicable for the Post-Kyoto mechanism.**

Train a practitioner of emission reduction project in Sri Lankan organization to maximize project/environmental value.

Thank you.

Renewable Energy CDM Projects (Non-biomass & Biomass)

13th May 2011

JICA Expert Team

Ai Kawamura

Contents

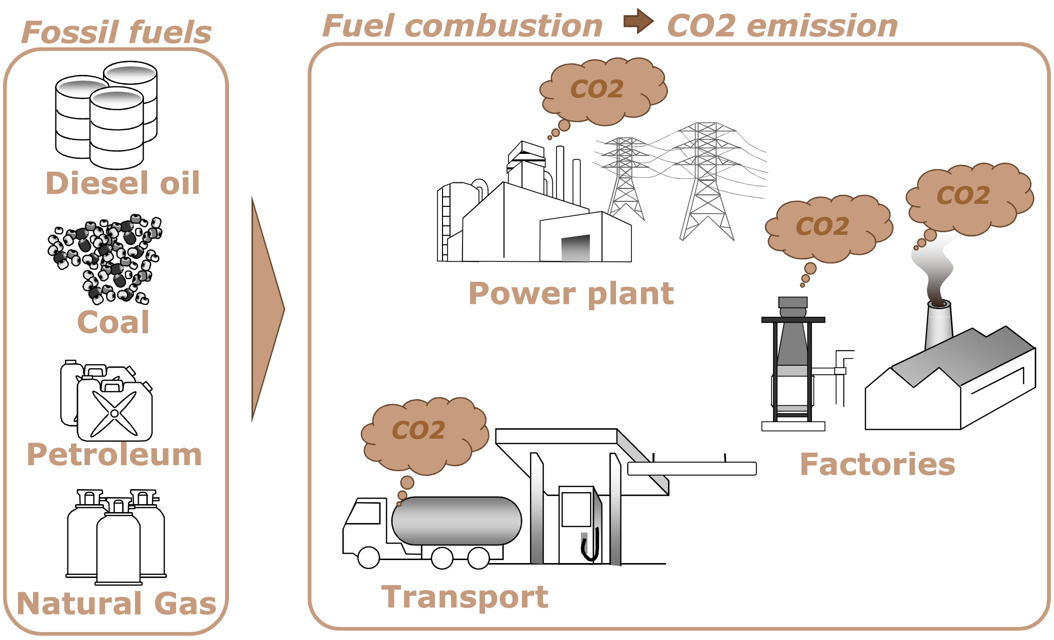
Session 1:

1. **How emission reduction is achieved by RE Project**
2. **Energy Source of Renewable Energy**
3. **Applicable Approved Methodology for RE projects**
4. **CDM Project Prototypes**
5. **Basic Formula for Emission Reduction Calculation of RE project**
6. **Calculation of Grid Emission Factor**

Session 2:

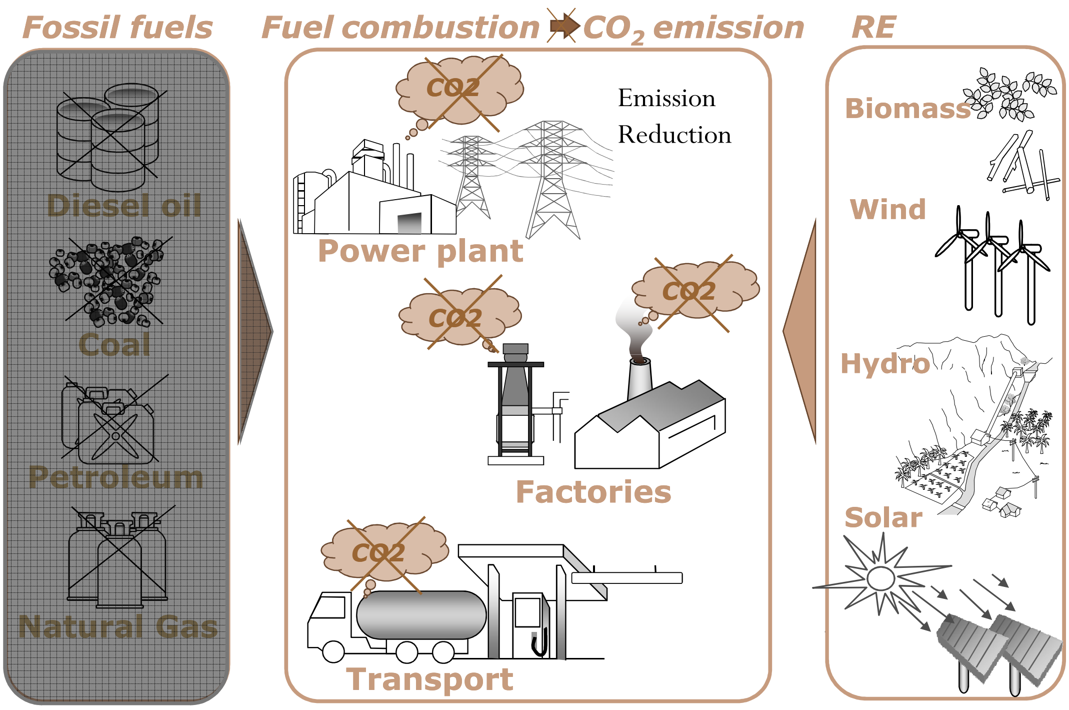
1. **Calculation Exercise: Hydro power**
2. **Calculation Exercise: Biomass**

1. How emission reduction is achieved by RE Project (1)



CO2 is emitted by combustion of fossil fuels

1. How emission reduction is achieved by RE Project (2)

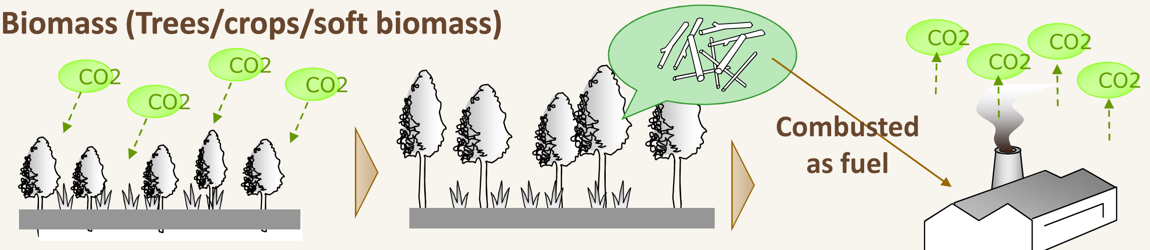


RE reduces GHG emissions by reducing the use of fossil fuel.

1. How emission reduction is achieved by RE Project (3)

Non-biomass (Wind/Hydro/Solar) etc *Produced energy does not come from fossil fuels*

Biomass (Trees/crops/soft biomass)



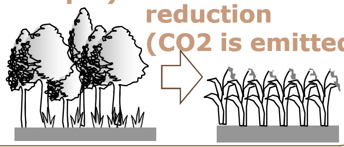
The emitted CO_2 is absorbed by the air when plants grow

carbon neutral energy source

However, emissions associated to project activities must be considered as CO_2 emissions.

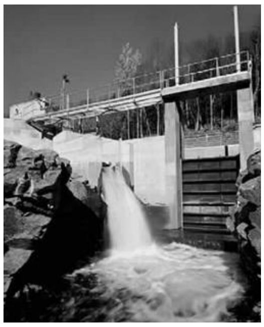
- **Carbon stock change by land use change**
- **Fossil fuel use for the production process**
- **Methane emission from waste treatment (solid & wastewater)**

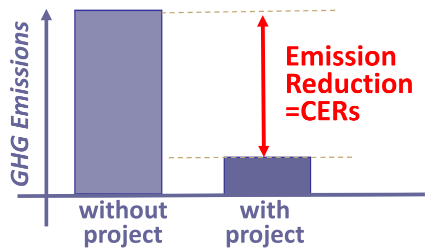
(Example) **Carbon stock reduction (CO_2 is emitted)**



2. Energy Source of Renewable Energy

- **Non-biomass:**
  - **Wind**
  - **Hydro**
  - **Solar**
  - **Others (geothermal & wave etc)**
- **Biomass:**
  - **Residue biomass (wood residue, rice husk, bagasse & garbage etc)**
  - **Energy crops (gliricidia, jatropha etc)**





3. Applicable Approved Methodology for RE projects (1)

- Full scale and Combined methodology

Category	Number	Title
Electricity	AM0019	Renewable energy project activities replacing part of the electricity production of one single fossil-fuel-fired power plant that stands alone or supplies electricity to a grid, excluding biomass projects
Electricity	AM0042	Grid-connected electricity generation using biomass from newly developed dedicated plantations
Electricity	ACM0002	Consolidated baseline methodology for grid-connected electricity generation from renewable sources
Electricity/ Thermal	ACM0006	Consolidated methodology for electricity and heat generation from biomass residues
Liquid fuel	ACM0017	Production of biodiesel for use as fuel
Electricity	ACM0018	Consolidated methodology for electricity generation from biomass residues in power-only plants

3. Applicable Approved Methodology for RE projects (2)

- Small Scale Methodology

Category	No	Title
Electricity	I-A	Electricity generation by the user
	I-B	Mechanical energy for the user with or without electrical energy
Electricity	I-D	Grid connected renewable electricity generation
Electricity	I-F	Renewable electricity generation for captive use and mini-grid
Thermal/ Cogeneration	I-C	Thermal energy production with or without electricity
Thermal	I-E	Switch from non-renewable biomass for thermal applications by the user
Thermal	I-I	Biogas/biomass thermal applications for households/small users
Liquid fuel	I-G	Plant oil production and use for energy generation in stationary applications
Liquid fuel	I-H	Biodiesel production and use for energy generation in stationary applications
Liquid fuel	III-T	Plant oil production and use for transport applications

4. CDM Project Prototypes (1)

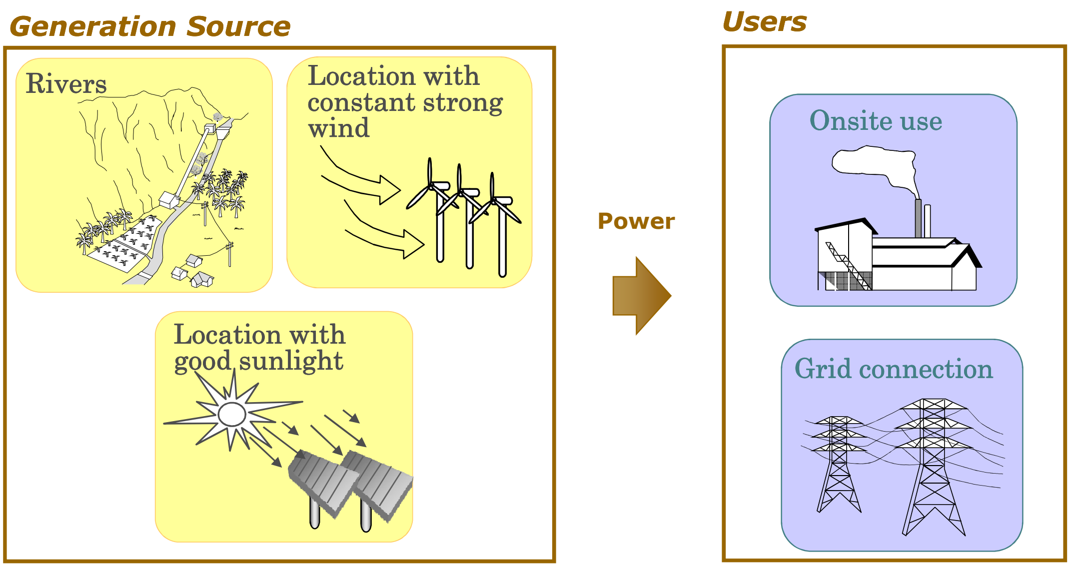
- Usage of energy

Electricity	Grid-connection, On site (by the user)
Thermal	Onsite (by the user)
Liquid fuel	(mainly for vehicle)

- Energy sources and types of energy use

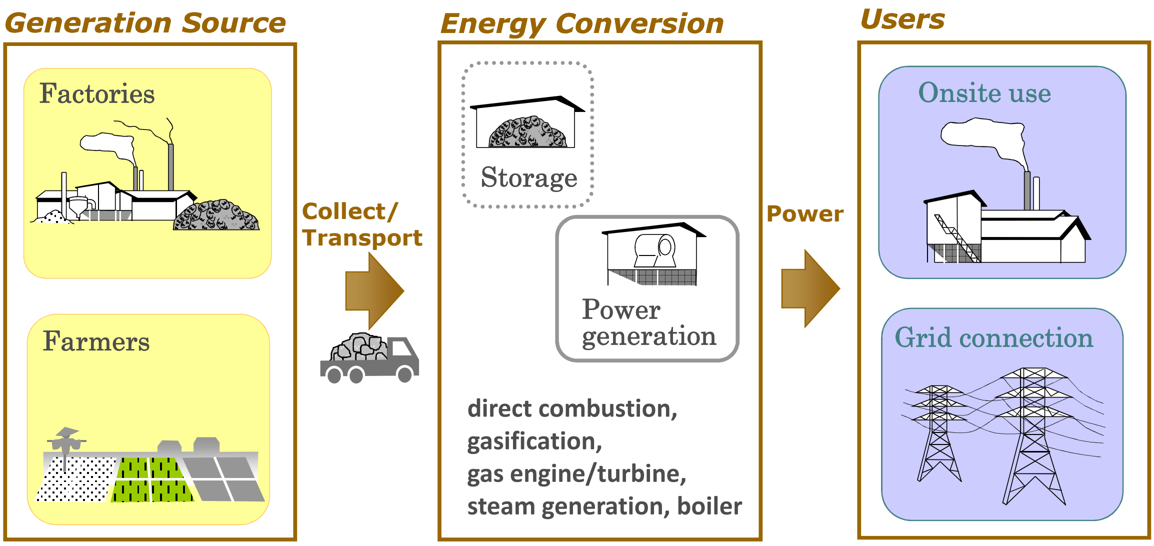
Source	Electricity	Heat	Liquid fuel
Biomass	✓	✓	✓ (plant oil)
Hydro/Wind	✓		
Solar	✓	✓	

4. CDM Project Prototypes (2): Non-biomass



- **Hydro power: constant river flow (seasonal fluctuation)**
- **Wind power: constant wind (seasonal fluctuation)**
- **The distance between the generation source and location of users (e.g., national grid)is the very important factor (location)**

4. CDM Project Prototypes (3): Biomass



- Enough amount of biomass should be assured (seasonal fluctuation)
- Procurement cost: distance of transport, purchasing price (market fluctuation)
- In case of grid connection, larger scale may have advantage if enough biomass with reasonable price is assured (scale merit)

5. Basic Formula for Emission Reduction Calculation of RE project (1)

- **Basic formula**

GHG emission reduction by RE project = Amount of energy to be replaced [A] × Emission factor of energy to be replaced [B] — Project/ Leakage Emission [C]

If energy to be replaced is:
- Grid electricity: [A]=Amount of grid electricity [MWh]
- On site electricity: [A]=Amount of fuel used for electricity generation [ton]

If energy to be replaced is:
- Grid electricity: [B]=Emission factor of Grid electricity [tCO_2/MWh]
- On site electricity: [B]=Emission factor of fuel used for electricity generation [tCO_2/t_fuel]

- Emission from on-site electricity and fossil fuel consumption in the project scenario
- Emission from transportation (for biomass)
- Emission from biomass competition (for biomass)

MWh= MW × hours | MWh= kWh × 1,000 | ton= kg × 1,000

5. Basic Formula for Emission Reduction Calculation of RE project (2)

Amount of energy to be replaced [A]

Energy to be replaced:	Unit	Remarks
Electricity	MWh/y	Hourly output (MW)× hours(h/y)
Fuel to produce electricity	t/y, kL/y	e.g., Hourly consumption (t)× annual operating hours(h/y)

Emission factor of energy to be replaced [B]

For Grid Electricity

Grid Emission Factor: 0.65~0.73 tCO_2/MWh

(No national official figure, PP has to calculate by themselves)

For On-Site Electricity

Fuel Type	Net Calorific Value (TJ/t) [a]	CO2 Emission Factor(tCO2/TJ) [b]	Oxidation factor [c]	CO2 emission factor(tCO2/t) [a]*[b]*[c]
Furnace Oil	0.041	77.4	1.0	3.173
Gas/Diesel Oil	0.0433	74.1	1.0	3.209
Naphtha	0.0456	73.3	1.0	3.342
Residual Oil	0.041	77.4	1.0	3.173
Source	Energy Data 2007, SEA	2006 IPCC Guidelines for National GHG Inventories, vol.2		

Unit check: $\frac{\cancel{TJ}}{t\_Fuel} \times \frac{tCO2}{\cancel{TJ}} = \frac{tCO2}{t\_Fuel}$

5. Basic Formula for Emission Reduction Calculation of RE project (3)

Project/ Leakage Emission [C]

- **Electricity & fossil fuel consumption by the project facilities**
- **(biomass)Transportation of biomass resources**
- **(biomass)Leakage emission from biomass competition**

Grid electricity

Emissions associated to grid electricity (tCO2/y) = Electricity Consumption (MWh/y) × Emission factor of grid electricity (t_CO2/MWh)

Fuel consumption

Emissions associated to fossil fuel consumption (tCO2/y) = Fuel Consumption (t/y) × Net calorific value of fuel (TJ/t) × CO2 emission Factor (tCO2/TJ)

Default value is available

5. Basic Formula for Emission Reduction Calculation of RE project (4)

Biomass transportation

Fuel consumption(t/y)

Emissions Associated to transportation (tCO2/y) = [Number of trips (no.of trip/y) × Distance (round trip) (Km/trip) × Fuel Efficiency (L/km) × Specific Gravity of diesel (kg/L) ÷1000] × Net calorific value of fuel (TJ/t) × CO2 emission Factor of fuel (tCO2/TJ)

Default value is available

Leakage associated to biomass competition

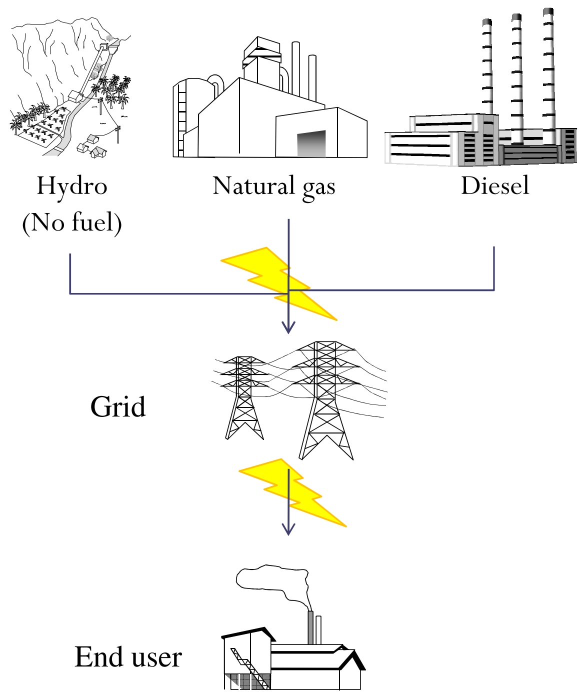
Emissions associated to biomass competition (tCO2/y) = Quantity of biomass used by the project which cannot be ruled out from leakage calculation (t/y) × Net calorific value of Biomass fuel (MJ/kg) × CO2 emission Factor of most carbon intensive fuel (tCO2/TJ)

Biomass which cannot be proved the enough availability within the project boundary

6. Calculation of Grid Emission Factor (1)

- Grid emission factor is the amount of CO_2 emitted per unit of electricity (tCO_2/kWh).
- Multiple power plants supply the electricity to the grid.
- The power plant may be diesel, natural gas, hydro etc.
- It assumes that the electricity consumed by the end user originated from these mix of electricity sources. emitting various levels of CO_2.

Various power plants



6. Calculation of Grid Emission Factor (2)

Simplified formula for grid emission factor calculation:

Grid Emission Factor in year y [tCO2/MWh] =

Total CO_2 emission from all the power plants that are connected to the grid in year y if the CDM project activity did not take place [tCO2/y]

divided by

Total MWh of electricity produced by all the power plants that are connected to the grid in year y if the CDM project activity did not take place [MWh/y]

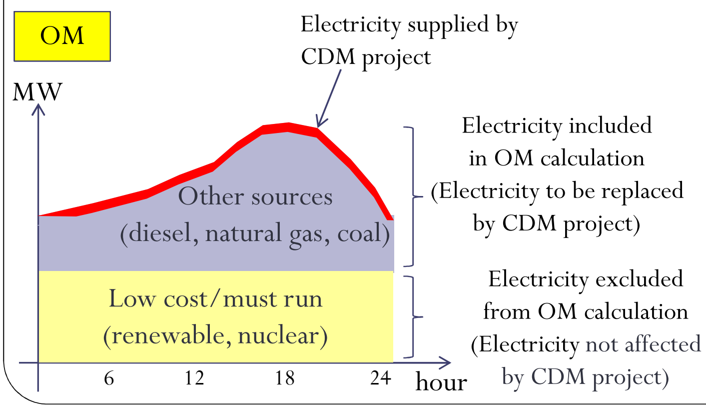
Reference: "Tool to calculate the emission factor for an electricity system"

- Grid Emission Factor is necessary for:
  - Renewable energy project that displaces grid electricity
  - Energy efficiency projects that reduces the use of the grid electricity
  - Projects using grid electricity in the project scenario (project emissions)
- Currently, all the registered Sri Lankan CDM projects requires grid emission factor data.

6. Calculation of Grid Emission Factor (3) Essential Terminologies

Terminology	Explanation
Operating Margin (OM)	Emission factor that refers to the group of existing power plants whose current electricity generation would be affected by the proposed CDM project activity.
Built Margin (BM)	Emission factor of the group of prospective power plants whose construction and future operation would be affected by the proposed CDM project activity.
Combined Margin (CM)	Weighted average of OM & BM of the electricity system.
Low-cost/must-run resources	Power plants with low marginal generation costs or power plants that are dispatched independently of the daily or seasonal load of the grid.

OM

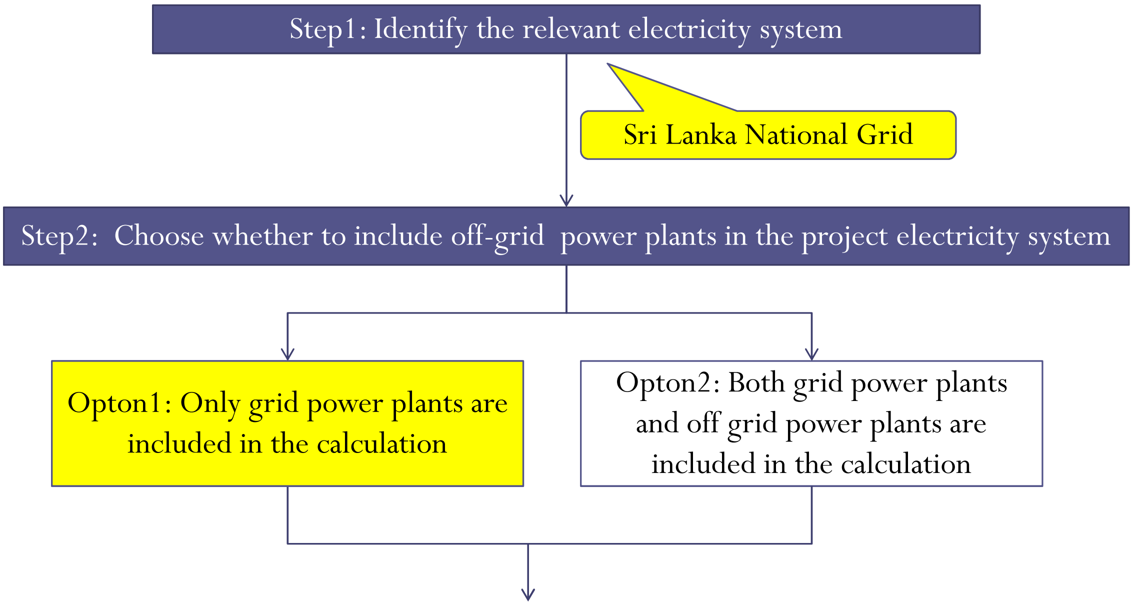


BM

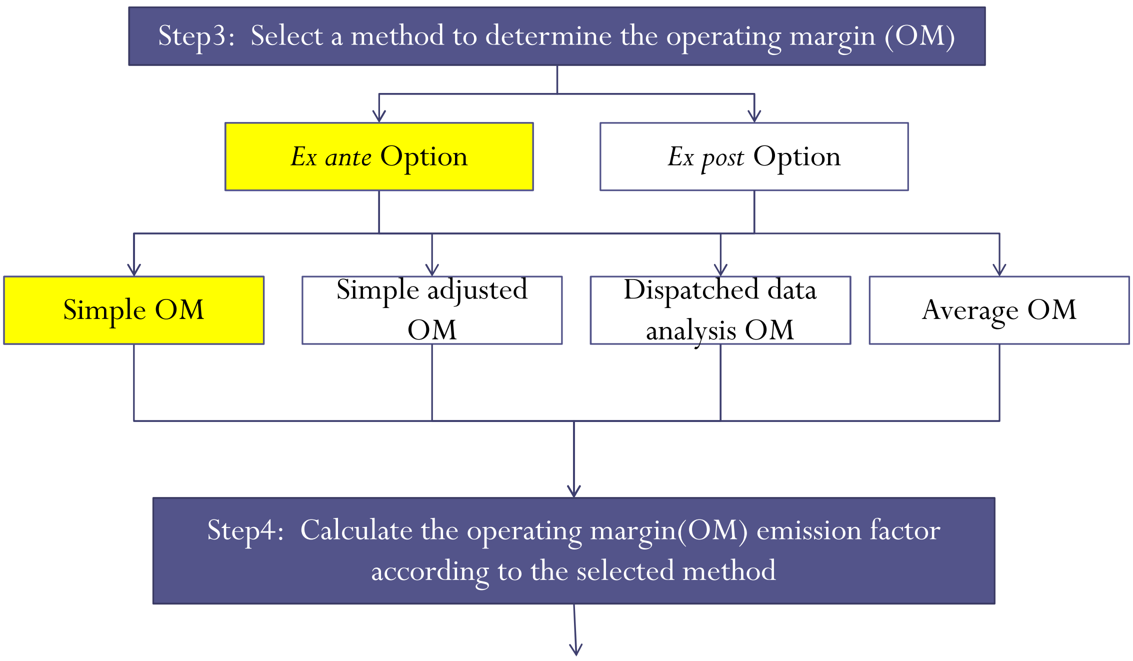
The set of power capacity additions in the electricity system that comprise 20% of the system generation (MWh) and that have been built most recently

The set of 5 power units that have been built most recently

6. Calculation of Grid Emission Factor (4) Calculation Process



6. Calculation of Grid Emission Factor (5) Calculation Process



6. Calculation of Grid Emission Factor (6) Calculation Process

Step5: Identify the group of power units to be included in the build margin (BM)

The set of five power units that have been built most recently

The set of power capacity additions in the electricity system that comprise 20% of the system generation (MWh) and that have been built most recently

Step6: Calculate the build margin (BM) emission factor

Step7: Calculate the combined margin (CM) emission factor

Sri Lanka National Grid Emission (need to update annually)

6. Calculation of Grid Emission Factor (7)

Example: 2007 Sri Lanka National Grid Emission Factor (I)

Conditions apply for Simple OM

- Low-cost/must-run resources needs to be less than 50% of total grid generation.
- low-cost/must run resources is calculated as the average of the five most recent years.

(GWh/y)

Year	Low Cost / Must Run				Thermal Generation					Total Generation	% of low-cost / must run
	CEB Hydro	CEB Wind	SPP Hydro	Total	CEB	IPP	SPP	Hired	Total		
2003	3,190	3.39	121.0	3,314	2,248	1,746	1.2	394	4,389	7,704	43.0%
2004	2,755	2.70	207.0	2,965	2,507	2,087	1.5	509	5,105	8,069	36.7%
2005	3,223	2.44	280.0	3,505	2,162	3,177	2.3	-	5,341	8,847	39.6%
2006	4,290	2.31	346.4	4,638	1,669	3,136	1.7	-	4,807	9,445	49.1%
2007	3,603	2.27	345.0	3,950	2,336	3,559	1.1	-	5,896	9,846	40.1%
Total	17,060	13.11	1299.4	18,373	10,921	13,705	7.8	903	25,537	43,910	41.8%

6. Calculation of Grid Emission Factor (8)

Example: 2007 Sri Lanka National Grid Emission Factor (II)

Parameters Applied and Emission Factors of Each Fuel Type

Fuel Type	Net Calorific Value (TJ/t)	Effective CO_2 emission factor (tCO_2/TJ)	Oxidation factor	CO_2 emission coefficient (tCO_2/t)
	(a)	(b)	(c)	(a)*(b)*(c)
Furnace Oil [Fuel oil]	0.041	77.4	1.0	3.173
Gas/Diesel Oil [Auto oil]	0.0433	74.1	1.0	3.209
Naphtha	0.0456	73.3	1.0	3.342
Residual Oil	0.041	77.4	1.0	3.173
Sourece	Energy Data 2007, Ministry of Power and Energy	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Table 1.4		

6. Calculation of Grid Emission Factor (9)

Example: 2007 Sri Lanka National Grid Emission Factor (II)

Simple OM:

Generation-weighted average CO_2 emissions per unit net electricity generation of all generating power plants serving the system, not including the low-cost/must-run resources.

Option B:

Based on total net electricity generation of all power plants serving the system and the fuel types and total fuel consumption of the project electricity system.

2005 | kL=m3 | 1G = 10^9, 1M = 10^6, 1K = 10^3

Fuel Type	Fuel Consumption (1,000kL/y)	Specific Gravity of Fuel (t/m3)	CO_2 emission factor (tCO_2/t_fuel)	CO_2 Emission (tCO_2/y)	Electricity Generation (GWh)	Grid Emission Factor (kg_CO_2/kWh)
	(a)	(b)	(c)	(d)	(e)	(f)
Furnace Oil	500	0.972	3.173	1,542,554		
Gas/Diesel Oil	306	0.846	3.209	830,733		
Naphtha	180	0.690	3.342	415,076		
Residual Oil	270	0.972	3.173	832,979	5,341	0.678
Total	-	-	-	3,621,343		
Source	Energy Data 2007, Table "Fuel Consumption in Power Plants"	Energy Data 2007, Table "Conversion Factors and Coefficients"		(a)*(b)*(c)	Energy Data 2007, Table "Summary"	(d)/(e)

6. Calculation of Grid Emission Factor (10)
Example: 2007 Sri Lanka National Grid Emission Factor (III)

2006

Fuel Type	Fuel Consumption 1000kL/y	Density of Fuel t/m3	COEF (tCO2/t_fuel)	Emission (tCO2/y)	Electricity Generation (GWh)	Grid Emission Factor (kg_CO2/kWh)
	(a)	(b)	(c)	(d)	(e)	(f)
Furnace Oil	469	0.972	3.173	1,446,916		
Gas/Diesel Oil	308	0.846	3.209	836,163		
Naphtha	91	0.690	3.342	209,844		
Residual Oil	266	0.972	3.173	820,639		
Total	-	-	-	3,313,561	4,807	0.689
Source	Energy Data 2007, Table "Fuel Consumption in Power Plants"	Energy Data 2007, Table "Conversion Factors and Coefficients"		(a)*(b)*(c)	Energy Data 2007, Table "Summary"	(d)/(e)

2007

Fuel Type	Fuel Consumption 1000kL/y	Density of Fuel t/m3	COEF (tCO2/t_fuel)	Emission (tCO2/y)	Electricity Generation (GWh)	Grid Emission Factor (kg_CO2/kWh)
	(a)	(b)	(c)	(d)	(e)	(f)
Furnace Oil	513	0.972	3.173	1,582,660		
Gas/Diesel Oil	466	0.846	3.209	1,265,103		
Naphtha	138	0.690	3.342	317,303		
Residual Oil	296	0.972	3.173	913,809		
Total	-	-	-	4,078,875	5,896	0.692
Source	Energy Data 2007, Table "Fuel Consumption in Power Plants"	Energy Data 2007, Table "Conversion Factors and Coefficients"		(a)*(b)*(c)	Energy Data 2007, Table "Summary"	(d)/(e)

OM

2005 (kg_CO2/kWh)	2006 (kg_CO2/kWh)	2007 (kg_CO2/kWh)	Average (kg_CO2/kWh)
0.678	0.689	0.692	0.686

6. Calculation of Grid Emission Factor (11)
Example: 2007 Sri Lanka National Grid Emission Factor (III)

BM

No.	Plant	Date of commissioning	Fuel Type	Fuel Consumption (million Ltr)	Generation of the unit in 2007 (million kWh)
1	ACE- Embilipiyiya	2004, Mar 2005	Furnace Oil	160	663
2	Heladhanavi	Oct 2003	Furnace Oil	158	748
3	AES-Kelanitissa	Mar 2003	Auto Oil	209	789
			Total of 1-3	528	2,200
			Total grid generation (million kWh)		9,814
			Proportion within the grid		22.4%

> 20%

Fuel Type	Fuel Consumption 1000kL/y	Density of Fuel t/m3	COEF (tCO2/t_fuel)	Emission (tCO2/y)	Electricity Generation (GWh)	Grid Emission Factor (kg_CO2/kWh)
	(a)	(b)	(c)	(d)	(e)	(f)
Fuel Oil	318	0.972	3.173	981,681		
Auto Oil	209	0.846	3.209	568,482		
Naptha	0	0.690	3.342	0		
Heavy Oil	0	0.972	3.173	0		
Total	-	-	-	1,550,163	2,200	0.705
Source	SEA Data	Energy Data 2007		(a)*(b)*(c)	CEB data	(d)/(e)

CM

Year	OM	BM	CM
2005	0.678		
2006	0.689		
2007	0.692		
AVERAGE	0.686	0.705	0.695

Calculation Exercise

Non-biomass, Biomass

1. Calculation Exercise: Mini-hydro power(1)

- Company A has a CDM project plan with the following details:
  - New mini-hydro power plant project selling the power to CEB
  - Capacity: 1.2 MW
  - Expected operation: (dry season) 0.8MW, (wet season)1.2MW
  - 0.1MW of generated electricity is required for operating the mini-hydro plant
  - Daily operating hours: 24 hours
  - Monthly operating days: 25 days
  - Season: (dry season) 4 months, (wet season) 8 months
  - Grid emission factor: 0.70 kgCO2/kWh

(Question)
How much emission reduction is expected by this project activity?

1. Calculation Exercise: Mini-hydro power(2)

Step1
- How many hours does the plant operate in dry season?
- How many hours does the plant operate in wet season?

Step2
- How much electricity to be sold to the grid in dry season?
- How much electricity to be sold to the grid in wet season?

Step3
- How much electricity to be sold to the grid annually?

Step4
- How much GHG emission is reduced annually by the project?

1. Calculation Exercise: Mini-hydro power(3)

Step1
- How many hours does the plant operate in dry season?
- How many hours does the plant operate in wet season?

- Daily operating hours: 24 hours
- Monthly operating days: 25 days
- Season: (dry season) 4 months, (wet season) 8 months

Dry season:

24 hours/day × 25days/month × 4 months/y = **2,400 hours/y**

Wet season:

24 hours/day × 25days/month × 8 months/y = **4,800 hours/y**

1. Calculation Exercise: Mini-hydro power(4)

Step2

- How much electricity to be sold to the grid in dry season?
- How much electricity to be sold to the grid in wet season?

- Operating hours in each season: (Dry) 2,400 hours, (Wet) 4,800hours
- Expected operation: (dry season) 0.8MW, (wet season) 1.2MW
- Electricity requirement by the plant: 0.1MW

Amount of electricity to be sold to the grid can be obtained by operation ratio (MW) times number of operating hours.

Amount of electricity (MWh/y) = Rate of electricity generation (MW) × Operating hours (hours/y)

Dry season: = (0.8 MW − 0.1MW)×2,400 hours/y = **1,680 MWh/y**

Wet season: =(1.2 MW − 0.1MW) × 4,800 hours/y = **5,280 MWh/y**

1. Calculation Exercise: Mini-hydro power(5)

Step3

- How much electricity to be sold to the grid annually?

- Amount of electricity to be sold to the grid in dry season: 1,680 MWh/y
- Amount of electricity to be sold to the grid in wet season: 5,280 MWh/y

Annual Electricity (MWh/y) = **Electricity (Dry season) (MWh/y)** + **Electricity (Wet season) (MWh/y)**

= 1,680 MWh/y + 5,280 MWh/y

= **6,960 MWh/y**

1. Calculation Exercise: Mini-hydro power(6)

Step4

- How much emission is reduced annually by the project?

- Amount of electricity to be sold to the grid annually: 6,960 MWh/y
- Grid emission factor: 0.70 $kgCO_2/kWh$

Emission Reduction (tCO_2/y)	=	Amount of Electricity (MWh/y)	×	Grid emission factor (tCO_2/MWh)
	=	6,960 MWh/y	×	0.70 tCO_2/MWh
	=	**4,872 tCO_2/y**		

Emission Reduction = Baseline emission − Project emission
= 4,872 tCO_2/y − 0 tCO_2/y
= 4,872 tCO_2/y

Answer:
4,872 tCO_2/y

2. Calculation Exercise: Biomass(1)

- Company B has a CDM project plan with the following details:
  - Biomass power generation project selling the electricity to CEB
  - The biomass assumed to be used is saw dust and rice husk
  - Electricity generation operation rate: 0.8 MW
  - Daily operating hours: 20 hours
  - Monthly operating days: 20 days
  - Seasonal operation: operation is constant
  - Grid emission factor: 0.70 $kgCO_2/kWh$
  - Furnace oil required for operation of the new plant: 6ton/month
  - Diesel required for transportation of biomass: 2 t/month

(Q2)
How much emission reduction is expected by this project activity?

2. Calculation Exercise: Biomass(2)

Step1
- How many hours does the plant operate annually?

Step2
- How much electricity to be sold to the grid annually?

Step3
- How much GHG emission is reduced annually by selling the electricity to the grid? [baseline emission]

Step4
- How much fossil fuel is required for operating the plant annually?
- How much fossil fuel is required for biomass transportation annually?
- How much fossil fuel is required by the project activity ?

Step5
- How much GHG is emitted annually through fossil fuel consumption by the project activity? [project emission]

Step6
- How much GHG emission is reduced annually by the project activity? [Emission reduction]

2. Calculation Exercise: Biomass(3)

Step1
- How many hours does the plant operate annually?

- Daily operating hours: 20 hours
- Monthly operating days: 20 days
- Seasonal operation: operation is constant

Annual operation hours

20hours/day × 20 days/month × 12 months/y = **4,800 hours/year**

2. Calculation Exercise: Biomass(4)

Step2

- How much electricity to be sold to the grid annually?

- Annual operation hour: 4,800 hours/y
- Electricity generation operation rate: 0.8 MW

Amount of electricity to be sold to the grid

Amount of electricity (MWh/y) = Rate of electricity generation (MW) × Operating hours (hours/y)

= 0.8MW × 4,800 hours/year

= **3,840 MWh/y**

2. Calculation Exercise: Biomass(5)

Step3

- How much GHG emission is reduced annually by selling the electricity to the grid? [baseline emission]

- Amount of electricity to be sold to the grid annually: 3,840 MWh/y
- Grid emission factor: 0.70 kgCO2/kWh

Baseline emission (tCO2/y) = **Amount of Electricity (MWh/y)** × **Grid emission factor (tCO2/MWh)**

= 3,840 MWh/y × 0.70 tCO2/MWh

= **2,688 tCO2/y**

2. Calculation Exercise: Biomass(6)

Step4

- How much fuel is required for operating the plant annually?
- How much fuel is required for biomass transportation annually?

- Furnace oil required for operation of the new plant: 6t/month
- Diesel required for transportation of biomass: 2t/month

On-site fossil fuel consumption

6 t/month × 12 months = 72 t/year

Fossil fuel consumption for biomass transport

2 t/month × 12 months = 24 t/year

2. Calculation Exercise: Biomass(7)

Step5

- How much GHG is emitted annually through fossil fuel consumption by the project activity? [project emission]

- Furnace oil required for operation of the new plant: 72t/year
- Diesel required for transportation of biomass: 24t/year

Emission associated to on-site fossil fuel consumption

72 t_fuel/year × 3.173 tCO2/t_fuel

= 228.4 tCO2/y

Emission associated to biomass transport

24 t_fuel/year × 3.209 tCO2/t_fuel

= 77.0 tCO2/y

Project emissions

228.5 tCO2/y + 77.0 tCO2/y = 305.5 tCO2/y

Fuel Type	Net Calorific Value (TJ/t)	Effective CO2 emission factor (tCO2/TJ)	Oxidation factor	CO2 emission coefficient (tCO2/t)
	(a)	(b)	(c)	(a)*(b)*(c)
Furnace Oil	0.041	77.4	1.0	3.173
Gas/Diesel Oil	0.0433	74.1	1.0	3.209
Naphtha	0.0456	73.3	1.0	3.342
Residual Oil	0.041	77.4	1.0	3.173
Source	Energy Data 2007	2006 IPCC Guidelines for National GHG Inventories, Volume 2: Energy, Table 1.4		

2. Calculation Exercise: Biomass(8)

Step6

- How much GHG emission is reduced annually by the project activity? [Emission reduction]

- Baseline emissions: 2,688tCO2/year
- Project emissions: 305.5 tCO2/year

Emission reduction (tCO2/y)	=	**Baseline emission (tCO2/y)**	-	**Project emission (tCO2/y)**
	=	2,688 tCO2/y	-	305.5 tCO2/y
	=	2,382.5 tCO2/y		

Answer:
2,382.5 tCO2/y

Waste Management/Handling CDM Project

13 May 2011

Satoshi Sugimoto
JICA Expert Team

Contents

1. Waste Management and GHGs Emission
2. Wastewater Management and GHGs Emission
3. CDM Project Prototypes
4. Key Parameters in CH_4 Emission from Waste
5. Estimation of CH_4 Emission from Waste
6. Exercise: Estimation of CH_4 Emission from Solid Waste Disposal Site

1. Waste Management and GHGs Emission




Waste Discharge at Sources → Collection and Transportation → Intermediate Treatment → Final Disposal at Landfills

CO_2

Fuel combustion by collection vehicles

CO_2

In the case of incinerating waste with the use of fossil fuels

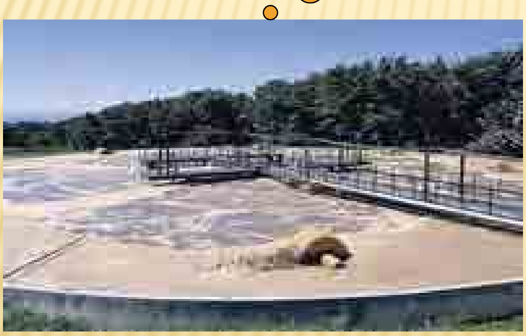
CH_4

Anaerobic decomposition of organic wastes

2. Wastewater Management and GHGs Emission

CH_4

(Anaerobic Decomposition of organic matter)



Domestic Wastewater

Agricultural Wastewater

3. CDM Project Prototypes

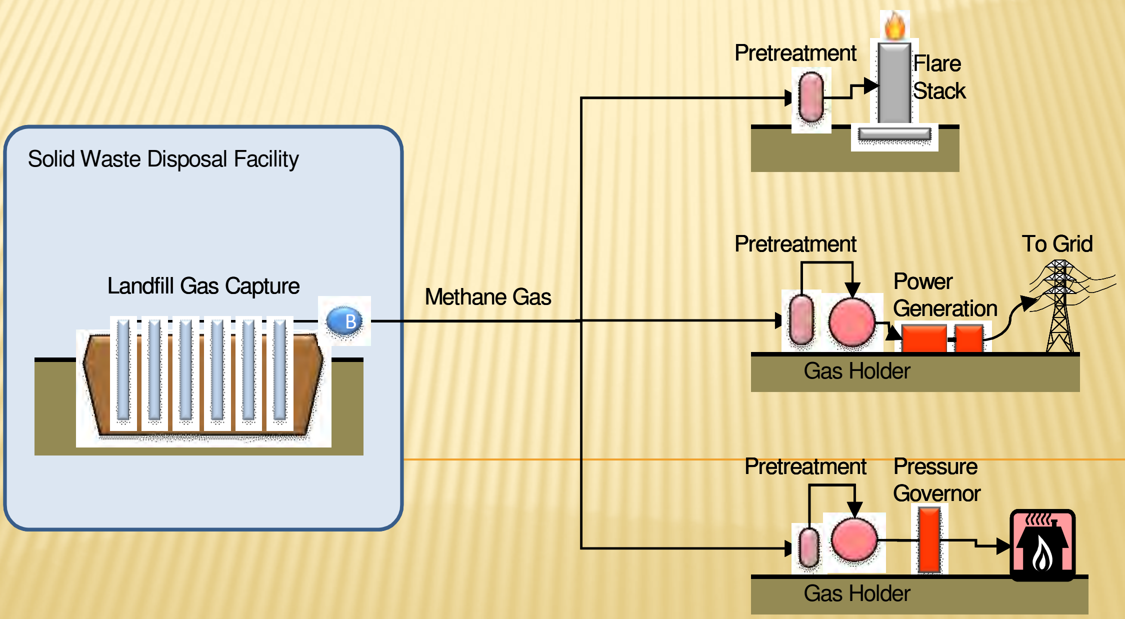
GHG emission source	Emission Reduction Methods	
Solid Waste/ Wastewater	CH_4 Capture	Flaring (Burning)
		Direct heat use
		Electricity generation
	CH_4 Emission Avoidance/Reduction by Aerobic Treatment of Organic Matter	

Including composting

Applicable GHGs emission reduction methods are basically same for solid waste and wastewater treatment.

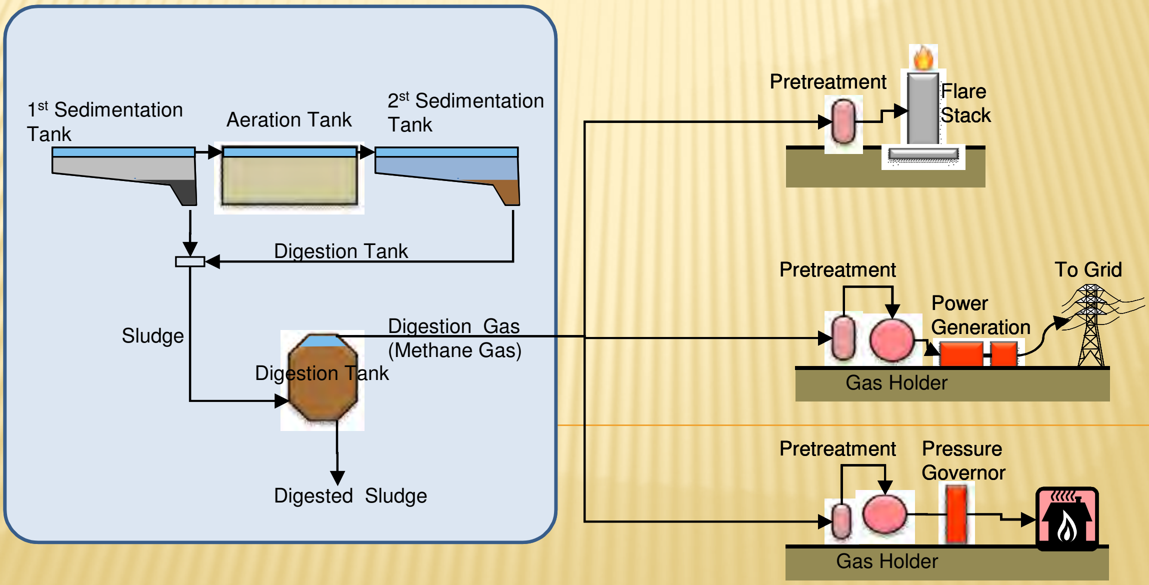
3. CDM Project Prototypes

(1) Methane capture from waste landfill



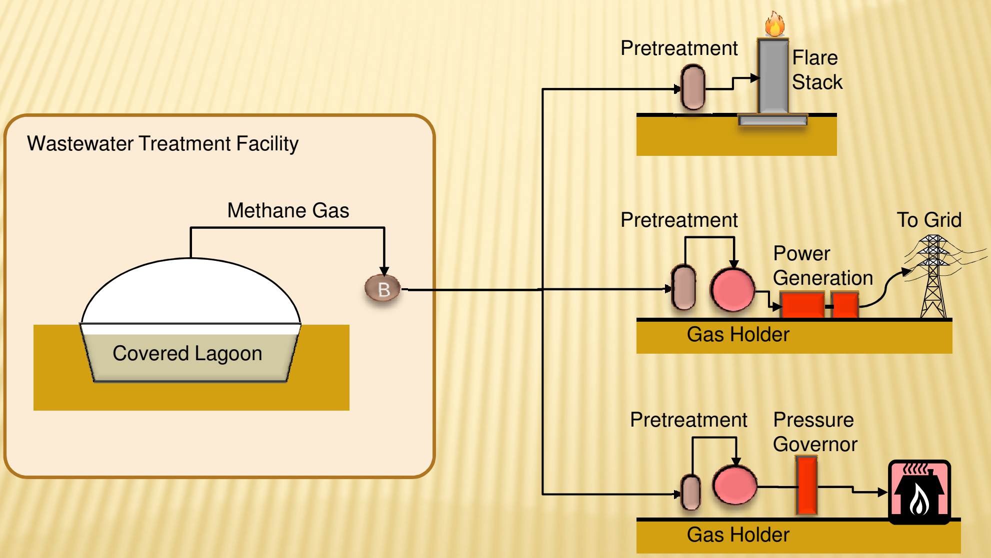
3. CDM Project Prototypes

(2) Methane capture from anaerobic wastewater treatment (Type A)



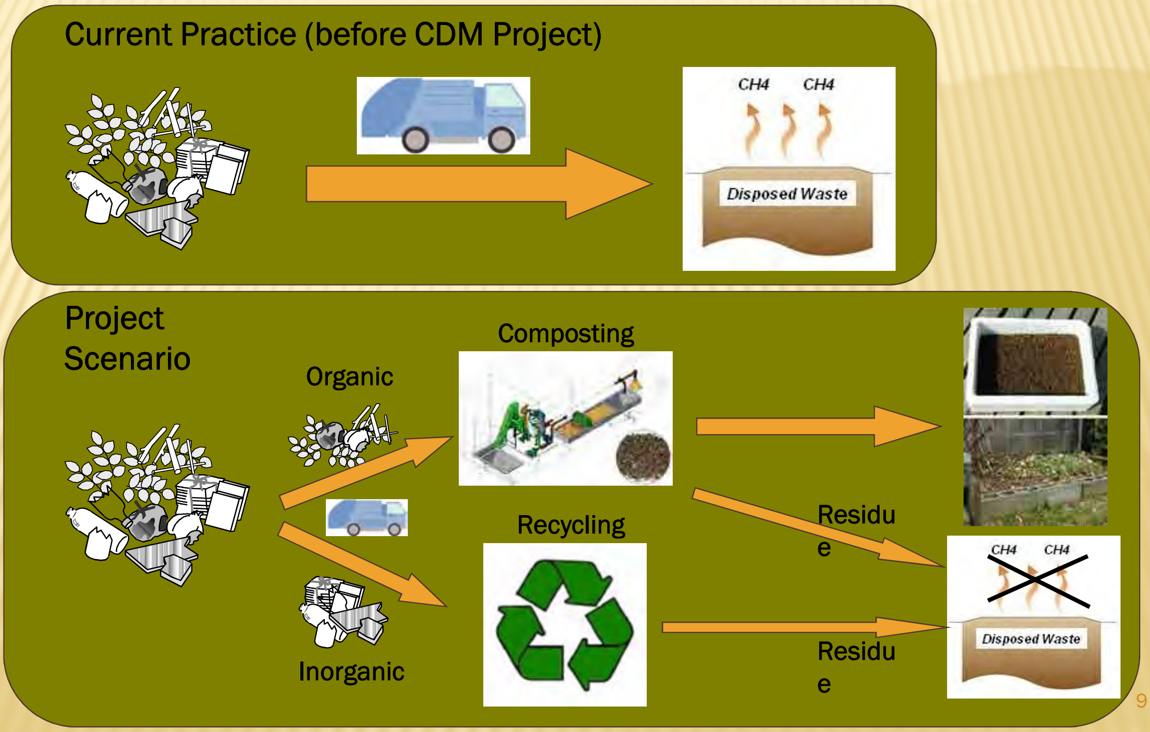
3. CDM Project Prototypes

(3) Methane capture from anaerobic wastewater treatment (Type B)



3. CDM Project Prototypes

(4) Methane avoidance by composting of organic matter in solid waste



4. Key parameters in CH_4 emission from waste

CH_4 emission from waste

- CH_4 is generated as a result of degradation of organic materials under anaerobic conditions.
- The time required for the waste to decay (half-life) is different among the types of waste.
- Part of CH_4 generated is oxidized in the cover of solid waste disposal (CH_4 oxidation by methanotrophic micro-organisms in cover soils).

Key Parameter in CH_4 emission

- Degradable organic materials (Degradable Organic Carbon: DOC) in waste.
- Degree of anaerobic condition in waste (Methane Correction Factor: MCF).
- The time required for the waste to decay (decay rate)

4. Key parameters in CH_4 emission from waste

(1) Content of DOC by types of waste

Type of Waste	DOC content (% on weight basis)	
	Wet waste	Dry waste
Paper/cardboard	40	44
Textiles	24	30
Food waste	15	38
Wood	43	50
Garden and park waste	20	49
Nappies	24	60
Rubber and leather	39	47
Inert waste (plastic, metal, glass)	-	-

<u>Content of organic waste is the key to amount of CH_4 emission.</u>

4. Key parameters in CH_4 emission from waste

(2) Degree of anaerobic condition (Methane Correction Factor)

Type of Waste disposal (Landfill)	Methane Correction Factor (MCF)
Managed – anaerobic	1.0
Managed – semi-aerobic	0.5
Unmanaged – deep (>5 m waste) and/or high water table	0.8
Unmanaged – Shallow (<5 m waste)	0.4
Uncategorised waste disposal	0.6

- The intensity of methane emission is considerably influenced by the anaerobic condition of waste varying with types of final disposal practices.
- The more anaerobic the condition of waste, the more CH_4 is generated.

4. Key parameters in CH_4 emission from waste

(2) Degree of anaerobic condition (Methane Correction Factor)

Type of Waste disposal (Landfill)	Definition
Managed – anaerobic	The landfills which have controlled placement of waste (i.e. waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and include at least one of the following: (i) cover material; (ii) mechanical compacting; or (iii) levelling of the waste.
Managed – semi-aerobic	The landfills which have controlled placement of waste and include all of the following structures for introducing air to waste layer: (i) permeable cover material; (ii) leachate drainage system; (iii) regulating pondage; and (iv) gas ventilation system.
Unmanaged – deep (>5 m waste) and/or high water table	All landfills not meeting the criteria of managed landfill s above and which have depths of greater than or equal to 5 meters and/or high water table at near ground level.
Unmanaged – Shallow (<5 m waste)	All landfills not meeting the criteria of managed landfills above and which have depths of less than 5 meters.

4. Key parameters in CH_4 emission from waste

(3) Time required for the waste to decay (Decay rate of waste)

Type of Waste		Tropical Climate (MAT >20℃)	
		Dry (MAP<1,000mm)	Moist and Wet (MAP>=1,000mm)
Slowly degrading waste	Paper/textiles waste	0.045	0.07
	Wood/straw waste	0.025	0.035
Moderately degrading waste	Other (non-food) organic putrescible/Garden and park waste	0.065	0.17
Rapidly degrading waste	Food waste/sewerage sludge	0.085	0.4

■ Decay rate of waste is given as a constant by types of waste based on the time required to decay.

5. Estimation of CH_4 from Waste Disposal Site

Equation

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1-e^{-k_j})$$

$BE_{CH4,\ SWDS,y}$	Methane emissions during the year y from waste disposal at the solid waste disposal site (SWDS) during the period from the start of waste disposal activity to the end of the year y (tCO_2e)
φ	Model correction factor to account for model uncertainties (0.9)
f	Fraction of methane captured at the SWDS and flared, combusted or used in another manner (in this case 0)
GWP_{CH4}	Global Warming Potential (GWP) of methane, valid for commitment (21)
OX	Oxidation factor (reflecting the amount of methane from SWDS that is oxidized in the soil or other material covering the waste (default value: 0.1)
F	Fraction of methane in the SWDS gas (volume fraction) (default value:0.5)
DOC_f	Fraction of degradable organic carbon (DOC) that can decompose (default value:0.5)

5. Estimation of CH_4 from Waste Disposal Site

Equation

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1-e^{-k_j})$$

MCF	Methane correction factor (determined by types of SWDS)
$W_{j,x}$	Amount of organic waste type j disposed at the SWDS in the year x (tons)
DOC_j	Fraction of degradable organic carbon (by weight) in the waste type j
k_j	Decay rate for the waste type j
j	Waste type category
e	The base of natural logarithm (Napier's number: 2.718)
X	Year during the crediting period: x runs from the first year of the first crediting period (x=1) to the year y for which avoided emissions are calculated (x=y)
Y	Year for which methane emissions are calculated.

6. Exercise: Estimation CH_4 emission from SWDS

Question	Estimate the amount of CH_4 emission from SWDS in 1 (one) year under the following preconditions

(Preconditions)

Items	Preconditions	
The amount of waste disposed		100 tons/day
Waste composition by types (% by weight)	Paper/Cardboard	10%
	Textiles	0%
	Food waste	30%
	Wood	0%
	Garden and park waste	20%
	Inert waste	40%
Type of Waste Disposal Landfill	Unmanaged –deep (>5m) landfill	

6. Exercise: Estimation CH_4 emission from SWDS

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1-e^{-k_j})$$

5.67 (constant)

Choose the factor from below

Type of Waste disposal (Landfill)	Methane Correction Factor (MCF)
Managed – anaerobic	1.0
Managed – semi-aerobic	0.5
Unmanaged – deep (>5 m waste) and/or high water table	0.8
Unmanaged – Shallow (<5 m waste)	0.4
Uncategorised waste disposal	0.6

Estimated by yourself

See next page

6. Exercise: Estimation CH_4 emission from SWDS

$$\sum_{x=1}^{y}\sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1 - e^{-k_j})$$

↓

Total amount of DOCs (Degradable Organic Carbons) decayed in the year

↓

Amount of Waste A	×	DOC content of A	×	Decay rate of DOC A
Amount of Waste B	×	DOC content of B	×	Decay rate of DOC B
Amount of Waste C	×	DOC content of C	×	Decay rate of DOC C
Amount of Waste D	×	DOC content of D	×	Decay rate of DOC D

6. Exercise: Estimation CH_4 emission from SWDS

Step 1: Total amount of waste disposed per year

Amount of waste disposed (tons/day)	Amount of waste disposed (tons/year)
100	36,500

Step 2: Amount of waste disposed by type of waste

Amount of waste disposed (tons/year)	Waste composition by types (%)		Amount of Waste by types (tons/year)
36,500	Paper/cardboard	10	3,650
	Textiles	0	0
	Food Waste	30	10,950
	Wood	0	0
	Garden/park waste	20	7,300
	Inert waste	40	14,600

6. Exercise: Estimation CH_4 emission from SWDS

Step 3: Total amount of DOCs decayed in a year

Amount of Waste by types (tons/year)		Content of DOC (% on weight basis)	Decay rate in the first year	Total amount of DOCs in a year (tons/year)
Paper/cardboard	3,650	40	0.068	99.28
Textiles	0	24	0.068	0
Food waste	10,950	15	0.330	542.025
Wood	0	43	0.034	0
Garden/park waste	7,300	20	0.156	227.76
Inert waste	14,600	0	0	0
			Total	869.065

6. Exercise: Estimation CH_4 emission from SWDS

Step 4: Total emission of CH4 from SWDS in the first year

$$BE_{CH4,SWDS,y} = \varphi \cdot (1-f) \cdot GWP_{CH4} \cdot (1-OX) \cdot \frac{16}{12} \cdot F \cdot DOC_f \cdot MCF \cdot \sum_{x=1}^{y} \sum_{j} W_{j,x} \cdot DOC_j \cdot e^{-k_j \cdot (y-x)} \cdot (1-e^{-k_j})$$

5.67 (constant) × MCF (0.8) × Total amount of DOCs decayed (869.065)

Answer	3,942Ton CO2/year

Afforestation Reforestation

20th May 2011
JICA Expert Team
Shiro Chikamatsu

Objectives of the Seminar

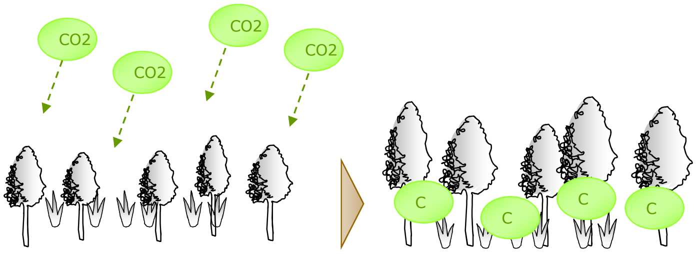
- To understand the major issues regarding A/R carbon credit projects
- To understand the basic components of the A/R CDM methodology
- To know that there are new approaches to forestry carbon credit projects

Table of contents

1. Basics

1. Basics
What are A/R projects?

- A/R→Afforestation Reforestation
- CO_2 is absorbed by the trees
- Trees fix the carbon during its growth, thus prevent emission of CO_2 to the atmosphere.

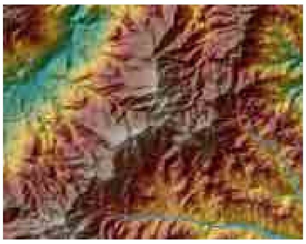


1. Basics
A/R definitions

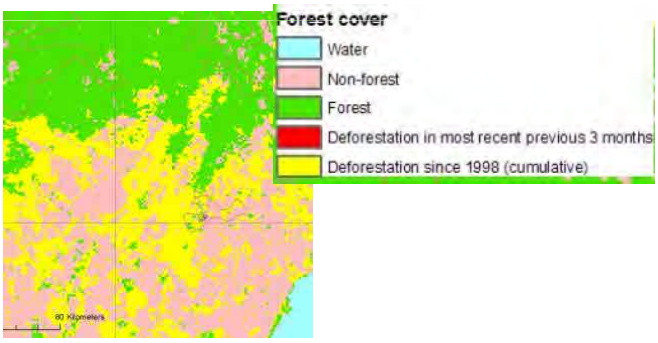
- **Reforestation (CDM definition)**
  is the direct human-induced conversion of non-forested land to forested land through planting, seeding and/or the human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forested land. <u>For the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989</u>.
- **Afforestation (CDM definition)**
  is the direct human-induced <u>conversion of land that has not been forested for a period of at least 50 years to forested land</u> through planting, seeding and/or the human-induced promotion of natural seed sources.

1. Basics
Remote Sensing Technology

Remote Sensing involves acquisition of the land surface data using aerial sensor technologies, such as aerial surveillance and satellite imaging.



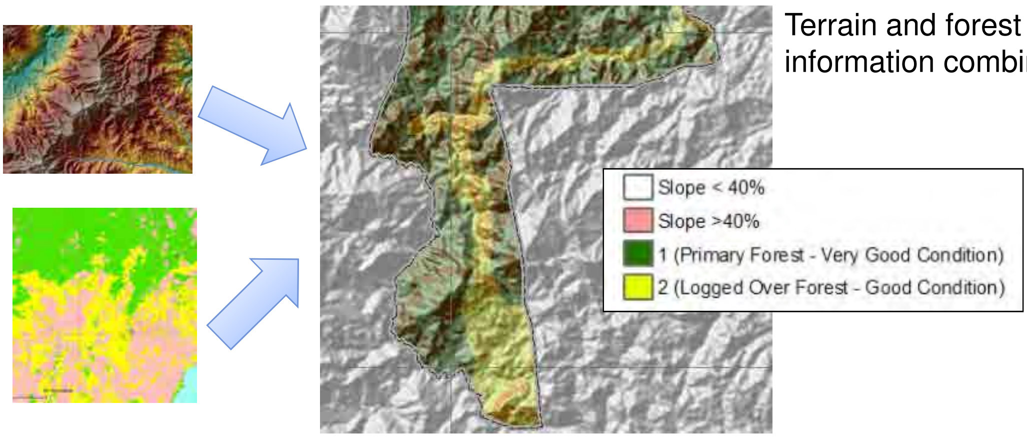
Terrain information



Forest Cover Information

1. Basics
Geographic Information System

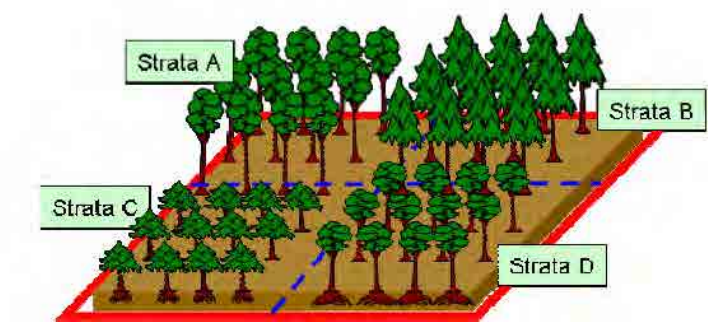
Geographic Information System (GIS) is an information technology system which manages data in reference to geographic location data.



Terrain and forest cover information combined

1. Basics
Stratification

- REDD project sites are divided into strata.
- Each strata is in homogenous condition
- Sampling needs to be conducted at each strata.



Factors which affects carbon stock change:

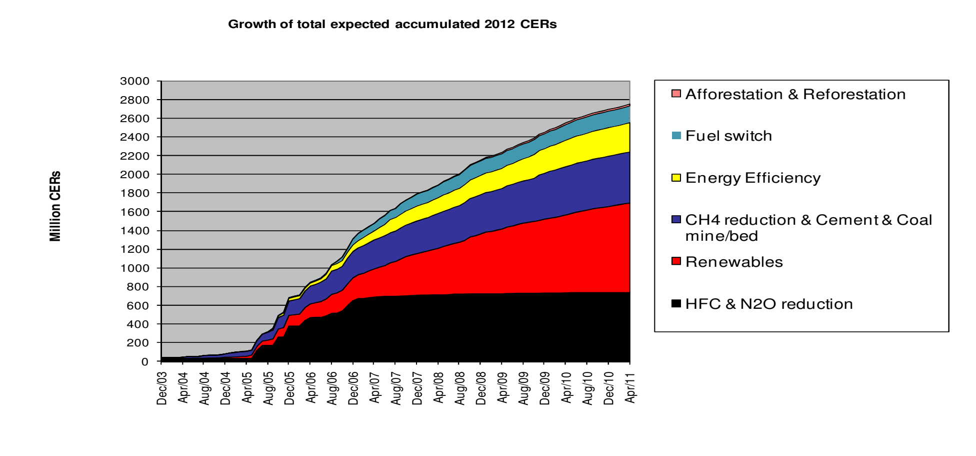
- ☐ Soil
- ☐ Climate
- ☐ Slope
- ☐ Previous land use
- ☐ Project plan
  - ➢ Tree species
  - ➢ Timing of planting & harvesting

Source: JICA (2008) Guidebook for Small Scale AR CDM activities

2. A/R Issues

2. A/R Issues
CDM Statistics

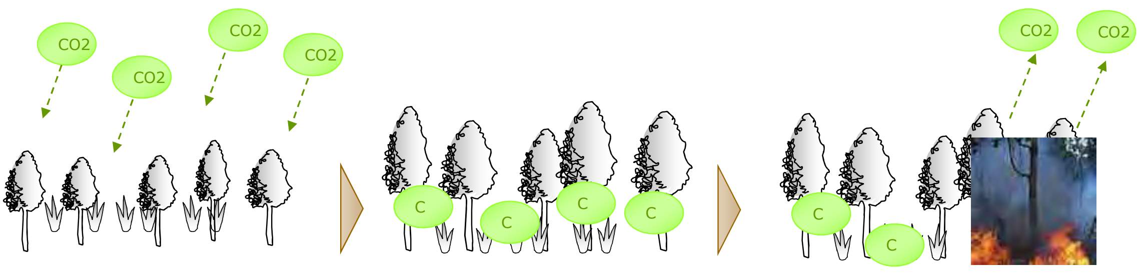
- As of May 2011, there are 3034 registered projects.
- Of which 21 projects are registered A/R projects.
- That is 0.7% of the total registered projects.



There are two major issues regarding A/R CDM…

2. A/R Issues
Issue1: Non-Permanence

- Trees stocks carbon (thus it is a carbon sink).
- Once the tree is combusted or rotten, CO_2 and methane are released to the atmosphere.



Carbon credit generated from A/R CDM activities are different from the other CDM projects. **They are time limited credits.**
l-CER: expires at the end of the crediting period (end of project)
t-CER: expires during every commitment period (end of Kyoto Protocol)

2. A/R Issues
Issue2: Monitoring

Monitoring of forestry activity involves covering vast area of land, from 1,000 ha to even 10,000ha.
It involves field survey (per strata) and that requires significant manpower.
Therefore monitoring activity is often carried out every 5 years, in which case carbon credit could only be issued every 5 yeas.

Example of Monitoring Parameters for Hydro Power Project:

- Supply of electricity to the grid
- Flow rate of the water
- CO2 emission factor of the grid
- Inhouse electricity consumption

Specific monitoring points

Example of Monitoring Parameters for AR CDM project:

- Fossil fuel use at the site (chainsaw/ tractors)
- Burning of biomass
- Nitrogen Fertilization
- Tree diameter sampling

AR CDM needs to cover vast area

3. A/R Methodology

3. A/R Methodology
Types of methodologies

There are currently 12 large scale and 6 small scale approved CDM methodologies.
Small scale methodology is less than 60,000t

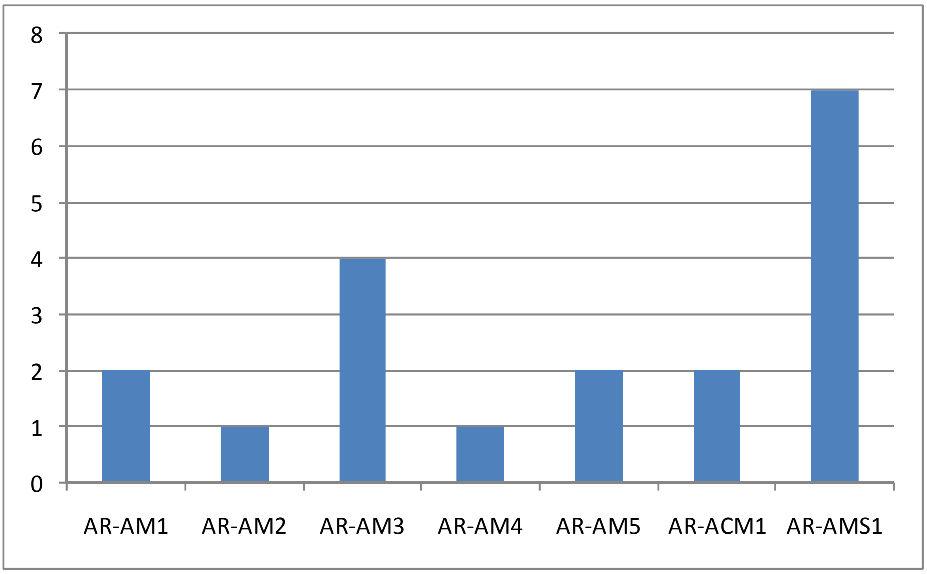
Large scale Methodologies

AR-AM0002 Restoration of degraded lands through afforestation/reforestation
AR-AM0004 Reforestation or afforestation of land currently under agricultural use
AR-AM0005 Afforestation and reforestation project activities implemented for industrial and/or commercial uses
AR-AM0006 Afforestation/Reforestation with Trees Supported by Shrubs on Degraded Land
AR-AM0007 Afforestation and Reforestation of Land Currently Under Agricultural or Pastoral
AR-AM0009 Afforestation or reforestation on degraded land allowing for silvopastoral activities
AR-AM0010 Afforestation and reforestation project activities implemented on unmanaged grassland in reserve/protected areas
AR-AM0011 Afforestation and reforestation of land subject to polyculture farming
AR-AM0012 Afforestation or reforestation of degraded or abandoned agricultural lands
AR-AM0013 Afforestation and reforestation of lands other than wetlands
AR-ACM0001 Afforestation and reforestation of degraded land
AR-ACM0002 Afforestation or reforestation of degraded land without displacement of pre-project activities

Small scale Methodologies

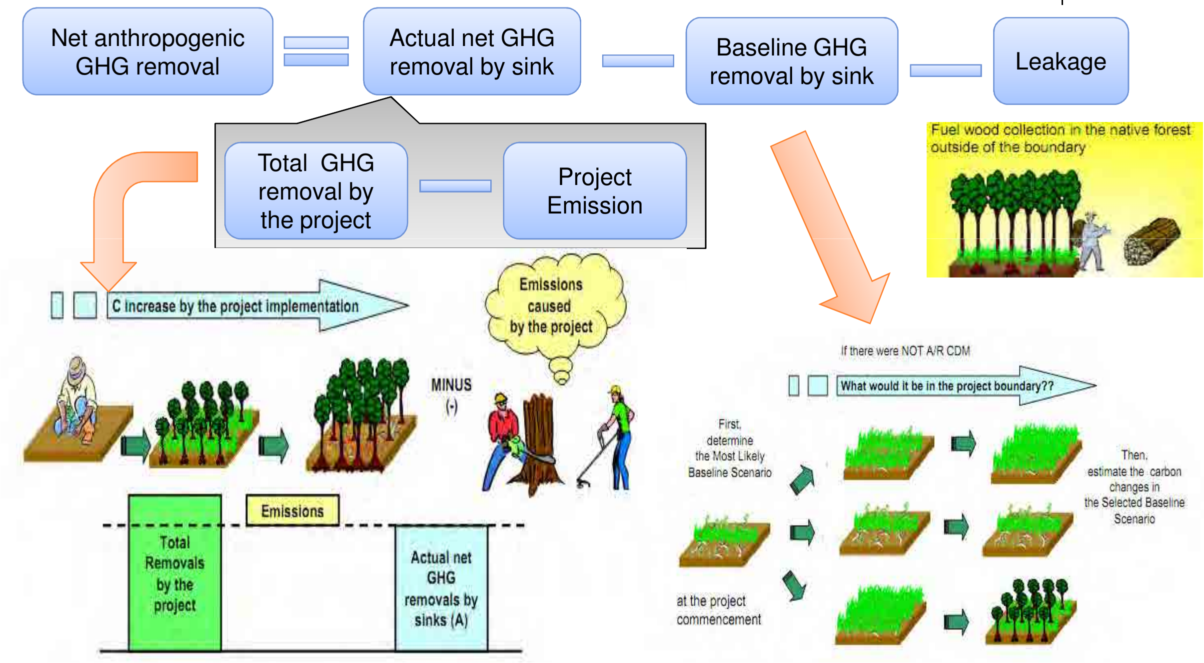
AR-AMS0001 Simplified baseline and monitoring methodologies for small-scale A/R CDM project activities implemented on grasslands or croplands with limited displacement of pre-project activities
AR-AMS0002 project activities under the CDM implemented on settlements
AR-AMS0003 Simplified baseline and monitoring methodology for small scale CDM afforestation and reforestation project activities implemented on wetlands
AR-AMS0004 Simplified baseline and monitoring methodology for small-scale agroforestry - afforestation and reforestation project activities under the clean development mechanism
AR-AMS0005 Simplified baseline and monitoring methodology for small-scale afforestation and reforestation project activities under the clean development mechanism implemented on lands having low inherent potential to support living biomass
AR-AMS0006 Simplified baseline and monitoring methodology for small-scale silvopastoral - afforestation and reforestation project activities under the clean development mechanism
AR-AMS0007 Simplified baseline and monitoring methodology for small-scale A/R CDM project activities implemented on grasslands or croplands

3. A/R Methodology
Methodologies used for registered projects



AR-AMS0001 Simplified baseline and monitoring methodologies for small-scale A/R CDM project activities implemented on grasslands or croplands with limited displacement of pre-project activities

3. A/R Methodology Basic Concept



Source: JICA (2008) Guidebook for Small Scale AR CDM activities

3. A/R Methodology Procedure

Delineation of the project activity

Stratification of project boundary

Selection of carbon pools
Determination of Baseline Scenario
Identification of emission by source
Addtionality

Provide calculation methods for ex-ante estimation of baseline, actual removals, Emission, leakage

Determination of ex-ante estimation of net anthropogenic GHG removals

Confirmation of the project boundary

Confirmation of stratification

Sampling design for monitoring

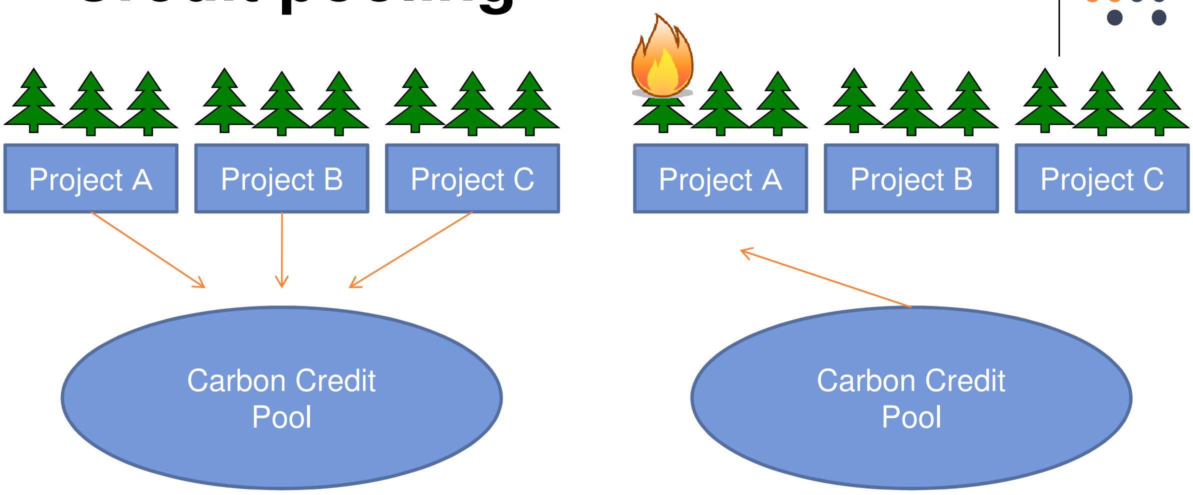
Provide method for field measurement

Provide calculation methods for ex-post estimation of baseline, actual removals, Emission, leakage

Determination of ex-post estimation of net anthropogenic GHG removals

4. New Apporach

4. New Approach
Credit pooling



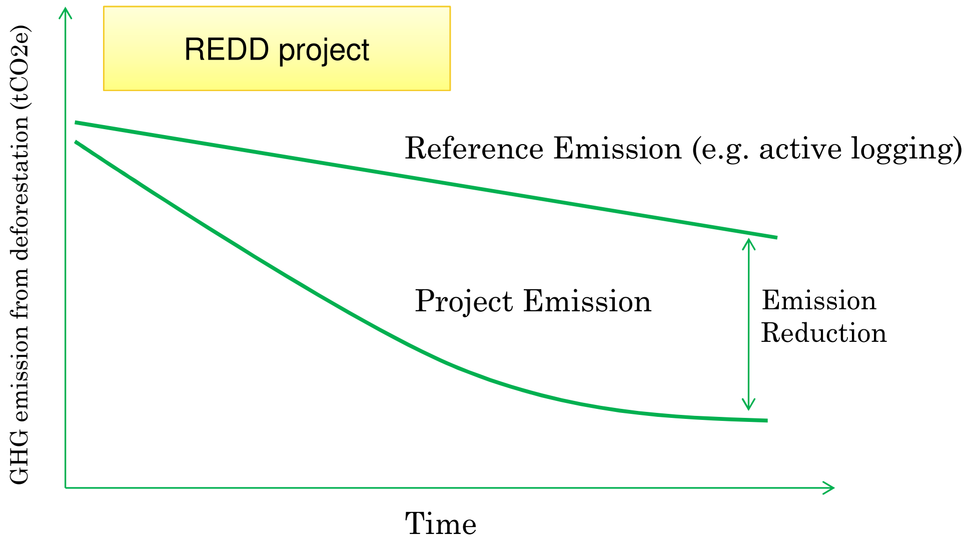
Portion of the carbon credit from each projects are pooled to a specific fund

If the CO_2 is emitted from one of the project the carbon credit from the pool could be utilized to offset the loss

As long the carbon credit pool is managed correctly, the carbon credit from these projects, could be treated as “permanent ”.

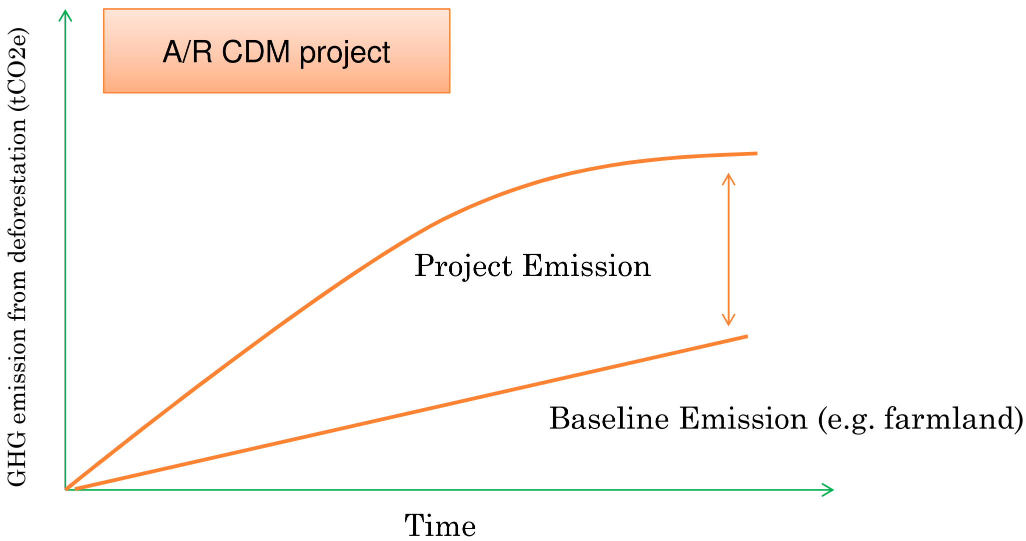
4. New Approach REDD

REDD:
Reducing Emissions from Deforestation and forest Degradation



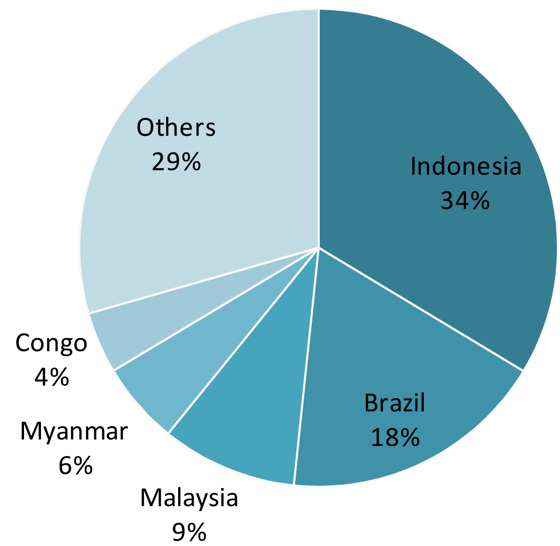
4. New Approach REDD & A/R Comparison

AR/CDM stocks carbon, where as REDD project avoids the GHG emission cased by the loss of forest cover.



4. New Approach

Countries which may benefit from REDD projects



IPCC Report states that emissions from deforestation accounts for 20% of global GHG emissions.
WRI, US based research organization, highlights that 34% of the GHG emission from Land Use and Land Use Change and Forestry (LULUCF) resulted from Indonesia followed by Brazil 18% in 2000.

4. New Approach

REDD, REDD+ and REDD++

Avoiding deforestation in one part of the land may cause increase in timber harvesting activities in another part of the land.
By providing timber from a sustainably managed REDD+ site, it ensures sufficient quantity of timber will be supplied to the market.

REDD, REDD+ and REDD++ categorisation

REDD	DD	Deforestation
		Forest Degradation
REDD+	+	Reforestation
		Sustainable Forest Management
REDD++	Another+	Management of the buffer zones (social aspec)

Potential projects in Sri Lanka

- REDD+ and REDD++
- Sustainable forest management
- A/R projects may be beneficial, if it has significant social and/or environmental benefits such as watershed conservation and agroforestry.