Renewable Energy CDM Projects (Non-biomass & Biomass)

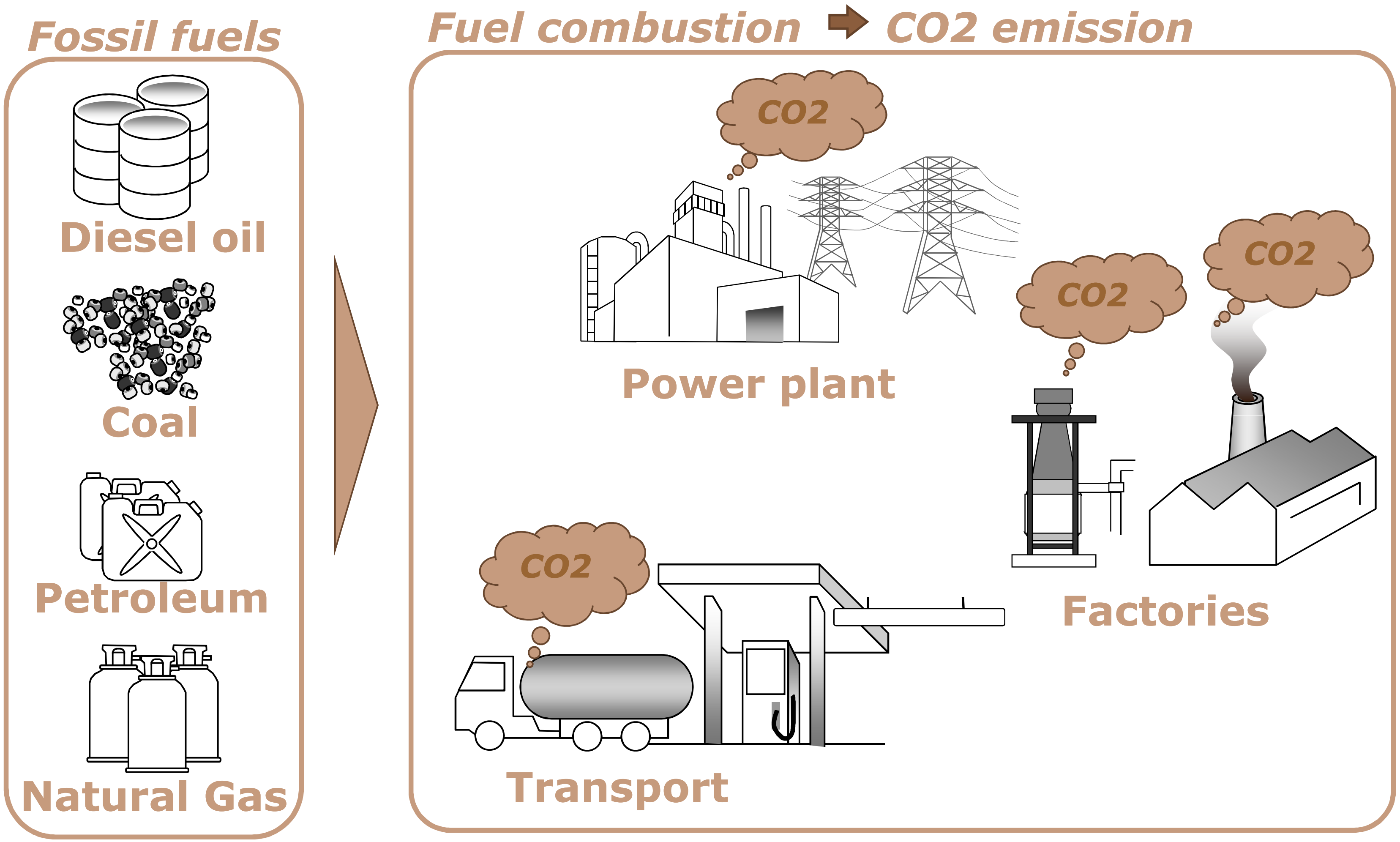
13th May 2011

JICA Expert Team

Ai Kawamura

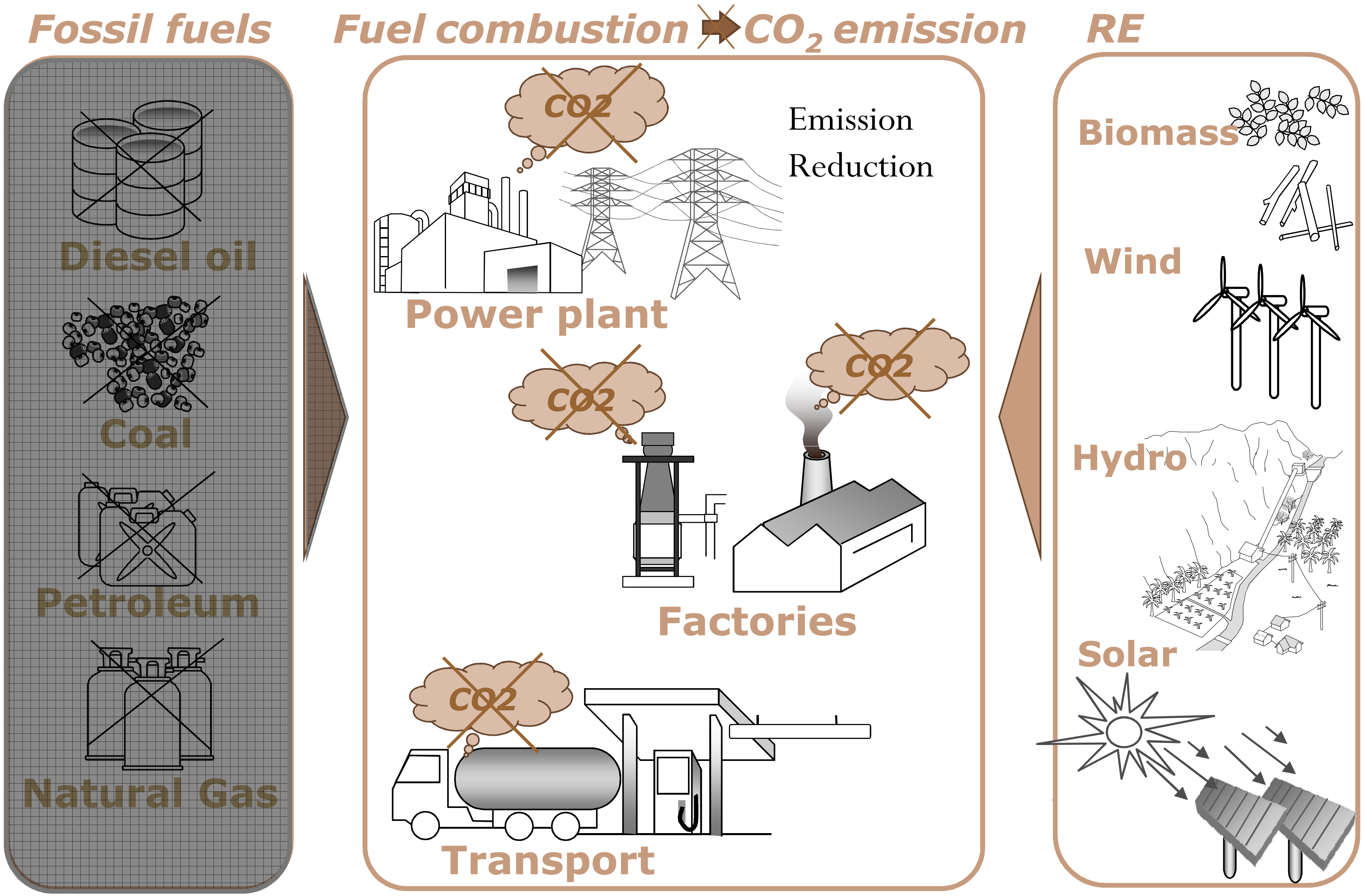
Contents

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)



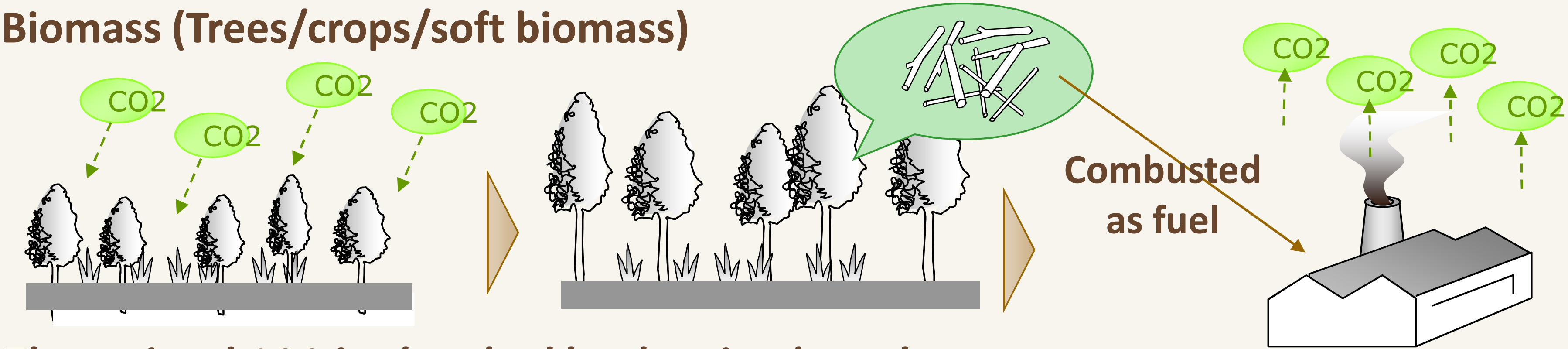
RE reduces GHG emissions by reducing the use of fossil fuel.

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)



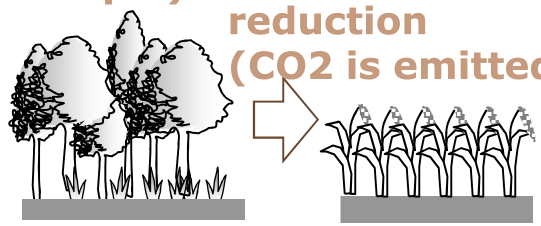
The emitted CO_2 is absorbed by the air when plants grow

carbon neutral energy source

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

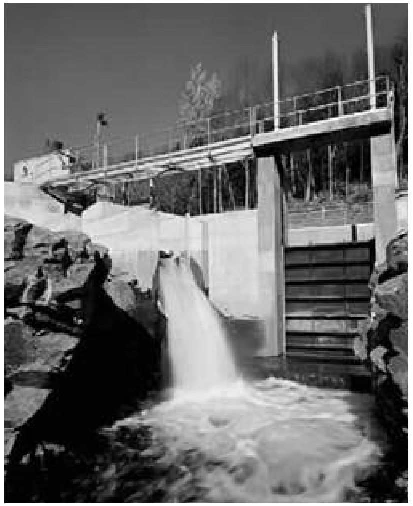
- **Carbon stock change by land use change**
- **Fossil fuel use for the production process**
- **Methane emission from waste treatment (solid & wastewater)**

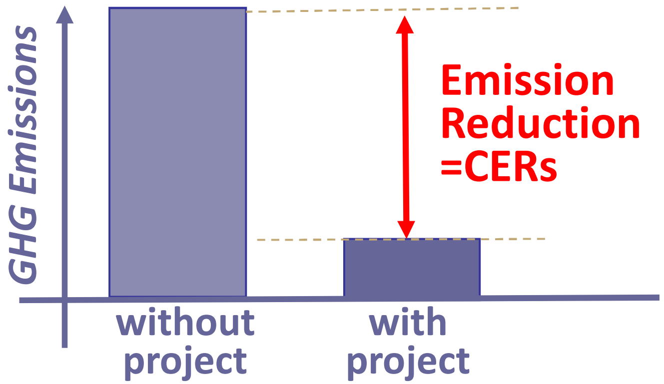
(Example) Carbon stock reduction (CO_2 is emitted)



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)

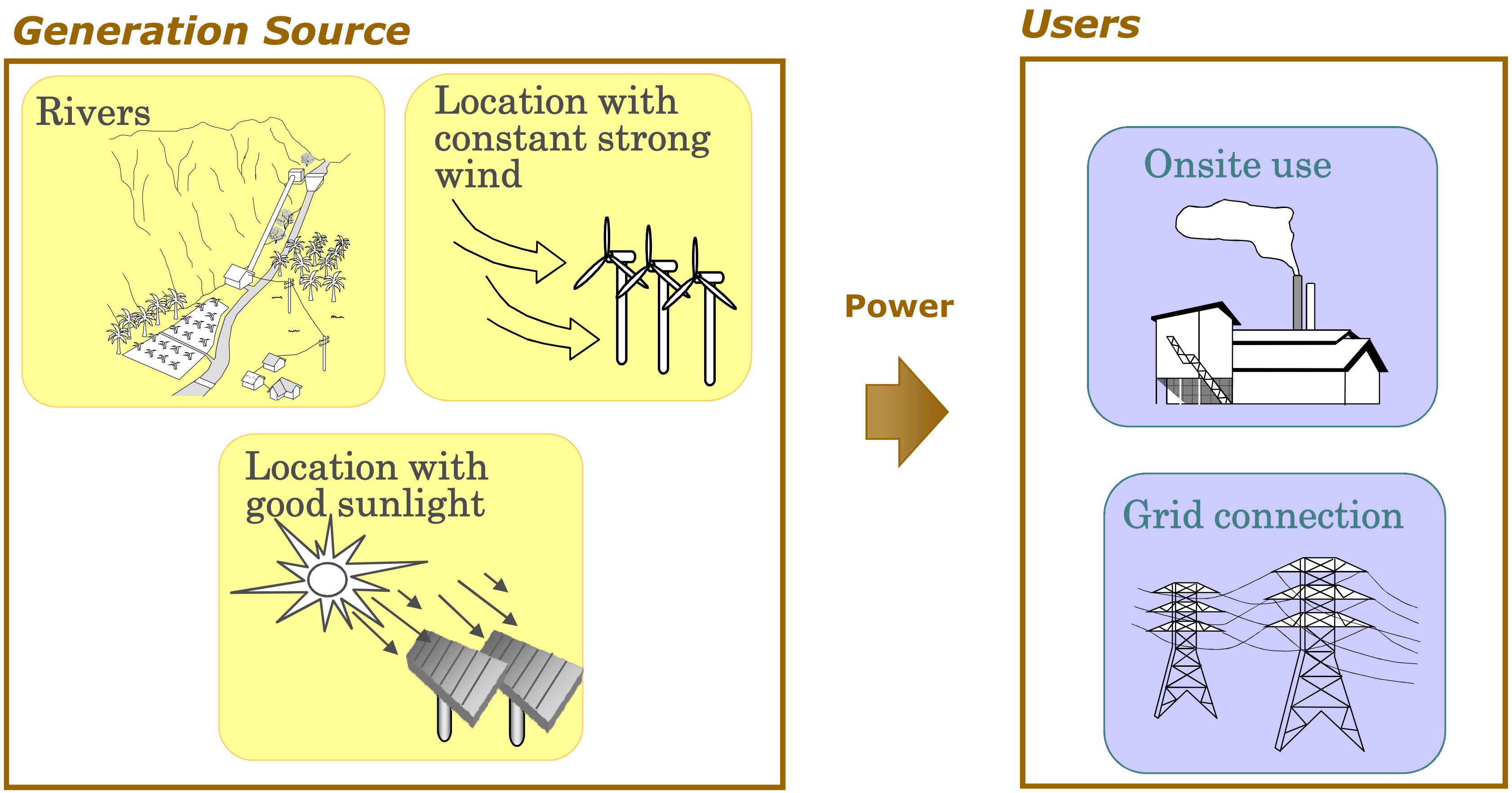
- Usage of energy

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

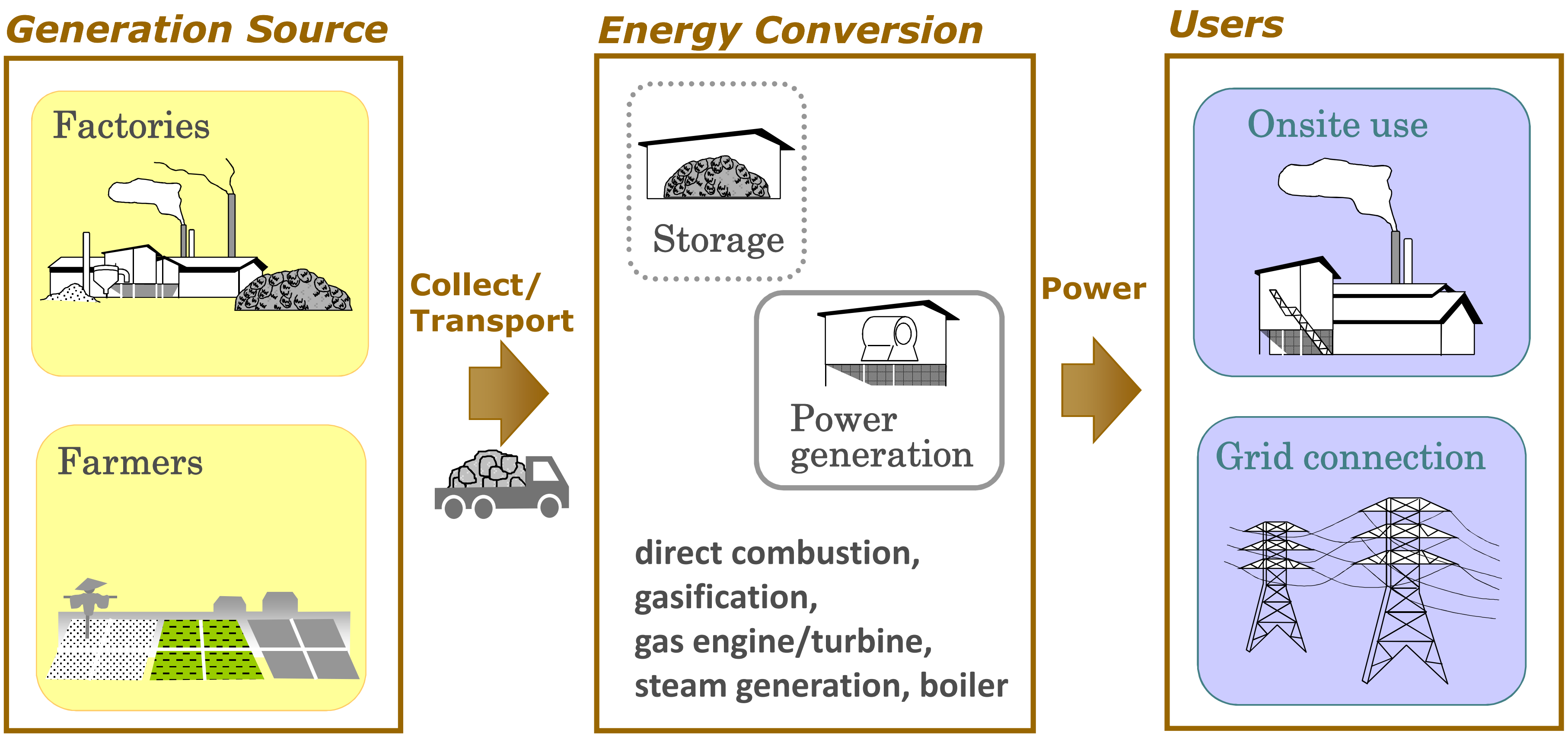
Source	Electricity	Heat	Liquid fuel
Biomass	✓	✓	✓ (plant oil)
Hydro/Wind	✓		
Solar	✓	✓	

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 [tCO2/MWh]
- On site electricity: [B]=Emission factor of fuel used for electricity generation [tCO2/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: $$\frac{\cancel{TJ}}{t\_Fuel} \times \frac{tCO_2}{\cancel{TJ}} = \frac{tCO_2}{t\_Fuel}$$

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 (Net calorific value of fuel; CO2 emission Factor)

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

Biomass transportation

Fuel consumption(t/y)

Emissions Associated to transportation (tCO_2/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) × CO_2 emission Factor of fuel (tCO_2/TJ)

Default value is available

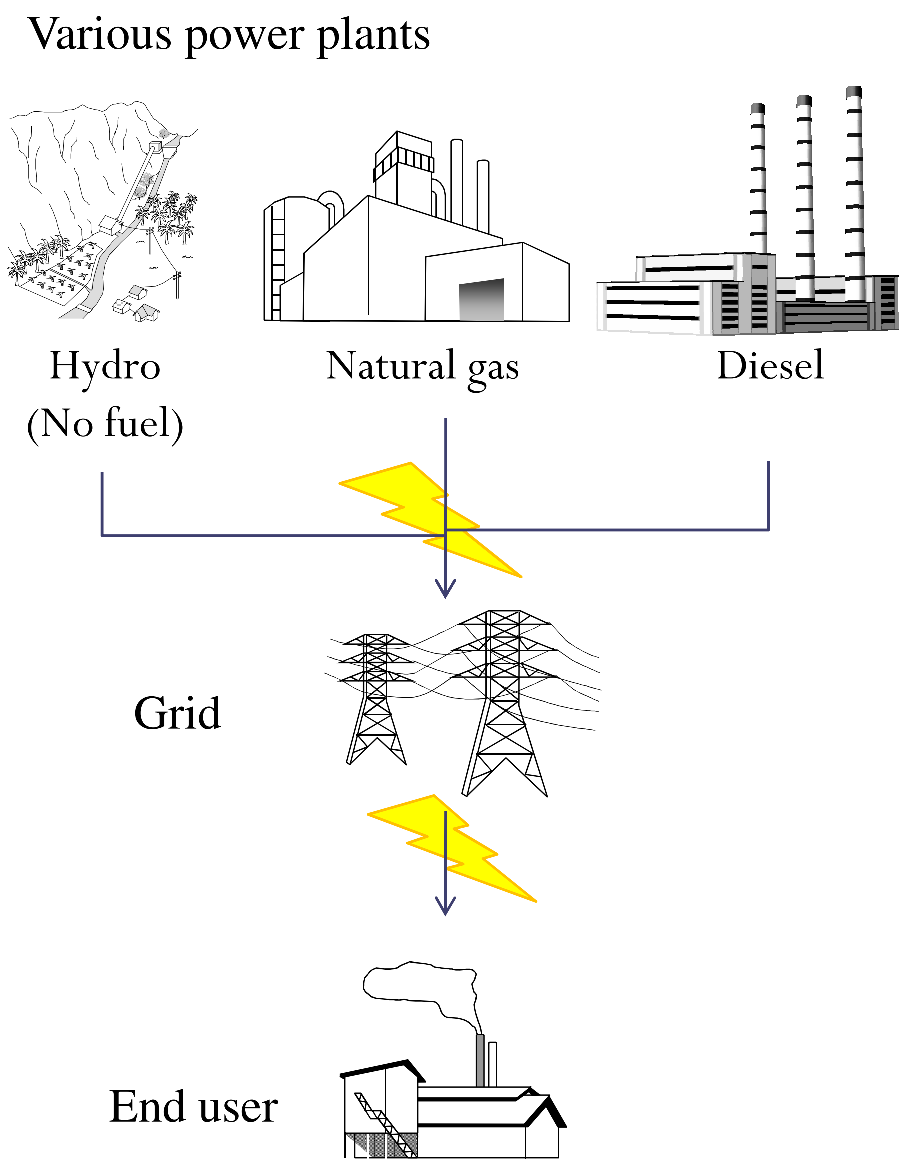
Leakage associated to biomass competition

Emissions associated to biomass competition (tCO_2/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) × CO_2 emission Factor of most carbon intensive fuel (tCO_2/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.



6. Calculation of Grid Emission Factor (2)

Simplified formula for grid emission factor calculation:

$$\text{Grid Emission Factor in year } y \; [tCO2/MWh] = \frac{\text{Total } CO_2 \text{ emission from all the power plants that are connected to the grid in year } y \text{ if the CDM project activity did not take place } [tCO2/y]}{\text{Total MWh of electricity produced by all the power plants that are connected to the grid in year } y \text{ if the CDM project activity did not take place } [MWh/y]}$$

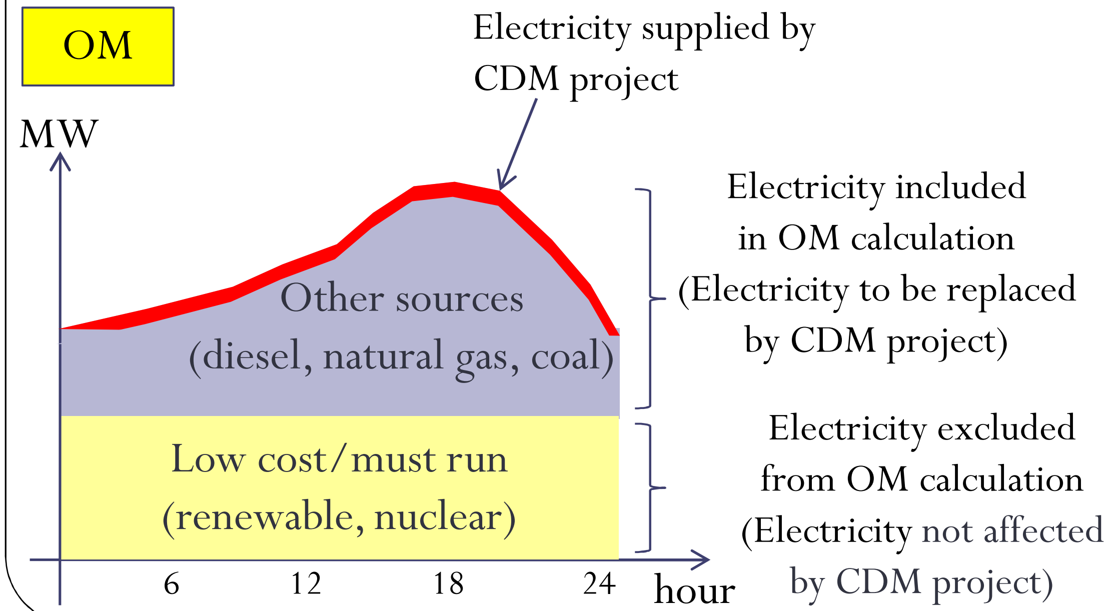
Reference: "Tool to calculate the emission factor for an electricity system"

- 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

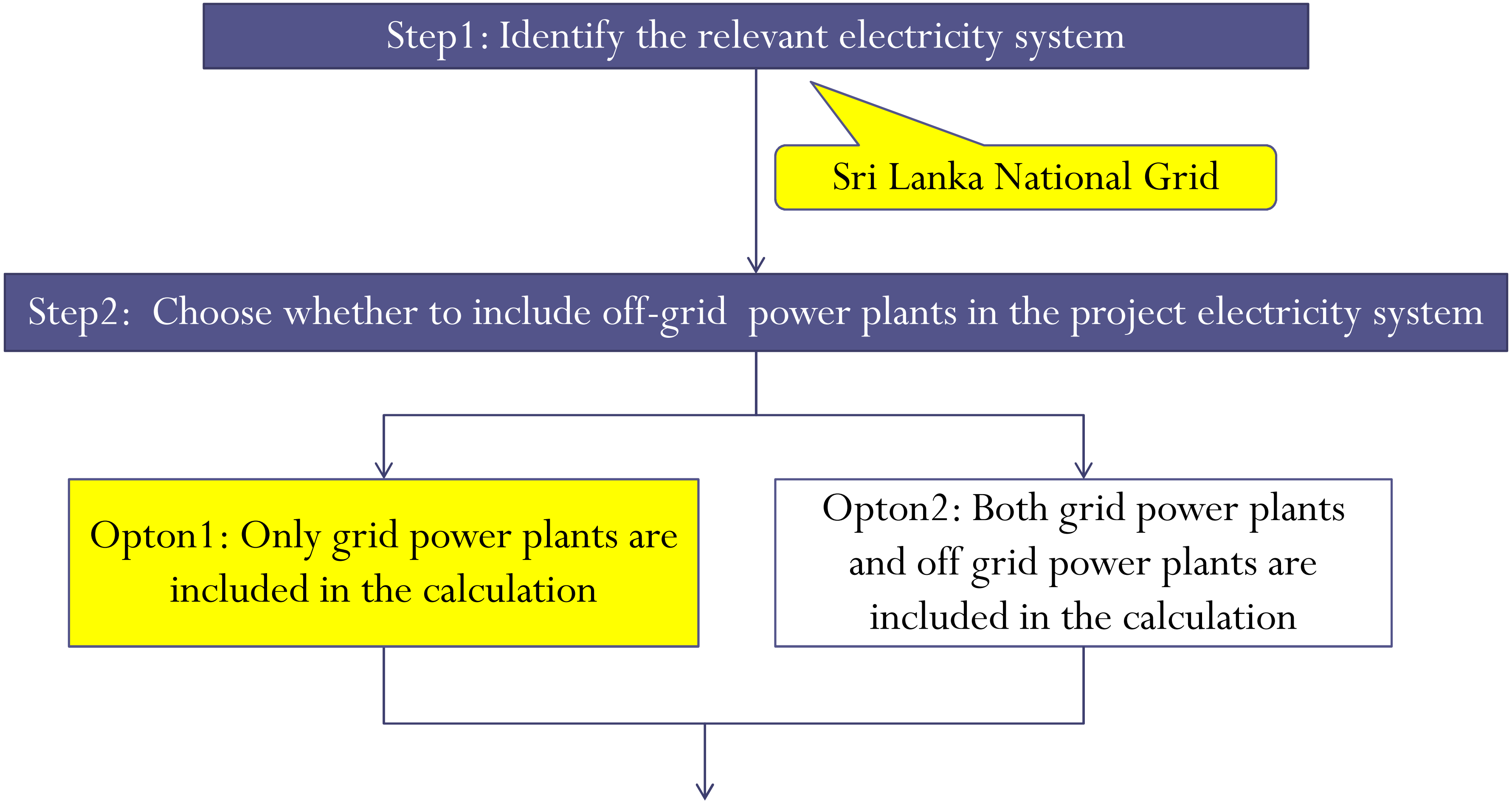


BM

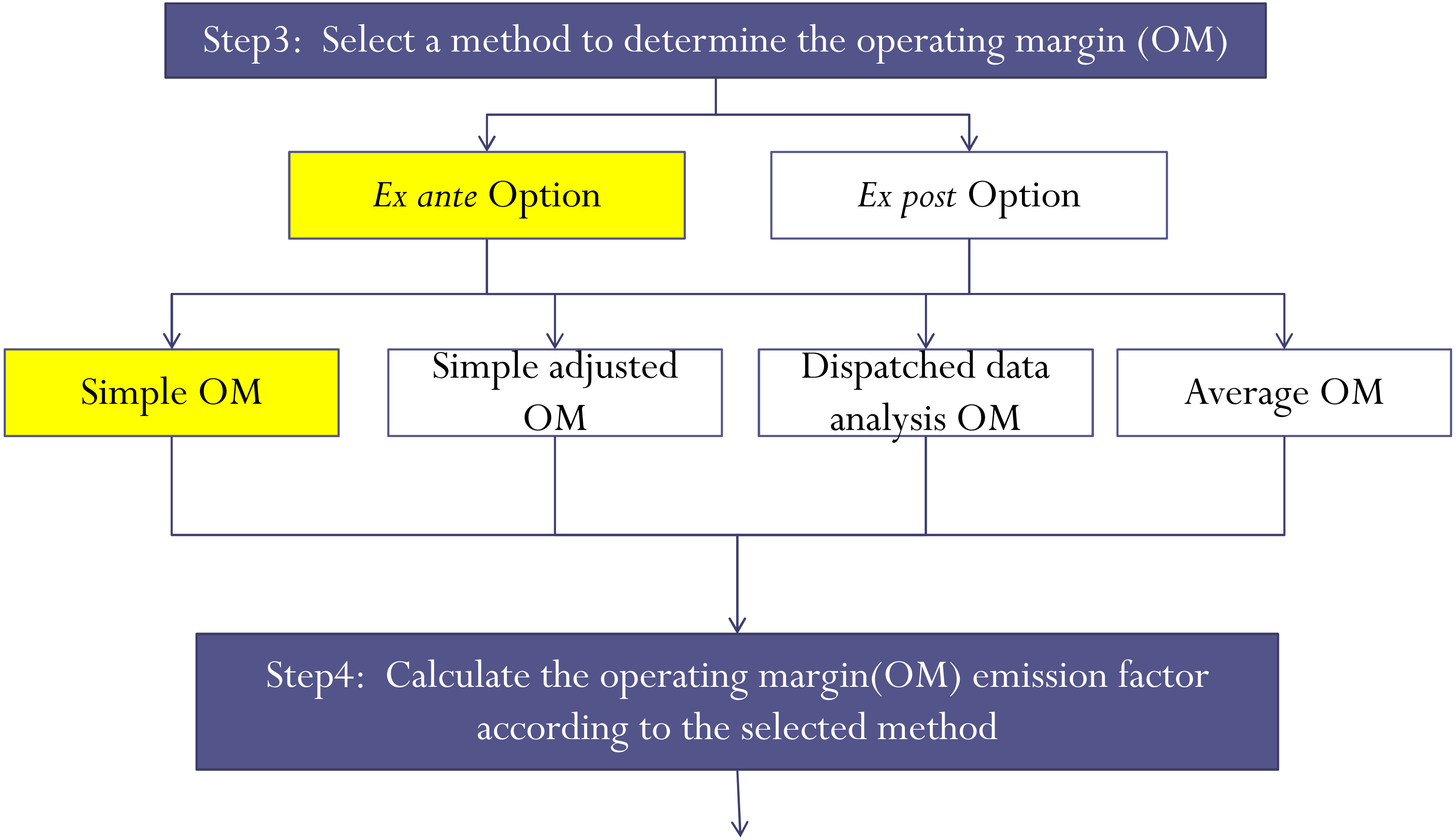
The set of power capacity additions in the electricity system that comprise 20% of the system generation (MWh) and that have been built most recently

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 CO2 emission factor (tCO2/TJ)	Oxidation factor	CO2 emission coefficient (tCO2/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		
Total	-	-	-	3,621,343	5,341	0.678
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	Density of Fuel	COEF	Emission	Electricity Generation	Grid Emission Factor
	1000kL/y	t/m3	(tCO2/t_fuel)	(tCO2/y)	(GWh)	(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: <u>0.8 MW</u>
  - Daily operating hours: <u>20 hours</u>
  - Monthly operating days: <u>20 days</u>
  - Seasonal operation: operation is constant
  - Grid emission factor: <u>0.70 kgCO2/kWh</u>
  - Furnace oil required for operation of the new plant: <u>6ton/month</u>
  - Diesel required for transportation of biomass: <u>2 t/month</u>

(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: <u>4,800 hours/y</u>
- Electricity generation operation rate: <u>0.8 MW</u>

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

= **<u>3,840 MWh/y</u>**

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 $kgCO_2/kWh$

Baseline emission (tCO_2/y) = **Amount of Electricity (MWh/y)** × **Grid emission factor (tCO_2/MWh)**

= 3,840 MWh/y × 0.70 tCO_2/MWh

= **2,688 tCO_2/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 tCO_2/t_fuel

= 228.4 tCO_2/y

Emission associated to biomass transport

24 t_fuel/year × 3.209 tCO_2/t_fuel

= 77.0 tCO_2/y

Project emissions

228.5 tCO_2/y + 77.0 tCO_2/y = 305.5 tCO_2/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