Fuel Switch & Energy Efficiency CDM Project Case Study

Prepared for 2nd Training Program Session
May 20, 2011

JICA CDM Expert Team

Objective & Content

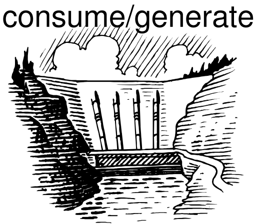
Content:

- Scale of Energy Saving & Fuel Change
- What is Fuel Change project?
- What is Energy Saving project?
- Case Study

Objective: **? & !**

0. Before Step Into CDM

Be familiar with the unit of energy to have a scale.
How much energy do they consume/generate??


	Fukushima 1	Hydro Power	Gas Engine	Household
Capacity	460,000 kW	25,000 kW	312 kW	0.48 kW
Runtime	6,000 hours	4,800 hours	4,000 hours	8,760 hours
Power	MWh	MWh	MWh	MWh
Heat (MJ)	x 10^6 MJ	x10^6 MJ	x10^6 MJ	x 10^6 MJ
Energy(TOE)	x 10^3 TOE	x 10^3 TOE	x 10^3 TOE	x 10^3 TOE

Calculate and fill the table.
1kWh =3.6 MJ
1 TOE =41.686 GJ
1kcal = 4,166J

kilo	mega	giga	tera	peta
k	M	G	T	P
10^3	10^6	10^9	10^{12}	10^{15}

Fukushima 1

460,000kW x 6,000 hours
= 276 x 10^7 kWh
= 276 x 10^4 MWh
(1MWh =1,000kWh = 10^3kWh)
= 2,760,000 MWh

276 x 10^7 kWh x 3.6 MJ/kWh
= 993.6 x 10^7 MJ
= 9,936 x 10^6 MJ

9,936 x 10^6 MJ ÷ 41.686GJ/TOE
= (9,936,000 x 10^3 GJ) ÷ 41.686GJ/TOE
= 238.353 x 10^3 TOE

Hydro Power Station

25,000kW x 4,800hours
= 1,200 x 10^5 kWh
= 120 x 10^3 MWh

1,200 x 10^5 kWh x 3.6MJ/kWh
= 4,320 x 10^5 MJ
= 432 x 10^6 MJ

432 x 10^6MJ ÷ 41.686GJ/TOE
= (432 x 10^3 GJ) ÷ 41.686GJ/TOE
= 10.36 x 10^3 TOE

Gas Engine

312kW x 4,000hours
= 1,248 x 10^3 kWh
= 1,248 MWh

1,248 x 10^3 kWh x 3.6 MJ/kWh
= 4,492 x 10^3 MJ

4,492 x 10^3 MJ ÷ 41.686 GJ/TOE
= (4.492 x 10^3 GJ) ÷ 41.686 GJ/TOE
= 107.9 TOE
= 0.108 x 10^3 TOE

Household

0.48 kW x 8,760 hours
= 4,204.8 kWh
= 4.20 MWh

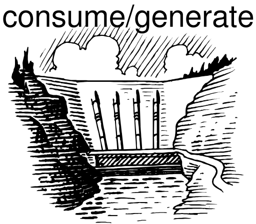
4.200kWh x 3.6 MJ/kWh
= 15,120 MJ
= 0.015 x 10^6 GJ
= 15 x 10^3 GJ

15 x 10^3GJ ÷ 41.686 GJ/TOE
= 0.0032 x 10^3 TOE

1kcal =4,166J

0. Before Step Into CDM

Be familiar with the unit of energy to have a scale.
How much energy do they consume/generate??

	Fukushima 1	Hydro Power	Gas Engine	Household
Capacity	460,000 kW	25,000 kW	312 kW	0.48 kW
Runtime	6,000 hours	4,800 hours	4,000 hours	8,760 hours
Power	2,760,000 MWh	120,000 MWh	1,248 MWh	4.20 MWh
Heat (MJ)	$9,936 \times 10^6$ MJ	432×10^6 MJ	4.5×10^6 MJ	0.015×10^6 MJ
Energy(TOE)	$2,383.5 \times 10^3$ TOE	10.4×10^3 TOE	0.108×10^3 TOE	0.0032×10^3 TOE

Calculate and fill the table.
1kWh =3.6 MJ
1 TOE =41.686 GJ
1kcal = 4,166J

kilo	mega	giga	tera	peta
k	M	G	T	P
10^3	10^6	10^9	10^{12}	10^{15}

SmartEnergy

0.Emission Factors of Major Energy Sources

Fuel	Heat Value	COEF	EF	Gravity	
	TJ/MT	tCO2/TJ	tCO2/MT	t/m3:t/kl	
Furnace Oil	0.0410	77.4		0.972t/kl	tCO_2/kl
Diesel Oil	0.0433	74.1		0.846t/kl	tCO_2/kl
Residual Oil	0.0410	77.4		0.972t/kl	tCO_2/kl
Coal	0.0293	101.0		1.300t/m^3	tCO_2/t
LPG	0.0502	63.1	3.168		3.168tCO_2/kg
Natural Gas	0.0411	64.2	2.639		*2.108$kgCO_2$/Nm^3*
Grid Electricity					0.686tCO_2/MWh

Data source
1. Energy Data 2007, Sustainable Energy Authority
2. IPCC Guideline for National Greenhouse Gas Inventories, 2006, Table 1-4
3. Natural Gas's gravity data was not available and utilized Japanese data for reference purposes.
Nm^3 is a unit of gas under normal state.

SmartEnergy

0.Emission Factors of Major Energy Sources

Fuel	Heat Value	COEF	EF	Gravity	
	TJ/MT	tCO2/TJ	tCO2/MT	t/m3:t/kl	
Furnace Oil	0.0410	77.4	3.173	0.972t/kl	3.264tCO_2/kl
Diesel Oil	0.0433	74.1	3.209	0.846t/kl	3.793tCO_2/kl
Residual Oil	0.0410	77.4	3.173	0.972t/kl	3.264tCO_2/kl
Coal	0.0293	101.0	2.816	1.300t/m^3	3.661tCO_2/t
LPG	0.0502	63.1	3.168		3.168tCO_2/kg
Natural Gas	0.0411	64.2	2.639		*2.108$kgCO_2$/Nm^3*
Grid Electricity					0.686tCO_2/MWh

Data source
1. Energy Data 2007, Sustainable Energy Authority
2. IPCC Guideline for National Greenhouse Gas Inventories, 2006, Table 1-4
3. Natural Gas's gravity data was not available and utilized Japanese data for reference purposes.
Nm^3 is a unit of gas under normal state.

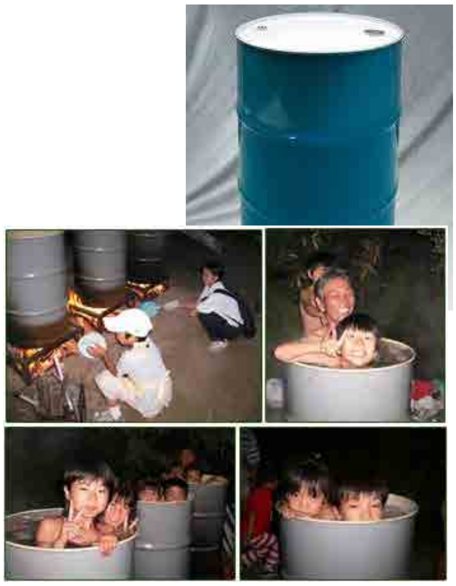
More Questions

Question A:

A volume of steel drum is 200litres.

① Calculate CO_2 emissions by combusting a full of furnace oil in steel drum . Also calculate heat value, one can derive from this combustion. heat value of fuel shall be derived as a product of unit heat value and gravity of fuel.

② Calculate how many kg of coal do you need to burn, if you earn same amount of heat? Also calculate CO_2 emissions from this coal combustion.



Still More Questions

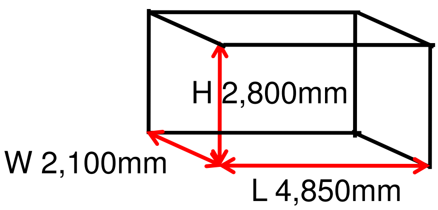
Question B:

A factory is introducing sawdust alternate for furnace oil.

A dimension of cargo box of 4 tone loading truck(photo) is shown in figure below. A density of saw dust is 1.51kg/m^3 and unit heat value is 2000kcal/kg.

① Calculate heat and CO_2 emissions by combusting full cargo load of saw dust.

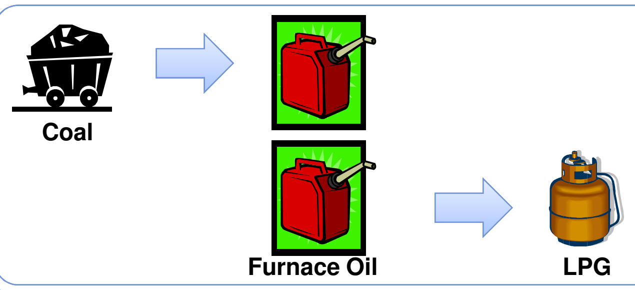
② Calculate how much furnace oil can replaced by amount of sawdust calculated in QB-1.



1. What is Fuel Switching?

Other Energy Efficiency Measures

Boiler Replacement, Efficient Motors



Fuel switch measures in this category will replace carbon-intensive fossil fuel with a less-carbon-intensive fossil fuel, whereas a switch from fossil fuel to renewable biomass is categorized as “renewable energy”.

In Reality….

Number of CDM project registered and issued CER.

	On Track	Registered	Issued	CER %
Total	71	57	---	
Coal to NG	9	5	3	65%
Coal to Oil	0	0	0	
Lignite to NG	0	0	0	
New NG plant*	30	26	14	42%
New NG plant utilize LNG	1	8	3	74%
Oil to Electricity	2	0	0	
Oil to LPG	1	0	0	
Oil to NG	28	18	13	100%

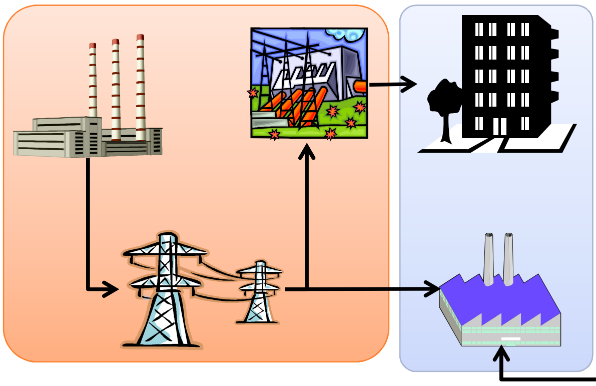
*AM0029: Grid Connected electricity generation plants using natural gas is widely used in high performance combined cycle gas pwer generation projects in China and in India.

SmartEnergy

2. What is Energy Efficiency project?

Energy Efficiency Project

The category energy efficiency includes all measures aiming to enhance the energy efficiency of a certain system. Due to the project activity, a specific output or service requires less energy consumption. Waste energy recovery is also included in this category.



Supply Side Energy Efficiency

Power supplier and distributer implement energy efficiency measures, inc. auxiary power –gen.

Heat recovery Combined cycle

•Rehabilitation of power station Smart grid

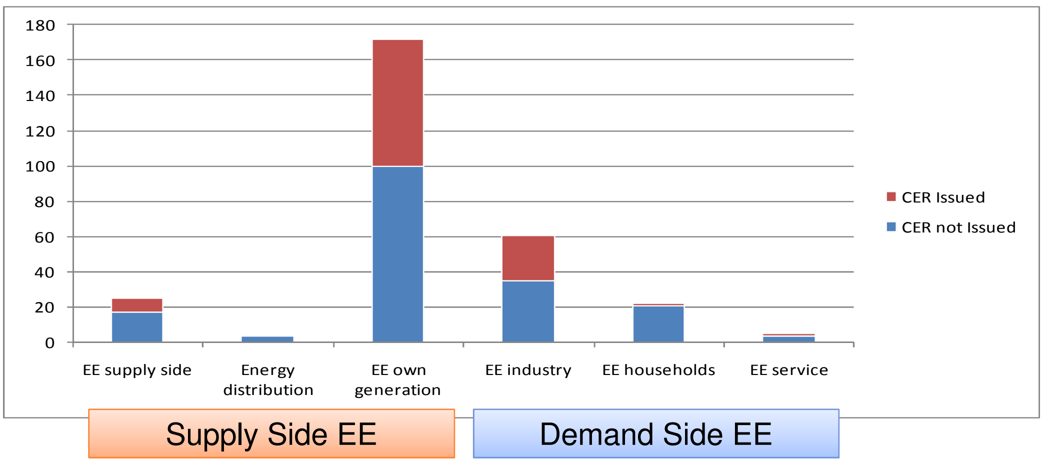
Demand Side Energy Efficiency

the adoption of energy-efficient equipment, lamps, ballasts, refrigerators, motors, fans, air conditioners, appliances in many sites. inc. BEMS(building Energy management System).

SmartEnergy

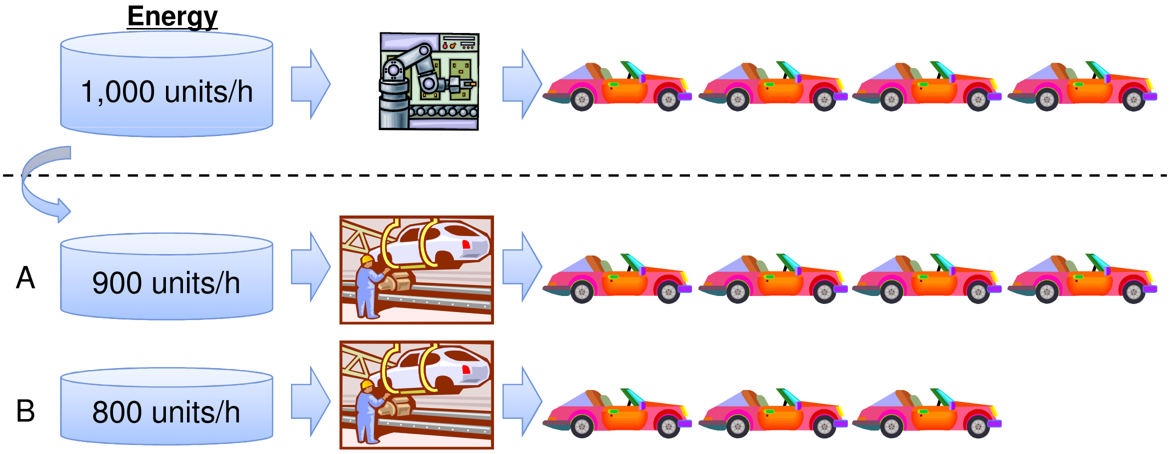
2. Energy Efficiency Statistics

- As of May 2011, there are 289 registered Energy Efficiency CDM projects.
- Of which 88 projects are demand side energy efficiency projects and the rest are supply side (including transmission) energy efficiency projects.
- Of all the registered energy efficiency CDM,108 projects have issued CER.



2. Key Insight of Energy Efficiency Project

In project, the output has to be maintained before and after the energy efficiency project



Which is “energy efficient”??

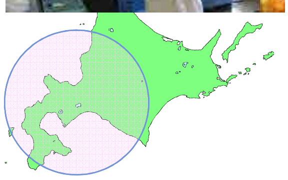
SmartEnergy

3. Case: Project in Laundromat Services

The company is locates in northern Japanese island. The facility receives linens and daily laundry through retail shops within 150km area’s hotels, restaurants an households. The facility used heavy oil combustion boiler for 20 years. The regional natural gas catering company extends the pipeline to the neighborhood and connects to the company's facility.

The project has four components including,

a) Replacing fuel from heavy oil to natural gas.
b) Replace lamps to high efficient LEDs.

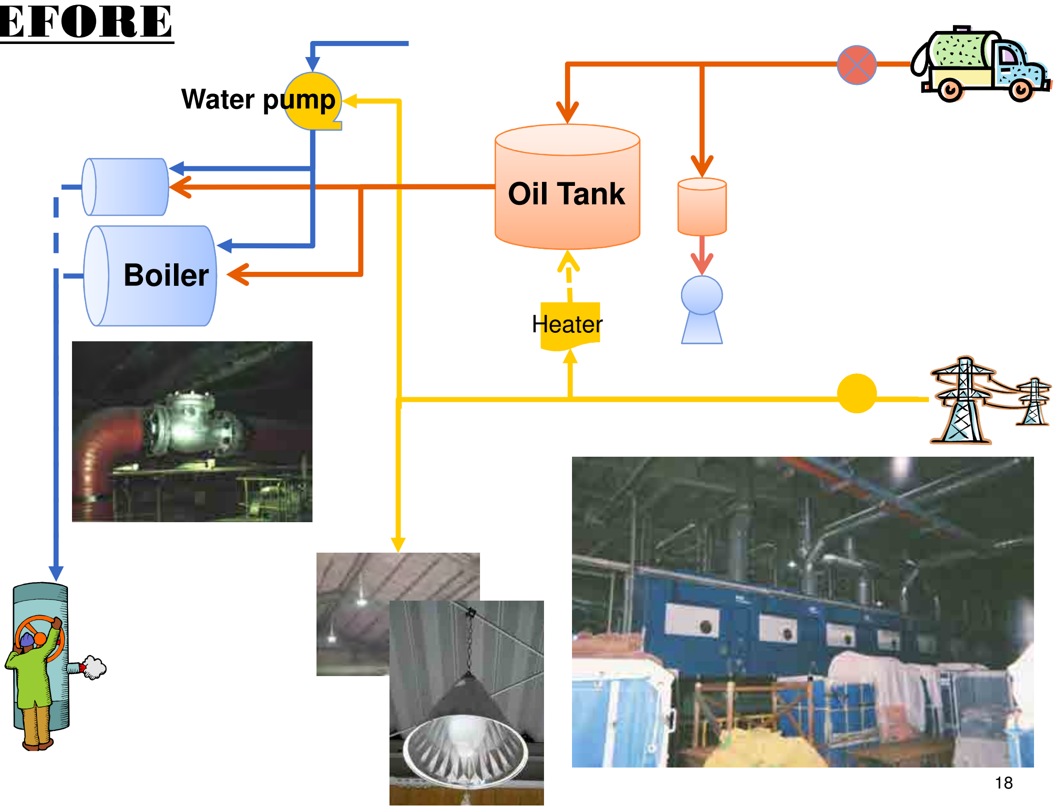


3. Case: Project in Laundromat Services (Cont’d)

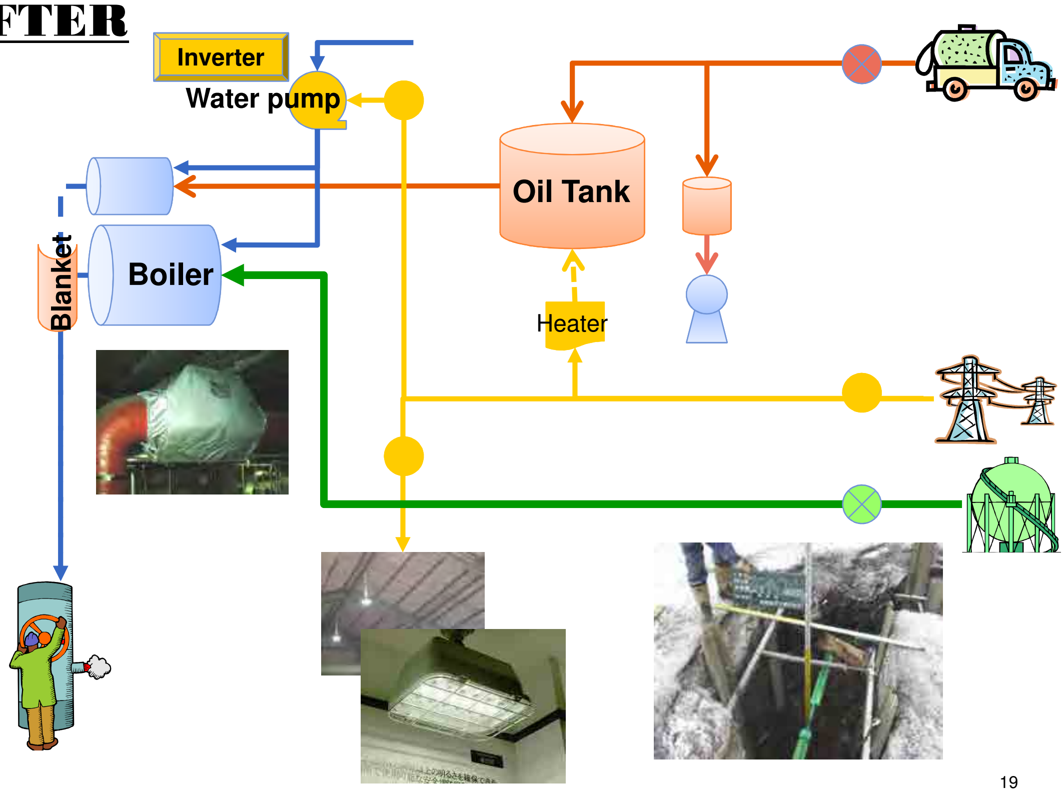
Feature of Energy Use

- Requires intensive energy for pressing (steam), laundry (hot water).
- Heat requirements varied with peripheral temperatures but stable for year-round.
- Outside temperature varies from 32℃ in August to -20℃ in February.
- Energy costs, electricity and fuel, occupies 50% of expenses.

BEFORE

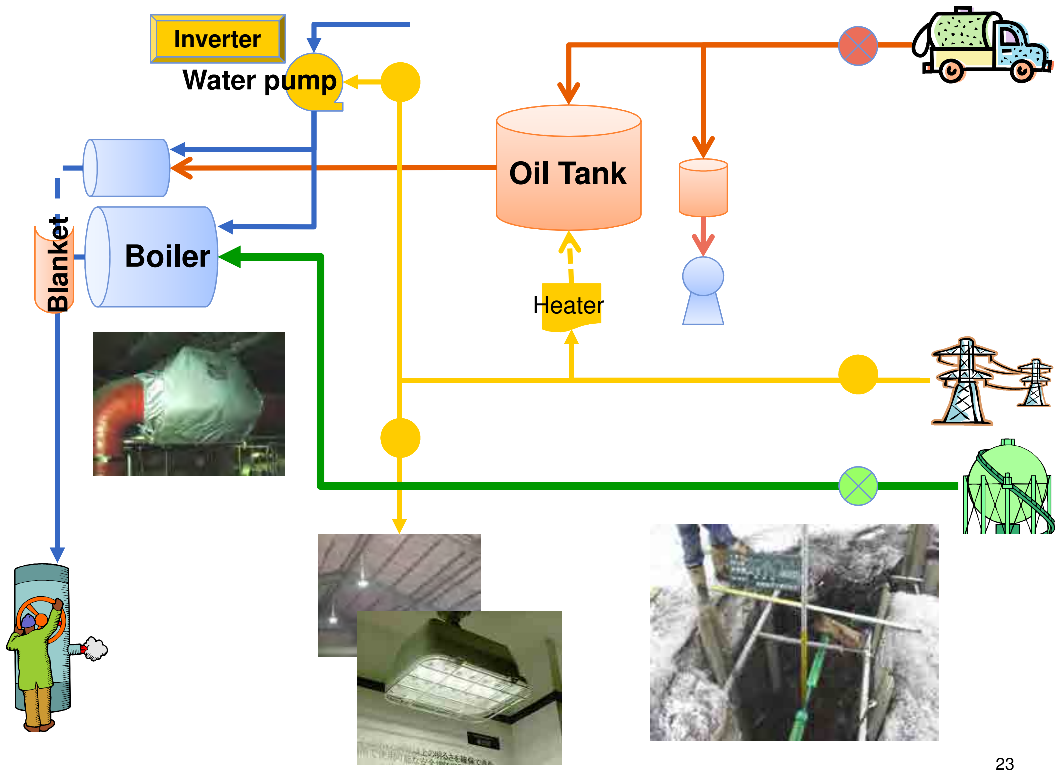


AFTER



Inverter
Water pump
Oil Tank
Boiler
Blanket
Heater

IHI
呉ボイラ



SmartEnergy

4. Project A: Boiler Fuel Change

The factory runs 1 x 2.0t boiler and 1 x 0.5t boiler for back up to generate steam and hot water for laundry machine and dry clanging.
Normally, only 2.0t boiler operates.

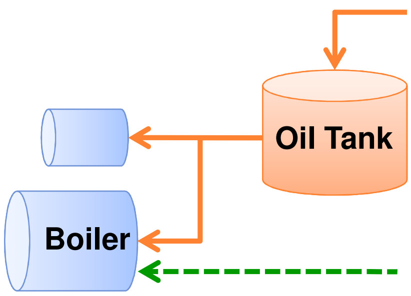
Both boiler uses heavy oil/furnace oil catered by a tanker truck of oil company upon order.

The project changes fuel only for 2.0t boiler from heavy oil to natural gas.

Fuel consumption	1,752	kl/year
Run-time	12	Hours/day
	264	Day/year

Monitoring parameters
- ◆Flow-meters at the heavy oil tank
- ◆Flow meters of the gas line
- ◆Invoice from gas/oil company

Project Baseline
Continuous use of carbon intensive fossil fuel.



4. Project B: LED Lighting

Light Emittng Diode (LED) is a lighting devices to alternate traditional lamps.

LED gives more concentrated lighting than conventional lighting thus uses less electricity to give a same illuminance.

The price of LED light is still expensive compared to usual lightings, but it lasts longer and economy in longer term.

Project replace old halogen lamps in factory and warehouse space to LED.

Elec. Power of Hg lamp	400	W
Number of Hg lamp	137	Units
Elec. Power of LED lamp	118	W
Number of LED	83	Units
Operating Hours	3,168	hours

Monitoring

- ◆ Electric Power of light bulb (W)
- ◆ Number of light bulbs
- ◆ Operating hours to turn on light bulbs (hours)
- ◆ Emission factor of the electricity consumed (tCO2e/MWh)

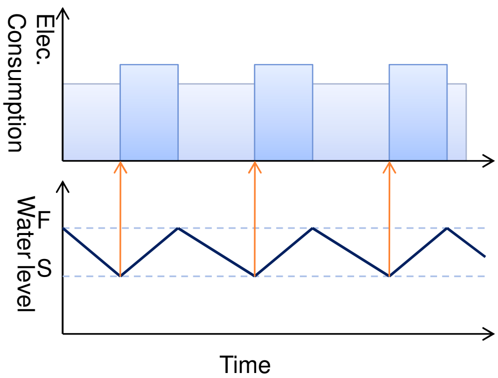
Project Baseline

Continuous use of conventional lamps.

4. Project C: Inverter & Load Variable

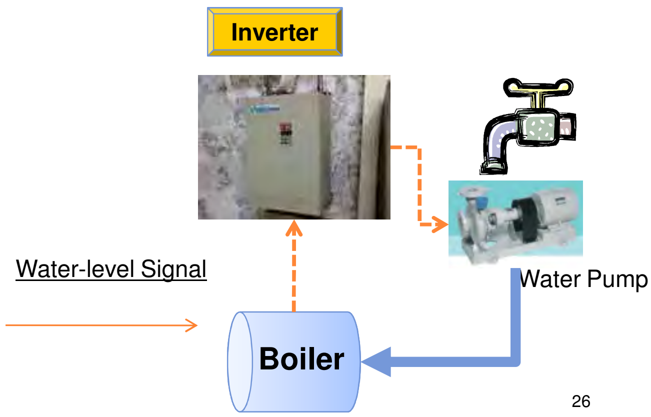
Boiler water pump continuously pumping water, regardless water amount in the boiler tank.

Inverter technology on/off the pump be referring water level of the tank.
By reducing idle time of the pump, it reduces an electricity consumption.



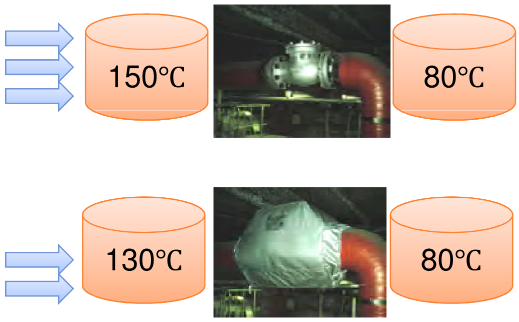
Monitoring

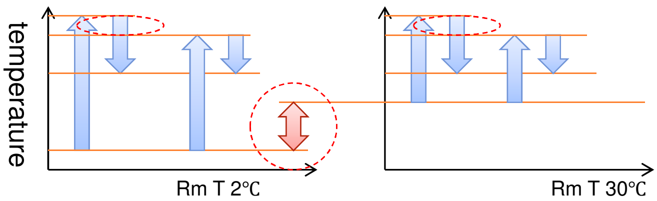
- ◆Power consumption of the system (kWh)
- ◆Number of operational hours (hrs)
- ◆Emission factor of the electricity (tCO_2e/kWh)



4. Project D: Pipe Blanket

Pipe Blanket is a method to cover pipe and high temperature parts by glass wool.





Monitoring
- ◆Temperature of in/outflow (℃)
- ◆External temperature (℃)
- ◆Flow rate (m^3/sec)
- ◆Consumption of fuel/electricity to generate steam(L of fuel or kWh of electricity)
- ◆Emission factors

Energy saving can achieved due to external temperature and other multiple variables. Blanket project is difficult to prove causality.

4. What can be done in CDM & what not?

	Project A: Boiler Fuel Change	Project B: LED application	Project C: Inverter Application	Project D: Blanket Application
AMS Methodology	III.B	II.E	II.C	---
Baseline	Keep using furnace oil.	Keep using mercury lamp	Keep operating pump regardless load/demand	Expose valve where heat are easily leak.
Project	Replace furnace oil to natural gas.	Replace mercury lamp to LED lamp to reduce electricity consumption	Control and limit pump action depends on water level of boiler.	Cover valve to avoid heat expose to atmosphere
Monitoring	Gas consumption with gas flow meter with gas company's invoice.	Electricity Consumption with metering devices and electricity bill.	Metering devices	Continuous monitoring of temperature of fluid and exposed environment.
CDM?				

SmartEnergy

5. Calculations: Fuel Change

Fuel Consumption before the Project

Furnace Oil Consumption	1,752	kl/year
HV of furnace oil		GJ/kl
Heat obtained with furnace oil		GJ
CO_{EF}		tCO_2/kl
$CO_{2\ Emissions\_before}$		tCO_2

Fuel Consumption after the Project

HV of natural gas		MJ/Nm^3
Amount of Natural gas needed		$Nm^3/year$
CO_{EF}		$kgCO_2/Nm^3$
$CO_{2\ Emissions\_after}$		$tCO_2/year$

SmartEnergy

5. Calculations: Fuel Change

Fuel Consumption before the Project

Furnace Oil Consumption	1,752	kl/year
HV of furnace oil	39.85	GJ/kl
Heat obtained with furnace oil	69,817.2	GJ
CO_{EF}	3.264	tCO_2/kl
$CO_{2\ Emissions\_before}$	5,718.53	tCO_2

Fuel Consumption after the Project

HV of natural gas	46.1	MJ/Nm^3
Amount of Natural gas needed	1,514 x 10^3	$Nm^3/year$
CO_{EF}	2.108	$kgCO_2/Nm^3$
$CO_{2\ Emissions\_after}$	3,194.51	$tCO_2/year$

5. Calculations: LED Application

Electricity Consumption before the Project

Unit Elec. Cons of Hg light	400	W/unit
Number of lights	137	Units
Daily Working hours	12	Hours/day
Annual Working days	264	Days/year
Electricity Consumption		kWh/year

Electricity Consumption after the Project

Unit Elec. Cons of LED	118	W/unit
Number of lights	83	Units
Annual Working hours	3168	Hours/year
Electricity Consumption		kWh/year
Electricity Saving		kWh/year
CO_{EF}	0.686	tCO_2/MWh
$ER_{\_LED}$		tCO_2

5. Calculations: LED Application

Electricity Consumption before the Project

Unit Elec. Cons of Hg light	400	W/unit
Number of lights	137	Units
Daily Working hours	12	Hours/day
Annual Working days	264	Days/year
Electricity Consumption	173,606.4	kWh/year

Electricity Consumption after the Project

Unit Elec. Cons of LED	118	W/unit
Number of lights	83	Units
Annual Working hours	3168	Hours/year
Electricity Consumption	31,027.39	kWh/year
Electricity Saving	142,579.0	kWh/year
CO_{EF}	0.686	tCO_2/MWh
$ER_{\_LED}$	97.81	tCO_2

SmartEnergy

6. Grand-Sum of Project

Fuel Change		
CO_2 Emissions_before	5,718.53	tCO_2/year
CO_2 Emissions_after	3,194.00	tCO_2/year
ER _Fuel Change	2,524.53	tCO_2/year
LED Application		
ER _LED	97.81	tCO_2/year
Total		
	2,622.34	tCO_2/year

!

THE ONLY THING WE KNOW ABOUT THE FUTURE IS THAT IT WILL BE DIFFERENT.
PETER DRUCKER

Status and Outlook of Carbon Market

Prepared for Training Program for CCD, MOE Sri Lanka
May 27, 2011

JICA Expert Team

Answers for Fuel Switch & Energy Efficiency CDM Project Case Study,

JICA Training program lecture series

Page 3. Table of Energy Scale

Fukushima 1

460,000kW x 6,000 hours
460MW x 6,000 hours
= 276 x 10^4 MWh
(1MWh =1,000kWh = 10^3kWh)
= 2,760,000 MWh

276 x 10^7 kWh x 3.6 MJ/kWh
= 993.6 x 10^7 MJ
= 9,936 x 10^6 MJ

9,936 x 10^6 MJ ÷ 41.686GJ/TOE
= (993,600 x 10^3 GJ) ÷ 41.686GJ/TOE
= 2,383.53 x 10^3 TOE

Hydro Power Station

25,000kW x 4,800hours
= 25MW x 4,800 hours
= 120,000MWh

(120,000MWh) x 3.6 MJ/kWh
= (120 x 10^6 kWh) x 3.6MJ/kWh
= 432 x 10^6 MJ

432 x 10^6MJ ÷ 41.686GJ/TOE
= (432 x 10^3 GJ) ÷ 41.686GJ/TOE
= 10.36 x 10^3 TOE

Gas Engine

312kW x 4,000hours
= 0.312 MW x 4,000hours
= 1,248 MWh

1,248MWh x 3.6 MJ/kWh
(1,248 x 10^3 kWh) x 3.6 MJ/kWh
= 4,492 x 10^3 MJ

4,492 x 10^3 MJ ÷ 41.686 GJ/TOE
= (4.492 x 10^3 GJ) ÷ 41.686 GJ/TOE
= 107.9 TOE
= 0.108 x 10^3 TOE

Household

0.48 kW x 8,760 hours
= 4,204.8 kWh
= 4.20 MWh

4.200kWh x 3.6 MJ/kWh
= 15,120 MJ
= 0.015 x 10^6 GJ
= 15 x 10^3 GJ

15 x 10^3GJ ÷ 41.686 GJ/TOE
= 0.0032 x 10^3 TOE

p.4 Emission Coefficient Table

Basic equation is as follows.

Heat Value x COEF = EF, EF x 1/Gravity = trade unit's EF

Fuel	Heat Value	COEF	EF	Gravity	
	TJ/MT	KgCO2/TJ	tCO2/MT	t/m3:t/kl	
Furnace Oil	0.0410	77.4	3.173	0.972t/kl	3.084tCO_2/kl
Diesel Oil	0.0433	74.1	3.209	0.846t/kl	2.714tCO_2/kl
Residual Oil	0.0410	77.4	3.173	0.972t/kl	3.084tCO_2/kl
Coal	0.0293	101.0	2.816	1.300t/m^3	3.661tCO_2/t
LPG	0.0502	63.1	3.168		3.168tCO_2/kg
Natural Gas	0.0411	64.2	2.639		*2.108kgCO_2/Nm^3*
Grid Electricity					0.686tCO_2/MWh

p.5: Question A

① The emission factor of furnace oil is derived from the table in previous page.

Furnace Oil's heat value is given as 0.0410TJ/MT and its density is given as 0.972MT/kilo-liter.

Normally furnace oil traded with a unit of kilo-liters.

Hence

0.0410TJ/MT x 0.972MT/kilo-liter

= 0.0410 x 10^6MJ/MT x 0.972 MT/kl

= 39,852 MJ/kl

Therefore, heat derived from 200 liters furnace oil is

200 liters x 39,852 MJ/kl

= 0.2kl x 39,852 MJ/kl

= 7.97 x 10^3 MJ

200 liters x 3.086tCO2/kl

0.2kl x 3.086tCO2/kl

= 0.6172tCO2

② 7.97 x 10^3 MJ ÷ 0.0293TJ/MT

= 7.97GJ ÷ 29.3GJ/MT

= 0.272MT

= 272kg

p.6: Question B

2,800mm x 2,100mm x 4,850mm

= 2.8m x 2.1m x 4.85m

= 28.518m^3

28.518m^3 x 1.51kg/m^3 x 2,000kcal/kg

= 86,124.36kcal

1kcal =4,166J

86,124.36 kcal x 4,166 J

= 358,794,084J

= 358.8MJ

Furnace Oil's HV is derived as 0.039852 TJ/kl, which is 39.85GJ/kl

Therefore,

358.8MJ ÷ 39.85GJ/kl

358.8MJ ÷ 39.85 MJ/l

= 9.0 liters

p.26: Fuel Change

furnace Oil Consumption in volume	1,752	kl/year
Emission factor of furnace oil	3.086	tCO_2/kl
$CO_{2\ Emissions\_before}$	5,406	$tCO_2/year$
Conversion rate of weight/volume	0.972	t/kl
Heavy Oil Consumption in weight	1,703	t/year
Unit HV of furnace oil	41.0	GJ/t
Heat derived from furnace Oil	69,823	GJ/year

HV of natural gas	46.1	MJ/m^3
Amount of Natural gas needed	$1,515 \times 10^3$	$m^3/year$
Emission Factor of natural gas	2.108	$kgCO_2/m^3$
$CO_{2\ Emissions\_after}$	3,194	$tCO_2/year$

Consumption of furnace oil before the project is 1,752kl/year.

CO2 emission factor of furnace oil is 3.086tCO2/kl

Therefore, CO2 emission from furnace oil is derived as

1,752kl/year x 3.086tCO2/year

= 5,406.67 tCO2

As the gravity of furnace oil is 0.972t/kl.

Thus the amount of furnace oil consumed is

1,752kl/year x 0.972t/kl

= 1,703t/year

Heat value of furnace oil is 41.0GJ/t from the table (0.0410TJ/t = 41.0GJ/t)

The heat derived from furnace oil combustion is

1,703 t/year x 41.0GJ/t

= 69,823GJ/year

The natural gas's heat value is given as 0.0461GJ/m^3 = 46.1MJ/m^3

69,823GJ/year ÷ 46.1MJ/m^3

= 1,515 x 10^3 m^3

CO2 emission factor of natural gas given as 2.108kgCO2/m^3

1,515 x 10^3 m^3 x 2.108 kgCO2/m^3

= 3,194tCO2/year

p.27 LED lump application

Unit Elec. Cons of Hg light	400	W/unit
Number of lights	137	Units
Daily Working hours	12	Hours/day
Annual Working days	264	Days/year
Electricity Consumption	173,606.4	kWh/year

Unit Elec. Cons of LED	118	W/unit
Number of lights	83	Units
Annual Working hours	3168	Hours/year
Electricity Consumption	31,027.39	kWh/year
Electricity Saving	142,579.0	kWh/year
CO_{EF}	0.686	tCO_2/MWh
$ER_{\_LED}$	97.81	tCO_2

Electricity consumption of halogen lamp is

400W/unit x 137 units x 12 hours/day x 264days/year

= 54.8kW x 3,168 hours/year

= 173,606.4kWh/year

By converting to LED lamp

118W/unit x 83 units x 12 hours/day x 264days/year

= 9.794kW x 3,168 hours/year

= 31,027.39kWh/year

The emission coefficient of electricity is derived as 0.686tCO2/MWh

(173,606.4kWh/year – 31,027.39kWh/year) x 0.686tCO2/MWh

= 142,579kWh/year x 0.686tCO2/MWh

= 142.58MWh/year x 0.686tCO2/MWh

= 97.81tCO2/year

p.28 Grand-Sum

Deduct CO2 emissions of natural gas from furnace oil combustion as follows.

5,406.67tCO2/year – 3,193.62tCo2/year

= 2,213.05tCO2/year

As a grand-sum of project, it reduces

2,213.05tCO2/year + 97.81tCO2/year

= 2,310.86tCO2/year

Renewable Energy CDM Projects (Review Session)

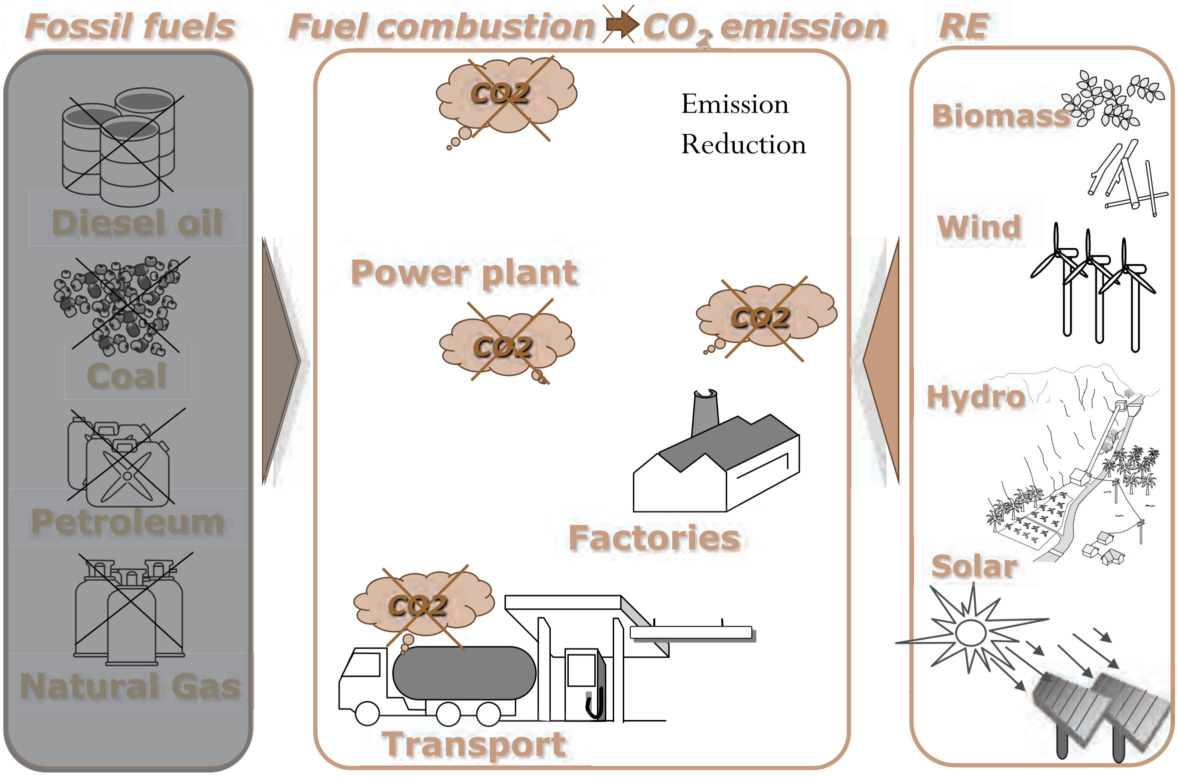
8th July 2011

JICA Expert Team

Ai Kawamura

Summary of the Lecture of Renewable Energy

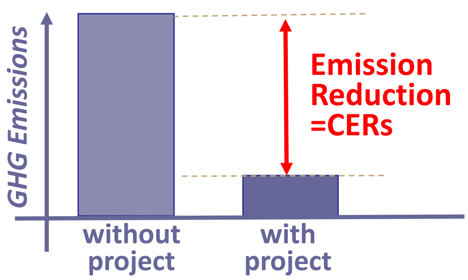
1. How emission reduction is achieved by RE Project (2)



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

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)**



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

- **Basic formula**

GHG Emission Reduction by RE project (tCO_2) = Amount of energy to be replaced [A] × Emission factor of energy to be replaced [B] − Project/ Leakage Emission [C]

1) Grid electricity replacement

= [A] Amount of electricity (MWh) × [B] Grid emission factor [tCO_2/MWh]

Unit Check

MWh × $\frac{tCO_2}{MWh}$ = tCO_2

2) Replacement of Electricity Generated On-site

= [A] Amount of fuel used for electricity generation (ton_fuel) × [B] Emission factor of fuel used for electricity generation [tCO_2/ton_fuel]

Ton × $\frac{tCO_2}{Ton}$ = tCO_2

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

6. Calculation of Grid Emission Factor (2)

Simplified formula for grid emission factor calculation:

Grid Emission Factor in year y [tCO_2/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 [tCO_2/y]* / *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"

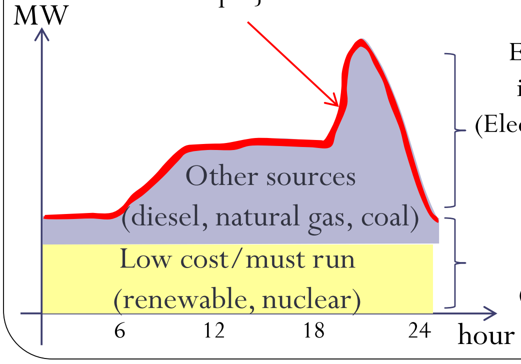
- Grid Emission Factor is necessary for:
  - Renewable energy project that displaces grid electricity
  - Energy efficiency projects that reduces the use of the grid electricity
  - Projects using grid electricity in the project scenario (project emissions)
- Currently, all the registered Sri Lankan CDM projects requires grid emission factor data.
- Grid Emission Factor: 0.65~0.73 tCO_2/MWh
  (National official figure is under preparation, Currently, PP has to calculate by themselves)

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

Electricity supplied by CDM project



Electricity included in OM calculation (Electricity to be replaced by CDM project)

Electricity excluded from OM calculation (Electricity not affected by CDM project)

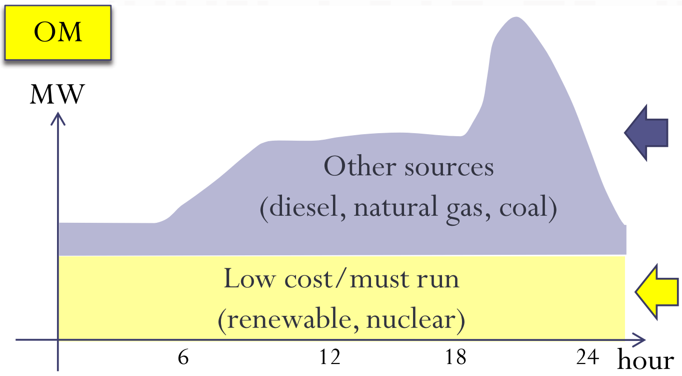
BM

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 (3) Essential Terminologies

OM



Emission is calculated based on the emission factor of each fuel used for power generation

Considered as 0(zero) emission in CDM calculation

Emission factor of each fuel

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		

Grid Electricity factor for CDM project

Grid Emission Factor: 0.65~0.73 tCO_2/MWh
(National official figure is under preparation, Currently, PP has to calculate by themselves)

Grid emission factor for existing electricity consumers is not the same

Calculation Exercise

Non-biomass, Biomass

1. 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 to be used is saw dust and rice husk
  - Net electricity generation operation rate: 1.0 MW
  - Daily operating hours: 20 hours
  - Monthly operating days: 25 days
  - Seasonal operation: operation is constant
  - Grid emission factor: 0.70 kgCO2/kWh
  - Furnace oil required for operation of the new plant: 5ton/month
  - Diesel required for transportation of biomass: 10 ton/month
  - Emission factor of fossil fuel is shown as below:

Fuel Type	CO2 emission coefficient (tCO2/t)
Furnace Oil	3.173
Diesel Oil	3.209

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

1. 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]

1. Calculation Exercise: Biomass(3)

Step1
- How many hours does the plant operate annually?

- Daily operating hours: 20 hours
- Monthly operating days: 25 days
- Seasonal operation: operation is constant

Annual operation hours

$$20\frac{hours}{day}\times 25\frac{days}{month}\times 12\frac{month}{year}=6{,}000\frac{hour}{year}$$

Unit Check

$$\frac{hours}{\cancel{day}}\times\frac{\cancel{days}}{\cancel{month}}\times\frac{\cancel{month}}{year}=\frac{hour}{year}$$

1. Calculation Exercise: Biomass(4)

Step2

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

- Annual operation hour: 6,000 hours/y
- Electricity generation operation rate: 1.0 MW

Amount of electricity to be sold to the grid

6,000 hours/year × 1.0MW = **6,000 MWh/y**

Unit Check

$$\frac{hour}{year} \times MW = \frac{MWh}{year}$$

1. 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: 6,000 MWh/y
- Grid emission factor: 0.70 kgCO2/kWh

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

= 6,000 MWh/y × 0.70 tCO2/MWh

= **4,200 tCO2/y**

Unit Check

$$\frac{kg}{kWh} = \frac{1000 \times kg}{1000 \times kWh} = \frac{t}{MWh}$$

$$\frac{MWh}{year} \times \frac{t\_CO2}{MWh} = \frac{t\_CO2}{MWh}$$

1. 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: <u>5ton/month</u>
- Diesel required for transportation of biomass: <u>10ton/month</u>

On-site fossil fuel consumption

5 ton/month × 12 months/year = <u>60 ton/year</u>

Fossil fuel consumption for biomass transport

10 ton/month × 12 months/year = <u>120 ton/year</u>

Unit Check

$$\frac{ton}{\cancel{Month}} \times \frac{\cancel{Month}}{Year} = \frac{ton}{Year}$$

1. 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: <u>60ton/year</u>
- Diesel required for transportation of biomass: <u>120ton/year</u>

Emission associated to on-site fossil fuel consumption

60 t/year × 3.173 tCO2/t
= <u>190.4 tCO2/y</u>

Emission associated to biomass transport

120 t/year × 3.209 tCO2/t
= <u>385.1 tCO2/y</u>

Project emissions

190.4 tCO2/y + 385.1 tCO2/y = <u>575.5 tCO2/y</u>

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		

1. Calculation Exercise: Biomass(8)

Step6

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

- Baseline emissions: 4,200 tCO_2/year
- Project emissions: 575.5 tCO_2/year

Emission reduction (tCO_2/y)	=	Baseline emission (tCO_2/y)	-	Project emission (tCO_2/y)
	=	4,200 tCO_2/y	-	575.5 tCO_2/y
	=	3,624.5 tCO_2/y		

Answer:
3,624.5 tCO_2/y

2. 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: 1.1 MW
  - Expected operation: (dry season) 0.6MW, (wet season)1.1MW
  - 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 $kgCO_2/kWh$

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

2. 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 is the total electricity to be sold to the grid annually?

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

2. 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**

2. 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) 0.6MW, (wet season) 1.1MW
- 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.

Dry season:

2,400 hours/y × (0.6 MW －0.1MW) = **1,200 MWh/y**

Wet season:

4,800 hours/y × (1.1 MW －0.1MW) = **4,800 MWh/y**

2. 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: 1,200 MWh/y
- Amount of electricity to be sold to the grid in wet season: 4,800 MWh/y

Annual Electricity	=	**Electricity (Dry season)**	+	**Electricity (Wet season)**
	=	1,200 MWh/y	+	4,800 MWh/y
	=	**6,000 MWh/y**		

2. 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: 6,000 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)
	=	6,000 MWh/y	×	0.70 tCO_2/MWh
	=	**4,200 tCO_2/y**		

Emission Reduction = Baseline emission − Project emission
= 4,200 tCO_2/y − 0 tCO_2/y
= 4,200 tCO_2/y

Answer:
4,200 tCO_2/y