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