Chapter 15 Energy Efficiency Promotion Potential of Six Sub-sectors

In this chapter, energy efficiency promotion potential for the whole of Malaysia is estimated for the three commercial sub-sectors (hotels, shopping complexes, and hospitals) and the three industrial sub-sectors (cement, food, and iron/steel), assuming recommended measures in the study are diffused through out the country.

15-1 Methodology

Figure 15-1 illustrates the methodology for estimation of energy efficiency promotion potential.

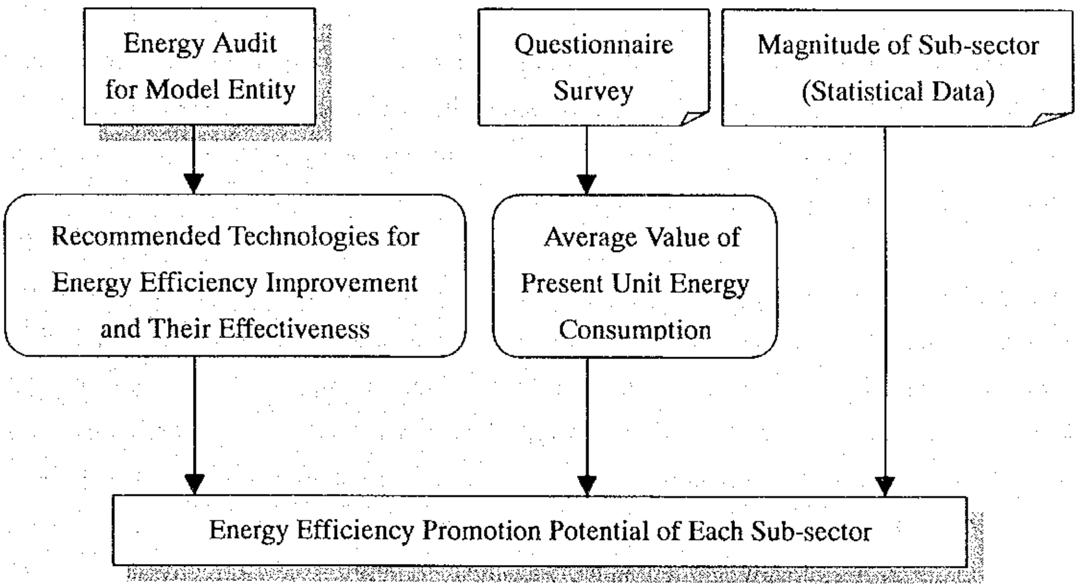

Figure 15-1 Methodology for Estimation of Energy Efficiency Promotion Potential

The first step in estimating the energy efficiency promotion potential for the whole of Malaysia is to carry out energy audits of the model entities selected for the six sub-sectors, in order to recommend measures based on the audits, and to estimate the effectiveness of the measures. The results of these investigations are presented in Chapters 9 through 14.

The second step is the questionnaire survey, which was conducted during July and August 1998 jointly by JBE&G and the study team to inquire about the individual entities in the commercial and industrial sectors. The forms of questionnaire are attached in Appendix 15-1. From the results of the questionnaire, the average value of unit energy consumption is obtained for each sub-sector.

The third step is to obtain data on the magnitude of sub-sectors from statistics.

Energy efficiency promotion potential is estimated based on the results of the first step, assuming the applicable range and current diffusion of measures in terms of energy-saving per total floor area in the commercial sector and per production volume in the industrial sector. The estimated potential per unit multiplied by the magnitude of each sub-sector obtained in the third step produces the absolute value of potential.

On the other hand, the current average value of unit energy consumption obtained in the second step multiplied by the magnitude of each sub-sector obtained in the third step produces the current energy consumption of each sub-sector. The calculated energy consumption is compared with the absolute value of potential.

It must be noted that the energy efficiency promotion potential estimated by this method is not larger than expected. The measures from which the potential is estimated are limited to measures recommended to the model entity. Because of this limited number of measures, the estimated potential is rather small. In some cases, selected measures may reflect features of the model entities. Bandar Utama Shopping Center, for which an energy audit was carried out as the model entity of shopping complexes, is a notable example. This shopping complex, newly established in 1995, has already applied some measures. Therefore, the effectiveness of such measures already applied to the model entity is not extended any further to the shopping complex sub-sector throughout Malaysia.

A database of energy efficiency, essential for estimation of potential by this method, has not been prepared in Malaysia. Efforts were made to supplement the data shortage as much as possible by means of the questionnaire survey and the statistical survey. However, detailed surveys of individual entities other than the six model entities are considered beyond the scope of the study and quite difficult to conduct due to the limited number of study team members and the study period. Therefore, data that requires detailed surveys, especially the current diffusion rate of the measures, is estimated by the study team.

It should be noted that the estimated potential is inevitably somewhat rough and small due to the aforesaid factors. It is desired that Malaysian authorities concerned with energy efficiency promotion develop potentials more accurately from the results of the study.

15-2 Energy Efficiency Promotion Potential in Hotel Sub-sector

15-2-1 Energy Efficiency Promotion Potential for Model Hotel

In Chapter 9 of the report, energy efficiency promotion measures are recommended for Mingcourt Vista Hotel, based on the energy audit conducted for the hotel as the model entity. Table 15-1 shows the recommended measures and their effectiveness.

Table 15-1 Energy Efficiency Promotion Measures and Their Effectiveness for Model Entity (Hotels)

Measures	Effectiveness
Apply inverter control for lifts (introduce VVVF system into lifts)	50% reduction in power consumption for lifts
Introduce VAV system into motors of fresh air intake blower	Potential is 15,000 kcal /year/ m^2.
Raise room temperature by 2 degrees centigrade	20% reduction in power consumption for chillers

15-2-2 Results of Questionnaire Survey for Malaysian Hotel Sub-sector

Questionnaires were delivered to 43 hotels in the questionnaire survey. Among them, 9 hotels replied to the questionnaire with a response rate of 21%. Table 15-2 shows data of the 9 hotels and Mingcourt Vista Hotel. The average energy consumption of these hotels is 690,810 kcal/year/m^2 in terms of the primary energy.

Figure 15-2 illustrates the relationship between the total floor area of hotels and their unit energy consumption. The energy consumption per total floor area is distributed in a relatively narrow range in the hotel sub-sector. Among 10 hotels, the model entity is the nearest hotel to the average in terms of both total floor area and unit energy consumption.

Table 15-2 Results of Questionnaire Survey for Hotels

Hotel	Answer						Energy Consumption (Calculated)		
	Total Floor Area	No. of Rooms	Electricity	Diesel	Medium Fuel Oil	LPG	Electricity	Total Fuel	Total Energy
	m^2		kWh/year	Litter / year	litter / year	kg/year	kWh/year /m^2	kcal /year /m^2	kcal/year /m^2
HT-1	14,292	154	1,871,370	0	0	29,830	130.9	22,704	317,310
HT-2	18,480	364	5,089,750	294,840	0	39,732	275.4	159,193	778,886
HT-3	66,000	721	23,400,000	0	0	222,000	354.5	36,590	834,317
HT-4	23,968	294	5,992,800	132,300	0	50	250.0	47,008	609,583
HT-5	55,000	383	15,000,000	0	0	5,000	272.7	989	614,625
HT-6	67,890	468	17,200,000	520,000	0	136,800	253.4	87,117	657,156
HT-7	57,578	565	10,980,000	480,000	0	87,600	190.7	87,510	516,581
HT-8	51,858	577	16,812,000	0	554,463	81,570	324.2	118,107	847,541
HT-9	15,400	250	5,400,000	90,000	0	60,000	350.6	92,127	881,088
Model	35,100	447	9,568,000	354,700	0	122,700	272.6	124,044	737,377
Average	40,557	422					274.5	73,263	690,810

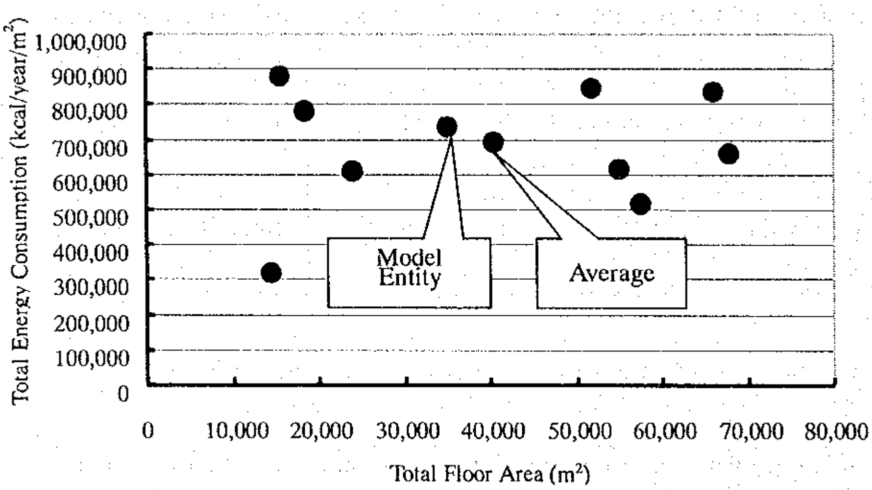

Figure 15-2 Energy Consumption Per Total Floor Area of Hotels

15-2-3 Magnitude of Malaysian Hotel Sub-sector

Table 15-3 shows the number of hotels by state and size. The numbers of hotels by size are: 96 hotels with 300 rooms and above, 224 hotels with 100 - 299 rooms, 213 hotels with 50-99 rooms, 657 hotels with 20 - 49 rooms, and 441 hotels with 10 – 19 rooms. In Malaysia, there are 1,631 hotels, which have 121,030 rooms in total.

Table 15-3 Number of Hotels by Size and State

State	Size 1 (300 rooms & above)		Size 2 (100-299 rooms)		Size 3 (50-99 rooms)		Size 4 (20-49 rooms)		Size 5 (10-19 rooms)		Total	
	No. of Hotel	No. of Room	No. of Hotel	No. of Room	No. of Hotel	No. of Room	No. of Hotel	No. of Room	No. of Hotel	No. of Room	No. of Hotel	No. of Room
JOHOR	8	4,543	16	2,467	30	2,082	71	2,132	30	434	155	11,658
KEDAH	3	1,381	37	5,886	17	1,154	35	1,097	21	393	113	9,911
KELANTAN	1	320	2	295	7	471	22	694	16	222	48	2,002
MELAKA	5	2,481	12	2,293	10	582	33	1,031	12	166	72	6,553
NEGERI SEMBILAN	4	1,273	10	1,726	8	496	13	390	11	146	46	4,031
PAHANG	11	5,799	19	2,921	22	1,364	80	2,291	82	1,156	214	13,531
PERAK	1	310	17	2,813	14	948	51	1,464	54	758	137	6,293
PERLIS	0	0	1	145	0	0	4	117	0	0	5	262
PULAU PINANG	14	5,442	16	2,724	14	973	30	906	18	269	92	10,314
SABAH	7	3,072	12	1,840	23	1,521	63	1,872	38	570	143	8,875
SARAWAK	2	705	19	3,223	22	1,473	104	3,034	84	1,234	231	9,669
SELANGOR	11	4,498	18	3,268	3	220	21	626	12	156	65	8,768
TERENGGANU	2	671	11	1,590	10	638	64	1,907	31	412	118	5,218
WILAYAH PERSEKUTUAN KUALA LUMPUR	27	12,826	31	5,629	29	2,044	57	1,807	26	379	170	22,685
WILAYAH PERSEKUTUAN LABUAN	0	0	3	578	4	279	9	314	6	89	22	1,260
MALAYSIA	**96**	**43,321**	**224**	**37,398**	**213**	**14,245**	**657**	**19,682**	**441**	**6,384**	**1,631**	**121,030**

Source: By the Study Team based on Accommodation Directory 1998/99

15-2-4 Estimation of Energy Efficiency Promotion Potential in Hotel Sub-sector

(1) Introduction of VVVF system into lifts (Application of inverters to lifts)

This measure aims at energy efficiency promotion by changing non-inverter type lifts used in hotels to Variable Voltage Variable Frequency (VVVF) system lifts. The energy efficiency promotion potential by diffusion of this measure through malaysia is estimated under the following assumptions.

- A 50% saving on energy used for lifts is assumed by changing non-inverter type lifts to VVVF system lifts.
- It is assumed that this measure would be applicable to hotels with a total floor area above 2,000 square meters. It is difficult for this measure to be cost-effective in the

case of smaller hotels, as lifts are used less frequently. Therefore, the measure is assumed to be applicable to hotels with a total floor area above 2,000 square meters.

- A 50% of the current diffusion percentage of the measure is assumed, as almost all lifts installed in recent years are supposed to be inverter type.

The energy efficiency promotion potential is estimated in the following sequence.

1) Average energy consumption of lifts is estimated at 4.2% of total energy consumption in the hotel sub-sector, using the example of Mingcourt Vista Hotel. The unit energy consumption of lifts is estimated at 29,014 kcal/year/m^2 from this value and the average unit energy consumption of Malaysian hotels shown in Table 15-2, 690,810 kcal/year/m^2.

$$690{,}810 \text{ kcal/year/m}^2 \times 4.2/100 = 29{,}014 \text{ kcal/year/m}^2$$

2) The unit energy efficiency promotion is estimated at 14,507 kcal/year/m^2 assuming 50% saving.

$$29{,}014 \text{ kcal/year/m}^2 \times 50/100 = 14{,}507 \text{ kcal/year/m}^2$$

3) Average values of total floor area and the number of guest rooms are 40,557 m^2 and 422, respectively, as shown on Table 15-2. Total floor area per one guest room is calculated at approximately 96 m^2 from these values.

$$40{,}557 / 422 = 96 \text{ m}^2$$

4) Hotels with a total floor area of 2,000 m^2, the applicable range of the measure, correspond to hotels with approximately 20 guest rooms.

$$2{,}000 \text{ m}^2 / 96 \text{ m}^2 = 20.8$$

5) The number of hotels with more than 20 guest rooms is 114,646 from Table 15-3. The total floor area of these hotels is calculated at 11,006,016 m^2.

$$43{,}321 + 37{,}398 + 14{,}245 + 19{,}682 = 114{,}646$$

$$96 \text{ m}^2 \times 114{,}646 = 11{,}006{,}016 \text{ m}^2$$

6) The potential in Malaysia is calculated at 79.8 x 10^9 kcal/year from the above in consideration of the 50% of the current diffusion percentage.

$$14{,}507 \text{ kcal/year/m}^2 \times 11{,}006{,}016 \text{ m}^2 \times (100-50)/100 = 79.8 \times 10^9 \text{ kcal/year}$$

On the other hand, the current energy consumption by all hotels in Malaysia is estimated as follows.

1) The total number of customer rooms is 121,030 in Malaysia, as Table 15-3 shows. This multiplied by 96 m^2 that is the average total floor area per one guest room gives 1,1618,880 m^2 of total floor area.

$$96\ m^2 \times 121{,}030 = 11{,}618{,}880\ m^2$$

2) Total energy consumption of hotels is calculated at 8.03×10^{12} kcal/year, from the above total floor area, and 690,810 kcal/year/ m^2 for the unit energy consumption of hotels shown in Table 15-2.

$$690{,}810\ kcal/year/\ m^2 \times 11{,}618{,}880\ m^2 = 8.03 \times 10^{12}\ kcal/year$$

(2) Installation of Variable Air Volume (VAV) system in the motors of fresh air intake blowers

Fresh air intake is provided to maintain a comfortable indoor atmosphere, however, excess volume of fresh air is observed in some cases. This measure is to install the VAV system in the motors of fresh air intake blowers so that the intake volume of fresh air can be controlled for the purpose of reducing electric power consumption of the blower. The energy efficiency promotion potential by diffusion of this measure through Malaysia is estimated under the following assumptions.

- A 15,000 kcal /year/ m^2 saving on energy is assumed by installing VAV system in the motor of fresh air intake blowers in the same way as the example of Mingcourt Vista Hotel.
- It is assumed that this measure would be applicable to hotels with a total floor area above 10,000 square meters. The current diffusion percentage is also assumed as 50%.

The potential is estimated in the following sequence.

1) As the total floor area per one guest room is 96 m^2 as mention above, hotels with a total floor area of 10,000 m^2, where the measure is assumed to be applicable, correspond to the hotels with approximately 100 guest rooms.

$$10{,}000\ m^2 / 96\ m^2 = 104$$

2) The number of hotels with more than 100 customer rooms is 80,719 from Table 15-3.

The total floor area of these hotels is calculated at 7,749,024 m^2.

$$43{,}321 + 37{,}398 = 80{,}719$$

$$96\ m^2 \times 80{,}719 = 7{,}749{,}024\ m^2$$

3) The potential in Malaysia is calculated at 58.1 x 10^9 kcal/year from the above in consideration of the 50% diffusion percentage.

$$15{,}000\ kcal/year/m^2 \times 7{,}749{,}024\ m^2 \times (100-50)/100 = 58.1 \times 10^9\ kcal/year$$

(3) Increase room temperature by 2 degree centigrade

Almost all hotels are air-conditioned throughout the year in Malaysia to provide a comfortable space sheltered from hot weather. However, overcooling by excess air conditioning is observed in some cases. Under such circumstances, it is recommended that the set temperature be moderated, with the aim of reducing energy consumption in the chiller system under investigation. The energy efficiency promotion potential by increasing room temperature by 2 degrees centigrade is estimated under the following assumptions.

- A 20% saving on energy consumption in the chiller system is assumed by increasing room temperature by 2 degrees centigrade.
- It is assumed that this measure would be applicable to all hotels except where air conditioning is not required, such as those located in cool highlands such as Genting Highlands and Cameron Highlands. The exceptional hotels are assumed to account for 7% of all hotels in Malaysia in terms of total floor area.
- Temperature may be controlled to an adequate level in the case of hotels constructed recently. It is assumed that such hotels account for 30% of all hotels in Malaysia.

The potential is estimated in the following sequence.

1) Average energy consumption of the chiller system is estimated at 24.1% of the 690,810 kcal/year/m^2 total energy consumption in the hotel sub-sector, from the example of Mingcourt Vista Hotel. The unit energy consumption of chiller systems is estimated at 166,485 kcal/year/m^2.

$$690{,}810\ kcal/year/m^2 \times 24.1/100 = 166{,}485\ kcal/year/m^2$$

2) The unit energy efficiency promotion is estimated at 33,297 kcal/year/m^2, assuming a 20% saving.

$$166{,}485\ kcal/year/m^2 \times 20/100 = 33{,}297\ kcal/year/m^2$$

3) The total floor area of hotels where this measure is applicable is calculated at 10,805,558 m^2 on the basis of

- 96 m^2 of total floor area per one guest room,
- 121,030 guest rooms in total as shown on Table 15-3, and
- 7% of hotels in terms of total floor area having no air conditioning

$$96\ m^2 \times 121{,}030 \times (100-7)/100 = 10{,}805{,}558\ m^2$$

4) The potential in Malaysia is calculated at 251.9 x 10^9 kcal/year from the above in consideration of the 30% diffusion percentage.

$$33{,}297\ kcal/year/m^2 \times 10{,}805{,}558\ m^2 \times (100-30)/100 = 251.9 \times 10^9\ kcal/year$$

(4) Energy efficiency promotion potential in hotel sub-sector

Table 15-4 shows energy efficiency promotion potential assuming diffusion of recommended measures, and the percentage of the potential of total energy consumption. The potential totals 389.8 x 10^9 kcal/year in terms of primary energy, accounting for 4.9% of total energy consumption in the hotel sub-sector. The total potential is 173 GWh/year in terms of electric power and 38,980 TOE/year in terms of oil.

Table 15-4 Energy Efficiency Promotion Potential in Hotel Sub-sector

Measures	Potential	
	10^9 kcal/year	% of Total Energy Consumption
(1) Apply inverter control for lifts (introduce VVVF system into lifts)	79.8	1.0
(2) Introduce VAV system into motors of fresh air intake blowers	58.1	0.7
(3) Raise room temperature by 2 degrees centigrade	251.9	3.1
Total	389.8	4.9

15-3 Energy Efficiency Promotion Potential in Shopping Complex Sub-sector

15-3-1 Energy Efficiency Promotion Potential for Model Shopping Complex

In Chapter 10 of the report, measures are recommended for Bandar Utama Shopping Center based on the energy audit conducted. Table 15-5 shows the recommended measures and their effectiveness.

Table 15-5 Energy Efficiency Promotion Measures and Their Effectiveness for Model Entity (Shopping Complex)

Measures	Effectiveness
Decrease the illumination intensity	1.3% power saving for lighting system
Raise room temperature by 2 degrees centigrade	20% reduction in power consumption of chillers
Prevent heat loss from entrances	80% reduction in heat loss from entrances (1.6% power saving for chiller)

15-3-2 Results of Questionnaire Survey for Malaysian Shopping Complex Sub-sector

Table 15-6 Results of Questionnaire Survey for Shopping Complex

Shopping Complex	Answer				Energy Consumption (Calculated)		
	Total Floor Area m^2	Electricity kWh/year	Diesel Litter / year	LPG kg/year	Electricity kWh/year /m^2	Total Fuel kcal /year /m^2	Total Energy kcal/year /m^2
SH-1	20,708	6,058,665	0	0	292.6	0	658,289
SH-2	60,434	14,803,800	200	0	245.0	28	551,187
SH-3	58,000	24,201,053	0	0	417.3	0	938,834
SH-4	33,480	2,775,181	0	33,946	82.9	11,029	197,533
SH-5	69,675	12,332,160	900	0	177.0	110	398,350
SH-6	110,000	13,200,000	6,000	6,300	120.0	1,087	271,087
SH-7	93,000	14,616,534	455	0	157.2	42	353,667
SH-8	16,000	5,400,000	0	0	337.5	0	759,375
SH-9	NA	NA	NA	NA			
SH-10	NA	7,787,640	0	0			
SH-11	NA	3,457,540	400	0			
SH-12	80,642	4,796,000	1,820	0	59.5	192	134,006
SH-13	5,910	3,224,590	750	0	545.6	1,080	1,228,762
Model	191,752	61,947,665		25,056	323.1	1,421	728,311
Average	82,178				220.9	1,077	498,035

Questionnaires were delivered to 36 shopping complexes in the questionnaire survey. Among them, 13 complexes replied to questionnaire with a response rate of 36%. Table 15-6 shows data of the 13 shopping complexes and Bandar Utama Shopping Center. The average energy consumption of these shopping complexes is 498,035 kcal/year/m^2 in terms of primary energy.

Figure 15-3 illustrates the relationship between the total floor area of shopping complexes and their unit energy consumption. The energy consumption per total floor area is distributed in a wider range than the hotel sub-sector. The model entity is a large shopping complex with a total floor area that is triple the average. Its unit energy consumption is 1.5 times more than the average.

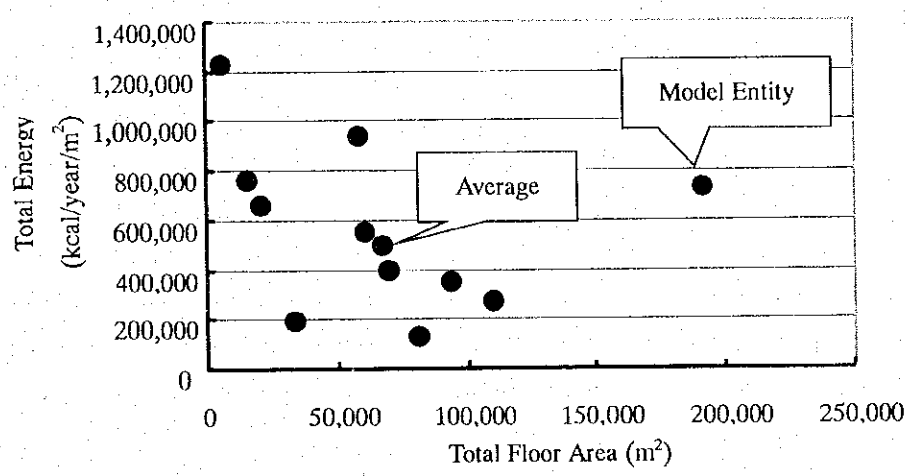

Figure 15-3 Energy Consumption Per Total Floor Area of Shopping Complexes

15-3-3 Magnitude of Malaysian Shopping Complex Sub-sector

The total floor area of shopping complexes in Malaysia is approximately 3.83 million square meters, according to *the Property Market Report, 1997,* by the Valuation and Property Services Department, Ministry of Finance.

15-3-4 Estimation of Energy Efficiency Promotion Potential in Shopping Complex Sub-sector

(1) Reduction of illumination intensity

Decreasing the illumination intensity of common areas highlights the interior of shops better. The energy efficiency promotion potential by decreasing the illumination intensity is estimated under the following assumptions.

- A 1.3% power saving for lighting system is assumed by decreasing the illumination intensity. It is assumed from the results for Bandar Utama Shopping Center that this saving accounts for 0.34% of the total energy consumption.
- This measure is supposed to be applicable to shopping complexes of all scales.
- A 60% current diffusion percentage is assumed for this measure, as some shopping complexes are observed to control the illumination intensity within a reasonable range.

The energy efficiency promotion potential is estimated in the following sequence.

1) The unit energy consumption of Malaysian shopping complexes is 498,035 kcal/year/m^2 from the results of the questionnaire survey shown in Table 15-6. As the potential of the measure is assumed at 0.34% of this value, the unit potential amounts to 1,693 kcal/year/m^2.

$$498{,}035 \text{ kcal/year/m}^2 \times 0.34/100 = 1{,}693 \text{ kcal/year/m}^2$$

2) The potential in Malaysia is calculated at 2.6×10^9 kcal/year from the unit potential, a 3,830,000 m^2 total floor area, and a 60% diffusion percentage.

$$1{,}693 \text{ kcal/year/m}^2 \times 3{,}830{,}000 \text{ m}^2 \times (100\text{-}60)/100 = 2.6 \times 10^9 \text{ kcal/year}$$

On the other hand, the unit energy consumption for the whole of Malaysia is 498,035 kcal/year/m^2, as Table 15-6 shows. This value multiplied by the 3,830,000 m^2 total floor area gives 1.91×10^{12} kcal/year of current energy consumption in the shopping complex sub-sector.

$$498{,}035 \text{ kcal/year/m}^2 \times 3{,}830{,}000 \text{ m}^2 = 1.91 \times 10^{12} \text{ kcal/year}$$

(2) Increase room temperature by 2 degrees centigrade

Overcooling by excess air conditioning is observed in some shopping complexes in Malaysia.

Under such circumstances, it is recommended that set temperature be moderated with the aim of reducing energy consumption in the chiller system. The energy efficiency promotion potential by increasing room temperature by 2 degrees centigrade in the same way as Bandar Utama Shopping Center is estimated under the following assumptions.

- A 20% saving on energy consumption in chiller systems is possible by increasing room temperature by 2 degrees centigrade. It is assumed from the results for Bandar Utama Shopping Center that this saving accounts for 13.3% of the total energy consumption.
- It is assumed that this measure would be applicable to shopping complexes of all scales.
- It is assumed that in approximately 50% of shopping complexes the measure is not applicable, as the set temperature is sufficiently high.

The potential is estimated in the following sequence.

1) The unit energy consumption of Malaysian shopping complexes is 498,035 kcal/year/m^2, from the results of questionnaire survey shown in Table 15-6. As the potential of the measure is assumed as 13.3% of this value, the unit potential amounts to 66,200 kcal/year/m^2.

$$498{,}035 \text{ kcal/year/m}^2 \times 13.3/100 = 66{,}200 \text{ kcal/year/m}^2$$

2) The potential in Malaysia is calculated at 126.8×10^9 kcal/year from the unit potential, a 3,830,000 m^2 total floor area, and a 50% diffusion percentage.

$$66{,}200 \text{ kcal/year/m}^2 \times 3{,}830{,}000 \text{ m}^2 \times (100\text{-}50)/100 = 126.8 \times 10^9 \text{ kcal/year}$$

(3) Prevention of heat loss from entrances

This measure is to minimize the heat loss from entrances by replacing existing entrances with air-tight types such as rotating doors. The energy efficiency promotion potential by this measure is estimated under the following assumptions.

- A 80% reduction of heat loss from entrances is possible by this measure. It is assumed from the results for Bandar Utama Shopping Center that this saving accounts for 1.1% of the total energy consumption.
- It is assumed that this measure would be applicable to shopping complexes of all scales except for cases where application of this measure is difficult because of building structure, for instance, natural ventilation for common spaces such as halls, passages

and staircases. The exceptional cases are assumed to account for 40% of the shopping complexes in terms of total floor area.

- It is assumed that this measure has already been applied to approximately 50% of shopping complexes.

The potential is estimated in the following sequence.

1) The unit energy consumption of Malaysian shopping complexes is 498,035 kcal/year/m^2 from the results of questionnaire survey shown in Table 15-6. As the potential of the measure is assumed as 1.1% of this value, it amounts to 5,500 kcal/year/m^2.

$$498{,}035 \text{ kcal/year/m}^2 \times 1.1/100 = 5{,}500 \text{ kcal/year/m}^2$$

2) The total floor area of Malaysian shopping complexes is 3,830,000 m^2. This measure is assumed to be applicable to shopping complexes apart from the 40% of exceptional cases owing to structural reasons. A 50% diffusion percentage is also assumed. From these values, the total floor area to which this measure is applicable is calculated at 1,149,000 m^2.

$$3{,}830{,}000 \text{ m}^2 \times (100-40)/100 \times (100-50)/100 = 1{,}149{,}000 \text{ m}^2$$

3) The potential in Malaysia is calculated at 6.3×10^9 kcal/year from the above values.

$$5{,}500 \text{ kcal/year/m}^2 \times 1{,}149{,}000 \text{ m}^2 = 6.3 \times 10^9 \text{ kcal/year}$$

(4) Energy efficiency promotion potential of shopping complex sub-sector

Table 15-7 shows energy efficiency promotion potential assuming diffusion of recommended measures, and the ratios of potential to total energy consumption. The potential is totally 135.7×10^9 kcal/year in terms of primary energy, accounting for 7.1% of total energy consumption in the shopping complex sub-sector. The total potential is 60.3 GWh/year in terms of electric power and 13,570 TOE/year in terms of oil.

Table 15-7 Energy Efficiency Promotion Potential of Shopping Complexes

Measures	Potential	
	10^9 kcal/year	% of Total Energy Consumption
(1) Decrease the illumination intensity	2.6	0.13
(2) Raise room temperature by 2 degrees centigrade	126.8	6.64
(3) Prevent heat loss from entrances	6.3	0.33
Total	135.7	7.10

15-4 Energy Efficiency Promotion Potential in Hospital Sub-sector

15-4-1 Energy Efficiency Promotion Potential for Model Hospital

In Chapter 11 of the report, measures are recommended for Hospital Seremban based on an energy audit conducted of the hospital as the model entity. Quantitative benefits were obtained for two measures among those investigated in Chapter 11. However, the first measure, "Introduction of Inverter Control System for Lift Power Supply", was concluded as financially unfeasible, and the second measure, "Introduction of Latent Heat Storage System", aims at shifting the peak load to the off-peak period without reducing the total energy consumption. Accordingly, for the hospital sub-sector, energy efficiency promotion potential for the whole of Malaysia cannot be obtained from the results of the energy audit.

15-4-2 Results of Questionnaire Survey for Malaysian Hospital Sub-sector

Questionnaires were delivered to 12 hospitals in the questionnaire survey. Among them, 6 hospitals replied to the questionnaire with a response rate of 50%. Table 15-8 shows data of the 6 hospitals and Hospital Seremban. The average energy consumption of these hospitals is 261,969 kcal/year/m^2 in terms of the primary energy.

Table 15-8 Results of Questionnaire Survey for Hospital

Hospital	Answer							Energy Consumption (Calculated)		
	Total Floor Area	No. of Bed	Electricity	Diesel	Light Fuel Oil	Medium Fuel Oil	LPG	Electricity	Total Fuel	Total Energy
	m^2		KWh/year	litter / year	litter / year	litter / year	kg/year	KWh/ year/m2	kcal /year/m2	kcal /year/m2
HS-1	214,500	812	5,868,000	131,040	0	0	0	27.4	5,200	66,753
HS-2	41,235	250	720,000	4,546	0	0	0	17.5	938	40,225
HS-3	171,516	990	10,080,000	5,400	0	777,600	18,360	58.8	44,258	176,490
HS-4	8,581	760	11,672,760	40,267	388,800	0	144,000	1,360.3	650,483	3,711,164
HS-5	14,800	344	13,962,100	0	194,400	0	9,600	943.4	131,130	2,253,747
HS-6	2,600	23	40,000	200	0	0	0	15.4	655	35,270
HS-7	40,000	800	4,501,000	14,000	786,000	0	0	112.5	188,593	441,774
Average	70,461	568						95.0	48,279	261,969

Figure 15-4 illustrates the relationship between the total floor area of hospitals and their unit energy consumption. The energy consumption per total floor area is distributed very widely with very high values at two small hospitals. Both the percentage of air-conditioned area and type of air conditioning vary according to hospitals. This variation is considered as one of the reasons for the wide distribution of unit energy consumption.

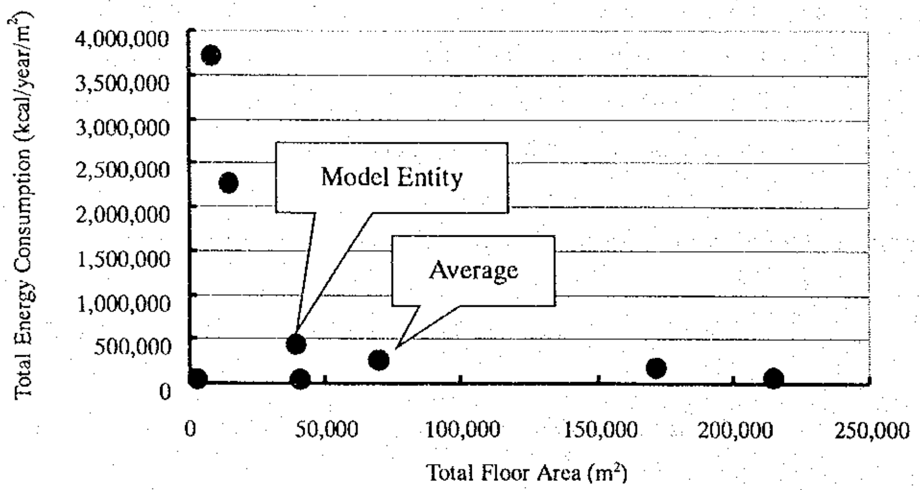

Figure 15-4 Energy Consumption Per Total Floor Area of Hospitals

15-4-3 Magnitude of Malaysian Hospital Sub-sector

There are 111 government hospitals, 7 special medical institutions and 203 private hospitals and maternity homes, which have 27,126 beds, 6,692 beds and 7,471 beds, respectively, as Table 15-9 shows.

Table 15-9 Malaysian Hospitals by State (1996)

State	Government Hospitals			Special Medical Institutions			Private Hospitals, Nursing and Maternity Homes		
	No. of Hospital	Total No. of Bed	Av. No. of Bed	No. of Hospital	Total No. of Bed	Av. No. of Bed	No. of Hospital	Total No. of Bed	Av. No. of Bed
Malaysia	**111**	**27,126**	**244**	**7**	**6,692**	**956**	**203**	**7,471**	**37**
Johor	10	2,645	265	1	2,080	2,080	35	637	18
Kedah	9	2,017	224				11	262	24
Kelantan	8	1,394	174				1	10	10
Melaka	2	835	418				7	614	88
Negeri Sembilan	5	1,298	260				6	120	20
Pahang	9	1,585	176				7	116	17
Perak	14	3,991	285	1	3,000	3,000	16	755	47
Perlis	1	404	404						
Pulau Pinang	5	2,023	405				21	1,323	63
Sebah	17	2,740	161	1	302	302	11	224	20
Sarawak	19	2,937	155	2	358	179	15	376	25
Selangor	6	1,547	258	1	836	836	29	1,078	37
Terengganu	5	1,182	236				2	21	11
W.P. Kuala Lumpur	1	2,528	2,528	1	116	116	42	1,935	46
W.P. Labuan	0			0			0		

Remarks: As from 1995, general hospitals and district hospitals have been classified as government hospitals.
Source: Social Statistics Bulletin Malaysia, 1997, Department of Statistics, Malaysia

15-5 Energy Efficiency Promotion Potential in Cement Industry

15-5-1 Energy Efficiency Promotion Potential for Model Cement Factory

In Chapter 12 of the report, measures are recommended for APMC Rawang Works based on the energy audit conducted for this cement factory as the model entity. Table 15-10 shows the recommended measures as well as power and heat saving by these measures.

Table 15-10 Energy Efficiency Promotion Measures and Their Effectiveness for Model Entity (Cement Industry)

	Measures	Power Saving (kWh/ton-clinker)	Heat Saving (10^3 kcal/ton-clinker)
1.	Prevention of air leakage	3.8	0
2.	Rationalization of transportation system	5.3	0
3.	Construction of coal dryer/grinding mill	- 0.3	15.6
4.	Change of feeding point and feeding system of coal shale	0	5.0
5.	Reduction of cyclone pressure loss	2.0	0
6.	Improvement of C5 cyclone collecting efficiency	- 1.1	33.7
7.	Waste heat boiler/generator system	61.2	0
8.	Lifter brick at kiln backend part	0	11.7
9.	Replacement of cooler GBF	0.6	18.2
10.	Grinding aids	4.5	0

15-5-2 Results of Questionnaire Survey for Malaysian Cement Industry

Questionnaires were delivered to 7 cement factories in the questionnaire survey. Among them, 3 factories replied to the questionnaire with a response rate of 43%. Table 15-11 shows data of the 3 factories and APMC Rawang Works.

Table 15-11 Results of Questionnaire Survey for Cement Industry

Cement	Answer								Energy Consumption (Calculated)		
	Clinker Tons/year	Electricity kWh/year	Diesel litter / year	Fuel Oil Ton/ year	Medium Fuel Oil litter / year	LPG kg/year	Coal ton/year	Coal Shale ton/year	Electricity kWh/ ton-clin'	Total Fuel kcal/ ton-clin'	Total Energy kcal/ ton-clin'
CM-1	1,617,850	199,779,000			8,202,234		197,200		123.5	840,176	1,118,015
CM-2	2,606,769	301,630,000	252,441		23,577	1,581	325,692		115.7	813,032	1,073,380
CM-3	1,319,662	167,428,115		3,665			161,993		126.9	826,225	1,111,687
Model	1,560,055	233,670,000		33,447			130,401	296,664	149.8	892,972	1,229,985
Average	1,776,084								127.0	839,689	1,125,520

Figure 15-5 illustrates the relationship between clinker production volume and unit power consumption in cement factories. The unit power consumption is distributed in a somewhat narrower range than the commercial sector. The unit power consumption of the model factory is larger than other three factories by 20% to 30%.

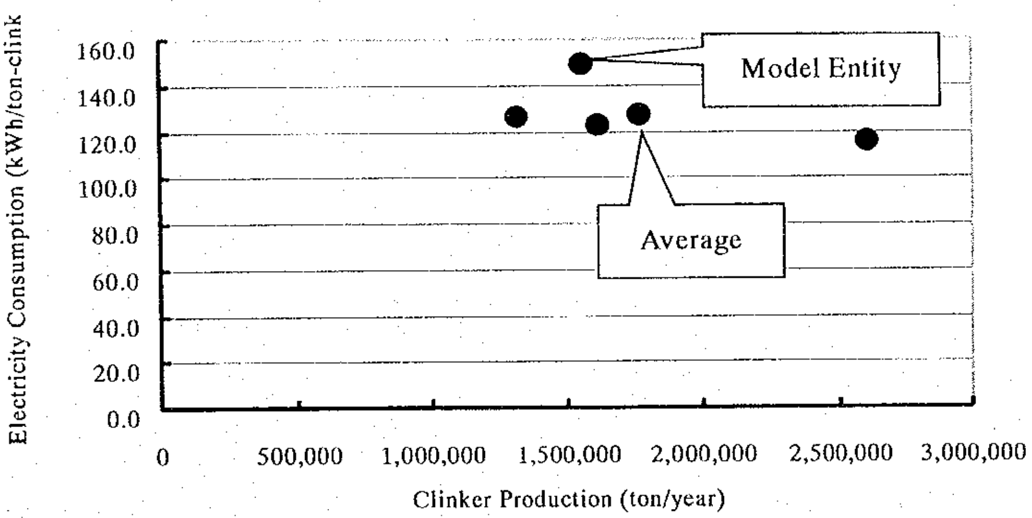

Figure 15-5 Electric Consumption Per Clinker Production (Cement Industry)

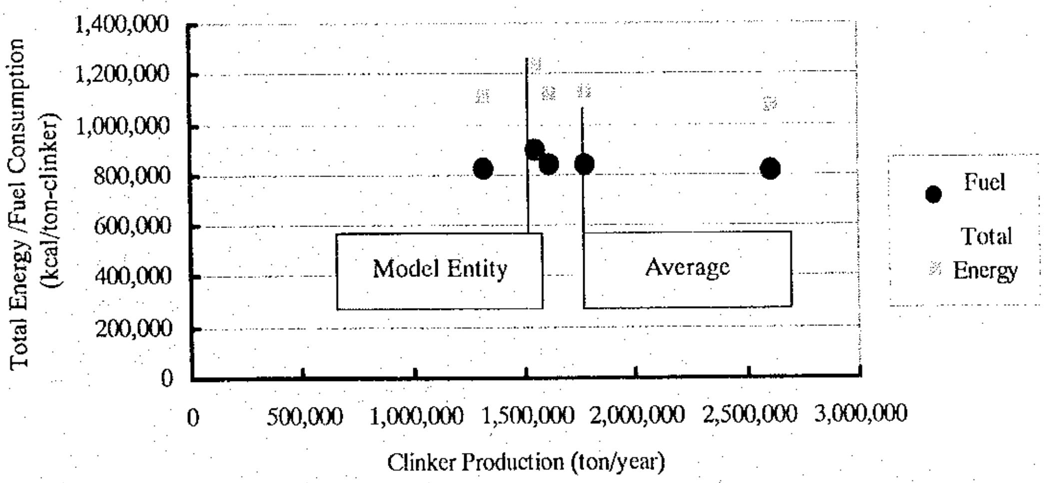

Figure 15-6 Total Energy/Fuel Consumption Per Clinker Production (Cement Industry)

Figure 15-6 illustrates the relationship between clinker production volume and unit total energy consumption, as well as the unit fuel consumption in cement factories. The unit total energy consumption and the unit fuel consumption are distributed in rather narrow ranges as well. The values of the model factory are larger than those of other three factories.

15-5-3 Magnitude of Malaysian Cement Industry

In Malaysia, the following volumes of cement and clinker were produced in 1996 according to Cement and Concrete Association.

- Cement: 9.29 million tons
- Clinker : 12.71 million tons

15-5-4 Estimation of Energy Efficiency Promotion Potential in Cement Industry

(1) Prevention of air leakage

This measure aims at power reduction by preventing air leakage from various locations in a plant. The potential by diffusion of this measure throughout Malaysia is estimated under the following assumptions.

- 3.8 kWh/ton-clinker of power saving is assumed based on the example for APMC Rawang Works, although it varies according to the current conditions of air leakage at individual plants.
- This measure is assumed to be applicable to all cement factories.

Power saving by this measure is estimated at 48.3 x 10^6 kWh/year for the whole of Malaysia from production volume of clinker and power saving per clinker.

$$3.8 \text{ kWh/ton-clinker} \times (12.71 \times 10^6) \text{ ton-clinker/year} = 48.3 \times 10^6 \text{ kWh/year}$$

This value is converted to heat in terms of the primary energy as follows.

$$48.3 \times 10^6 \text{ kWh/year} \times 2{,}250 \text{ kcal/kWh} = 109 \times 10^9 \text{ kcal/year}$$

(2) Rationalization of transportation system

This measure aims at power reduction by changing the transportation system of coal shale and cement from a pneumatic system to a mechanical elevator and air slide system.

The energy efficiency promotion potential by diffusion of this measure throughout Malaysia is estimated under the following assumptions.

- 5.3 kWh/ton-clinker of power saving is assumed based on the example for APMC Rawang Works.
- This measure is applicable to factories using the pneumatic transportation system. Although researches were not conducted for any current systems of Malaysian cement factories other than APMC Rawang Works, it is assumed that 30% of factories use the pneumatic system throughout Malaysia.

Power saving by this measure is estimated at 20.2 x 10^6 kWh/year for the whole of Malaysia from production volume of clinker and power saving per clinker.

5.3 kWh/ton-clinker x (12.71x 10^6) ton-clinker/year x 0.3 = 20.2 x 10^6 kWh/year

This value is converted to heat in terms of the primary energy as follows.

20.2 x 10^6 kWh/year x 2,250 kcal/kWh = 45.5 x 10^9 kcal/year

(3) Construction of coal drying/grinding mill

This measure aims at improving combustion efficiency by combustion of finer powder as well as changing the fuel type from fuel oil to coal to reduce energy cost.

The energy efficiency promotion potential by diffusion of this measure throughout Malaysia is estimated under the following assumptions.

- 15,600 kcal/ton-clinker of heat saving is assumed, although additional electricity is required for the operation of a coal drying/grinding mill by 0.3 kWh/ton-clinker.
- This measure is applicable to 60% of cement factories in Malaysia.

Heat saving by this measure is estimated for the whole of Malaysia from production volume of clinker and heat saving per clinker.

15,600 kcal/ton-clinker x (12.71x 10^6) ton-clinker/year x 0.6 = 119 x 10^9 kcal/year

Additional power consumption is estimated as follows.

0.3 kWh/ton-clinker x (12.71x 10^6) ton-clinker/year x 0.6= 2.3 x 10^6 kWh/year

The total energy saving is estimated in terms of the primary energy as follows.

$$119 \times 10^9 \text{ kcal/year} - 2.3 \times 10^6 \text{ kWh/year} \quad \times \quad 2{,}250 \text{ kcal/kWh} = 114 \times 10^9 \text{ kcal/year}$$

(4) Change of feeding point and feeding system of coal shale

This measure aims at heat saving by changing the feed point of coal shale from direct feeding into the F.F furnace to the C4 cyclone inlet, as well as by changing the feeding system from a pneumatic to a mechanical system.

As this measure is specific to APMC Rawang Works, it cannot be diffused to the whole of Malaysia. Thus the total energy saving is limited to 8.2×10^9 kcal/year for APMC Rawang Works.

(5) Reduction of cyclone pressure loss

This measure aims at power reduction by reducing pressure loss in the cyclones. The energy efficiency promotion potential by diffusion of this measure throughout Malaysia is estimated under the following assumptions.

- 2.0 kWh/ton-clinker of power saving is assumed based on the example for APMC Rawang Works.
- It is assumed that a similar pressure loss is observed in the cyclones of 50% of Malaysian cement factories and that this measure is applicable to those factories.

Power saving by this measure is estimated at 12.7×10^6 kWh/year for the whole of Malaysia from production volume of clinker and power saving per clinker.

$$2.0 \text{ kWh/ton-clinker} \times (12.71 \times 10^6) \text{ ton-clinker/year} \times 0.5 = 12.7 \times 10^6 \text{ kWh/year}$$

This value is converted to heat in terms of the primary energy as follows.

$$12.7 \times 10^6 \text{ kWh/year} \times 2{,}250 \text{ kcal/kWh} = 28.6 \times 10^9 \text{ kcal/year}$$

(6) Improvement of bottom cyclone collecting efficiency

This measure aims at heat saving by improving bottom cyclone efficiency followed by reduction of the exhaust gas temperature. The energy efficiency promotion potential by diffusion of this measure throughout Malaysia is estimated under the following assumptions.

- 33,700 kcal/ton-clinker of heat saving is assumed, although 1.1 kWh/ton-clinker of additional electricity is required.
- This measure is applicable to 30% of cement factories in Malaysia.

Heat saving by this measure is estimated for the whole of Malaysia from production volume of clinker and heat saving per clinker.

$$33{,}700 \text{ kcal/ton-clinker} \times (12.71 \times 10^6) \text{ ton-clinker/year} \times 0.3 = 128 \times 10^9 \text{ kcal/year}$$

Additional power consumption is estimated as follows.

$$1.1 \text{ kWh/ton-clinker} \times (12.71 \times 10^6) \text{ ton-clinker/year} \times 0.3 = 4.2 \times 10^6 \text{ kWh/year}$$

The total energy saving is estimated in terms of the primary energy as follows.

$$128 \times 10^9 \text{ kcal/year} - 4.2 \times 10^6 \text{ kWh/year} \quad \times \quad 2{,}250 \text{ kcal/kWh} = 119 \times 10^9 \text{ kcal/year}$$

(7) Waste heat boiler/power generating system

This measure aims at waste heat recovery by installation of waste heat boiler/power generating systems. By the waste heat boiler, steam is generated utilizing the heat of hot exhausted gas. Generated steam is utilized for power generation in the steam turbine power generating system.

The energy efficiency promotion potential by diffusion of this measure throughout Malaysia is estimated under the following assumptions.

- Generated power is estimated at 61.2 kWh/ton-clinker for the model cement factory, although it varies with the types and operating conditions of factory cement production processes. Because of high temperatures and the large volume of exhaust gas, the above generated power for the model factory seems larger than other Malaysian cement factories. Possible generated power is assumed at 30 kWh/ton-clinker on average for this study, in consideration of Japanese examples ranging from 20 to 30 kWh/ton-clinker.
- It is assumed that this measure would be applicable to all cement factories.
- This measure has not been under taken to any degree in Malaysia.

Power generated by this measure is estimated at 381 x 10^6 kWh/year for the whole of Malaysia from production volume of clinker and generated power per clinker.

$$30 \text{ kWh/ton-clinker} \times (12.71 \times 10^6) \text{ ton-clinker/year} = 381 \times 10^6 \text{ kWh/year}$$

This value is converted to heat in terms of the primary energy as follows.

$$(381 \times 10^6 \text{ kWh/year}) \times 2{,}250 \text{ kcal/kWh} = 858 \times 10^9 \text{ kcal/year}$$

(8) Lifter bricks at kiln backend part

This measure, aimed at fuel reduction, involves the laying of lifter bricks at the kiln backend part, which enables effective burning of unburned fuel that is brought into the kiln from the pre-heater section. The energy efficiency promotion potential by diffusion of this measure throughout Malaysia is estimated under the following assumptions.

- A 11.7 kcal/kg-clinker fuel reduction is assumed based on the example for APMC Rawang Works.
- This measure is assumed to be applicable to all cement factories.

The potential by this measure is estimated as follows from the 12.71 x 10^6 ton-clinker/year clinker production and the above assumptions.

$$11.7 \text{ kcal/kg-clinker} \times (12.71 \times 10^9) \text{ kg-clinker/year} = 149 \times 10^9 \text{ kcal/year}$$

(9) Replacement of cooler GBF

By replacing the existing Gravel Bed Filter (GBF) with an Electrostatic Precipitator (EP), heat and electricity saving are expected as well as recovery of clinker. This measure is specific to APMC Rawang Works and cannot be diffused to the whole of Malaysia. Thus the energy saving is limited to 30 x 10^9 kcal/year of heat and 0.96 x 10^6 kWh/year of electricity which are estimated for APMC Rawang Works.

The total Energy Efficiency Promotion is estimated in terms of the primary energy as follows.

$$30 \times 10^9 \text{ kcal/year} + 0.96 \times 10^6 \text{ kWh/year} \times 2{,}250 \text{ kcal/kWh} = 32.2 \times 10^9 \text{ kcal/year}$$

(10) Grinding aids

This measure aims at power saving in the grinding mill by utilizing grinding aids. The energy efficiency promotion potential by diffusion of this measure throughout Malaysia is estimated under the following assumptions.

- 0.3 kWh/ton-clinker of power saving is assumed, provided that grinding aids are utilized by 0.02%.
- This measure is applicable to all cement factories in Malaysia.

Power saving is estimated as follows.

0.3 kWh/ton-clinker x (12.71x 10^6) ton-clinker/year = 3.8 x 10^6 kWh/year

The total energy saving is estimated in terms of the primary energy as follows.

3.8 x 10^6 kWh/year x 2,250 kcal/kWh = 8.6 x 10^9 kcal/year

(11) Annual energy consumption in cement industry

Unit consumption of power, fuel and total energy (the sum of power and fuel) are estimated at 127.0 kWh/ton-clinker, 839,689 kcal/ton-clinker and 1,125,520 kcal/ton-clinker, respectively, as Table 15-11 shows. These values of unit consumption multiplied by the annual production volume of clinker give the annual consumption of power, fuel and total energy in the entire Malaysian cement industry as follows.

- Power : 1,610 x 10^6 kWh/year
- Fuel : 10.7 x 10^{12} kcal/year
- Total energy (the primary energy basis) : 14.3 x 10^{12} kcal/year

(12) Energy efficiency promotion potential in cement industry
Table 15-12 shows energy efficiency promotion potential assuming diffusion of the recommended measures, as well as the ratios of potential to total energy consumption. 460 GWh/year of power saving and 434 x 10^9 kcal/year of fuel saving are estimated. The potential, a total of power and fuel saving potential, is 1,472 x 10^9 kcal/year in terms of the primary fuel, accounting for 10.3% of energy consumption in the Malaysian cement industry. The potential is 147,200 TOE/year.

Table 15-12 Energy Efficiency Promotion Potential in Cement Industry

Measures	Electricity	Fuel	Total Energy	
	10^6 kWh/y	10^9 kcal/y	10^9 kcal/y	% of Current Energy Consumption
Energy Efficiency Promotion Potential				
Prevention of air leakage	48.3	0	109	0.76
Rationalization of transportation system	20.2	0	45.5	0.32
Construction of coal dryer/grinding mill	-2.3	119	114	0.80
Change of feeding point and feeding system of coal shale	0	8.2	8.2	0.06
Reduction of cyclone pressure loss	12.7	0	28.6	0.20
Improvement of C5 cyclone collecting efficiency	- 4.2	128	119	0.83
Waste heat boiler/generator system	381	0	858	6.0
Lifter brick at kiln backend part	0	149	149	1.0
Replacement of cooler GBF	0.96	30	32.2	0.22
Grinding aids	3.8	0	8.6	0.06
Total (1)	460.46	434.2	1,472.1	10.3
Current Energy Consumption (2)	1,610	10,700	14,300	
Energy Efficiency Promotion Potential (1) / (2) x 100	28.6%	4.06%	10.3%	

15-6 Energy Efficiency Promotion Potential in Food Industry

15-6-1 Energy Efficiency Promotion Potential for Model Food Factory

In Chapter 13 of the report, measures are recommended for Central Sugars Refinery, based on the energy audit conducted for this factory as the model entity. Table 15-13 shows the recommended measures and their effectiveness.

Table 15-13 Energy Efficiency Promotion Measures and Their Effectiveness for Model Entity (Food Industry)

Measures	Effectiveness
To improve heat energy efficiency in steam and steam condensate recovery system	Fuel saving of 1,600 ton/year
To replace failed steam traps	Steam saving of 15,629 RM/year

15-6-2 Results of Questionnaire Survey for Malaysian Food Industry

Questionnaires were delivered to 30 food factories in the questionnaire survey. Among them, 8 factories replied to the questionnaire with a response rate of 27%. Table 15-14 shows data of the 8 factories and Central Sugars Refinery.

Table 15-14 Results of Questionnaire Survey for Food Industry

	Answer								Energy Consumption (Calculated)		
	Products	Annual Production	Electricity	Diesel	LFO	MFO	NG	LPG	Elect-ricity	Total Fuel	Total Energy
		ton/year	kWh/y	litter/year	litter/year	litter/year	M3/y	kg/year	KWh/ton	kcal/ton	kcal/ton
FD-1	Wheat Flour	61,355	5,716,500	26,200					68.0	2,651	155,542
	Wheat Bran	766									
	Wheat Pollard										
	Wheat Germ										
	Wheat Meal										
	Semolina										
FD-2	Biscuit	4,500	480,000	380,000					106.7	718,791	958,791
FD-3	Jelly	5,000	1,701,100		393,100			9,600	223.8	502,323	1,005,938
	Ice Pop	1,600									
	Beverages	1,000									
FD-4	Liquid Milk	43,000	10,039,945			1,740,689			130.4	213,540	506,915
	Sweetened Condensed Milk	34,000									
FD-5	Monosodium Glutamate	12,500	30,096,000	600		5,900	576		2,286.9	5,013	5,150,606
	Hydrolysed Vegetable Protein	660									
FD-6	Refined Sugar	125,000	26,000,000	320,000	50,000				165.6	20,358	392,969
	Molasses	32,000									
FD-7	Palm Oil Products	429,000	26,500,000	2,300,000		9,400,000			59.4	243,091	376,839
	Soaps	16,800									
FD-8	Sweetened Condensed Milk	104,808	15,960,000			3,700,000		540,000	105.0	28	236,331
	Evaporated Milk	31,488									
	Ice Cream	11,000									
	Sterlised/Past, Milk/Fruit Juice	4,670									
Model	Refined Sugar								78.1	187,000	362,725

According to the above table, energy use varies significantly according to the product. The energy used in the factory for wheat flour, wheat bran, etc. is about 160,000 kcal/ton; that for monosodium glutamate and others is about 5,150,000 kcal/ton; and that for biscuits is about 960,000 kcal/ton. Because of the wide variety of products produced by these factories and the types of energy use, it is quite difficult to characterize the food industry in terms of energy use and even more difficult to estimate energy efficiency promotion potential by this method.

Even if discussion narrows down to the sugar refining branch, it is difficult to estimate the potential for the whole of Malaysia, since the recommended measures are strongly affected by the model factory's characteristics. The model has quite a large boiler capacity to supply steam to its own power plant, which seems a unique feature of the factory, and the recommended measures are concentrated on the boiler and steam system. Therefore, it is unreasonable to estimate the potential for the whole of Malaysia by this method.

15-7 Energy Efficiency Promotion Potential in Iron/Steel Industry

15-7-1 Energy Efficiency Promotion Potential for Model Steel Factory

In Chapter 14 of the report, measures are recommended for Amsteel Mills (ASM) based on the energy audit conducted for this factory as the model entity. Table 15-15 shows the recommended measures and their effectiveness.

Table 15-15 Energy Efficiency Promotion Measures and Their Effectiveness for Model Factory (Iron/Steel Industry)

Measures	Effectiveness
Reduction in Temperature Variation of Extracted Material	0.46 kg-fuel/ton-billet
Reduction in Air/Fuel Ratio of Reheating Furnace	0.5 kg-fuel/ton-billet
Reduction in Heat Loss from Reheating Furnace Wall	0.71 kg-fuel/ton-billet
Introduction of Hot Billet Charging	0.9 kg-fuel/ton-billet
Reduction in Electricity Consumption of EAF	15 kWh/ton

15-7-2 Results of Questionnaire Survey for Malaysian Iron/Steel Industry

Questionnaires were delivered to 12 iron and steel factories in the questionnaire survey. Among them, 7 factories replied to the questionnaire with a response rate of 58%. Table 15-16 shows data of the 7 factories and ASM.

The factories that replied are composed of several plants such as electric arc furnaces, ladle furnaces, rod mills, bar mills, and direct reduction iron plants, however, energy usage data of individual plants is not available from the questionnaire survey, and only the total for all plants in each factory is available. Because of the wide variety of plant kinds and capacities, it is difficult to ascertain the energy uses of an individual plant from the total of all plants in each factory. Therefore, the quest to obtain average energy uses from the results of the questionnaire survey was abandoned.

Table 15-16 Results of Questionnaire Survey for Iron and Steel Industry

No.	Answer								Energy Consumption (Calculated)		
	Products	Annual Production tons/year	Electricity KWh/y	Diesel kl / y	LFO kl / y	MFO kl / y	Natural Gas 10^3m^3 / y	LPG ton/y	Elect-ricity kWh /ton	Total Fuel kcal/ton	Total Energy kcal/ton
IS-1	Hot Roll Steel	414,000	329,265,000	3,963	17,301			191	795.3	481,246	2,270,730
IS-2	Bar & Wire Rod	499,038	87,851,000		38.9	15,766			147.2	250,086	581,207
	Beam & Section	97,918									
IS-3	Billet/Bloom/ Blanks	825,106	811,101,850	7,581			267,439		983.0	2,967,795	5,179,607
	DRI	820,595									
IS-4	Steel Welded Mesh	125,000	5,896,227	120					47.2	8,227	114,359
IS-5	High Yield Deformed Bar	100,134	9,414,794	155		4,358			94.0	424,375	635,924
IS-6	Billet	393,905	276,778,320		6,357		14,616		702.7	483,251	2,064,219
	Round bar	242,785									
	Angle bar	21,022									
IS-7	Cold Drawn Steel Bar	12,000	850,000	7.2	160				70.8	131,054	290,429
Model	Billet	660,286									
	Wire Rod	369,464									
	Bar	525,605									

15-7-3 Magnitude of Malaysian Iron/Steel Industry

Table 15-17 shows production in the Malaysian Iron/Steel industry in 1995. 1,178,000 tons of iron and 2,450,000 tons of crude steel were produced in 1995. All crude steel was produced by the electric arc furnace method. In addition, 3,071,000 tons of hot-rolled steel products were produced in the same year.

Table 15-17 Malaysian Iron and Steel Production in 1995

Item	Production, '000 ton/year
1. Pig iron, Ferro-alloys, Crude Steel	
(1) DRI/HBI	1,178
(2) Ferro-alloys	0
(3) Crude Steel Total	2,450
(a) Ingots	0
(b) Continuous Cast	2,450
(c) Steel for Casting	0
(d) by Oxygen-blown Converters	0
(e) by Electric Furnace	2,450
(f) by Other Furnace	0
2. Hot-rolled Steel Products	
(1) Sections	215
(2) Bars	2,176
(3) Wire Rods	680
Hot-rolled Steel Products Total	3,071
3. Cold-rolled, Coated, Pipes & Tubes, Cold-formed Sections	
Total	1,338

Source: South East Asia Iron & Steel Institute

15-7-4 Estimation of Energy Efficiency Promotion Potential in Iron/Steel Industry

(1) Reduction in temperature variation of extracted material

This measure aims at fuel reduction in the reheating furnace by reducing the temperature range of extracted billet to the lower side. The energy efficiency potential by diffusion of this measure throughout Malaysia is estimated under the following assumptions.

- 0.46 kg-fuel/ton of fuel saving is assumed based on the example of ASM, although this figure varies according to the current operational conditions in individual plants.
- It is assumed that this measure is applicable to all plants.

The fuel oil saving by this measure is estimated at 1,413 ton-fuel/year for the whole of Malaysia from production volume of hot-rolled steel products and fuel saving per billet.

0.46 kg-Fuel/ton x 3,071,000 ton/year /1,000 = 1,413 ton-Fuel/year

This value is converted to heat as follows by using a 9,463 kcal/kg net heating value.

1,413 x 1,000 x 9,463 = 13.4 x 10^9 kcal/year

(2) Reduction in air/fuel ratio of reheating furnace

This measure aims at fuel reduction in the reheating furnace by reducing the current air/fuel ratio to the optimum attainable level. The energy efficiency promotion potential by diffusion of this measure throughout Malaysia is estimated under the following assumptions.

- 0.5 kg-fuel/ton of fuel saving is assumed based on the example of ASM, although this figure varies with the current operational conditions in individual plants.
- It is assumed that this measure is applicable to all plants.

The fuel oil saving by this measure is estimated at 1,536 ton-Fuel/year for the whole of Malaysia from production volume of hot-rolled steel products and fuel saving per billet.

0.5 kg-fuel/ton x 3,071,000 ton/year /1,000 = 1,536 ton-fuel/year

This value is converted to heat as follows by using a 9,463 kcal/kg net heating value.

1,536 x 1,000 x 9,463 = 14.5 x 10^9 kcal/year

(3) Reduction in heat loss from reheating furnace wall

This measure aims at fuel reduction in the reheating furnace by reducing the heat loss from the furnace wall. The energy efficiency promotion potential by diffusion of this measure throughout Malaysia is estimated under the following assumptions.

- 0.71 kg-fuel/ton of fuel saving is assumed based on the example of ASM, although this figure varies according to the degree of current heating loss in individual plants.
- It is assumed that this measure is applicable to all plants.

The fuel oil saving by this measure is estimated at 2,180 ton-fuel/year for the whole of Malaysia from production volume of hot-rolled steel products and fuel saving per billet.

0.71 kg-Fuel/ton x 3,071,000 ton/year /1,000 = 2,180 ton-fuel/year

This value is converted to heat as follows by using 9,463 kcal/kg of net heating value.

2,180 x 1,000 x 9,463 = 20.6 x 10^9 kcal/year

(4) Introduction of hot billet charging

This measure aims at fuel reduction in the reheating furnace by hot billet charging. The energy efficiency promotion potential by diffusion of this measure throughout Malaysia is estimated under the following assumptions.

- 0.9 kg-Fuel/ton of fuel saving is assumed based on the example of ASM. However, the required investment is strongly dependent upon the existing facilities and facility layout.
- It is assumed that this measure is applicable to all plants.

The fuel oil saving by this measure is estimated at 2,205 ton-fuel/year for the whole of Malaysia from production volume of crude steel and fuel saving per billet.

0.9 kg-fuel/ton x 2,450,000 ton/year /1,000 = 2,205 ton-fuel/year

This value is converted to heat as follows by using a 9,463 kcal/kg net heating value.

2,205 x 1,000 x 9,463 = 20.9 x 10^9 kcal/year

(5) Reduction in electricity consumption of EAF

For ASM, it is recommended that the oxygen lance position be well into the molten phase and influence the metal phase, so that the boiling reaction is not localized only in the slag phase. Electricity could be saved for other EAFs throughout Malaysia, although specific measures may vary with individual plants. The energy efficiency promotion potential by such measures throughout Malaysia is estimated under the following assumptions.

- 15 kWh/ton of electricity saving is assumed based on the example of ASM.
- It is assumed that this measure is applicable to all plants.

The fuel oil saving by this measure is estimated at 36.8 x 10^6 kWh/year for the whole of Malaysia from production volume of crude steel and electricity saving per unit crude steel.

15 kWh/ton x 2,450,000 ton/year = 36.8 x 10^6 kWh/year

This value is converted to heat in terms of the primary energy as follows.

$$(36.8 \times 10^6 \text{ kWh/year}) \times 2{,}250 \text{ kcal/kWh} = 82.8 \times 10^9 \text{ kcal/year}$$

(6) Energy efficiency promotion potential in Steel and Iron Industry

Table 15-18 shows energy efficiency promotion potential, assuming diffusion of the recommended measures. 36.8 GWh/year of power saving and 69.4 x 10^9 kcal/year of fuel saving are estimated. The potential, a total of power and fuel saving potential, is 152.2 x 10^9 kcal/year in terms of the primary fuel.

Table 15-18 Energy Efficiency Promotion Potential in Iron and Steel Industry

Measures	Electricity	Fuel	Total Energy
	10^6 kWh/y	10^9 kcal/y	10^9 kcal/y
Reduction in Temperature Variation of Extracted Material	0	13.4	13.4
Reduction in Air/Fuel Ratio of Reheating Furnace	0	14.5	14.5
Reduction in Heat Loss from Reheating Furnace Wall	0	20.6	20.6
Introduction of Hot Billet Charging	0	20.9	20.9
Reduction in Electric Consumption of EAF	36.8	0	82.8
Total	36.8	69.4	152.2

Appendix 15

Questionnaire Forms for Energy Consumption

Study On Promotion Of Energy Efficiency In Malaysia
(JBE&G and JICA)

Questionnaire (Commercial Sector)

1. **Particulars**
   - i) Name of Organisation : ____________________
   - ii) Name and Title of Respondent : ____________________
     ____
   - iii) Address of Organisation : ____________________
     ____
     ____
   - iv. Telephone and facsimile : ____________________
     ____
   - v. Category (**Please (✓) accordingly**)

     ☐ Hotel ☐ Shopping/Commercial Complex ☐ Hospital

2. **Total Floor Area** : ____________________ m^2
3. **Number of Rooms (for hotels only)** : ____________________ rooms
4. **Numbers of Beds (for hospitals only)** : ____________________ beds
5. **Annual Electricity Consumption** : ____________________ Kwh/year
6. **Annual Fuel Consumption** (please indicate suitable measurement unit)

Type of Fuel	**Annual Consumption**
i) Diesel	Litres/year
ii) Light Fuel Oil	Litres/year
iii) Medium Fuel Oil	Litres/year
iv) Natural Gas	m^3/year
v) Others (please state)	/year

7. **Annual Water Consumption** : ____________________ m^3/year
8. **Electrical Power Demand**
   - i) Air Conditioning : ____________________ Kw
   - ii) Lighting : ____________________ Kw

Study On Promotion Of Energy Efficiency In Malaysia (JBE&G and JICA)

Questionnaire (Industrial Sector)

1. **Particulars**
   - i) Name of Organisation : ____________________
   - ii) Name and Title of Respondent : ____________________
     ____
   - iii) Address of Organisation : ____________________
     ____
   - iv) Telephone and facsimile : ____________________
     ____
   - v) Category (Please (✓) accordingly) :
     ❑ Iron and Steel ❑ Cement ❑ Food Product

2. **Annual Production Volume** (please use extra sheet, if necessary)

Name of Product	Annual Production Volume
i)	tons/year
ii)	tons/year

3. **Annual Electricity Consumption** : ____________________Kwh/year

4. **Annual Fuel Consumption** (please indicate suitable measurement)

Type of Fuel	Annual Consumption
i) Diesel	Litres/year
ii) Light Fuel Oil	Litres/year
iii) Medium Fuel Oil	Litres/year
iv) Natural Gas	m^3/year
v) Others (please state)	/year

5. **Annual Water Consumption** : ____________________m^3/year

6. **Electrical Power Demand**
   - i) Air Conditioning : ____________________Kw
   - ii) Lighting : ____________________Kw
   - iii) Others : ____________________Kw

JICA