International Journal of Mechanical and Materials Engineering (IJMME), Vol. 2 (2007), No. 1, 84-92.

AN ANALYSIS OF ENERGY USE, ENERGY INTENSITY AND EMISSIONS AT THE INDUSTRIAL SECTOR OF MALAYSIA

R. Saidur[1], M. Hasanuzzaman[1], M. A. Sattar[1], H. H. Masjuki[1], M. Irfan Anjum[1] and A.K.M. Mohiuddin[2]
[1]Department of Mechanical Engineering
University of Malaya
50603 Kuala Lumpur, Malaysia
Email: ehasan99@yahoo.com
[2]Mechanical Engineering Department, International Islamic University Malaysia,
Jalan Gombak, Kuala Lumpur 53100, Malaysia,
E-mail: mohiuddin@iiu.edu.my

ABSTRACT

Malaysia is a developing country which has transformed itself from more on producer of raw materials to an emerging multi-sector economy in a span of 40 years. Growth was almost exclusively driven by exports - particularly of electronics. This paper presents the energy consumption trend in Malaysian industrial sector. Malaysian Industrial Development Authority (MIDA) conducts survey to get raw data of energy (Fuel oil, diesel, petrol, kerosene, gas and electricity) consumption behavior for each year. The raw data has been processed by the data processors to analyze the actual behavior of energy consumption in different sub-sectors over that period. Energy intensity which is the key indicator of energy performance of a country and emissions has been calculated. The study was carried out for 2 years in 1988 and 1998. It was found that during the year 1988 and 1998, fuel oil is used more than other fuels. The energy intensity of the non-metallic section was higher both in the years 1988 and 1998. In the year 1998, the energy intensity of chemical industries was lower. Where as, the energy intensity of wood and chemical industries were low in the year of 1988. The emissions of the food sector are higher both in the year 1988 and 1998. The emissions of the entire sector are more in the year of 1998 compare to the year of 1988. The analysis shows that over all emission is 5 times in the year of 1998 compare to that of 1988.

Keywords: Energy intensity; Industrial sector; Energy consumption; Emission.

1 INTRODUCTION

Energy is one of the indispensable factors for continuous development and economic growth. Energy efficiency improvement is one of the most important functions to reduce energy cost as well as production cost in the industries. Energy efficiency improvement is the main objective of many national energy policies. Monitoring of the energy consumption and developments in energy efficiency is necessary in order to check and apply desired policies. Energy is the most important sector for automation and modernization. Automation and modernization is increasing rapidly day by day in the industrial sectors. Rahman Mohamed and Lee (2006) investigated that the energy demands in Malaysia increasing rapidly. The energy demand increased almost 20% within the last 3 years (from 1999 to 2002). The energy demand is further expected to increase almost 60% within 8 years (from 2002 to 2010).To supply the demand energy on need to increase power stations. As a result, emission of greenhouse gases (CO_2, SO_2, NO_x, CO) increase. It is a worldwide concern for the environment of the acceleration of global warming and climate change by the emission of gases. Kato (1996) analyzed the energy consumption and estimated emissions (CO_2, SO_2 and NO_x) in Asia that is shown in the Table 1. Marland *et al.* (1999) investigated the global, regional and national CO_2 emissions in the year 1996 and estimated that 77.5% of CO_2 emissions are emitted from liquid and solid fuels where as, 18.3% of CO_2 emissions are emitted from gaseous fuels burning. Limmeechokchaia and Suksuntornsiri (2007) investigated the energy consumption and greenhouse gas emissions of Thailand in the years of 1995, 1998, 2001 and 2006. They found that the highest energy intensive sector is the electricity sector where fossil fuel is primarily used, but the highest total GHG emitter is the cement industry where the major sources of the emissions are industrial processes and the combustion of fossil fuels. The emission factor was low in the year of 2001and 2006 compare to the year of 1995 and 1998. Mahlia (2002) estimated emissions from electricity generation in Malaysia and observed that emissions increase and it will be around 3 times in 2020 than in 2002.

Table 1 CO_2, SO_x and NO_x emissions in some Asian countries and total Asia (Source: Kato, 1996)

Country	CO_2 (kton)			SO_x (kton)			NO_x (kton)		
	1975	1980	1987	1975	1980	1987	1975	1980	1987
Bangladesh	1,290	1,919	2,839	40	57	49	46	58	66
Indonesia	11,219	21,194	29,888	201	329	485	331	465	639
Japan	271,943	281,165	271,786	2,571	1,604	1,143	2,229	2,132	1,935
Malaysia	5,086	7,311	10,052	193	272	263	90	126	177
Singapore	3,521	5,186	6,414	85	122	155	43	69	88
Thailand	7,397	11,034	16,679	224	420	612	182	255	384
Asia total	779,297	955,492	1,228,676	18,340	22,997	29,136	9,388	11,352	15,483

The energy requirement is sensitive to the rate of economic growth and energy intensity of industrial sectors. The energy intensity of producing sectors is a function of technological progress and varies from sector to sector. Ramirez *et al.* (2006) investigated energy use and energy efficient indicator in the food and tobacco industry in the Netherlands. The cumulative energy savings was about 11 PJ for the period 1993–2001 and this savings had been mainly due to improvement efficiency of fossil fuels/heat per unit of product. Reddy and Balachandra (2003) investigated that industrial sector consumed about 42% of total energy in India in 2000 and the energy intensity was 263 MJ/US$. Bala Subrahmanya (2006) investigated energy use and energy cost features of brick making enterprises in India that brick enterprise consumed about US$ 0.73 thousand worth of energy and nearly US$318.2 per unit of labour.

Indicators of industrial energy intensity and ratio of energy cost input to industrial output are often used as a basis for policy decisions. It provides a simple and easy way to compute summary of the efficiency with which energy is utilized. Gaps between average and best-practice energy intensity at plant level, for example, often prompt calls for policies that encourage the adoption of best-practice technology. Trends in industry-level energy intensity indicators are often used to identify the industries that lag behind other industries in reducing energy intensity. A decreased in energy intensity in industry may reflect the fact that producers on average are becoming more efficient at producing a ton of finished products or it may reflect the fact that producers are shifting production toward finished products that require less energy. Farla and Blok (2000) investigated the energy intensity developments in the Netherlands and estimated that the annual decrease in energy intensity was 1.4% for the period 1980–1995. Liu *et al.* (2006) analyzed the overall energy intensity of the Chinese Zhenzhou alumina refinery plant with Bayer–sinter combined method between 1995 and 2000. They investigated the effect of material flows on energy intensity in process industries and estimated the practical and standard energy intensity. The practical and standard energy intensity was 11.133 GJ/t-Al_2O_3 and 7.349 GJ/t-Al_2O_3 respectively. The variation of the intensity was the effects on product ratio and unit process energy intensity. The result shows that the overall energy intensity decreased and the energy savings were direct 49% and indirect 51%. Tiwari (2000) analyzed sectoral energy intensity in India for 1983-84 and 1989-90. The energy intensity of some sectors was low in 1989-90 compared to 1983-84. Where as, the energy intensity of some sectors were high in 1989-90 compared to 1983-84. But all the value of energy intensity was comparable. Priambodo and Kumar (2001) investigated energy use of Indonesian industrial sectors and estimated the energy intensity. The highest and lowest energy intensity was food and textile sector respectively in the year of 1993.

The aim of the research is to develop meaningful physical indicators of the industries, estimate energy use, energy intensity, emissions and investigate the development in the industrial sector in the Malaysia.

2 ENERGY SURVEY DATA

In this study, energy audit has been conducted in various types of industries (Chemical, base metal, paper, wood, non-metal and food) in Malaysia for the years 1988 and 1998. The conducted survey has collected the data of various types and amount of energy consumption (fuels, electricity), types and amount of fuels, amount of purchased and generated electricity, no of employees, types and amount of products etc all of the sub-sectors of the industries in Malaysia.

Table 2 Two digit MIC code and number of audited factories in the years of 1988 and 1998.

Sector	Two digit MIC code	Number of audited factories
Food	31	112
Wood	33	39
Paper	34	16
Chemical	35	33
Non metallic	36	45
Base metal	37	7

Table 3 Sector wise employees in the industrial sector in the years of 1988 and 1998.

Sector / MIC	Employee	
	1988	1998
31	22,521	23,970
33	9,597	9,836
34	4,412	4,648
35	3,226	3,948
36	5,356	7,391
37	2,341	2,087

3 ENERGY USE

Energy is the main source to run machines and produce products in the industries. Vicious types of energy are used in the industries. Most of the industries have used both fuel and electricity.

3.1 Fuel

Diesel, petrol, gas, fuel oil and kerosene are the main fuel energy used in the industrial sector that shown in the Table 4. Very few industries use kerosene as fuel. Uses of gas have increased rapidly to fulfill the increasing energy demand in the industrial sector. In the food industries sector, the gas is used almost 2 times in the year of 1998 than in the year of 198

Table 4 Sector wise fuel energy consumption in the industrial sector in the years of 1988 and 1998.

Sector / MIC code	Fuel Oil(kLiters)		Diesel (kliters)		Petrol (kliters)		Kerosene (kliters)		Gas (kliters)	
	1988	1998	1988	1998	1988	1998	1988	1998	1988	1998
31	5,582,572	21,919,379	29,064	31,064	922	785	30	3	4,148	7,293
33	1,190,978	1,030,978	8,538	7,432	336	201	1	1	38	1,273
34	1,008,712	765,546	643	1,651	10	140	2	7	0	103
35	2,175,148	22,052,637	4,065	138,590	101	181	4	0	1	199
36	607,930	1,628,449	12,662	8,180	1,543	210	2	0	7,006	9,422
37	270,328	674,232	2,488	3,928	9	39	0	444	14	111

3.2 Electricity

Electricity uses in the industrial sector are very much common. The amount of electricity used in the various industrial sectors is shown in the Table 5. Most of the industries purchase electricity. Very few industries have generated electricity. Base metal industries sector had purchased electricity and had not generated both in the year of 1988 and 1998. This sector had purchased electricity 3 times in the year of 1998 compare to the year of 1988. In the food industrial sector, the electricity is used almost 6 times in the year of 1998 than in the year of 1988.

Table 5 Sector wise electricity consumption in the industrial sector in the years of 1988 and 1998.

Sector / MIC code	Electricity purchased(GWh)		Electricity generated(GWh)		Total electricity consumed(GWh)	
	1988	1998	1988	1998	1988	1998
31	557	3,287	16	262	573	3,549
33	141	123	2	58	143	181
34	63	117	182	28	245	145
35	147	319	7	16	154	335
36	425	804	47	5	472	809
37	82	249	0	0	82	249

4 ENERGY INTENSITY AND EMISSION ANALYSIS

The energy efficiency in the considered sectors could be expressed in the form of energy intensity. The energy intensity or the energy consumed per unit of economic which is usually indicated by value addition and is calculated by:

$$EI = \frac{\text{total energy (fuel and/or electricity) consumption in the factory during the year}}{\text{value addition of the product from the factory during the year}} \quad (1)$$

The energy intensity also calculated considering the employees of the factories during the year. The energy consumed per employee is expressed as:

$$EI = \frac{\text{total energy (fuel and/or electricity) consumption in the factory during the year}}{\text{total number of employees in the factory during the year}} \quad (2)$$

4.1 Energy intensity

Energy intensity (EI) of the years 1988 and 1998 has been calculated for all sectors in Malaysia by using equations 1 and 2. Energy intensities sectors namely, chemical, base metals, paper, wood ,non metallic and food have been shown in Figs. 1,2,3,4,5and 6 respectively. From Fig. 1, it has been observed that energy intensity (Fuel, electricity and total) declined in the year 1998 compared to 1988. This implies that chemical industries were more energy efficient in 1998 compared to 1988. Figs. 2 and 3, shows that fuel energy intensity were

more efficient in 1998 compared to 1988 where as electrical energy intensity is less efficient in 1998 compared to 1988. But total energy intensity both of the years 1988 and 1998 all most same. Fuel, electrical and total energy intensity both of the years 1988 and 1998 all most same that are shown in Fig. 4. Fuel, electrical and total energy intensity was more efficient in the year of 1998 compared to 1988 that are shown in Fig. 5. From Fig. 6, electrical energy efficiency was low in the year of 1998 compared to 1988.

The highest and lowest fuel energy intensity was paper and wood sector respectively in the year of 1988. But in the year of 1998 the highest and lowest fuel energy intensity was food and wood sector respectively. The highest electrical energy intensity was non-metallic sector both of the years 1988 and 1998. But the lowest electrical energy intensity was paper and chemical in the year of 1988 and 1998 respectively. The total energy intensity of the non-metallic sector was highest both of the years of 1988 and1998. But more energy efficient in the year of 1998 compared to 1988. The lowest total energy intensity was wood and chemical in the year of 1988 and 1998 respectively. The chemical sector was more energy efficient in the year of 1998 compared to 1988. While the food sector was very less energy efficient in the year of 1998 compared to 1988. The energy efficiency of the other sector was almost same.

Considering the employee of the sector, the lowest fuel energy intensity was wood sector and almost same both in the years of 1988 and 1998 that shown in Table 6. Where as, the highest fuel energy intensity was paper and chemical sector in the year of 1988 and 1998 respectively. The lowest electrical

energy intensity was paper and wood sector in the years of 1988 and 1998 respectively. The highest electrical energy intensity was non metal and food sector in the years of 1988 and 1998 respectively. But the lowest total energy intensity was wood sector and almost same both in the years of 1988 and 1998. Where as, the highest totals energy intensity was chemical and food sector in the years of 1988 and 1998 respectively. The total energy intensity of food, chemical and base metal sector were to much higher in the year of 1998 compared to 1988.where as, the total energy intensity of wood and paper sector were lower in the year of 1998 compared to 1988.

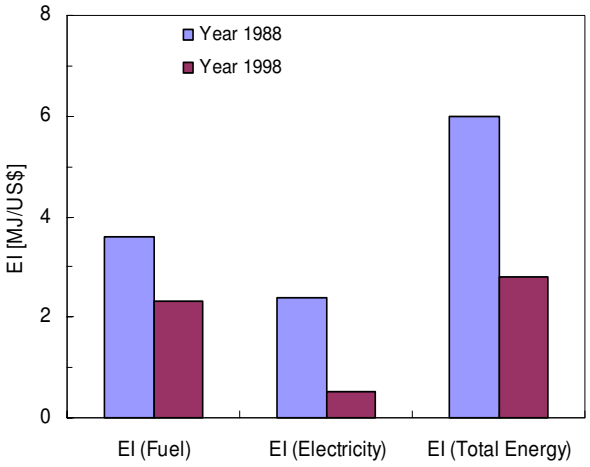

Fig. 1 Energy intensity in chemical sector in the years of 1988 and 1998

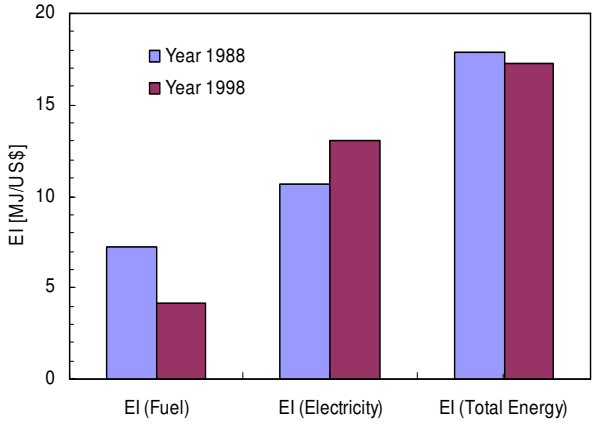

Fig. 2 Energy intensity in base metal sector in the years of 1988 and 1998

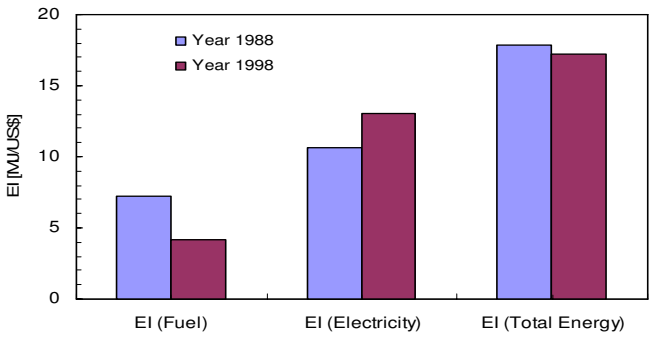

Fig. 3 Energy intensity in paper sector in the years of 1988 and 1998

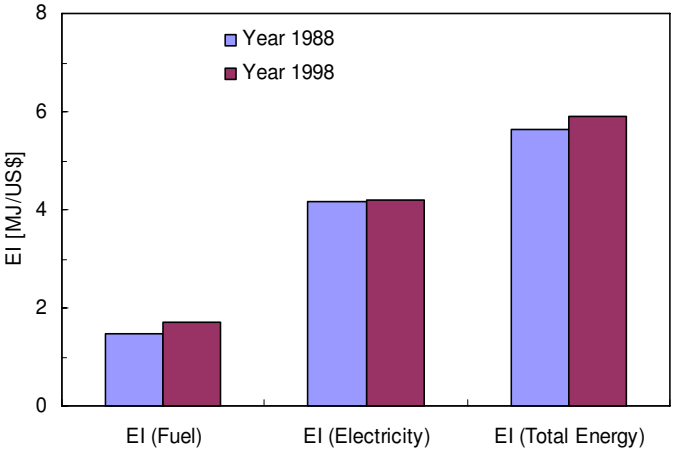

Fig. 4 Energy intensity in wood sector in the years of 1988 and 1998.

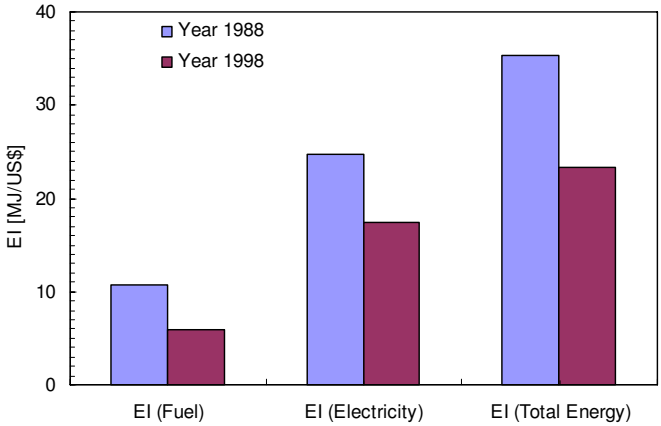

Fig. 5 Energy intensity in non metallic sector in the years of 1988 and 1998

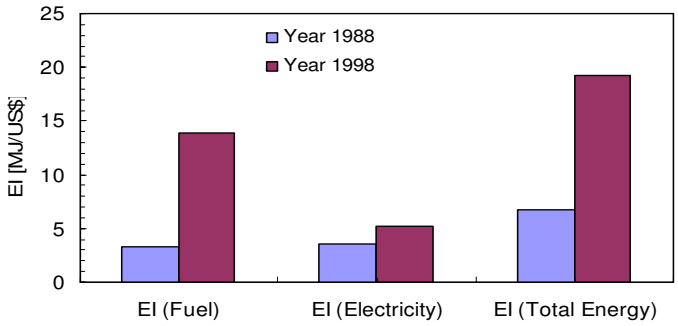

Fig. 6 Energy intensity in food sector in the years of 1988 and 1998

Table 6 Sector wise energy intensity in GJ/Employee in Malaysia in the years of 1988 and 1998.

Sector / MIC code	EI (Fuel)		EI (Electricity)		EI (Total)	
	1988	1998	1988	1998	1988	1998
31	225.3	3,541.8	242.3	1,343.7	467.6	4,885.6
33	50.9	49.1	143.6	122.5	194.4	171.6
34	881.4	583.2	140.8	245.6	1,022.2	828.8
35	675.3	3,576.5	445.6	790.5	1,120.9	4,367.0
36	337.2	363.0	778.5	1,065.7	1,115.8	1,428.7
37	231.3	375.3	341.6	1,171.2	572.9	1,546.5

4.2 Emissions

Greenhouse gases (GHGs) are increasing in the atmospheres that have a negative impact on the environment. Burning fossil fuels release emissions such as carbon dioxide (CO_2), sulfur dioxide (SO_2), nitrogen oxide (NO_x) and carbon monoxide (CO). Based on the available data on fuel and electricity consumption in the industries both in the years of 1988 and 1998 emissions are estimated.

4.2.1 Emissions for fuel consumption:

4.2.1.1 CO2 emission for fuel consumption:

To estimate the amount of CO_2 released from fossil fuels that consumed in the industrial sectors, fuel types, calorific value, emission factor and fraction of oxidized of fuel have to be considered. CO_2 emissions due to fuel use are calculated based on Intergovernmental Panel on Climate Change (IPCC) guideline (Revised, 1996).The CO_2 emissions by fuel used is estimated as:

$$CO_2 emission = FC \times CEF \times f \times 44/12 \quad (3)$$

Where: *FC*=Fuel consumption in the industrial sector (TJ), *CEF*=Carbon emission factor of specific fuel (t C/TJ), *f*=Fraction oxidized. The IPCC has established CEF values of fuel which can be used for general cases. The fraction carbon oxidized is given the actual carbon emissions. The ratio of 44/12 converts the mass of carbon into the CO_2 emissions. Carbon emission factor of fuel (IPCC guideline: revised, 1996): fuel oil (21.1tC/TJ), gasoline (18.9tC/TJ), diesel (20.2tC/TJ), natural gas (15.3tC/TJ), kerosene (19.6tC/TJ). Fraction oxidized (IPCC guideline: revised, 1996): coal (0.99), oil and oil product (0.99) and gas (0.995).

4.2.1.2 SO_2, NO_x and CO emission for fuel consumption:

To estimate the amount of SO_2, NO_x and CO released from fossil fuels that consumed in the industrial sectors, fuel types, calorific value and emission factor of fuel have to be considered. SO_2, NO_x and CO emissions due to fuel use are calculated based on IPCC guideline (Revised, 1996).The SO_2, NO_x and CO emissions by fuel used is estimated as:

$$Emission = EF_{ab} \times Activity_{ab} \quad (4)$$

Where: *EF*= Emission Factor (kg/TJ), *Activity* = Energy Input (TJ), *a* = Fuel type, *b* = Sector-activity. SO_2, NO_x and CO

emissions factor of fuel are taken from IPCC guideline (Revised, 1996).

Table 7 Sector wise and total CO_2, SO_2, NO_x and CO emission for fuel consumption in the industrial sector in Malaysia in the years of 1988 and 1998.

Sector / MIC code	CO_2 (ktons)		SO_2(ktons)		NO_x(ktons)		CO(ktons)	
	1988	1998	1988	1998	1988	1998	1988	1998
31	16,933	66,228	33	129	44	173	2	9
33	3,618	3,134	7	6	9	8	0.47	0.41
34	3,045	2,315	6	4	8	6	0.40	0.30
35	6,573	66,915	13	130	17	175	0.86	9
36	1,888	4,956	4	10	5	13	0.25	0.66
37	823	2,046	2	4	2	5	0.11	0.27
Total	32,879	145,594	64	284	86	380	4.30	19.03

4.2.2 Emissions for electricity consumption:

To estimate the amount of GHGs released for generation of electricity from fossil fuels that consumed industrial sectors, emission factors and fraction of electricity generated by each type of fuel (i.e. coal, gas, and oil) have to be considered. Emissions per unit of electricity generation are dependent on the characteristics of the fuel and power plant. Characteristics of a fuel are its contents of energy, carbon, sulfur, nitrogen or their compounds. The power plant characteristic is the amount of heat required to produce one unit of electricity.

Emissions due to electricity use are calculated based on fuel type, percentage of electricity generated by the specific fuel and the emission factor of fuel to produce the electricity in Malaysia. The emissions by electricity used are estimated as:

$$Emission = EC \times PEGF \times EFF \quad (5)$$

Where: *EC*=Electricity consumption (kWh),
PEGF=Percentage of electricity generated by the specific fuel,
EFF=emission factor of fuel (kg/kWh).

According to the Table 9, the percentages of electricity generation are estimated based on fuel types in the years of 1988 (coal 8%, petroleum 27%, Gas 55% and hydro 10%) and 1998 (coal 13%, petroleum 6%, gas 67% and hydro 14%) in the Malaysia.

Table 8 Emission factors of fossil fuels for electricity generation (Source: Mahlia, 2002)

Fuels	Emission factor (kg/kWh)			
	CO_2	SO_2	NO_x	CO
Coal	1.1800	0.0190	0.0052	0.0002
Petroleum	0.8500	0.0164	0.0025	0.0002
Gas	0.5300	0.0005	0.0009	0.0005
Hydro	0.0000	0.0000	0.0000	0.0000

Table 9 Percentage of electricity generation based on fuel types (Source: Mahlia, 2002)

Year	Coal (%)	Petroleum (%)	Gas (%)	Hydro (%)
1994	9.30	22.30	51.70	16.70
2000	15.00	5.00	70.00	10.00
2002	14.96	4.24	65.20	15.60
2003	15.06	3.89	62.95	18.10
2004	15.24	3.56	60.80	20.40
2005	15.50	3.25	58.75	22.50
2006	15.84	2.96	56.80	24.40
2007	16.26	2.69	54.95	26.10
2008	16.76	2.44	53.20	27.60
2009	17.34	2.21	51.55	28.90
2010	18.00	2.00	50.00	30.00
2011	18.74	1.81	48.55	30.90
2012	19.56	1.64	47.20	31.60
2013	20.46	1.49	45.95	32.10
2014	21.44	1.36	44.80	32.40
2015	22.50	1.25	43.75	32.50
2016	23.64	1.16	42.80	32.40
2017	24.86	1.09	41.95	32.10
2018	26.16	1.04	41.20	31.60
2019	27.54	1.01	40.55	30.90
2020	29.00	1.00	40.00	30.00

Table 10 Sector wise and total CO_2, SO_2, NOx and CO emission for electricity consumption in the industrial sector in Malaysia in the years of 1988 and 1998.

Sector / MIC code	CO_2 (ktons)		SO_2(ktons)		NO_x(ktons)		CO(ktons)	
	1988	1998	1988	1998	1988	1998	1988	1998
31	381	2331	4	14	1.3	5.3	0.19	1.30
33	95	119	0.9	0.7	0.3	0.3	0.05	0.07
34	163	95	1.5	0.6	0.6	0.2	0.09	0.05
35	102	220	1	1.3	0.2	499	0.05	0.12
36	314	531	2.9	3.2	1.1	1.2	0.16	0.30
37	54	164	0.5	1	0.2	0.4	0.28	0.09
Total	1109	3461	10	21	3.8	7.8	0.58	1.92

4.2.3Over all emissions:

The over all GHGs are shown in the Table 11. The CO_2 emission in the food sector is higher both in the years of 1988 and 1998.Where as, the base metal sector is lower both in the years of 1988 and 1998. The CO_2 emission all the sectors are higher in the year 1998 compare to the year 1988. The SO_2, NO_x and CO emission in the food sector is higher both in the years of 1988 and 1998.Where as, the base metal sector is lower both in the years of 1988 and 1998. The SO_2, NO_x and CO emissions of some sectors are high and some sectors are low in the year 1998 compare to the year 1988.

Table 11 Sector wise and total CO_2, SO_2, NO_x and CO emission in the industrial sector in Malaysia in the years of 1988 and 1998.

Sector / MIC code	CO_2 (ktons)		SO_2(ktons)		NO_x(ktons)		CO(ktons)	
	1988	1998	1988	1998	1988	1998	1988	1998
31	17,314	68,560	37	143	45	178	2	10
33	3,712	3,253	8	7	10	8	0.52	0.48
34	3,208	2,409	7	5	9	6	0.48	0.36
35	6,676	67,135	14	131	17	175	1	8.86
36	2,201	5,487	7	13	6	14	0.41	1
37	877	2,210	2	5	2	6	0.14	0.36
Total	33,988	149,054	74	304	89	387	4.55	21.06

5 COMPARISONS WITH OTHER COUNTRIES

A comparison of the energy intensity in Malaysia and some other countries are presented in the Table 12 with 6 sectors of industries. The highest energy intensity is found in non metallic sector both in years of 1988 and 1998 in Malaysia. In Thailand 1994 (Priambodo and Kumar,2001) and India 1983-1984 (Tiwari, 2000)) also the highest energy intensity was non metallic sector. But in Indonesia 1993 the lowest energy intensity is found in non metallic sector.

In Thailand 1994 the lowest energy intensity is found in wood sector. The highest energy intensity is found in chemical sector in Indonesia in the year of 1993 (Priambodo and Kumar, 2001).Where as, the lowest energy intensity is found in chemical sector in Malaysia in the year of 1998. The energy intensity of Malaysia, Indonesia and Thailand are comparable values. The CO_2 emission of chemical sector is 66,228 ktons in 1998 in Malaysia. The CO_2 emission of chemical sector in USA was 77,000 ktons in 1994 (Ernst Worrell *et al.* 2000)

Table 12 Sector wise energy intensity in MJ/US$ in Malaysia and other countries.

Sector / MIC code	Malaysia (1988)	Malaysia (1998)	Indonesia (1993)	Thailand (1994)	India (1983-84)	India (1989-90)
	EI(MJ/US$)	EI(MJ/US$)	EI(MJ/US$)	EI(MJ/US$)	EI(MJ/US$)	EI(MJ/US$)
31	6.8	19.2	24.7	29.2	1,380.8	2,396.7
33	5.6	5.9	7.8	3.8	1,362.5	1,493.9
34	16.1	18.1	11.1	21.8	8,205.3	7,860.5
35	6.0	2.8	24	12.3	7,943.5	7,117.2
36	35.4	23.3	4.7	66.6	11,991.4	7,793.5
37	17.9	17.2	-- -- --	-- -- --	9,119.6	10,027.4

6 CONCLUSIONS

The energy intensity of the non-metallic sector is higher both in the year of 1988 and 1998 compare to other sector, but more energy efficient in the year of 1998 compare to the year of 1988. Where as, the energy intensity of the food sector is not highest in the year of 1998 but lower energy efficient compare to the year of 1988. The energy intensity in the sector of chemical is low both in the years of 1988 and 1998.This sector is also more energy efficient (both fuel and electrical) in year of 1998 compare to the year of 1988. Considering the employee, the energy intensity both food and chemical sector are very high in the year of 1998 compare to 1988. Where as the energy intensity both wood and paper sector are low in the year of 1998 compare to 1988

Emissions are higher in the year 1998 compare to 1988 in the industrial sectors in Malaysia. The amounts of emitted CO_2, SO_2, NO_x and CO are around 149,055 ktons, 305 ktons, 388 ktons and 21 ktons respectively in the industrial sectors in the year of 1998. Where as, the amounts of emitted CO_2, SO_2, NO_x and CO are emitted around 33,988 tons, 74 ktons, 90 ktons and 5 ktons respectively in the industrial sectors in the year of 1988.

REFERENCES

[1] Abdul Rahman Mohamed and Keat Teong Lee, 2006. Energy for sustainable development in Malaysia: Energy policy and alternative energy .*Energy Policy* .VOl-34. pp-2388–2397

[2] Nobuo Kato, 1996. Analysis of structure of energy consumption and dynamics of emission of atmospheric species related to the global environment change (SOx, NOx and CO_2) in Asia. *Atmospheric Environment*. Vol. 30, No. 5, pp. 757-785.

[3] Marland G, Boden TA, Andres RJ, Brenkert, Johnston C, 1999. Global, regional CO_2 emissions. Trends: A compendium of data on global change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Department of Energy, USA.

[4] Limmeechokchaia, B., Suksuntornsiri, P., 2007. Embedded energy and total greenhouse gas emissions in final consumptions within Thailand. *Renewable and Sustainable Energy Reviews*.Vol-11.pp 259–281.

[5] Mahlia, T.M.I., 2002. Emissions from electricity generation in Malaysia. *Renewable Energy* 27, 293–300.

[6] Ramirez, C.A., Blok, K., Neelis, M., Patel, M., 2006. Viewpoint adding apples and oranges: The monitoring of energy efficiency in the Dutch food industry. *Energy Policy* Vol-34.pp 1720–1735

[7] Reddy, B.S., Balachandra, P., 2003. Integrated energy-environment-policy analysis - a case study of India. *Utilities Policy* .Vol-11.pp- 59–73.

[8] Bala Subrahmanya, M.H., 2006. Labour productivity, energy intensity and economic performance in small enterprises: A study of brick enterprises cluster in India. *Energy Conversion and Management.* Vol-47.pp 763–777

[9] Jacco C.M. Farla, Kornelis Blok, 2000. The use of physical indicators for the monitoring of energy intensity developments in the Netherlands, 1980–1995. *Energy*. vol -25. pp 609–638.

[10] Liru Liu, Lu Aye, Zhongwu Lu, Peihong Zhang, 2006. Analysis of the overall energy intensity of alumina refinery process using unit process energy intensity and product ratio method. *Energy*. Vol-31. pp1167-1176

[11] Piyush Tiwari, 2000. An analysis of sectoral energy intensity in India. *Energy Policy.* Vol 28, pp771-778

[12] Architrandi Priambodo and S. Kumar, 2001. Energy use and carbon dioxide emission of Indonesian small and medium scale industries. *Energy Conservation and Management.* Vol 42 pp1335-1348.

[13] IPCC Guidelines for National Greenhouse Gas Inventories, volume 3.Greenhouse Gas Inventory Reference Manual. IPCC (Intergovernmental Panel on Climate Change) .Revised 1996.

[14] Ernst Worrell, Dian Phylipsen, Dan Einstein, Nathan Martin, 2000.Energy Use and Energy Intensity of the U.S. Chemical Industry. Energy Analysis Department, Environmental Energy Technologies Division, Ernest Orlando Lawrence Berkeley National Laboratory. April 2000.