INDUSTRIAL ENERGY CONSUMPTION ANALYSIS

by

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Abstract

An industrial energy analysis was conducted to identify the local energy pattern for every industrial sector and the improvement that can be undertaken on energy consumption by the industry in Malaysia..

A Questionnaire was distributed to the FMM members. Energy management awareness among the respondents were fairly high where the majority of the large scale companies have their own Energy Management Team (EMT) and the majority of the SMI do not have their own EMT . Most companies have introduced energy saving measures in their operations of which most of the current and future activities are in the area of thermal system, energy auditing, instrumentation and building envelope. Lack of relevant information on energy technology was the main obstacle to the implementation of energy conservation program in these companies. Other problems identified according to priority were costing, technology, manpower, government measures and supply of energy. The energy consumed by the industries are derived from diesel, heavy and light fuel oil, LPG, electricity and others (including coal, rubber wood chips, petrol etc.). The overall energy consumptions comprised of 12% diesel, 33% light fuel oil, 7% heavy fuel oil, 2% LPG, 0.01% electricity and 46% of other energy sources.

Energy audit, conducted on 10 factories of various sectors, identified the potential energy conservation measures. These measures were recommended to the management of the individual factory or their technical staff for economic feasibility studies.

Finally, recommendations were made for the government to play an important role in guiding, informing and monitoring the energy usage through relevant policies and the setting up of a center for energy studies.

INTRODUCTION

Energy awareness has increased among the industrial sectors in Malaysia in which FMM has its own committee on energy and together with the government they conducted an energy conservation week where competition on implementation of energy conservation measures were held. It was hoped that through the above activities greater awareness on energy conservation would be achieved throughout wider industrial sectors. To achieve the objective we need more information on the current status of the Malaysian energy scene on consumption and conservation measures. The Ministry of Energy, Telecommunication and Post, Malaysia had taken the lead by sponsoring a survey on the energy scene in the Malaysian industries conducted by UTM with cooperation from SIRIM and other higher learning institutions.

OBJECTIVE

The main objectives of the project are:

1. To develop a database on energy related information from the industries.

2. To identify the local energy pattern (energy consumption per unit production) for every industrial sector.

3. To identify the improvement that can be undertaken on energy consumption.

METHODOLOGY

The project was conducted through the "Energy System Questionnaire" survey which were distributed to FMM members. Replies from the respondence were then analyzed to identify the local energy scene.

Energy audit of 10 factories from various sectors were then conducted to identify the potential energy saving measures that could be implemented in the particular factory.

RESULT AND DISCUSSION

The analysis was based on data collected from 77 companies which responded to the Energy System Questionnaire circulated in late 1990. The overall response was poor (approximately 10% of FMM members responded). Data for each sector were available. The data base developed shows the energy scenario for less than 10% of the Malaysian industries.

The companies which responded to the questionnaires were divided into 12 sectors according to the FMM industry sectorization and also into two scales based on investment paid-up capital:

a) large : > RM 2.5 million
b) small-medium (SMI) : < RM 2.5 million

Table 1 shows a summary of the response by each sector. 73 % the response came from large scale industries and 27 % from SMI.

Table 1: Overall Response of the Energy System Questionnaire

Sector	Large	Small-Medium
1. Food, Beverage and Tobacco	8	1
2. Textile, Wearing Apparel & Leather	1	1
3. Wood & Wood Products including Furniture	2	1
4. Paper & Paper Products, Printing & Publishing	2	1
5. Chemical & Chemical Products	5	1
6. Petroleum, Coal, Rubber and Plastics	9	4
7. Non-Metallic Material (Cement)	5	0
8. Non-Metallic Material (Glass/Clay/Pottery)	2	0
9. Basic Metal	3	0
10. Fabricated Metal. Machinery & Equipment	8	3
11. Electrical & Electrical Products	7	6
12. Other	4	3
Total	56	21

As for the energy audit, only 10 factories were audited. They represent Large and SMI industries of various sectors.

Energy System Questionnaire

Energy Management Awareness

Awareness on the importance of energy conservation is the first step toward effective implementation of conservation measures. Industrialized countries ,such as Japan and other European countries, have proved that successful implementation of energy conservation had reduced the energy consumption per GDP of the countries.[1]

In this project, energy management awareness was measured through the response on the availability of the energy management team (EMT), energy auditing practices and the implementation of energy saving devices.

In general the energy management awareness among the respondents were fairly high. This was reflected by the high percentage of the companies which were interested to be audited and have their own EMTs. The majority of the SMI do not have their own EMT but some of them were also interested to be audited.

Energy Saving Measures

Table 2 shows that most companies have introduced energy saving measures in their operations. Some measures were also being planned to be incorporated in their future operations. Most of the current activities, according to priority, are in the area of thermal system, energy auditing, instrumentation and building envelope. Future plans also show a similar trend. The survey did not take into consideration the amount of investment and energy saving in implementing the saving measures.

Table 2: Current and Future Saving Measures

Saving Measures		No. of Companies			
		Current		Future	
		Large	SMI	Large	SMI
1	Thermal	28	5	28	2
2	Energy audit	11	1	13	1
3	Instrumentation	11	1	13	1
4	Building Envelope	1	1	13	1
5	Others	3	1	3	1

Problems Encountered in the Promotion of Energy Conservation

Both large and SMI industries encountered almost the same five most significant problems in promoting energy conservation as shown in Table 3.

Large scale industries encountered low employee's consciousness, lack of measuring equipment, engineers, personnel to educate employees, funding and time to analyze energy consumption rate as their problems. Low proportion of energy cost was also a problem.

SMI industries considered small proportion of energy cost , lack of information on active cases, no time to analyze the energy consumption rate and shortage of information on government's measures as their most significant problems.

Table 3. List of Most Significant Problems Encountered

LARGE SCALE	SMI SCALE
o Employee's consciousness is low	o The proportion of energy cost in the whole cost of enterprise is small
o Shortage of measuring equipment	o Information such as active cases is not easy to obtain
o Shortage of engineers	o No time to analyze energy consumption rate
o No personnel is available who can educate the employees	o Shortage of information on government's measures/ Shortage of government's subsidiary measures
o The proportion of energy cost in the whole cost of enterprise is small/ Shortage of fund for facility improvement/ No time to analyze energy consumption rate	o Difficulty in obtaining energy audit services/ Shortage of measuring equipment/ No personnel is available who can educate the employees/ Instability of energy supply (power failures etc.)

Energy Consumption

The main sources of energy are diesel, light fuel, heavy fuel, LPG and electricity. Other energy resources are classified under "others".

Table 4 shows the high and low energy consumption by each sector and industry scale. The energy consumption is reported in tones of oil equivalent (toe).

Table 4. Energy consumption by each sector.

	ENERGY CONSUMPTION (toe)					
	OVERALL		LARGE SCALE		SMI SCALE	
SECTOR	HIGH	LOW	HIGH	LOW	HIGH	LOW
1	1,711,516	21,511	1,711,516	169,019	21,511	-
2	1,244,108	159,258	1,244,108	-	159,258	-
3	362,709	8,696	362,709	8,696	-	-
4	341,811	12,562	341,881	34,918	12,562	-
5	5,228,648	207	5,228,644	207	117,447	-
6	6,410,106	34,837	6,410,106	422,701	163,566	34,847
7	9,474,375	123,762	9,474,375	123,762	-	-
8	924,024	639,819	924,024	639,819	-	-
9	18,517,779	86,106	18,517,779	86,106	-	-
10	598,396	2,839	598,396	2,839	31,063	18,241
11	2,952,189	998	2,952,189	998	747,964	3,151
12	731,530	3,011	731,530	77,540	38,547	3,011

Energy Audit

Energy audit is one of the tools to identify the energy usage in a plant. Energy audit which is properly carried out will identify the efficiency, wastage and also potential savings.[2]

Ten energy audits were conducted. The factories audited include ceramic, textile, plastic, foundry, engineering (assembly) and cement.

The main objective of the energy audit is to identify the energy usage and the potential energy conservation/saving measures of the audited factories.

Energy Usage

Table 5 shows the various energy sources used by the individual factories. Almost all the SMI factories audited were using electricity as the energy supply. The electricity provide

the need for heating, cooling and running of motors and compressors. Some of the factories used medium fuel oil for the boilers.

LARGE scale industries used various sources of energy. Less than 50% of the energy needed comes from electricity and the rest of the energy comes from hydrocarbon fuels.

Potential Energy Conservation Measures

Table 5 also shows the overall summary of the energy audits. All factories audited have the potential for energy conservation/saving measures. These measures do not necessarily need a big capital investment.

The no-cost measures include regular service and maintenance of the equipments. Properly maintained equipments will ensure them to operate at optimum level.

Other energy conservation measures are aimed at conserving thermal and electrical energy. In the conservation of thermal energy, the following measures have been identified;

1. improve insulations
2. install heat recovery systems
3. increase combustion efficiency
4. installation of collector pipe in the boiler house
5. installation of polystyrene balls to reduce water evaporation.

The energy conservation measures for electricity include;

1. improve lighting efficiency
2. change lighting system to 36 W fluorescent lamps and low loss ballast
3. set air conditioning of office space to 25°C
4. improve the running of the air compressors and motors
5. replace old motors
6 replace oversized motors
7. improve transformer load (switch to 1500kVA transformer)
8. change tariff to E2 (Peak/Off-Peak industrial tariff)
9. disconnect transformers for welding sets which are not frequently used.

The potential energy conservation/saving measures mentioned above have been recommended to the management of the factories concerned. The management have to evaluate the measures as any other projects to determine the technical and economical feasibility of the recommended measures.

RECOMMENDATIONS

Currently, our energy consumption per unit GDP is showing an increasing trend. This is not a healthy trend to be competitive in the open market.

Therefore, it is necessary to formulate and plan energy conservation measures and

standards for the Malaysian industries. This is in line with the utilization objective of the National Energy Policy which seeks to promote and encourage the efficient utilization of energy and discourage wasteful and non-productive patterns of energy consumption within the given sosio-cultural and economic parameters. The followings are vital considerations :

Energy Conservation Law/guideline

There is a need for an energy conservation law or guideline which should have the following provisions :

(a) The law should provide guidelines for the management of energy use in the industries.

b) New factories must provide enough energy monitoring instruments in addition to regularly controlled procedures as well as an energy management program.

c) Reporting requirements to provide information to the government regarding the factory energy situation.

Tax and Financing

Providing tax incentive and low interest financing in investing on effective energy conservation equipments would encourage factories to invest in these equipments. This would further promote energy conservation in the industries.

Environmental Impact

It is also necessary to incorporate guideline on the impact of energy utilization on the environment. Such a guideline will help minimize the deterioration of environment due to inefficiency of energy usage.

Promotion of Energy Conservation

Active promotion of energy conservation through :

a) Information and outreach

This could be accomplished through awareness campaign, exhibition, seminars, dissemination of poster and pamphlets, energy conservation week/month and award schemes for excellent energy conservation in the SMIs.

b) Technological advice by audit experts to the SMIs subsidized by the government would be an effective dissemination procedure in promoting energy conservation.

c) Training and Education

Setting up an energy conservation center which should have available

- an extensive database and information on the current research, technology, projects implemented and expertise on energy conservation and management related area
- training courses on technical aspects, advanced energy management technologies and strategic measures.

Diversification of Energy Resources

In view of a long term strategy, the use of energy resources in the country should be optimized by exploiting the use of renewable energy resources such as solar and biomass and thus preserve the depletable non-renewable resources.

The use of natural gas should be encouraged to take advantage of our abundant natural gas reserves. The natural gas is also a better fuel with less environmental impacts as compared to other liquid hydrocarbon fuels.[3]

Cooperation with International Agencies

Projects such as the DITECH project on the cooperation in the dissemination and development of technology for energy efficiency in the industry should be encouraged. The findings of such projects would promote efforts in upgrading the level of energy conservation activities in the industrial sector since the potential of energy savings is substantial.[4]

CONCLUSIONS

This project has been successful in achieving its objectives through the analysis of the questionnaires and energy audits conducted at the individual factories. From the findings of the above activities, recommendations on policy formulation and planning are forwarded.

The results of the energy audits are encouraging. Potential energy saving measures were identified and recommended to the particular factory concerned.

The government can play an important role in establishing nation-wide energy efficient industries so that the industries would be able to compete in the free market and at the same time fulfill the environmental needs. The government can set up a center for energy studies to provide guidelines and policies, dissemination of information, monitoring energy efficiency and conduct research related to energy conservation in industries.

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REFERENCES

1. "Energy Conservation Handbook 1991," The Energy Conservation Center, Japan, Tokyo Japan 1991.

2. Azman Ikhsan and Mohd. Norani Abd. Rahman, "Energy Audit: A tool for Energy Management," Seminar-Workshop on Energy Conservation, AEEMTRC, Singapore, 15-19 July 1991.

3. James C. White et. al., "Global Climate Change Linkages: Acid Rain, Air Quality and Stratospheric Ozone," Elsiever Science Publishing Company Inc, New York USA, 1989.

4. Rozali Mohamed Ali, "Energy Co-operation: Status and Outlook," Conference on Regional Development and Security: The Ties that Bind, The Second Meeting of ASEAN Institutes of Strategic Studies, ISIS Malaysia, Kuala Lumpur, Jan 12-16, 1989.

Table 5. Summary of Energy Audits

	Energy		Potential Energy Conservation Measures					
Factory	Resources	%	Thermal	Saving	Electrical	Saving	Other	Saving
Textile	Medium Fuel Oil Electricity LPG Kerosene	58 32 4 6	Installation of enclosure around drying section. Installation of polystyrene balls or block on the washer surface. Recover heat from polluted hot water. Insulate the steam distribution system (steam traps, etc). Installation of collector pipe in the boiler house to manage the steam distribution. Increase the combustion efficiency and reduce the stack loss of the boiler.	15% Reduce 80% of the losses 35-35 ton of medium fuel per annum	Improve the transformer load (switch to 1500kVA transformer will reduce iron losses) Improve motor efficiency (proper sizing, annual services and overhaul). Part of the load during peak period should be shifted to off-peak period. Lighting system can be replaced with 36W fluorescent lamp and low loss ballast. The running of the compressors cn be improved by reducing the percentage of unloading current to rated current (normally 20-30%).	$40000 per year 6% $5400 per year.	Maintenance of the air treatment system will ensur e optimum working level of air pressure.	
Ceramic	Diesel LPG Electricity	49 43 8	Heat loss through the wall of the kiln can be reduced by switching the existing insulator with other insulation of higher resistance value. Heat loss through the srack can be utilised by heat exchanger to be recycled to the vertical dryers. This heat can also be used to pre-heat the combustion air.				Check insulation around the rollers of the kiln daily and replace missing and dirty wool. Service burners monthly during roller changes.	
Foundry (SMI)	Electricity	100			Replace motors with present day energy efficient motors. Replace the existing old oversized compressor with smaller size compressor.	69%		
Plastic (SMI)	Electricity	100			Change of tariff to E2 with 1200kVA supply to take advantage of Medium Voltage Peak/Off-Peak industrial tariff (invest on substation and metering). Reduce the ratio of unloading current to the rated current of the compressor.	$18000 per month.		

Engineering Assembly	Electricity	100			Disconnect the transformer which are not frequently used (28 welding transformer unit installed, only 15-20 units are fully used). Air-cinditioning of the office space set at 25 deg C. Use of daylight can be maximised at the workshop.			
Steel Mill	Oil Electricity	45 55			20% load shift of peak demand. Improve power factor from 0.93 to 0.98 which will reduce reduce 5% of power losses. Analyse the running time of the air-compressor to reduce the leakage and thus reduce the power losses.	$43200/ month		
Paper	Fuel oil LPG Electricity	20 10 70	Install a smaller boiler at the deink plant. Replace steam dryer with LPG dryer which is more efficient. Adjusting the air fuel ratio for the combustion to reduce the stack loss.	$45000/ annum	Improve plant power factor to .95 or higher. Change old motor with the new energy efficient motor.			
Concrete poles	Diesel fuel Electricity	38 62			Change tariff from D to E1. Improve the low power factor.		Start energy management program. Good housekeeping.	10%