

Pollution Reduction and Increasing of Efficiency Use of Fuel by Building Up the Bus Preventive Maintenance System and Environmental Management System

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Abstract

The research project on pollution reduction and increasing of efficiency use of fuel by developing the bus preventive maintenance system and environmental management system was conducted in Bangkok and vicinity with 26 private joint bus companies/entrepreneurs. The result of bus preventive maintenance management of investigated entrepreneurs was found that 3 entrepreneurs were excellent management, 9 entrepreneurs are good and moderate management each, 4 entrepreneurs were fair management, and 1 entrepreneur was less management with improvement requirements. In good practice of environmental management, the result was found that 1 entrepreneur was excellent management, 4 entrepreneurs are good management, 11 entrepreneurs were moderate management, and 6 entrepreneurs were fair management. Also there were 4 entrepreneurs need for improvement.

Key words: pollution prevention / efficiency increase of fuel use / preventive maintenance system

1. Introduction

In B.E. 2549, the pilot project on preventive maintenance system was launched to support 6 companies/entrepreneurs who were aware and interesting in development of preventive maintenance system and good practice in environmental management. Anyway, as almost of them lacked of investment fund and personnel readiness experiencing in systematically environmental management and preventive maintenance system, the subsequent project in B.E. 2550, "The Private Joint Bus Operation Development for Preventive Maintenance and Good Practice in Environmental Management Project" was accordingly implemented to develop based on the antecedent idea. The program was enrolled for voluntarily private joint bus 26 companies/entrepreneurs in Bangkok and vicinity of which the scheme had objectives on encouraging and supporting such companies/entrepreneurs to develop preventive maintenance system, efficient use of fuel oil measure with less

pollution emission, enhanced and developed good practice in environmental management system.

2. Implementation Procedure

2.1 Launching Seminar for Project Dissemination

Seminar for project dissemination was held on 1 June B.E. 2550 at the conference room of Pollution Control Department (PCD) for providing related information to companies/entrepreneurs and enrollment for private joint bus entrepreneurs with following criteria:

- Being the entrepreneurs of BMTA joint bus
- Having intention and readiness of workplace
- Providing designated area for maintenance and repair
- Providing necessary tools for maintenance and repair

2.2 Data Based Collection

- Survey of problems, obstacles and readiness in bus preventive maintenance operation and good practice in environmental management of 63 private bus companies/entrepreneurs was operated by secondary data based collection and questionnaire.

-Survey of entrepreneurs requirement was performed to develop their business for achieving preventive maintenance operation and good practice in environmental management system.

- Analysis and assessment was made on their potential, readiness, problems and requirement of private joint bus entrepreneurs for preventive maintenance and good practice of environmental management system in their workplace and garage including reasons for project participation and non participation of each company for baseline of further assessment and operation.

- Criteria, conditions and operation guideline in private joint bus operation with preventive maintenance and good practice environmental management system were determined in compliance with international standard of ISO 14001: 2004.

- Manual preparation of entrepreneurs in preventive maintenance operation and good practice environmental management system in the workplace for operational guideline and training was needed on Preventive Maintenance Manual for Executive, Preventive Maintenance Manual for Technician, Environmental Management Manual for Bus Operation Workplace.

- Training courses were held in 4 times for providing knowledge and building

up experts and staffs of entrepreneurs in good practice management.

- Site visit for guideline development in workplace. It was necessary for visiting bus operation workplace, training, consulting, establishing and developing environmental system on preventive maintenance and good practice management system in workplace. The operation was conducted on both system establishing and personnel assignment with monthly evaluation. In this regard, consultation and knowledge dissemination were made for 6 times.

3. Result of Implementation

After enrollment and selection, there were totally 26 companies/entrepreneurs interesting in project participation.

3.1 Basic Data

From data collection for data base preparation of each bus entrepreneur, there were complete data of 58 entrepreneurs off 64 entrepreneurs. Brief of preventive maintenance and environmental management could be presented as below:

1) Bus maintenance

The bus preventive maintenance management of investigated entrepreneurs in workplace was found that all of entrepreneurs performed bus maintenance. It could be categorized to 3 levels: fair management (75%), less management (23%), and moderate management (2%).

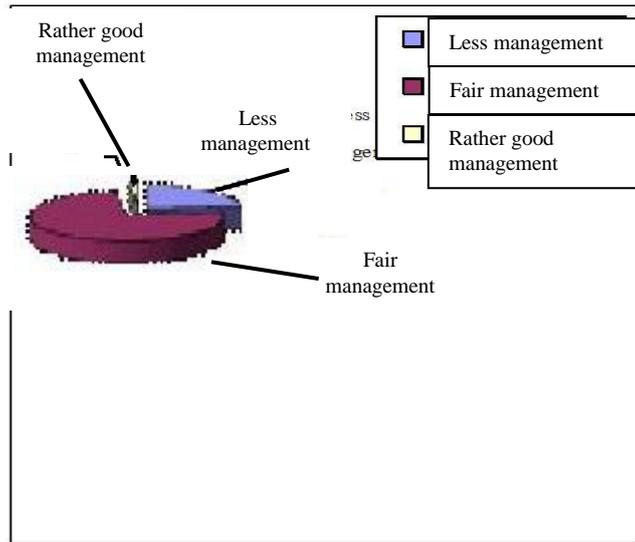


Figure 1 Diagram of Proportional Criteria for Bus Preventive Maintenance

2) Environmental Management

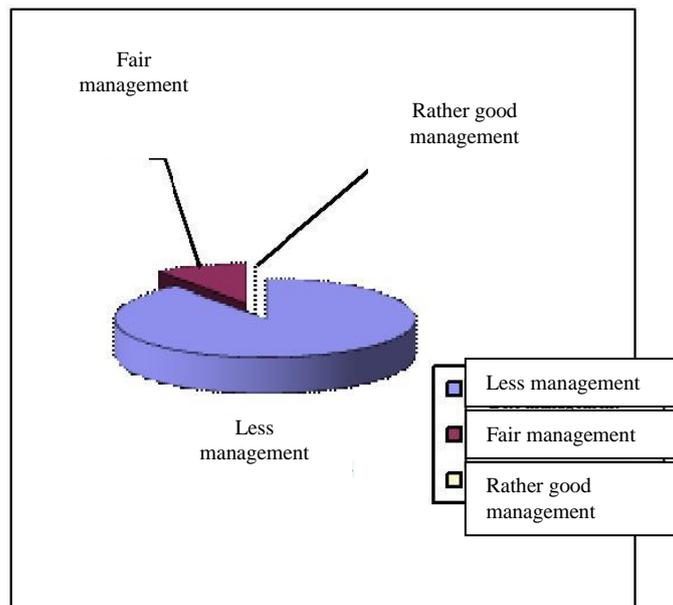


Figure 2 Diagram of Proportional Criteria for Environmental Management

With 90% of the investigated entrepreneurs representing less management, the operation was substantially on separation of some kinds of hazard waste and sewage. For example, used engine oil filter, and used engine oil for selling to buyer (no verification on legal license for hazard waste collection). Moreover, some recyclable garbage was separated i.e. paper box, plastic bottle etc. With 10 % remaining entrepreneurs had waste water treatment

system (grease and sediment trap) with regular maintenance.

3.2 Criteria, Conditions and Guidelines for Operation

Criteria, conditions, and guidelines for operation of preventive maintenance and good practice in environment management system of bus operator could be summarized in Table 1: Guideline and Operating Criteria for preventive maintenance and good practice in environmental management

Table 1 Guideline and Operating Criteria for preventive maintenance and good practice in environmental management

Criteria	Principle for Practice
1. Policy on Preventive Maintenance and Good Practice in Environmental Management	Appropriate policy for its agency was announced by the highest authority showing an intention of improvement and development on practice in compliance with concerned law and communicating to all staffs. The program has been done for declaration of agency's aim and goal in anticipation of staff cooperation.
2. Working team establishment	Personnel in charge appointment with clear role, duty, responsibility, and authority for effective performing on preventive maintenance and good practice in environmental management system had to be done in written evidence. Such persons would be undertaken for system establishment and be trained for operation and improvement of system.
3. Bus preventive maintenance	
3.1 Bus record	Bus record on history and maintenance with entrepreneur's designed format had to be performed (the consultant could provide a sample format that would be modified to fit for entrepreneur).
3.2 Tools/Equipments Record	The same as bus record.
3.3 Maintenance Plan	Bus inspection and spare part replacement as well as tools/equipment inspection for maintenance schedule was prepared based on spare parts' live expectancy that could be flexible to age of tools/equipment or engine. Prepared by the consultant for each entrepreneur, a sample of maintenance schedule could be modified according to entrepreneurs' status.
3.4 Practice according to maintenance plan	Operation and practice was performed according to the plan prepared by such entrepreneur. The maintenance data would be kept in bus book record and equipment book record.
4. Environmental Management	
4.1 Waste water treatment	A countermeasure for waste water management in garage had to be specified appropriately to waste water from those entrepreneurs. Such as providing grease and sediment trap in waste water way with maintenance regularly. In case of no waste water way, it should be focused on staff's preventive practice on water contamination etc.
4.2 Noise pollution control	A countermeasure for noise pollution control in garage had to be specified appropriately to those entrepreneurs. Such as machine (noise pollution point source) should be located on area that low noise reflex etc.
4.3 Air pollution control	A countermeasure for air pollution control in garage has to be specified appropriately to those entrepreneurs' area. Staff's procedure guideline which involves in air pollution should be specified such as avoidance of acceleration bus's engine if not necessary.
4.4 Garbage and sewage management	A countermeasure for hazard solid waste management had to be specified for waste separation for environment prevention from hazard waste contamination as well as outsource of legal garbage collector by entrepreneur itself or recommendation from consultant.
4.5 Chemical substance management and keeping	A countermeasure for chemical substance keeping and using must be built up in order to prevent a contamination of toxic chemical substance to environment such as area allocation for chemical substance safety keeping etc.

Table 1 Guideline and Operating Criteria for preventive maintenance and good practice in environmental management (Cont.)

Criteria	Principle for Practice
4.6 Neatness	In regard to entrepreneur's neatness, the countermeasure was elaborated for neat and orderly workplace. Initially, the consultant would recommend that each entrepreneur should reallocate area and reassign personnel in charge for their area neatness.
5. Correction and prevention of defect	An appropriate schedule for reviewing on preventive maintenance and good practice in environmental management system had to be indicated continuously and regularly to finding causes of defect, countermeasure, protection of re-deflect mechanism, and reviewing such efficiency of collection & protection.
6. Meeting for reviewing of operation	An appropriate period of meeting for reviewing system and reporting result of operation to high authority of entrepreneur had to be scheduled.

3.3 Work Place Development

Upon the work place development was conducted both preventive maintenance

and good practice in environmental management, the result could be classified for 26 participating entrepreneur as follows

Table 2 Level of Preventive Maintenance Management of Participating Entrepreneur

Management Level	Company/Entrepreneur	Score
Excellent	Chai Viset Transport Co., Ltd.	98.25
	Sahaiyont Co., Ltd.	93.67
	Bright Star Supply (1999) Co., Ltd.	93.34
Good	Khun Sa-Ing Robkhob	89.17
	Phai Chanakij Co., Ltd.	88.19
	Thai Bus Transport Co., Ltd.	86.25
	Rawee Choke Co., Ltd.	84.90
	Phetkasem Engineering Co., Ltd.	84.67
	Khanasiam Yanyont Co., Ltd.	84.48
	Khun Lek Sae-Lim	83.47
	Wang Sakarnkij Co., Ltd. (Hua Kra Bue)	82.15
	Saha Srisuphan Yanyont Co., Ltd.	80.94
Moderate	Nithithat Tour and Transport Co., Ltd.	78.17
	Siam Bus Transport Co., Ltd.(Phutthamonthon Sai 2)	74.77
	Wang Sakarnkij Co., Ltd (Phutthamonthon Sai 2)	72.77
	Wang Sakarnkij Co., Ltd. (Om-Yai)	67.17
	Phaisarn Samakkhi Transport Co., Ltd.	66.05
	Bangkok Five Star Transport Co., Ltd.	64.33
	Wang Sakarnkij Co., Ltd. (Bang Khun Tien)	63.15
	Lert Suwan Doen Rod Co., Ltd.	63.19
	Wang Sakarnkij Co., Ltd. (Bang Bua Thong)	62.41
	Fair	Harn Transport Co., Ltd.
Bangkok Bus Air Transport Co., Ltd.		55.17
Sawrin Service Co., Ltd.		53.83
Bangkok Joint Service Co., Ltd.		50.94
Poor	Bangkok Metropolitan Transport Co., Ltd.	37.39

From Table 2, the **excellent** management level of company/entrepreneur was composed of Chai Viset Transport Co., Ltd., Sahaiyont Co., Ltd. and Bright Star

Supply (1999) Co., Ltd. which could account for 11.54 % of total participating companies.

Both **good** and **moderate** level was the same figure that was 9 companies/entrepreneurs or 34.62 % of

total participating companies. With 4 companies/entrepreneurs or 15.38 % of total participating companies are categorized into **fair** level. About **poor** level, only one

company should be improved, Bangkok Metropolitan Transportation Co., Ltd., or 3.85 % of the total participating companies.

Table 3 Level of Good Practice in Environmental Management of Participating Entrepreneur

Management Level	Company/Entrepreneur	Score
Excellent	Chai Viset Transport Co., Ltd.	92.07
Good	Khun Sa-Ing Robkhob	86.15
	Khun Lek Sae-Lim	85.75
	Phetkasem Engineering Co., Ltd.	80.42
	Nithithat Tour and Transport Co., Ltd.	80.12
Moderate	Thai Bus Transport Co., Ltd.	77.62
	Phaisarn Samakkhi Transport Co., Ltd.	76.21
	Bangkok Metropolitan Transport Co., Ltd.	73.13
	Sawrin Service Co., Ltd.	69.00
	Wang Sakarnkij Co., Ltd. (Phutthamonthon Sai 2)	67.24
	Phai Chanakij Co., Ltd.	65.77
	Wang Sakarnkij Co., Ltd. (Om-Yai)	64.33
	Bright Star Supply (1999) Co., Ltd.	65.50
	Sahaiyont Co., Ltd.	65.31
	Saha Srisuphan Yanyont Co., Ltd.	62.85
	Rawee Choke Co., Ltd.	62.33
	Siam Bus Transport Co., Ltd.(Phutthamonthon Sai 2)	61.11
Fair	Khana Siam Yanyont Co., Ltd.	58.06
	Harn Transport Co., Ltd.	57.40
	Wang Sakarnkij Co., Ltd. (Hua Kra Bue)	57.35
	Wang Sakarnkij Co., Ltd. (Om-Yai)	51.84
	Wang Sakarnkij Co., Ltd. (Bang Bua Thong)	50.78
	Bangkok Bus Air Transport Co., Ltd.	50.37
Poor	Bangkok Five Star Transport Co., Ltd.	40.87
	Lert Suwan Doen Rod Co., Ltd.	39.31
	Wang Sakarnkij Co., Ltd. (Bang Khun Tien)	30.90
	Bangkok Joint Service Co., Ltd.	20.93

Based on Table 3, the companies/entrepreneur categorized into **excellent** level with 3.85 % of the total was Chai Viset Transport Co., Ltd.

Concerning **good** level category, there were 4 companies/entrepreneurs namely Khun Sa-Ing Robkhob, Khun Lek Sae-Lim, Phetkasem Engineering Co., Ltd., and Nithithat Tour and Transport Co., Ltd. or 15.38 % of total companies/entrepreneurs. Almost with eleven companies/entrepreneurs were classified into **moderate** level category or 42.31 % of companies/entrepreneurs and six companies/entrepreneurs or 23.07 % were classified into **fair** level.

Poor level representing improvement was composed of four

companies/entrepreneurs or 15.38 % namely Bangkok Five Start Transport Co., Ltd., Lert Suwan Doen Rod Co., Ltd., Wang Sakarnkij Co., Ltd.(Bang Khun Tien), Bangkok Joint Service Co., Ltd.

Timing of data collection on preventive maintenance of those companies was scheduled in three times: before project implementation, during implementation and post project implementation with following measures:

Inspection and data collection of exhaust and noise of vehicles from participating companies/ entrepreneur were performed by measuring three times (before, during, and post) of preventive maintenance process(PM). In this regard,

the statistical sampling was applied for vehicle's random.

Table 4 Summary of Smoke, Carbon Monoxide (CO), Hydrocarbon (HC), and Noise of Selected Buses

Indicators	Observation Period	Percentage of over standard limit
Smoke	1 st Time	31.42
	2 nd Time	34.76
	3 rd Time	33.52
Carbon Monoxide (CO)	1 st Time	10.00
	2 nd Time	6.20
	3 rd Time	3.23
Hydrocarbon (HC)	1 st Time	16.67
	2 nd Time	24.83
	3 rd Time	20.00
Noise	1 st Time	25.84
	2 nd Time	24.23
	3 rd Time	22.46

From the Table 4, the findings could be summarized as follows:

Smoke

Regarding the first measurement of the smoke (before preventive maintenance implementation), level of selected vehicles' **smoke** was found that 31.42% of measured vehicles emitted smoke over standard limit. The figures were increasing in the second measurement (during implementation program). The vehicles' smoke was up to 34.76%. But the third measurement, after implementation, the smoke of those vehicles over standard limit was relatively reduced to 33.52 %.

Carbon Monoxide (CO)

For the first measurement of Carbon Monoxide (CO), 10.00 % of investigated vehicles emitted CO over standard limit. However, the second and the third measurement are relatively reduced to 6.20 % and 3.23 % respectively.

Hydrocarbon (HC)

For the first measurement of Hydrocarbon (HC), there were investigated vehicles with 16.67% over standard limit. The figures were

augmented to 24.83% in the second measurement, however, reduced to 20.00 in the third measurement.

Noise

For the first measurement of noise, the investigated vehicles were 25.84% over standard limit. The figures were 25.84% over standard limit. The figures were reduced to 24.23% and 22.46 in the second and the third measurement respectively.

It is also found that noise pollution from the vehicle modified to NGV engine has tendency higher than diesel engine. As a result of noise measurement, the tendency declined to be reduced resulting from exhaust pipe improvement by some of entrepreneurs for better noise absorption. The practice could reduce noise pollution from NGV. However, the operation has been on test run and improvement of design regularly.

4. Conclusion

1. Bus Preventive Maintenance and Good Practice in Environmental Management System

In system establishment of bus preventive maintenance and good practice in

environmental management system for 26 participating companies/ entrepreneurs, the investigated entrepreneurs would intensively acquire knowledge, understanding and awareness of the project implantation. The bus would be intensively cared with preventive maintenance as earlier. Previously, none of bus preventive maintenance was performed in the condition that it would be needed repair upon its malfunction. The determination of maintenance plan started to proceed. The scheme included policy declaration of bus preventive maintenance, working team establishment, bus record, tools and machines maintenance plan. Some entrepreneurs initiated defect's correction and prevention programming as well as meeting for review of operation e.g. preventive maintenance etc. In regard to environmental management, it was found that surrounding area and operation area were more clean and tidy due to 5 S. The system enhanced separating and retaining of documents for further classification. The surrounding area was provided with specific types of litter bins to be convenient for waste disposal e.g. general garbage, recycling garbage and hazard waste. In operation area such as at maintenance area, the signs, tools and apparatus as well as spare parts were clearly provided including necessary tools for leakage prevention e.g. scraps of clothes, dust saw and sand at risk point of leakage. For waste water control, waste water treatment system (grease and sediment trap) was cleaned with regular maintenance to enhance more efficiency grease and sediment trap. The staffs could create sustainable development of environmental awareness and understanding.

2. Assessment on Air Pollution and Noise Pollution

Air Pollution

Based on assessment of air pollution, it was found that pollution over standard limit released from the participating buses was significantly reduced. As almost of entrepreneurs intensively developed proceeding preventive maintenance programming and followed their bus maintenance plan. The outcome conformed to the assessment. Specifically, most of them developed the bus maintenance intensively.

Noise Level

Upon vehicles' noise level measurement from participating companies/ entrepreneurs before, during, and post implementation, the result was that the amount of buses with noise over standard limit was reduced from 28.3% to 15.2% and 14.1% successively. As most of exhaust pipes were improved for larger size to absorb noise level caused from NGV engine.

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