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Maintenance Function's Performance Evaluation Using Adapted Balanced Scorecard Model

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Abstract**—**PT XYZ is a bottled drinking water company. To preserve production resources owned by the company so that the resources could be utilized well, it has implemented maintenance management system, which has important role in company's profitability, and is one of the factors influenced overall company's performance. Yet, up to now the company has never measured maintenance activities' contribution to company's performance.

Performance evaluation is done according to adapted Balanced Scorecard model fitted to maintenance function context. This model includes six perspectives: innovation and growth, production, maintenance, environment, costumer, and finance. Actual performance measurement is done through Analytic Hierarchy Process and Objective Matrix.

From the research done, we can conclude that the company's maintenance function is categorized in moderate performance. But, there are some indicators which has high priority but low performance, which are: costumers' complain rate, work lateness rate, and Return on Investment.

Keywords**—**maintenance, performance, Balanced Scorecard, Objective Matrix

I. INTRODUCTION

PT XYZ, as one of the biggest bottled drinking water companies in Indonesia, runs its production line twenty four hours a day. Therefore, this company has to maintain its machines in a good condition, by implementing maintenance activity (including preventive and corrective maintenance).

Maintenance management is aimed at keeping the production resources operated in their best performances. Maintenance has a great importance in company's profitability and is a factor that has an effect on company's overall performance [13].

Maintenance activity is an activity that has a significant contribution in operation costs, approximately 30 percent of operation costs, especially if the company is implementing automated production system [7]. Therefore, this activity must be planned in advance, including in planning maintenance personnel to be allocated in each production section. The number of maintenance personnel is affecting the effectiveness of maintenance management, the improvement of company's productivity, and also towards the availability and reliability of company's production system.

Maintenance management activity must be done as effective and efficient as possible because it has a significant part in company's total operating costs. It is better not to consider maintenance activity as a cost center activity, but it is better for the company to consider it as an activity that could give profit for the company in the long term.

The maintenance activity in this company is held by Engineering Department by allocating maintenance crews in each section of production department. These crews are responsible for the availability of production machines in their section. For all this time, the company has never measured the efficiency of maintenance activity held by engineering department, whether it is optimum or not, so that it can lessen company's operation and maintenance cost, and also improve the efficiency of resources used for this activity.

By using maintenance performance measurement, we will know what factors caused the low efficiency of recent performance, and also what factors could be improved in order to improve company's maintenance performance. Besides, performance measurement is also a way for the management to evaluate the condition of its system and make a decision related to maintenance policy adapted by the company. From above explanation, it is so important to measure the performance of maintenance activities in this company, and to recommend a performance measurement method to be implemented which appropriate with the company's requirements.

Performance measurement is a management tool to measure the direction and speed of change done by the company. Performance measurement plays an important role for the improvement of a progress (change) towards a better place. Therefore, we need to formulate appropriate performance indicators. These indicators must be directly linked with company's strategic objectives [9].

In order to measure Engineering Department's overall performance, we use Adapted Balanced Scorecard model in maintenance performance measurement step. Adapted Balanced Scorecard model is adoption of balanced scorecard model that can be adjusted with the need of performance measurement in certain support department [1].

For this research, adapted balanced scorecard model taken has been adjusted to measure maintenance performance. This model considers six performance perspectives, i.e.: financial, production, maintenance, growth and innovation, environment, and costumers [1].

But, before measure the maintenance performance, we first must identify which maintenance section has the lowest relative efficiency among others. Maintenance

section that has the lowest efficiency will be the focus of performance measurement, so we will know the value of its actual performance and some recommendations can be given to improve its performance.

The calculation of relative efficiency of each maintenance section is done by using Data Envelopment Analysis method. Data Envelopment Analysis is a non parametric approach based on linier programming. This method is used to calculate relative efficiency by weighting each input and output each Decision Making Unit (DMU) from the data. DMU is something that is being calculated its efficiency. For this research, the DMUs are maintenance section in production department and other support department. Then, the result of this calculation is used to determine the actual performance value of department with lowest relative efficiency.

II. METHODOLOGY

This research is divided into two parts. First, we determine which maintenance section has lowest relative efficiency using Data Envelopment Analysis. Formulation of Data Envelopment Analysis for this research is as follows:

$$Max\ E_b = \sum_{i=1}^{2} u_i o_{ib}$$

$$Subject\ to \quad \sum_{j=1}^{5} v_j x_{jb} = 1$$

$$\sum_{i=1}^{2} u_i y_{ib} - \sum_{j=1}^{5} v_j x_{jb} \le 0 \quad \text{for b = 1, ... , n}$$

$$u_i \ge 0 \text{ and } v_j \ge 0$$

With,

n = number of maintenance section under analysis

u_1 = weight of output *work hours on time*

u_2 = weight of output *percentage work hours on time*

v_1 = weight of input *maintenance crew number*

v_2 = weight of input *supervisor number*

v_3 = weight of input *actual work hours*

v_4 = weight of input *backlog hours*

v_5 = weight of input *manpower utilization*

o_{1b} = output *work hours on time* for DMU-*b*

o_{2b} = output *percentage work hours on time* for DMU-*b*

x_{1b} = input *maintenance crew number* for DMU-*b*

x_{2b} = input *supervisor number* for DMU-*b*

x_{3b} = input *actual work hours* for DMU-*b*

x_{4b} = input *backlog hours* for DMU-*b*

x_{5b} = input *manpower utilization* for DMU-*b*

The second step is the performance evaluation using adapted balanced scorecard model. From the section with the lowest relative efficiency, will be applied an Adapted Balanced Scorecard model to asses the contribution of maintenance function to company's overall performance. This model is used to generate maintenance performance indicators. Every indicator generated is validated by company's top management. By using Analytic Hierarchy Method, the weights of every indicator will be determined. Then, Objective Matrix will be used to asses actual performance of maintenance section analyzed compared to company's target. Importance-performance matrix is used to determine indicators which have high priority but sill indicate low performances.

III. RESULTS

A. *Determination of Maintenance Section with Lowest Relative Efficiency using Data Envelopment Analysis*

There are three maintenance section analyzed in this research, i.e.: utility and husky sidel (HS), glass drinking water, and bottle drinking water. Calculations of relative efficiency every maintenance section is done by using Data Envelopment Analysis method and counted for every period (months). Data are taken for six month, input for this model are numbers of maintenance crew, numbers of supervisor, backlog hours, actual work hours, and manpower utilization, and output data for this model are work hours on time and percentage work hours on time. In this case, these data are considered to be enough in analyzing the relative efficiency. The calculation results are showed in Table 1.

From Table 1, we can conclude that Utility and Husky Sidel has the lowest average efficiency from the six months period compared to the other section. This section will be the focus of our study, and we will measure the overall performance of this section.

TABLE I
RELATIVE EFFICIENCY MEASUREMENT OF EACH MAINTENANCE SECTION

Month	Maintenance Section		
	Utility and Husky Sidel	Glass	Bottle
Jan	0.8480	1	1
Feb	1	0.7870	1
Mar	1	1	1
Apr	1	1	1
May	1	1	1
June	0.8066	0.9297	1
Average Eff.	0.9424	0.9527	1.0000

B. *Maintenance Performance Measurement in Utility and Husky Sidel Section*

The first step in using adapted balanced scorecard model is identification of company's point of view,

mission, and strategy. This identification is very important because the indicators to be generated must be balanced with company's strategy.

After identifying the company's strategy, we will generate some maintenance performance indicators based on adapted balanced scorecard model. The indicators on this research are maintenance performance indicators (MPI). According to [22], MPI is a set of measurement (metrics) that is used to measure maintenance performance in a certain area or certain activity. MPIs used are including seven adapted balanced scorecard perspectives, but have to be adjusted with company's requirement and the availability of the data. All indicators are quantitative one. The data is taken from records and note available in the company, and also from management interview, especially for financial data. Total MPIs in this research, after being validated by the company's top management, are 20 MPIs. MPIs in this research are shown in Table 2, and hierarchy of validated MPIs is shown in Fig.1.

TABLE I
ADAPTED BALANCED SCORECARD MODEL MPI

Perspective	Indicators
Growth and innovation	Number of staff training
	Number of new ideas generated by staff
	Staff productivity rate
Maintenance	Schedule completion effectiveness
	Staff efficiency ratio
	Preventive maintenance efficiency ratio
	Maintenance work efficiency
	Equipment uptime
	Backlog hours
Production	Availability
	Performance
	Quality
	Overall Equipment Effectiveness (OEE)
	Planning Index
	Total Overall Equipment Effectiveness (TOEE)
Environment	Number of work accident
Costumers	Costumer's complain rate
	Work lateness rate
Financial	Maintenance cost every period
	Return on investment (ROI)

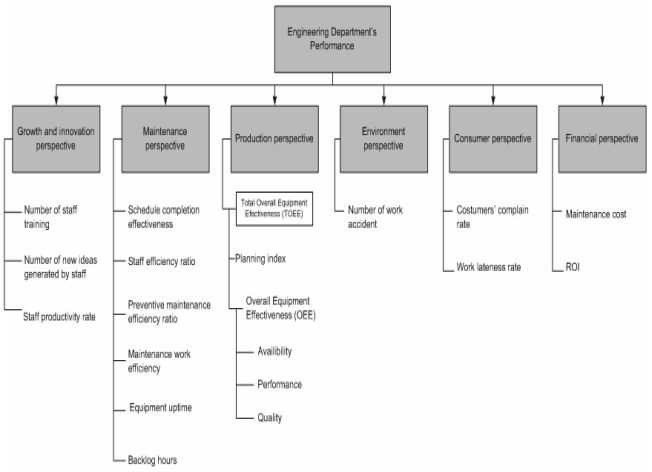

Fig. 1. Hierarchy of Validated Maintenance Performance Indicators

The next step is weighting each indicator. This step is done with the help of Super Decision 1.6.0 software. The value of each indicator's weight is taken from questionnaires filled by the top management. Perspective with the highest priority is consumer perspective. It means that the maintenance activity must give high attention to the requirements and specification specified by the costumers.

From the maintenance performance measurement done, we get the calculation of the company's actual performance in the period January to July 2008 is 4.4526. This means that the company's performance shows moderate performance. But it still needs some improvement so the company can reach better performance in the long term.

IV. DISCUSSION

The development process of balanced scorecard for maintenance function of the company is trying to translate each of the company's strategy into company's objectives and strategic measures adjusted with company's point of view and mission. A scorecard made should explain company's strategy in maintenance activity through causal measures.

The need of balance of each different indicator will result in short-term improvement, so that it can not be in contradiction with the long-term improvement. The most important thing is, that the causal relationship each indicators in a balanced scorecard must be linked with company's financial objectives as the last goal.

The clear identification and the reached balance between indicators can be seen in a causal relationship diagram shown in fig. 2.

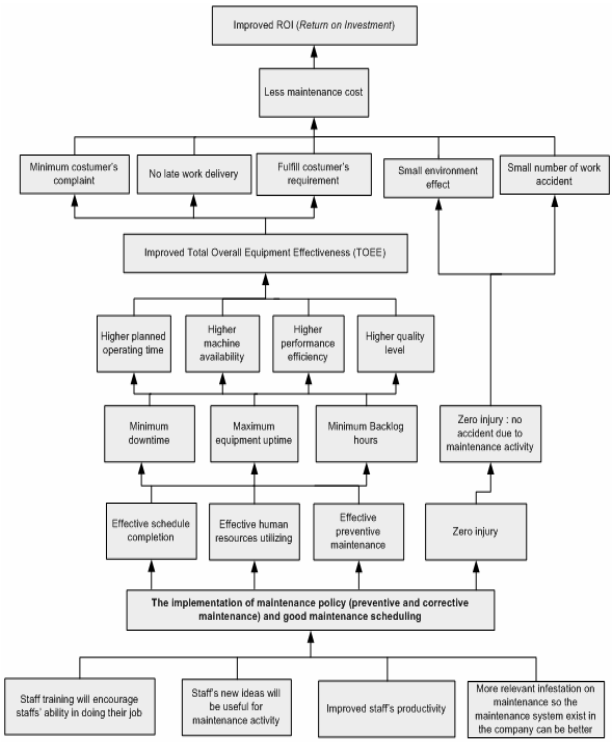

Fig. 2. Cause Effect Relationship Between Indicators in Adapted Balanced Scorecard Model

To determine the critical maintenance indicator (indicator with high priority but low performance), we use importance-performance matrix. The importance performance matrix of each indicator is shown in fig.3. Importance is represented by total priority weight. Meanwhile, performance is represented by actual value of each indicator.

From the importance performance matrix above, we can conclude that there are three indicators in that category, i.e.: costumers' complain rate, work lateness rate, and Return on Investment. Some recommendations are suggested to achieve better performance in the future evaluation.

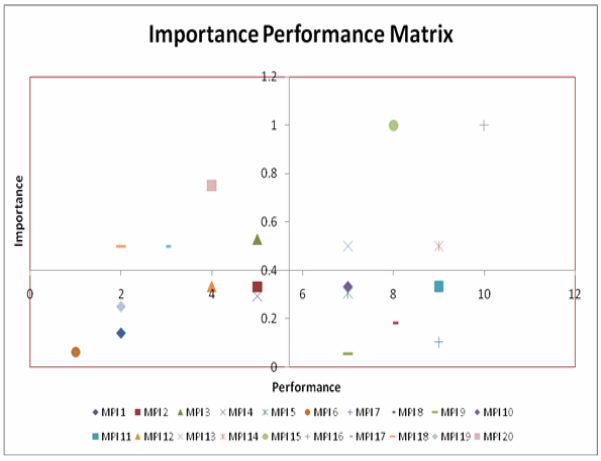

Fig. 3. Importance Performance Matrix

V. CONCLUSION

Using data envelopment analysis, we get Utility and Husky Sidel Section as research object, because of its lowest relative efficiency among other section in this company.

From the maintenance evaluation, there are six perspectives of adapted balanced scorecard model, with costumers as the highest priority perspective, followed by finance, production, innovation and growth, maintenance, and environment. The maintenance function's performance is classified in moderate category, which means the performance is rather good, but still needs some improvements so that the company can get better results in the future.

To analyze the indicators with high priority but low performance, we use importance-performance matrix. We can conclude that there are three indicators in that category: costumers' complain rate, work lateness rate, and Return on Investment. Some recommendations are suggested to achieve better performance.

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