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Research Article

Assessing Labor Efficiency Management in a Power Plant Company Using Data Envelopment Analysis

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Abstract.
To achieve company goals, labor is an essential resource. The presence and quality of labor, as aligned with the company's strategy and operations, can improve or develop company performance in the future. The importance of the workforce makes its management equally important because the strategy or method used in managing the workforce can determine its success. This research focuses on evaluating labor management in a power plant company that has a workforce with two statuses, namely permanent labor and outsourced labor. In order to evaluate the labor management in this power plant company, we use the Data Envelopment Analysis (DEA) approach, aiming to measure the efficiency of its labor management and then provide improvement recommendations for better labor management. The DEA calculation model is input-oriented, focusing on minimizing inputs with constant outputs. Input variables directly related to labor management are the reason for choosing this calculation model. The results of the evaluation show that labor management in the last year of the evaluation was already running optimally. However, implementing digitalization in the future could improve efficiency by reducing the number and cost of permanent workers.

Keywords: Data Envelopment Analysis (DEA), efficiency, labor, management, outsource

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1. Introduction

One of the resources that play an essential role in shaping and carrying out company strategies to achieve company goals efficiently and effectively is human resources or labor. Labor, as one of the resources in the company, has a significant role in the company's productivity. The ability of labor to manage information and operating technology in the company can accelerate the achievement of company goals [1]. The quality of labor also dramatically affects the company's performance, especially in the current company that grows amid a competitive business environment. The intangibles of labor, such as expertise, skills, knowledge, and adaptability, are values that are not easy to replicate or replace [2]. Therefore, the existence and quality of labor can support companies to compete with other companies in achieving company goals. The significant role that labor has in the company makes increasing labor productivity one of the company's priorities. Companies that do not have an appropriate workforce in terms of strategy, operations, quantity, and quality will hinder the company from developing or maintaining its position in the future [3]. The importance of labor makes its management no less important because the strategy used in managing labor can determine its success [2].

One of the tools that can be used to evaluate performance is DEA. The DEA method has been widely used in evaluating the performance of the power generation industry in diverse contexts, such as studies that measure the efficiency of power generation systems by taking into account the measurement of fluctuations in the level of sales to customers, as well as taking into account the effects of regulatory restrictions on emissions [4]. There is research investigating the performance of hydroelectric power plants in Brazil, considering indicators reflecting operation and maintenance costs and quality of service [5]. Furthermore, research that considers not only desirable but also undesirable outputs as a result of business operations, with an illustrative example of a US fossil-fuelled power plant showing the policy implication that they need to introduce new technologies for environmental protection [6]. DEA study investigating the impact of emissions regulation policies on the level of investment in reusable environmental facilities used by coal-fired power plants in China to improve their sustainable operations [7]. Further research demonstrates how DEA can be used to develop policy-making scenarios, allowing managers to identify productive power plants against different priorities regarding service demand, costs, and pollution emissions [8]. Research that uses DEA to evaluate the effects of corporate performance based on efficiency views and performance evaluation content to research that aims to assess the optimization of IT/IS investment in power plants using DEA [9,10].

This research will focus on evaluating labor management in a power plant company with a workforce with two statuses, namely permanent labor and outsourced labor. In order to evaluate the labor management in this power plant company, this research uses the DEA approach, aiming to measure the efficiency of its labor management and then provide improvement recommendations for better labor management. This research uses the input-oriented DEA approach, aiming to measure the efficiency of its labor management and then provide improvement recommendations for better labor management for the company. It is possible to improve efficiency, especially now that digitalization options are beneficial for customer service processes.

2. Literature Review

2.1. Productivity, Effectiveness, and Efficiency

Productivity is concerned with efficiently using resources (inputs) to produce goods and services. Efficiency is the ratio of actual output achieved to expected standard output. Meanwhile, effectiveness is the degree of goal achievement. In other words, effectiveness describes the size of the good or bad set of results achieved, while efficiency leads to a measure of the good or bad use of resources in achieving goals [11].

2.2. Data Envelopment Analysis

DEA is a non-parametric method that is the development of a linear programming model with a production frontier mapping that can be used as a material for analyzing the production function [12]. In its development, two DEA models exist, including the Constant Return to Scale (CRS) model and the Variable Return to Scale (VRS) model. The CRS model assumes that all DMUs have operated at the optimal scale. Meanwhile, the VRS model assumes the DMU does not operate at the maximum scale.

There are two orientations in the measurement of the DEA method, namely measurement with input orientation that occurs if the DEA linear programming model is configured to determine the amount of input that must be added or reduced to achieve a certain level of output and measurement with output orientation that occurs if the DEA linear programming model is configured to determine the amount of output that can be produced from the use of available inputs in order to achieve the level of efficiency.

3. Methodology Research

3.1. Research Flow

This research consists of four stages: identification, data collection, data processing, and analysis conclusion. At the identification stage, the formation of a research model is carried out. It starts from formulating the problem under study, determining the research objectives to be achieved, and determining the research boundaries to determine the research method. At the data collection stage, quantity data collection is carried out related to the variables that will be operated with DEA. Table 1 shows the data sources that will be used in this research.

Table 1: Data sources.

Variable	Data source
X1, X2	Employee data
X3, X4, X5, X6	Service quality level scale report
Y1, Y3	Electricity sales report
Y2	Public satisfaction index report

After the required data is obtained, data processing is then carried out through the following stages: DEA Input Oriented => Efficiency Scale (SE) => Peer Group => Determination of Improvement Target. At the analysis and conclusion stage, all the results of the data processing that has been carried out will be analyzed. Then, conclusions and recommendations will be drawn to answer the research objectives.

3.2. DMUs & Variables

The variables used do not have to have the same unit of measurement. To evaluate the effectiveness of workforce management at the company, a comparison is needed between the workforce management methods that have been implemented and the targets previously set. Table 2 shows the DMU used in this study. Variables are determined by identifying which variables have an essential influence on the efficiency of the DMU and classifying existing variables as input or output variables. The variables in this study are shown in Table 3.

Table 2: DMU.

DMU	Information
DMU 1	2017
DMU 2	2018
DMU 3	2019
DMU 4	2020
DMU 5	2021

TABLE 3: Variables.

Variable	Information	Reference
Input[X1]	Total manpower	Zhang [13], Azadeh et al. [10], Thakur et al. [14], Wang et al [15]
Input[X2]	Labor costs	Zhang [13], Azadeh et al. [10], Athanassopoulos et al. [8], Thakur et al. [14], Wang et al [15]
Input[X3]	Interference Response Speed	Zhang [13]
Input[X4]	Crash Recovery Speed	Zhang [13]
Input[X5]	PB Service Speed	Zhang [13]
Input[X6]	PD Service Speed	Zhang [13]
Output[Y1]	Number of Customers	Thakur et al. [14], Zhang [13]
Output[Y2]	Customer Satisfaction Index	Thakur et al. [14], Zhang [13]
Output[Y3]	Income	Zhang [13], Thakur et al. [14], Wang et al. [15]

The determination of the variables X3, X4, X5, and X6 as input variables is because the DEA model used is the classic VRS and CRS models, where these models aim to minimize the value of the input variables. These variables can be categorized as output variables by making these variables as Intermediate Output variables. This solution was not implemented because the Network DEA model required additional variables.

3.3. DEA

Analysis of workforce management efficiency by measuring technical efficiency using the input-oriented DEA method using mathematical formula 1.

$Min\ \theta_k - \epsilon \left(\sum_r^s \sigma_r + \sum_i^m s_i \right)$ (1)

subject to: $\sum_j^n y_{rj} \lambda_j - \sigma_r = y_{rk}\ \sum_j^n x_{ij} \lambda_j - \theta_k x_{ik} + s_i = 0$

$\lambda_i,\ \sigma_r \geq 0$

$\epsilon > 0$

Where:

θ_k = DMU *k* optimization

$s_i,\ \ \sigma_r$ = Slack of inputs *i*, output *r* (≥0)

λ_j = DMU *j* weight (≥0) against the DMU being evaluated

ϵ = Very small positive number (1 x 10-6)

Calculation of engineering efficiency using the DEA VRS model assumes that the DMU has not been operating at optimal conditions. A comparison of the value of the

CRS technique's efficiency and the VRS technique's efficiency shows the value of the SE, as shown in Formula 2. The SE will show whether the DMU is operating optimally or not.

$$SE = \frac{TE_{CRS}}{TE_{VRS}} \quad (2)$$

A peer group is determined to evaluate the results of the efficiency value of DEA, and the calculation of improvement targets is carried out. Peer groups are used to determine the reference DMU for DMUs whose performance is not yet optimal. After determining the peer group, target improvement can be calculated through variable slack calculations. The improvement target can be input minimization or output maximization. To assist data processing, this research uses MaxDEA software.

4. Result and Discussion

4.1. Company's Profile

The observed company is a power plant unit that serves the community with low-voltage electricity distribution with a working area of 40,491.55 m2. The unit is led by a manager who oversees SPV Engineering, SPV Electrical Energy Transactions, and SPV Customer Service & Administration. In carrying out business processes, this unit has undergone several changes. Since the launch of digital-based services in 2019, the company's operational efficiency has increased. However, this shift towards digital is still not fully operational, and there are still several aspects that can still be improved. Suppose the digital system is fully operational, and the company maximizes its use. In that case, some of the organizational structures in this unit can be further streamlined based on the current job desc. One of these alternatives will be included as a possibility for workforce management and compared with the evaluated workforce management process from 2017 to 2021.

4.2. Analysis & Discussion

The first step in measuring efficiency is to measure the Technical Efficiency (TE) VRS value. The TE VRS calculation results show that three out of five DMUs have an efficiency value of 1, namely DMU 2018, 2019, and 2021, as shown in Table 4. DMUs with an efficiency value of less than 1 are DMU 2017, with an efficiency value of 0.984860248, and DMU 2020, with an efficiency value of 0.971698113. This shows that workforce management other than 2017 and 2020 is already optimal. These results can be seen that when compared to the previous years, workforce management in 2021 has been efficient.

Table 4: Efficiency calculation results and peer groups.

DMU	TE (CRS)	TE (VRS)	SE Score	Peer Groups	Benchmark Scores
2017	0.960704668	0.984860248	0.975473089	2018 ; 2021	0.913043 ; 0.086957
2018	1	1	1		
2019	1	1	1		
2020	0.962580302	0.971698113	0.990616622	2021	1
2021	1	1	1		

To find out the value of the efficiency scale, the CRS efficiency value needs to be searched first. The TE CRS value measurement also shows something similar to the TE VRS measurement. From the results of the TE CRS calculation, it can be seen that only the 2017 DMU and 2020 DMU have an efficiency value of less than 1. From the TE CRS calculation results, assuming that workforce management at this unit has been running optimally, the 2017 and 2020 DMUs are still not running optimally.

After the TE VRS and TE CRS values are known, the SE value can be calculated by comparing the TE CRS value with the TE VRS value. After measuring the efficiency scale value of each DMU, it was found that the 2018, 2019, and 2021 DMU efficiency scale values were 1, and the efficiency scale values for the 2017 DMU and 2020 DMU were 0.956163653 and 0.988939504.

After measuring efficiency, the next step is determining peer groups for DMUs that do not yet have optimal workforce management from the TE VRS calculation results. Because the 2021 DMU has an efficiency value of 1, which shows that the management of the workforce in the last year at this unit has been running optimally, there is no need to determine peer groups. The peer group for DMU in 2017 is (2018;2021), and the peer group for DMU in 2020 is (2021), as shown in Table 4.

The final step is the measurement of improvement targets from the TE VRS calculation results. Just like the previous peer group analysis, because the DEA efficiency score for 2021 is 1, it is unnecessary to set improvement targets for workforce management in the last year of the analysis because workforce management has been operating optimally.

4.3. Sensitivity Analysis

Sensitivity analysis is a “what if” technique that examines the impact of changing the underlying assumptions on an answer. Sensitivity analysis is used to determine the effect of the possible different outcomes of a process. In the first sensitivity analysis, efficiency measurements will be carried out with a digital system that is fully operational and maximally implemented at the company. If this is realized, then part of the organizational structure at the unit can be further streamlined based on the current job desc by only using the resources of a manager (1 person), a team of Technical Supervisors (3 people) who work more in the field, and staff outsourced work (92 people). Moreover, labor costs will also shrink, following the number of existing workers. This is because all administration and transactions can be done online.

Table 5: Calculation of new design efficiency.

DMU	TE (CRS)	TE (VRS)	SE Score
2017	0.936491031	0.979425466	0.956163653
2018	1	1	1
2019	1	1	1
2020	0.926331423	0.936691698	0.988939504
2021	1	1	1
New Design	1	1	1

From the sensitivity analysis that has been done, it is known that the New Design DMU has an efficiency value of 1 or runs optimally, as shown in Table 5. There have been several changes to the DEA efficiency measurement, with the New Design DMU participating in the DEA efficiency measurement at this stage.

Table 6: Peer groups new design sensitivity analysis.

DMU	Peer Groups	Benchmark Scores
2017	2018 ; New Design	0.913043 ; 0.086957
2020	2019 ; New Design	0.253025 ; 0.746975

It can be seen in Table 6 that New Design DMUs are always in peer groups for each DMU that is not optimal and becomes a reference for DMUs that are not optimal. This change indicates that DMU New Design is the primary reference DMU for DMUs that do not have optimal performance. This is also supported by minimizing the variable value of the number of workers and labor costs that occur due to administrative and transaction processes that are fully digital when compared to DMU in 2021.

Sensitivity analysis was also carried out to determine the effect of input-output factors on efficiency. This is an essential aspect of DEA-based analysis. This is done to check the results' robustness by eliminating one of the variables from the observed DMU. Because DEA is a data-driven analysis, any error in the data set can significantly change the results [16].

TABLE 7: Efficiency value of variable sensitivity analysis.

DMU	SCORE								
	Without X1	Without X2	Without X3	Without X4	Without X5	Without X6	Without Y1	Without Y2	Without Y3
2017	0.9739	0.9794	0.9794	0.9794	0.9794	0.9794	0.9794	0.9206	0.9794
2018	1	1	1	1	1	1	1	1	1
2019	1	1	1	1	0.9621	1	1	1	1
2020	0.9215	0.9367	0.9367	0.9367	0.9057	0.9367	0.9367	0.9367	0.9367
2021	1	1	1	1	1	1	1	1	1
New Design	1	1	1	1	1	1	1	1	1

By eliminating input and output variables one by one by minimizing the number of model deviations, it can be seen which variable has the most significant role in achieving efficient workforce management in the observed DMUs. Table 7 shows that in the 2019 DMU, by eliminating the PB service speed variable, the 2019 DMU efficiency value decreased to 0.962123894, while it remained efficient when other variables were removed. This shows that the PB service speed variable is a strength of the 2019 DMU, so it is efficient when other variables are removed.

5. Conclusion

The following conclusions were obtained based on the results of data collection, data processing, analysis, and discussion that had been carried out previously regarding the evaluation of workforce management at the power plant's unit.

The previous DEA efficiency calculation process shows that of the five DMUs evaluated, there were three efficient DMUs, namely the 2018, 2019, and 2021 DMUs. Meanwhile, the 2017 and 2020 DMUs were not yet efficient.

From the process of determining peer groups for DMUs that are still not optimal, DMU 2021 is the DMU that has the most peer groups or references for DMUs that are still not efficient. However, after the DMU New Design was included in the efficiency calculation, the DMU New Design became the most referenced DMU for DMUs that were still not optimal.

From calculating the target for improvement at the DMU, which is not optimal, it is known that in the 2017 DMU, all variables except the Customer Satisfaction Index variable are still not optimal and need to be improved. Meanwhile, in the 2020 DMU, all variables without exception are still not optimal and need to be improved.

Based on the results of calculations related to the variables that have the most influence on the efficiency of DMU workforce management, which is not optimal, it is known that the variables Interference Response Speed, Disturbance Recovery Speed, and Power Add Service Speed are the variables that have the most influence on the efficiency of workforce management at the unit.

Based on the research results, the 2021 DMU, which is the last period to be evaluated, has run optimally, so there is no need to calculate improvement targets. However, by implementing the New Design scenario, permanent workers can be reduced by 36%, and permanent labor costs can be reduced by 41% from 2021. Therefore, implementing the New Design strategy can increase workforce management efficiency at this unit in the future.

Following are some suggestions or recommendations for further research in this field.

1. It is recommended for future research to expand the research object by comparing other Customer Service Units in order to produce a more comprehensive analysis.

2. Then, further research can add other related variables that have not been used in this study, such as the number of disturbances experienced by consumers that can affect the Customer Satisfaction Index.

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