Interdisciplinary Research Review
Volume 14, Number 5, Pages 55 – 64

Sensitivity analysis and validation of socio-eco-efficiency score (SEES) on companies doing business in Thailand

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Abstract

Since The word 'sustainability' was introduced in the 1980s to define an efficiency and responsible consumption. Sustainable Development Indicators (SDIs) and tools have been playing an important role on offering companies an improving performance with superior economic. Socio-Eco-Efficiency Score (SEES) is the SDIs that combines the advantages of each well-known and widely used sustainability tool together and allows a company to monitor and benchmark its positioning and sustainability performance on financial, environmental and social aspects. In this research, workability and sensitivity analysis on SEES model has been analyzed. The result showed that even though there are several important factors during data interpretation and sustainability performance ranking process, SEES model was still working well in terms of performance assessment and business evaluation and development. The sustainability score from each scenario of sensitivity analysis did not have significant difference from each other. Each scenario of sensitivity analysis has pointed out the same summary with the other. In terms of model evaluation, the results satisfied expectations on solving the lack of linkage between each indicator in sustainability tools. The companies would be able to realize perspective that they are falling behind in their business section.

Keywords: SEES, sustainability tools, performance indicators, sustainable, sustainability development
Article history: Received 7 April 2019, Accepted 18 October 2019

1. Introduction

Over the last few decades, Sustainability Development Indices (SDIs) and other sustainability measurement tools have started to play an increasingly important role in providing meaningful concepts in terms of how to balance corporate objectives and judge a company success or failure in sustainable way [1-3]. By comparing to ordinary indicator, SDIs is a set of indicator that is used to describe company sustainability in terms of economic, environmental, and social aspects. Previous research study has pointed out the main disadvantages of present SDIs in terms of two concerns, 1) the absence of any linkage between each indicator and the worldwide perception of sustainability, as well as 2) the lack of transparency regarding the input data [4-7]. Several SDIs have their perspective on providing the effective operating concept to the company but cannot derive the effective end result and solution to the company [1, 4-7]. For solving this limitation, several researchers tried to create new SDIs to justify the company sustainability performance. Some previous researchers used thermodynamics theory to develop new SDIs called Emergy analysis (EmA). EmA measure energy consumed in transformations process. By this regards, several researchers tried to link environmental assessment through EmA and economic as well as social assessment together [8-11]. However, the energy consumption alone may not be sufficient for evaluating the company sustainability. Moreover, some researchers used eco-efficiency concept, which has been introduced by World Business Council for Sustainable Development, to create SDIs to measure the environmental impact via processing process in many conditions [5, 7, 12-16]. Still, the linkage of each indicator in terms of social aspect was absent. Furthermore, some researcher used ISO to frame up the company sustainability development, but there were limitations in linkage between each ISO series that resulted in innovation reduction [17-20]. For the extensive discussion on modern SDIs limitation, it was recommended that the good SDIs need re-designation and shall provide company the ability to withstand sustainable challenges according to three main aspects as economic, environmental and social [21]. Moreover, good key indicators or guidelines should be easy to measure and comprehend, relevant, lead to positive action, empower the user, control company investment

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blueprints and reflect strategic value drivers[22-28].

Socio-Eco-Efficiency Score (SEES) is an SDIs that has been developed by combining the advantages of each well-known and widely used sustainability tool, such as Dow Jones Sustainability Index (DJSI)[29, 30], Global Reporting Initiative (GRI)[31], International Organization for Standardization (ISO)[32-37], Emergy Analysis (EMA) and other sustainable development guidelines [38, 39]. The main purpose of SEES is to eliminate the disadvantages of modern sustainability tools and provide companies the ability to monitor and benchmark its/their positioning and sustainability performance with regard to financial, environmental and social aspects.

SEES is defined as a single unit expressed in SDIs that uses normalization and an Analytical Hierarchy Process (AHP) technique to summarize the benchmark positioning of companies alongside current market trends. SEES is a type of SDIs that analyses evaluation of company sustainability performance with regard to financial, environmental and social aspects. In order to achieve this, the overall operating performance input (including financial performance, environmental impact performance and social satisfaction) must be categorized to be in line with each company's size and sector, and must factor in a conversion and weighted process through the application of a pairwise comparison known as 'qualitative scaling'.

During the processes of data interpretation and sustainability performance ranking, there are several sensitive factors that could cause deviations in the obtained results. In order to deal with this issue, the sensitivity analysis and the factorial adjustment have both been analyzed in order to ascertain the perfect parameters and numbers that suit the application of the SEES model for companies conducting business in Thailand

2. Methodology

To create perfect SEES, enhanced SDIs that solve the restrictions and limitations delivered by current SDIs, a total of 10 different sustainability indicators and sustainability criteria which were expected to cover all sustainability aspects were gathered from several well-known and widely used sustainability tools and reports. The workability, in terms of result delivery, and result sensitiveness of SEES were analyzed by comparing to 1) the result from other well-known and widely used sustainability tool and 2) company present circumstances and performance. The indices from well-known and widely use sustainable tools included DJSI, GRI, ISO, and other sustainable development guidelines. These indicators cover three categories, namely financial, environmental and social.

2.1. Baseline criteria and indices for analysis

In consideration of business sustainable development, three key aspects, financial, environmental and social were included. For each of these within the model of SEES, a set of key performance indicators (KPIs) were established which were formed around the DJSI, ISO, GRI, and the World Business Council for Sustainable Development (WBCSD) indexes and guidelines that are used to measure the sustainability of businesses around the world. For the SEES model, a classification system comprised of 11 levels (ranging from a low of -5 to a high of +5) was used to rank every sustainability index. This level system was used to visualize the performances of each company in comparison to other companies in the same industry. It also has the potential to be used to gain a clearer picture how each business' sustainability practices are evolving in line with society.

For the environmental consideration in terms of SEES, the criteria was formed on the basis of Thailand's official "Nationally Appropriate Mitigation Actions" (or "NAMAs") [40]. The financial aspect took into consideration the overall business performance in Thailand as well as the ability for such businesses to survive within the current market place.

Finally, in consideration of social aspect, only indicator in the part of market and employee concern are perfect since there is no perfect solution and scoring for social aspect has been found by any researchers. This may be due to the fact that the sustainability criteria in social aspect are related to both stakeholders and community. To compensate this imperfection, the number of different CSR activity in each category is used for scoring system instead. SEES indices covering three aspects which have their criteria related to Thailand's Department of Business Development (DBD), NAMAs, are shown in Table 1 and Table 2. The average NPS from Temkin Group [41] and the Net Promoter Network [42, 43] for each industry are shown in Table 3.

2.2. Framework of conceptual analysis

In this study, the researcher selected a total of eight companies to test the sensitivity and workability of SEES model. These covered a total of five different industries which are Oil and Gas industry(x1); food processing (x1); airline industry (x1); storage tank terminal industry (x1); and banking and finance industry(x4). The financial data of each companies were gathered from DBD. The performance over 12-month period was used for financial aspects. The data for environmental and social aspect of each company were collected from its annual reports, and its sustainability reports. In the case that a company refused to release essential data, such company would receive a -6 score for the corresponding index as a penalty for non-compliance and lacking of transparency.

2.3. Sensitivity analysis for making counter weight of the indices

The Analytic Hierarchy Process is a technique that has been developed for organizing and analyzing com-

Table 1. Sees insex criteria summary.

	Level -5	Level 0	Level +5
Financial			
Return on Assets ("ROA")	The ROA of the last in their business sector or 0 depending on which is higher	The average ROA of their business sector or 0 depending on which is higher	The ROA of the leading company in their business sector
Return on Equity ("ROE")	The ROE of the last in their business sector or 0 depending on which is higher	The average ROE of their business sector or 0 depending on which is higher	The ROE of the leading company in their business sector
Return on Fixed Assets * ("ROFA")	The ROFA of the last in their business sector or 0 depending on which is higher	The average ROFA of their business sector or 0 depending on which is higher	The ROFA of the leading company in their business sector
Net Profit Margin	The Net Profit Margin of the last in their business sector or 0 depending on which is higher	The average Net Profit Margin of their business sector or 0 depending on which is higher	The Net Profit Margin of the leading company in their business sector
Environmental	0% or more	-7%	-20%
GHG Emission per unit Reduction ("GHGE")			
Electricity Energy consumption per unit Reduction (EEC)	0% or more	-12.5%	-25%
Water consumption per unit ** (WC)	0% or more	-12.5%	-25%
Social			
Net Promoter Score (NPS)	0	Mean of NPS in that business sector	Maximum of NPS in that business sector
Employee Engagement (EE)	50%	59.22%	80%
Social Activity Indicator (SAI)	Not available	Not available	Not available

Remark: * ROFA= Net Income / Total Fixed Assets

** The indicator in this part can be changed to another environment and energy consumption issues of concern in Thailand. In this research, water consumption per unit (WC) was selected.

*** SAI measures the number of activities in each category that company has contributed to the social and surrounding environment (surrounding environment and communities) in which they operated(33).

plex decisions in wide variety fields such as government, business, industry, healthcare, shipbuilding and education. AHP can derive the complex decisions as well as transform the in-put, guts feeling into numerical counterweight and derive ratio scales. In this study, magnitude of each index was weighted through. In AHP, the pairwise comparison of alternatives on a qualitative scale is considered as the main factor that has a high effect on the result from the AHP since the AHP results are extremely sensitive to the pairwise comparison matrix [44-48]. In this regard, the sensitivity analysis for making a pairwise comparison of alternatives on a qualitative scale that is suitable for SEES has been conducted. Four cases of sensitivity analysis for finding suitable pairwise comparisons of alternatives on a qualitative scale have been conducted, which are as follows:

Case 1: High range differentiation

In the high range, the value difference in each range is set to two (2) and the total value difference, from equal to extremely strong, is equal to 8. The significant values are equal to 1 and 9 for equal and strong, respectively.

Case 2: Middle range differentiation

In the middle range, the value difference in each range is set to one (1) and the total value difference, from equal to extremely strong, is equal to 4. The significant values are equal to 1 and 5 for equal and strong, respectively.

Case 3: Low range differentiation

In the low range, the value difference in each range is set to zero point five (0.5) and the total value dif-

Table 2. Criteria for SAI

	Level -5	Level -4	Level -3	Level -2	Level -1	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5
Number of covered categories	>2	3	3*	4	4*	5	5*	6	6*	7	7*

Remark:* means there are two or more activities in each said category.

Table 3. Average NPS for each industry.

Industry Sector	Score
Department/Speciality store**	58
Brokerage/Investments**	45
Auto Insurance**	44
Home/Contents Insurance**	42
Tablet Computer***	40.5
Auto dealers*	40
Grocery Supermarkets**	39
Online Entertainment**	39
Online Shopping**	39
Smartphones**	38
Credit Cards**	37
Laptop Computers**	37
Shipping Services**	35
Hotels***	34
Supermarkets*	33
Investment Firms*	32
Life Insurances**	31
Airlines***	30.5
Cellular Phone Services**	30
Insurance carriers*	30
Retailers*	30
Software and Apps***	29.5
Banking***	29
Major appliances*	29
Drug Stores/Pharmacies**	28
Parcel delivery services*	26
Rental cars*	24
Fast food chains*	23
Health Insurance**	18
Wireless carriers**	18
Travel Websites**	16
Health plans*	14
Utilities*	12
Cable/Satellite TV Services***	3
Internet Service***	2

Remark:*The value from Tempin Group;
** The value from Net Promoter Network;
***The average value of Tempin Group and Net Promoter Network

ference, from equal to extremely strong, is equal to 2. The significant values are equal to 1 and 3 for equal and strong, respectively.

Case 4: Very fine differentiation range

In the fine case, the value difference in each range is set to zero point twenty-five (0.25) and the total value difference, from equal to extremely strong, is equal to 1. The significant values are equal to 1 and 2 for equal and strong, respectively.

2.4. Surveying

In order to analyze the significance level of each indicator in each aspect, the pairwise comparison patterns of each indicator must be found. The pairwise comparison surveys on the topic of "Which aspect do you consider as the most important in doing business in Thailand?" were sent to the business owner, employees, and government office. The data from the survey were analyzed through the Analysis of Variance method (ANOVA).

According to the previous studies and research that performed their investigations on unknown numbers of the population, the Cochran 1977 Sampling Technique has been considered in this study(49-52). As a result, a maximum sample size of 400 has been used to satisfy the weighting survey analysis. Therefore, 400 questionnaires were distributed to state enterprises, private companies, and government officers.

2.5. Data normalization

In order to prevent any anomalies or redundancies occurring from the collected raw data, a normalization was applied in this study. All company was first categorized based on their business size which announced by DBD. After that, the company was categorized and then further segmented into different business categories depending on their market segment and their core business value. The raw data of each category was normalized as below:

Financial: The raw data of interested company were converted into ranking level based on their business segment maximum performance and lowest performance.

Environmental: the collected data were used to calculate the amount of greenhouse gases emitted per product by that company. For example, the tank terminal company main product is the raw materials supplied to storage tanks and plants; this was calculated as a unit of emission (of greenhouse gas) and expressed as CO2 (carbon dioxide) eq emission per ton.

Social: companies used in this study were categorized by business type according to their industry sector and main business values. Data relating to each

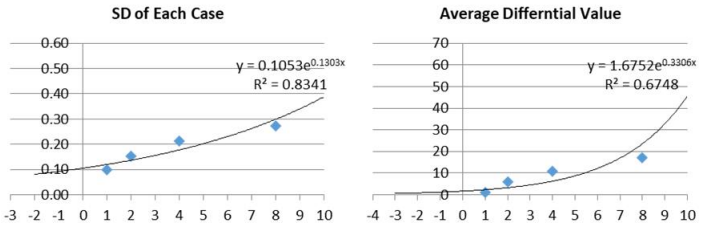

Figure 1: Exponentially prediction of standard deviation and Average Differential of each case

Table 4. Survey result of each business sector

	Public Company Limited	Non - Public Company Limited	Private Sector	State Enterprise	Government Officer
Economic	46	36	50	44	24
Environment	21	34	27	19	37
Social	33	30	23	37	39

company's performance on a social level were compared to the average values within the same industry. As an example, an airline company NPS was compared with average airline transportation service industry NPS in Thailand. This means that to calculate scores regarding employee engagement and social satisfaction, sampling companies was compared with their industry's average value in Thailand.

2.6. Data interpretation

In order to analyze the environment loaded and emission in environmental aspect, such as the emission of greenhouses gases and the consumption of unsustainable energy, a Life Cycle Assessment (LCA) was applied in this study.

The level of scoring in SEES was set from -5 to +5 (11 levels in total). Any score below zero represented a performance that below average or non-sustainable. A positive score (above zero) indicated an above average score and lying in sustainability area. This could be used to compare the performances of company with other in the same industry, as well as to compare the other companies in different industries. By using key performance indicators (KPIs) concept, company raw data were converted into single units score depending on each levels criteria. The single unit less score from three different aspects were further given a counterweighted from AHP and combined into final single unit less score that covered 3 sustainability aspects called SEES.

3. Results and Discussion

3.1. Surveying result

The survey results showed that different company sectors had an effect on the counterweight of the aspect that was being considered. In the private company sector, the economic aspect was considered as the most important, followed by the social aspect. For the state enterprise sector, the environmental and social aspects were considered more important than the economic aspect. In the government officer sector, environment was considered as the most important, followed by the social aspect. Moreover, the type of company also had an effect on the counterweight of the concerned aspect - public limited companies place greater emphasis on social and economic aspects than on the environmental aspect. The survey result of each business sector are show in Table 4.

3.2. Sensitivity analysis for AHP pairwise comparison matrix of alternatives on a qualitative scale

Four cases of sensitivity analysis for finding suitable pairwise comparisons of alternatives on a qualitative scale were conducted. Once all possible results from all cases were analyzed, the standard deviation and the average difference from the survey results of each case were analyzed and are shown in Table 5.

The analysis showed that high cases gave a large value deviation from the survey results. Middle cases and low cases delivered the value that resembled the survey result in every case. In some cases, for giving the significant difference between each aspect, the middle case would be selected for forcing companies to adapt their business plan to follow the criteria announced from the Thai government or any other organizations concerning sustainability development. However, in this thesis, the fine case was used to test the workability and sensitivity of SEES since every pillar could have a significant effect upon the final SEES score. Moreover, the sensitivity analysis shown that the data deviation of each scenario in the fine case was minimal compared to the high, middle, and low cases.

Table 5. Standard deviation and average differential from survey of each case

	High Case	Middle Case	Low Case	Fine Case
Average diff from actual	17%	11%	6%	1%
SD	0.271	0.214	0.153	0.098

Table. 6 The ranking comparison of SEES from different sector's perspectives

	Low Case	Company A	Company B	Company C	Company D	Company E	Company F	Company G	Company H
Scenario 1	46%								
(PLC Sector)	21%	-2.35	-4.82	-1.10	-1.90	-1.19	0.35	0.34	-2.34
	33%								
Scenario 2	40%								
(Non-PLC Sector)	33%	-1.76	-4.72	-1.74	-2.41	-0.56	0.89	0.47	-1.64
	26%								
Scenario 3	50%								
(Private Sector)	28%	-1.86	-4.76	-1.67	-2.02	-0.55	1.02	0.98	-1.69
	22%								
Scenario 4	45%								
(State ENT Sector)	20%	-2.45	-4.83	-0.97	-1.93	-1.35	0.18	0.13	-2.49
	36%								
Scenario 5	22%								
(Government officer	35%	-2.05	-4.70	-1.34	-2.95	-1.18	0.05	-0.95	-2.18
	42%								

3.3. Sensitivity analysis of SEES associated with each sector's point of view

From Table 6, it shows the ranking comparison of SEES from different sectors' point of view. The analysis showed that the changing in counterweight had an effect on the final score, SEES, but did not have a significant effect on the ranking. From scenarios 1, 3 and 4, SEES promoted company G as the number one sustainable company among the others while scenarios 2 and 5 promoted company F as the number one sustainable company among the others. This oscillation came from the difference in the main focus of each company depending on their business sector. Scenarios 1, 3 and 4 gave weighting to financial performance, which was two times higher than the others, and gave enormous benefit to company G which had the highest financial score among the others. On the other hand, the financial aspect did not have a huge effect on SEES by comparison to other aspects in scenario 2, and had the lowest effect in scenario 5.

The analysis and results from Table 7 and 8, showed that SEES has derived the different result if comparing to other well-known and widely used sustainable tools. The numerical measurable unit less score from each aspect in SEES had majority impact to the final sustainability score which derived superior result and in line with their business situation by comparing to the other well-known and widely used sustainable tools.

For example, Company A's main business focus is on the exploration and production of petroleum. Due to the growth in the US, Company A has struggled with decreasing global oil and gas prices. As a result, their annual turnover and net profits have been lower than predicted. In addition, political problems in Thailand has also hampered Company A's brand image which has been somewhat impaired due to a lack of transparency in relation to the activities of NGOs. However, after the on-going problems regarding the company's transparency were made evident, negotiations on the projects in which the company was involved with were cancelled.

The GRI awarded Company A with a grade of 'A+' and they were subsequently listed in DJSI. However, Company A received a score of between -2.45 and -1.76 for the SEES which was very much in contrast with the results from the more widely used sustainability measurement tools as mentioned above. In addition, there were also significant differences when it came to evaluating the company's environmental and financial concerns when compared with its competitors. Even though they did outline various schemes to address environmental issues in its sustainability report, the actual company results showed deterioration in this area.

SEES provides the ability to benchmark their sustainability performance to the others. For example, companies E, F, G and H are from Bank sector, SEES promotes company G as the leader in terms of financial aspect but promotes company F as the leader in social aspect. Moreover, the company can compare their

Table 7. GRI, DJSI, SEES sor companies A, B, C, and D.

	Company A	Company B	Company C	Company D
Finance				
ROA	-5.00	-5.00	-1.15	-2.84
ROE	-5.00	-5.00	-2.77	-3.07
ROFA	0.16	-5.00	-1.19	1.41
Net profit margin	0.34	-5.00	0.00	5.00
Environment				
GHG Emission per unit	0.62	-3.65	-5.00	-5.00
Energy Consumption per unit	-1.90	-5.00	-5.00	-5.00
water consumption per unit	5.00	-3.83	-5.00	-6.00*
Social				
NPS	-6.00*	-6.00*	5.00	-6.00*
Employee Engagement	-2.83	-6.00*	5.00	0.26
Social Satisfaction	-5.00	-3.00	-5.00	-2.00
SEES (average score)	-	-	-	-
DJSI	Yes	Yes	No	No
GRI	A+	B	No	B

Remark: *companiesnot providingdata received-6 as themaximum penalty

sustainability performance score via SEES. Company C which has main business in tank terminal section has better sustainability performance score by comparing to Company H which is lying in Bank section. The financial performance positioning of company C comparing to their competitor in Tank Terminal section are better and more sustainability by comparing to company H, but less sustainability than company F, and company G. Not only financial aspect that could be compared through SEES, Environmental and social aspect can be compared. By comparing company F and G, SEES showed that company G has better performance in environmental and social. This could be resulted from the fact that Company G recently started to focus more on improving its brand image and as well as regaining the trust of the public. In terms of expenditure, marketing and advertising cost the most money. It started an eco-friendly scheme that aimed to reduce its usage of raw materials such as paper and electricity and the result was a reduction in Company G's overall carbon footprint.

4. Conclusion

Results indicated that in comparison to ordinary sustainability tools SEES made sense for sustainability development with superior performance. SEES allowed companies the ability to monitor and benchmark their positioning and sustainability performance regarding financial, environmental and social perspectives. Companies could then identify which perspective needs improvement. Moreover, the single unit less score from SEES provided companies with the ability to benchmark against others in different business sectors. Every company can compare its performance as normalized and converted through SEES. For example, a company with below average ROA and ROE can manage and maximize their fixed assets to save expenses.

In terms of model evaluation, the results satisfied expectations on solving the lack of linkage between each indicator in sustainability tools. Linkages in SEES were demonstrated for the oil and gas, airline and banking sectors. However, investing in new technologies to improve carbon footprints would reduce short-term financial performance.

For the extensive conclusion on the sensitivity of SEES, the different point of view provided (1) great impact on SEES on the negative side; but (2) had a slight impact on SEES on the positive side; and (3) did not have the significant effect on the final ranking - the ranking was almost the same. By this meaningful conclusion, the SEES model worked well in terms of performance assessment and business evaluation and development.

However, there were some limitations that may dictate the result in this study. The evaluation of SEES from published reports alone might not be sufficient for flawless analysis. All reports, used in this analysis, have been deliberately published by companies to make themselves look superior when compared to their competitors' performances. In order to solve this issue, it is suggested that an independent party should be created for the purposes of validating such data. Furthermore, a more in-depth analysis is required for a more accurate interpretation of the social aspects, particularly when calculating scores for the social satisfaction index. It is suggested that a harsher penalty is imposed on those companies which fail to provide data and are noncompliant in offering full transparency. In order to make SEES available for controlling every company working in Thailand to be in line with each

Table 8. GRI, DJSI, SEES for companies E, F, G, and H.

	Company E	Company F	Company G	Company H
Finance				
ROA	-1.07	4.82	5.00	-3.48
ROE	0.47	4.21	5.00	-5.00
ROFA	0.13	-1.58	0.16	5.00
Net profit margin	-1.33	-0.35	5.00	-4.04
Environment				
GHG Emission per unit	-1.33	-0.35	5.00	-4.04
Energy consumption per unit	2.26	4.91	3.96	3.01
Water consumption per unit	2.35	2.74	2.60	-1.41
Social				
NPS	3.08	2.54	-5.00	3.87
Employee Engagement	-6.00*	-6.00*	-6.00*	-6.00*
Social Satisfaction	-6.00*	0.09	-6.00*	-6.00*
SEES (average score)	-	-	-	-
DJSI	No	No	No	No
GRI				

Remark: *companies not providing data received-6 as themaximum penalty

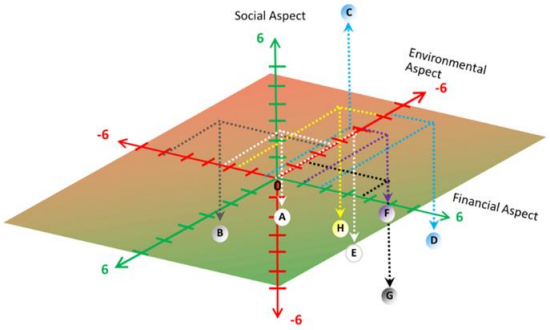

Figure 2: Sustainability development comparison based on SEES.

other, the supportive policy from government is considered as an indispensable concern. The government shall decree the final score in each year together with counterweight for each aspect that every company in Thailand shall comply with.

Acknowlegment

The authors would like to express their sincere gratitude to all anonymous reviewers and to Asst. Prof. Dr. Phairat Usubharatana for her valuable support. Special thanks to the Faculty of Engineering, Thammasat University for its valuable support throughout the preparation of this manuscript.

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