Journal of Critical Reviews

ISSN- 2394-5125 Vol 7, Issue 8, 2020

AWARENESS OF ENERGY CONSUMPTION IN CLOUD DATA CENTERS: A SURVEY ON EMPLOYEE ENGAGEMENT IN ENERGY MANAGEMENT

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Received: 20.05.2020 *Revised: 17.06.2020* *Accepted: 06.07.2020*

Abstract
The processing demand for high-performance application has increased adoption of Cloud computing among organizations. Such increment in Cloud usages has made Cloud data center incur high energy consumption due to high processing capacity that needed for longer time. It leads to several affect such as emission of heat, high carbon dioxide released and elevation of energy cost. Therefore, it is important to ensure the Cloud data centers are really have a good energy management policies and rules in the organizations. In respect to that, the organization needs to prepare their employees for realization of efficient energy consumption. In this work, a survey is conducted in the form of questionnaires that distributed to employees who have responsible for operating the Cloud data center. This survey aims to analyze level of awareness and satisfaction of energy management scopes such as technique, policy, auditing, and training that managed in the organization. It covers two main factors are the employee's roles and years of experience. The result shows that there is a significant increase of awareness in efficient energy management for operating the data center. Meanwhile, there is diverse feedback in satisfaction level of employees towards energy policy and training provided in the organization. Most of the respondents with higher roles and long experiences shown better awareness level and satisfaction against the specified energy management scopes.

Keyword-- Cloud data center, Energy awareness, Energy Management, Survey on employee role

DOI: http://dx.doi.org/10.31838/JCR.07.08.265

INTRODUCTION

The advent of information communication technology (ICT) makes Cloud computing a boom to societies and industries. Cloud computing has efficiently changed the way that IT infrastructure is delivered to meet the needs of the IT organizations both enterprise and consumer (Safari & Khorsand, 2018) (Zhou, et al, 2018) (El-Gazzar, 2014). Cloud computing provides those organizations to overcome their problem by providing various computing resources efficiently and cost-effectively (Haladu, & Samual, 2016). Generally, in this present era, the acceptance of Cloud computing in organization is increased due to its characteristic such as scalability, flexibility, agility, and simplicity. The existing survey in (Tang et al, 2015) (Masnida et al, 2017) shows that approximately 70% of the organizations in the world have adopted Cloud computing. Among this percentage, 77% of them are large-scale enterprises while 73% revealing from small-medium scale enterprises (SMEs) (Samual, & Hussin, 2018). According to survey in (Garg et al, 2011) (Beloglazov, & Buyya, 2010) the authors mentioned that the main reasons for adopting Cloud computing is due to the use of high-performance application that needed excellent in processing for meeting the consumers' requirements.

In recent years, Cloud data center has shown a swift development within the wide variety of hosted servers. Specifically, the Cloud data centers host varieties of applications starting from the applications that run for a few seconds (i.e., web applications), to applications which executed for longer duration of time such as simulations of big information of various set processing. Big Internet companies and IT equipment producers such as Google, Amazon, Microsoft, Dell, IBM, and HP are increased their existing data centers and building it in a new location (Connel, 2012) (Arroba et al, 2016). The major role of Cloud data centers is to store and process a big volume of data which belongs to a different organization so that the daily transaction of the organizations can be carried out successfully (Beloglazov, & Buyya, 2010) (Arroba et al, 2016). The data center has to provide a high-performance computing platform to process modern high-performance applications and ensure there is smooth communication system in 24/7 operation. However, it leads to the major problem where causes the Cloud data center consumed enormous amount of energy due to the high demand for computation power (Lu et.al, 2011) (Liu et al, 2016) (Sahoo, & Das, 2016) (Hsu et al, 2014) (Wang et al, 2017). Some are discussed that the inefficient energy management policies further raise the energy consumption (Zhou, et al, 2018)(Tang et al, 2015)(Masnida et al, 2017) (Arroba et al, 2016). According to authors in (Tang et al, 2015)(Arroba et al, 2016) (Buyya, Beloglazov, & Abawajy, 2010) (Anthony, Majid, & Romli, 2018) the huge amount of energy consumption emits a huge amount of heat and carbon dioxide in the atmosphere that affected an ecological balance. In our survey, we aim to analyze the energy-usage awareness and satisfaction level of energy management that maintained in the organization including energy audit process, training and energy saving policy. It tailored with the employee's roles and years of experience.

The rest of the papers are arranged in a following order: Section 2 contains some related works. The research design and methodology are discussed in Section 3. Section 4 presents the result for which the survey is done. The conclusion of the overall paper is given in Section 5.

RELATED WORK

In the recent years' energy management and energy consumption in Cloud data center become a most interesting area of research. According to the authors in (Garg et al, 2011)(Arroba et al, 2016)(Hussin, Lee, & Zomaya, 2011) the IT infrastructures such as server, storage, network devices, lights, and cooling systems are the major donors towards the energy

utilization. In (Beloglazov et al, 2016) (Patil, & Patil, 2019) (Beloglazov, Abawajy, & Buyya, 2012) the authors mentioned that there are two main factors which affect the energy consumption in Cloud data center. The first one is inefficient resource management and second, is the type of application used. According to the author in (Mastelic, & Brandic, 2015) the energy efficiency of resource can be classified as computational resources and physical resource. The studies in (Mastelic, & Brandic, 2015) (Bertoldi, 2014) (Avgerinou, Bertoldi, & Castellazzi, 2017) (Mastelic, & Brandic, 2015) (Garg, & Buyya, 2012) indicated that the energy intake of computing resources consumes about 50% of the whole energy consumption. In these the computation of servers consumes about 40 % of energy while the energy consumption of communication devices such as network devices is recorded up to 5% approximately. Furthermore, it said that the storage devices consume about 5% of the total energy. On the other side the energy intake of cooling systems is an important part of energy intake by means of physical sources, which accounts for about 40% of the total energy consumption.

Further the energy consumption of electricity source system and different miscellaneous factors is recorded up to 50% approximately. There are some researchers (e.g., (Samual, & Hussin, 2018) (Uchechukwu, Li, & Shen, 2014) (Rong et al, 2016)) mentioned that approximately 70% of the energy is consumed by the server when they are busy and about 30% of the energy is consumed during idle time.

This means that the moment when the server is switched on it consumed about 30% of the energy.One of the main reasons for enterprise servers consumed maximum energy is because of inefficient server management (Rahman, Khan, & Jadoon, 2016) (Khosravi, & Buyya, 2017) (EU SCIENCE HUB). The data center is allocated the entire tasks to the server besides the tasks should be accomplished as quickly as possible. It makes the servers put into a maximum frequency and utilized to the maximum that run continuously throughout the year.

Another major factor which raised the energy consumption in Cloud data center is the type of application running on it (Beloglazov et al, 2016). The author in (Mastelic, & Brandic, 2015) said that the primary factor that contributed to energy intake is the way the software packages are designed and carried out. In (Samual, & Hussin, 2018) (Amoon, Tarek, & Tobely, 2019)it stated that SaaS provides various types of application to the users. Every application running on the Cloud is not same.

They vary based upon different parameters and the computing requirements of every application are also different. These applications required variability of CPU capacity and memory requirement for effective processing. The allocation of resources based on maximum range of CPU and memory utilization caused high amount of energy consumption (Mastelic, & Brandic, 2015). Meanwhile, it might be some applications do not require fast execution but due to these types of applications might be small, it get the same treat as other applications. Thus, the energy consumption of the applications is not directly proportional to the application's profile. It further not thoroughly takes into account during the resource allocation approach is been positioned in the data center (Beloglazov et al, 2016) (Ghani et al., 2019).

In the year 2008 European Union introduced a code of conduct for the data center with the target to reduce data center energy consumption and its impact in environment, economy and energy security (Bertoldi, 2014) (EU SCIENCE HUB) (Avgerinou, Bertoldi, & Castellazzi, 2017) (Jauhar et al., 2015). According to the code the data center operators should be educated and encouraged to minimize the energy consumption cost-effectively without hindering the data center's mission-critical function. It is required for the data centers' operators to monitor their energy consumption and to adopt a set of established best practice. Further it said that the code of conduct for energy saving must focus on the IT load and facility, also the mechanical and electrical systems of the IT load.

In (Uchechukwu, Li, & Shen, 2014) it is stated that the efficiency of high energy consumption in the Cloud data center can be achieved by replacing the traditional equipment with high performance computing devices. In particular, the energy management system should investigate various factors such as total cost of ownership (TOC), energy cost for operating Cloud data center and protection of environment. The author in (Mastelic, & Brandic, 2015) identified several circumstances that indicates on how the energy is used inefficiently. One of them is the energy loss. It means the energy introduced into the system but not absorbed by any of its subsystems. The loss also involved the energy overhead from supporting subsystems such as cooling or lighting in the datacenter (Khosravi, & Buyya, 2017)(Hussain et al., 2016)(Mastelic, & Brandic, 2015). Another circumstance is the energy waste that related to system idle cycle, such as when the processor is switched on but left inactive. It can be formulated in other best practice, for instance, the process of maintaining the cooling machine at its peak during the summer (Khosravi, & Buyya, 2017) (Joarder et al., 2015) (Mastelic, & Brandic, 2015). There are several mechanisms and approaches in order to monitor and maintain the energy consumption at its efficient rate. In our survey, we mainly focus on how the personnel alert and response towards efficient energy consumption.

RESEARCH DESIGN AND METHODOLOGY

The awareness survey is done through a quantitative approach that using question and answer (Q&A) mechanism. The set of questionnaires are categorized into five sections. The first section contains a both open-ended and close-ended question that covers the background information of the respondent such as the designation of the respondent, role of the respondent, year of experience, rating of experience with the role, category of the organization, year of establishment, name of the organization.

Meanwhile the second section related to data center information (i.e., the architecture used in the data center, the type of Cloud services). The third, fourth and fifth section of the questionnaire focuses on energy consumption, energy management, and energy policy. In data analysis part we have analyzed the data by considering two major variables such as roles of the respondent and the year of experience. It mainly aims to know on how much these variables had influenced the awareness of energy management procedures in the data centers. Then, the data is been analyzed using Statistical Package for the Social Science for Window (SPSS) tool.

The questionnaires are distributed to the personnel those involved in day-to-day activities of monitoring and maintaining Cloud data centers located at Malaysia. Some questionnaires are taking away through online survey and others in printed form. Since the survey focuses on the Cloud service providers there is no sampling size is taken and the survey is not limited to one organization.

So, the questionnaires were distributed to all the available Cloud data centers in Malaysia which included public and private organizations without any restriction in number of participants. About 15 organizations are participated in the survey in which 2 of them are public organizations and others are private organizations. There are 51 respondents take respond to our survey.

Table I. Background studies of the respondent

No	Variables	Category	Freq	%
A	**Role of the Respondent**			
1	Administrator	Administrator	1	2.0
2	Cloud Administrator	Administrator	1	2.0
3	Cloud Delivery	Administrator	1	2.0
4	Cloud Engineer	Engineer	1	2.0
5	Cloud Operator	Administrator	9	17.6
6	Cloud Service Admin	Administrator	5	9.8
7	Data Center Facility	Manager	2	3.9
8	DB Admin	Administrator	3	5.9
9	Email & Lync Support	Administrator	1	2.0
10	Engineer	Engineer	14	27.5
11	Head of DC	Manager	1	2.0
12	Linux Support	Administrator	1	2.0
13	Manager	Manager	2	3.9
14	Managing Data center	Manager	1	2.0
15	Network &Security	Manager	1	2.0
16	System Admin	Administrator	1	2.0
17	Transformation Consultant	Manager	1	2.0
18	VMWare Admin	Administrator	2	4.0
19	VMWare Support Engineer	Engineer	1	2.0
20	Windows Lead Engineer	Engineer	1	2.0
21	Wintel Engineer	Engineer	1	2.0
	Total		**51**	**100**
B	**Years of Experience**			
1	1-3		25	49.0
2	4-7		11	21.6
3	8-12		12	23.5
4	Above 12		3	5.9
	Total		**51**	**100**
C	**Rating of Experience with the Role**			
1	Expert		14	27.5
2	Intermediate		19	37.3
3	Beginner		17	33.3
4	Trainee		1	2.0
	Total		**51**	**100**

Based on the respondent details (Table 1), we form the analysis of relation between the respondents' years of experience with the role in the organizations.

In Cloud data center for better planning and management of energy consumption it is important that the knowledge of the employees should be improved along with longer years of experience.

Therefore, we designed the years of experience is scaled from 1-3 years, 4-7 years, 8-12 years and above 12 years. We further classified the role according to their experiences given as beginner level, intermediate level, and expert level.

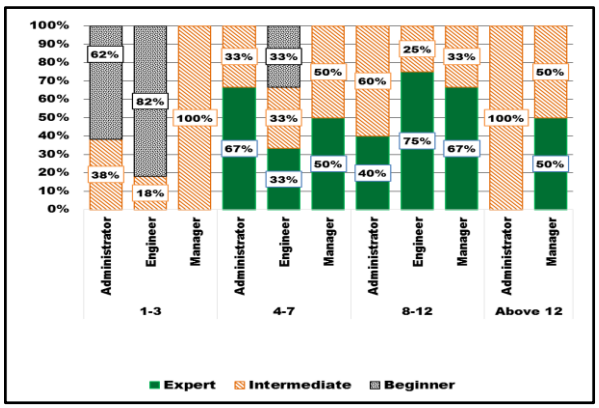

Figure 1. Data analysis with respect to collected samples

It shows in Figure 1 that maximum percentage of administrators has rated them at intermediate level even though they have long years of experience. It also reveals that most of the employees considered them-self at intermediate level even though they have 8-12 and above 12 years of experience.

This data scale is important to collect and to be known by the organization for planning better energy management while maintaining effective energy cost and bills. It is because the energy management is not a day operation, but it required long monitoring. The personnel that has capability able, at least to share their experiences to the upper management level for achieving efficient energy management.

RESULT AND DISCUSSION

In this section, we divided into four results and discussion according to the identified issues. In our survey, there are four issues that been studied; energy management techniques, the energy training provided, energy audit and energy saving policy.

For each issue, we analyzed the aspects of awareness and satisfaction levels against the factors of employees' roles and experiences. These aspects and factors are important in order to identify the organizations' concerned towards efficient energy consumption.

Awareness on energy management techniques

Fig 2 shows the awareness on energy management techniques that used in the data center. The analysis shows that the awareness among the employees with their designation increased along with their experiences.

It demonstrated a good awareness among the administrator and engineers even with less years of experience. Further from the analysis it can be viewed that there is a good awareness of the energy management techniques from the employees of 4-7 years experiences and above. This is because when the employees are responsible on the work for a longer period, hence they get more understand about the technique that is used.

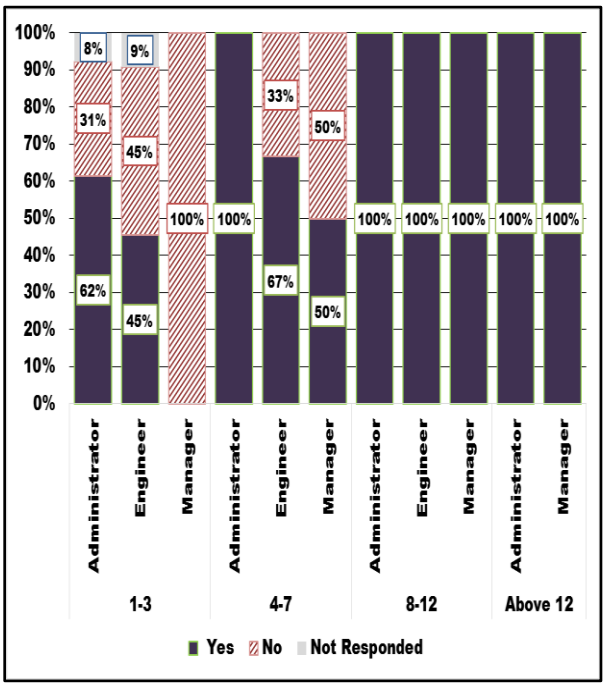

Figure 2. Awareness on energy management techniques

Satisfaction on Energy Management Technique Usages

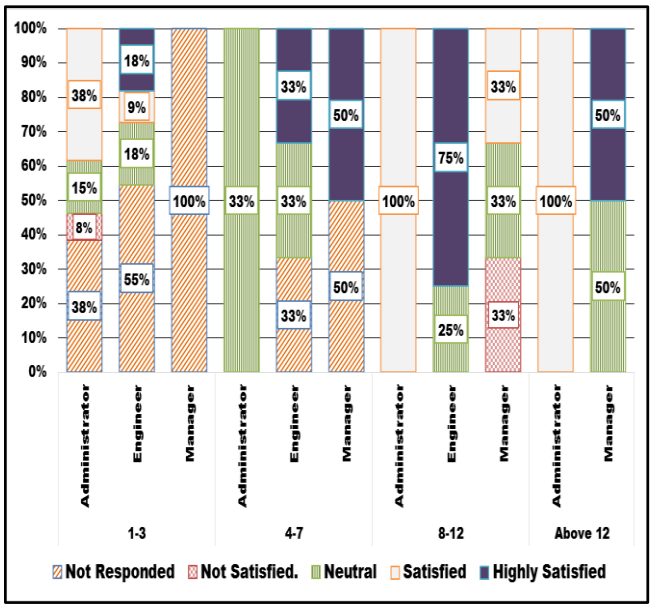

Figure 3. Satisfaction level of energy management technique usages

Fig 3 shows the satisfaction level of energy management techniques against with the roles and years of experience. Even though, there are various satisfactory level shown in accordance with the experience's levels, the employees whose gain longer years of the experience have higher convincing towards the energy management techniques that applied in the data center. This might be achieved through workshop, seminars, and case studies periodically. Interestingly, the engineers at all level of experiences shows highly satisfactory (in average 40%) towards the energy management techniques that used in the data center. It indicates positive response towards efficient energy management in Cloud data center. As we know that the engineer plays as the key role in the organization for designing suitable energy usage policy in data center.

Awareness on Energy Audit Process

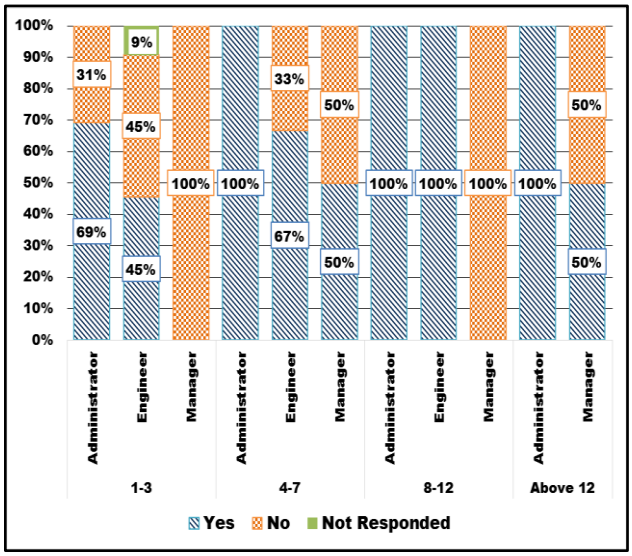

Figure 4. Awareness level of energy audit process

Fig 4 shows the awareness of the energy audit process the Cloud data center. Its indications that in all level of experiences the administrators are having a good awareness about the energy audit process as compare with engineers and managers. It meets the organization's expectation in gaining effective energy consumption by having data center administrators that aware their responsibilities.

However, the result reveals that the managers with 1 to 3 years of experience and 8 to 12 years of experience have no awareness of the energy audit process. These may be because of a lack of communication between the managers and the data center team.

This data might be critical to organization as the managers are supposed to take role in managing the audit process of data center. It also shows that there is an improvement in the level of audit process awareness among the engineers along with an increase in the years of experience. It is a good sign in preparing for green data center.

Satisfaction on Energy Reporting

Fig 5 shows the satisfaction level of employees about the audit report of the data center towards energy management. In average there is more 50% of employees did not respond to the question. We consider that the report either is not been reviewed by them or the feature of the reporting does not meet certain standard. Thus, they are not sure to respond on the question. However, in general the satisfaction rate of the audit report is quite high in accordance to the employees' roles and year of experiences.

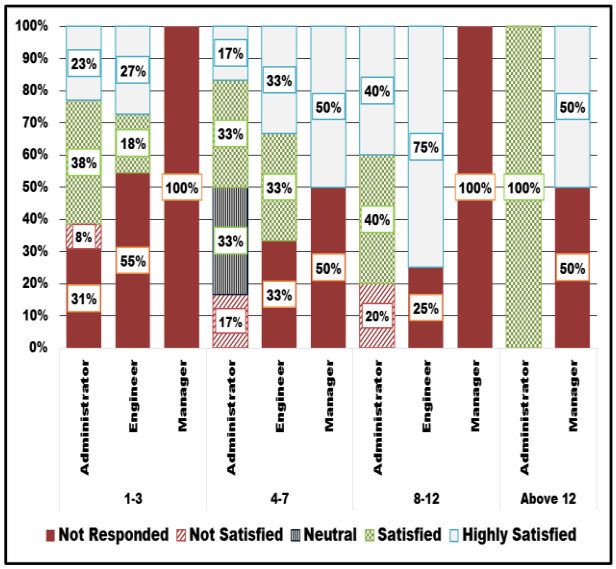

Figure 5. Satisfaction level of the energy audit report

Attentive on the Offered Energy Consumption Training

It is necessary for the organization to provide training for their staff in order to fulfill certain responsibility and improve awareness in certain area. Fig 6 shows the employees' awareness of training provided by the organization towards energy consumption. The analysis shows balance responds in aware and un-aware of the training provided by the organization. In general, the group of engineers is aware of the training. It is due to the engineers are the direct role that performing and managing the technical operation in data center. Hence, the training needed and offered are very important to them to increase knowledge and skill. Interestingly, the awareness on the training provided is not influenced by the years of experiences where the attentive occurs in every group of seniority. Thus, it is a useful indication to show that the training is needed as a form of lifelong knowledge in developing human capital capability, and implicitly beneficial to the organization.

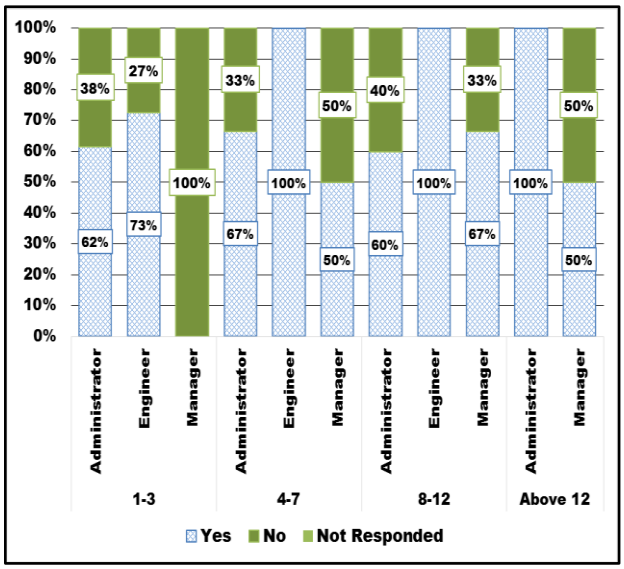

Figure 6. Awareness on energy consumption training provided by the organization

Satisfaction on Training Coverage

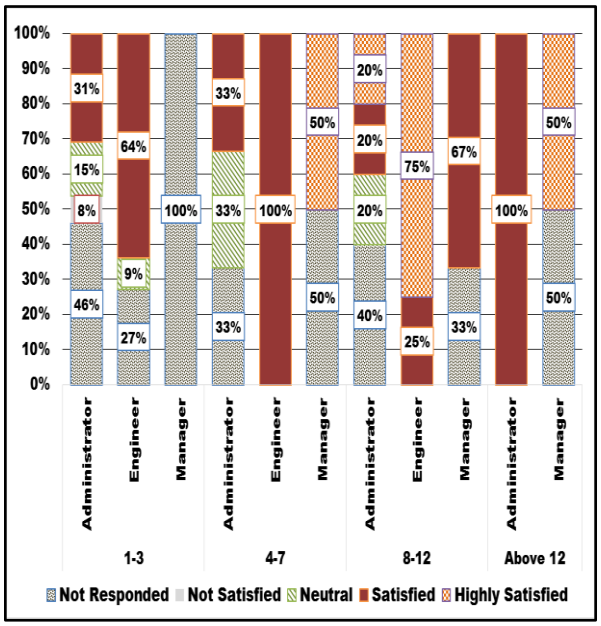

Figure 7. Satisfaction level of the content in the training

Generally, the energy management training is necessary to cover a wide range of energy information related to various components in the data center and latest energy management techniques. Hence, the employees are able to understand and play a suitable role in response to energy management policy in the organization.

In Fig 7 it shows the satisfaction level on the volume of energy management training among employees. In average about 53% of the employees in Cloud data centers are satisfied with the exposure gained from the provided training. It also shows that

most of the administrators and engineers are able to provide their satisfactoriness' level with the training contents compared to the managers.

It might be due to the managers are not anymore have a time to attend such training, hence they are not sure on how to response to the questions. Thus, it biased the results presented here.

Awareness on Energy Saving Policy

Fig 8 shows the awareness of energy saving policy against the roles and years of experiences. The analysis shows that the awareness about the energy saving policy increased along with the experience in the role.

The graph shows that the employees who have the experiences of 8 to 12 years and above 12 years are highly aware of the energy saving policy compared to those merely having 1-3 and 4-7 years of experiences. This reveals a great feedback as there is a mandatory for the employees to aware of energy saving policy in the data center along with their working experiences.

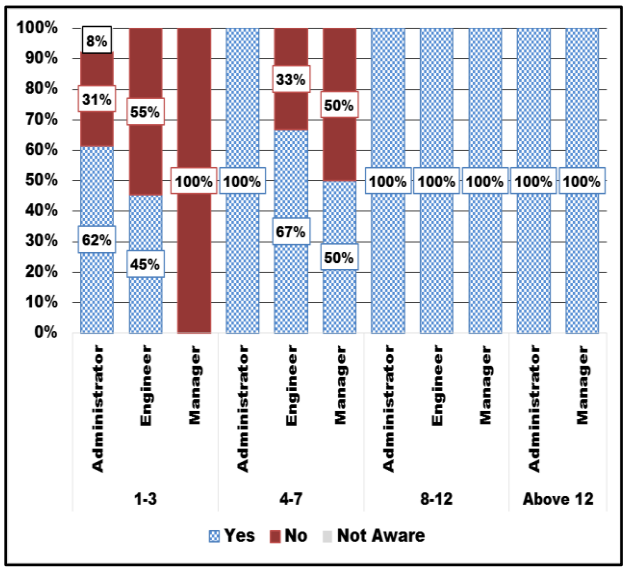

Figure 8. Awareness level of the energy saving policy

Satisfaction on Energy Saving Policy Applied

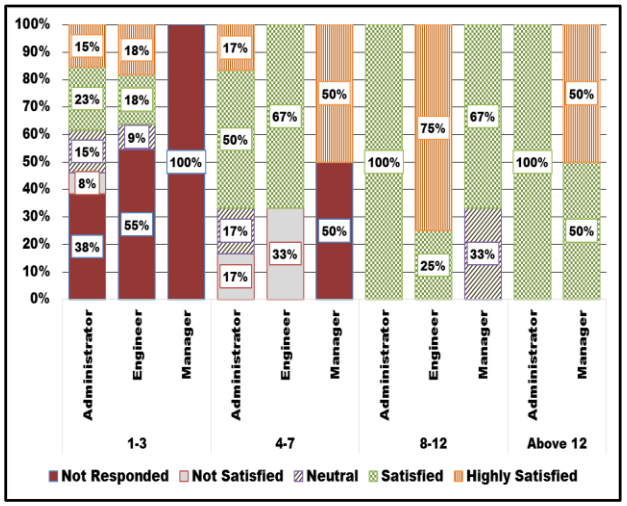

Figure 9. Satisfaction level of the applied energy saving policy in the organization

Fig 9 shows the satisfaction level of energy saving policy that applied in the Cloud data center. It shows that in average 85% of the employees satisfied with the energy saving policy that used and operated in the data center. It also indicates the least experience employees are still not thoroughly informed about the policy. As it shows that most of the employees with 1 to 3 years of experiences are do not response to the questions. On the other hand, it demonstrates a good sign where the data centers' administrators and managers fully satisfied with the energy policy that implanted into their data center. It at least reveals that the efficient energy management is part in their consideration in running and managing the Cloud data center.

CONCLUSION

In this study, we analyze the energy management awareness against the factors of employees' roles and experiences. We also highlighted the satisfactory aspect in identifying the efficient energy management for Cloud data center. Our survey is designed through Q&A mechanism that distributed among employees worked and related to the data center operation. There are several issues that been analyzed are energy management techniques, energy training provided, energy audit and energy saving policy. From the analysis, it shows that the awareness of the energy management has affected the satisfaction level in all the issues. Even though there are at some issues where less awareness is identified, it merely happens during in early phase in employees' working experiences. In overall, the organizations that run the Cloud data center are put the efficient energy management in their company plan and direction. Optimistically, it leads to produce green data center for better living environments.

ACKNOWLEDGMENTS

This work is supported by a Grant Putra-Incentive Postgraduate Student Grant GP-IPS/2018/9595900 from UPM.

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