Training Needs of Operation and Maintenance Personnel in Coal Fired Power Stations: Basis for Global Service Center Training Plan

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Abstract –*It is the aim of this study to find out the training needs of the coal fired power plants' operation and maintenance personnel and field engineers to come up with the Training Plan that will be used by Global Service Center. Specifically, it has the following objectives: to describe the demographic profile of operation and maintenance personnel at coal fired power station in Philippines in terms of age, gender, educational background, number of years of experience working in power plant station, number of years working in present division, job level, work division, training experience and preferred training period; to identify the courses preferred to take by the respondents; to identify the effective training method to be used; to determine the level of importance of training courses for each equipment; to test the differences of training method and training level of importance when grouped according to demographic profile; to seek suggestions on how training can be effectively conducted and to propose a training plan for coal-fired power plant operation and maintenance. The study utilized a questionnaire as its main instrument for data gathering. The answers in the retrieved questionnaires were tabulated and analyzed. The generated results revealed that the use of simulator is the most effective teaching method preferred by the power plant personnel and they are not so interested in virtual method and the training courses like basic technical knowledge, maintenance planning and procedure, failure analysis are considered very important courses that the power plant personnel should have. A proposed training plan was formulated that can be used as the basis in the conduct of training in Global Services Center.*

Keywords *–training needs, coal-fired power stations, training plan, operation and maintenance personnel*

INTRODUCTION

The energy market today continues to expand globally due to the growth of emerging economies [1]. Advances in technology enable coal to be used to meet the man's needs for fuel. Coal has been extensively used in power generation that ensures balance between ecology and economies to produce sustainable and affordable energy. Coal fire power plants boiler use different kinds of machinery that converts energy produced from combustion to mechanical energy [2].

In the Philippines, as support to the worlds' advocate for reaching the global consensus to limit the global temperature, the government approved the construction of twenty-five (25) new coal fired power plants in the country [3]. According to Sen. Legarda, the Philippine consumption for coal has increased by 27% in 2012-2014, and to meet the projected need for 13,167 megawatts of power by 2030, putting up more coal-fired power plants will address the needs [3]. At present, there are 16 (out of 18) operational coal fired power plant in the country, 32% in Luzon, 33% in Visayas and 11% in Mindanao [4].

Consequent to the increasing number of power plants operating in the county today, there should have also a reliable training program that should be provided to the operators and maintenance officers to continuously ensure the safe and responsive operations of the power plants. Unfortunately, there is no facility available in the country as per result of inquiry that will provide this need. Those that undergo trainings still need to go to Japan and other countries which is becoming expensive to the company. It is on this thought why MHPS, Inc. Ltd., launched their Global Services (training center) to help the country to achieve training at a lower cost of equally excellent quality as done in Japan. As the major and leading suppliers and providers of products and solutions to major power generation market was open to support the best possible operations and maintenance of coal power plant in the country and in Southeast Asia Region [1]. GSC will

provide training to enhance the competencies of the trainee in operation and maintenance covering the basic knowledge in broiler, turbine and generator, their maintenance and operation using simulators, maintenance planning and failure analysis.

The researcher who has been greatly involved in the company becomes interested to conduct this study. He believes that although MHPS supplies equipment that are designed with performance meeting the government regulations in terms of CO2 emissions, the effect of these emissions, even within acceptable limits, are still considered contributory to the global warming phenomena and because of this situation the market for coal fired Power Stations is facing difficulty. It is necessary that the operations and maintenance personnel are well trained and educated for the appropriate operation and preventive maintenance methods in Power Stations. MHPS recognizes, however, that due to various factors, the existing Power Stations and even manufacturers are facing a shortage of qualified and trained field engineers and plant operators and this concern is becoming a matter of great urgency. Henceforth, this research will aid the GSC as a training center.

OBJECTIVES OF THE STUDY

This study aimed to find out the training needs of the coal fired power plants' operation and maintenance personnel and field engineers of manufactures to come up with the Training Plan that will be used by Global Service Center. Specifically, it has the following objectives: to describe the demographic profile of operation and maintenance personnel at coal fired power station in Philippines in terms of age, gender, educational background, number of years of experience working in power plant station, number of years working in present division, job level, work division, training experience and preferred training period; to identify the courses preferred to take by the respondents; to identify the effective training method to be used; to determine the level of importance of training courses for each equipment; to test the differences of training method and training level of importance when grouped according to demographic profile; to seek suggestions on how training can be effectively conducted and to propose a training plan for coal-fired power plant operation and maintenance.

METHODS

Research Design

This research determines the present condition of needs for training on coal firing power station thus used the descriptive and type of research. The description is used for frequencies, average and other statistical calculations. Karangarajan and Shields [5] emphasized that it is used to obtain information concerning the current status of the phenomena with respect to variables or condition in the situation.

Participants of Study

Participants of the study are operations and maintenance engineers and their members from 10 coal fired power stations listed below. At the time of the study, there are 18 coal fired power stations in Philippines however only 16 are operational. The other 6 power plants were not considered due to their geographic location (Mindanao) which the researcher finds difficulty in reaching the area. There are around 120 participants who answered the questionnaire with the position of maintenance officers and operators.

Table 1.Coal Fired Power Plant Stations covered in the Study

Power Plant	Location
Sual Power Station; Team Energy Corporation	Pangasinan
Pagbilao Power Plant; Team Energy Corporation	Quezon
Masinloc Coal Fired Power Plant; AES	Zambales
Calaca Coal-Fired Power Plant; DMCI Holdings Inc.	Batangas
Quezon Power Station; Peal Energy Philippines Operating Inc.	Quezon
San Miguel Limay Power Plant; SMC Consolidated Power Corp.	Bataan
Panay Power Plant ; Global Business Power Corp.	Iloilo
Toledo Power ; Global Business Power Corp.	Pangasinan
Misamis CFB Coal Fired Plant; FDC Utilities Inc.	Misamis City
SMC Davao Power Plant; SMC Consolidated Power Corp	Davao

Instrument

The study utilized the self-structured questionnaire. It is composed of five parts. Part 1 contains the items for the demographic profile of the participants, the second part is focused on the courses that the respondents are willing to take, the third part is about the training method preferred to use, the fourth part is the level of importance of each course and the last part is about the suggestions of the participants on the conduct of the training. At first the questionnaire was drafted and checked by the adviser, validated by ten people who are not part of the actual study. There was little revisions done and afterwards presented to the

statistician and final approval was given to conduct the survey.

Procedure

The data gathering stage was conducted after the completion of the pre oral defense and validation of the research instrument. Upon the approval of each company on the conduct of the study, the researcher personally handed the questionnaire to get significant and reliable responses from the participants. The researcher explained the purpose of the study to the respondents and had given them the assurance the all data will be provided in the questionnaire will be treated with utmost confidentiality.

Data Analysis

The data gathered were tallied, tabulated and analyzed. Accordingly, different statistical treatments were used like frequency distribution, weighted mean and ranking. The study's hypothesis was analyzed using the Pearson product moment correlation which was tested at 0.05 level of significance.

The given scale was used to interpret the result of data gathered from the survey of preferred training method: *2.50 – 3.00 = Very Effective (VE); 1.50 – 2.49 = Effective (E); 1.00 – 1.49 = Not Effective (NE). The given scale was used to interpret the result of the survey on the importance of the training courses: 3.50 – 4.00 = Very Important (VI); 2.50 – 3.49 = Somewhat Important (SI); 1.50 – 2.49 = Of Little Importance (OLI); 1.00 – 1.49 = Not Important (NI)*

RESULTS AND DISCUSSION

Part 1 of the study dealt with the profile variables of the respondents such as age, gender, educational attainment, length of service in power plant station, job position, work division, number of years in current work division and training experience.

Figure 1**,** as to age, there are more of young engineers and less old employees both under Operation and Maintenance Division, about 42.40% or 50 are in the age below 30, 16.90% or 20 for the age bracket of 31-40 and 24.60% for ages 41-50, and then 19 or 16.10% for ages 51-50 which can be seen as there is alternation of generations which is now starting in the Philippines. According to Ray [6] there is generation gap in power plant such as nuclear training, electric utilities thus the government agencies and vendors like Westinghouse and General Electric are desperately seeking for engineers and other qualified professionals.

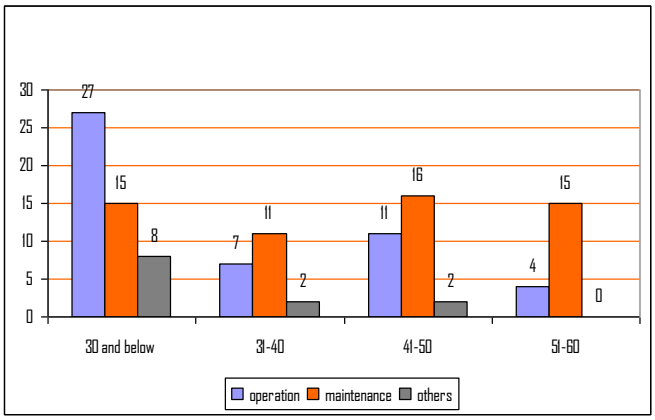

Figure 1. Age Distribution of the Respondents

On the other hand, the increase in the number of power plants in the Philippines in recent year caused the large number of young employees working in power plants. They are the newly graduate and licensed engineers who joined the industry. On the same article of Ray [6], it is said that every sector of the energy industry is expected to lose a large share of its work force as millions of experienced professionals, the baby boomers who are born between 1946 and 1964, are now eligible for retirement over the next few years. Thus, in the power sector, it will need more than 100,000 new skilled workers by 2018 as revealed by industry associations and consulting firms, which means the industry must hire 20,000 new workers over the next four years to replace those retiring workers [6].

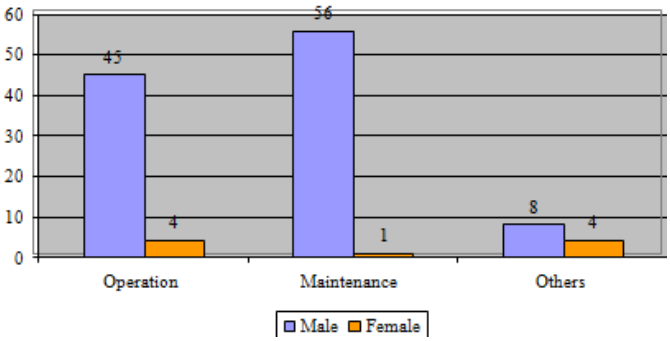

Figure 2. Gender of the Respondents

Figure 2 represents the gender of the respondents. It is obvious that the male are dominating in the field of power plant industry. In this study, 94.10% of the total respondents are men and only 5.90% are women. In the early days, in the Philippines, it is believed that the engineering courses are fit to men than women, however, with the new trends now, there are already

number of women who would like to work in the power plant.

According to Reitenback[7] *"with the increasing number of technical and economic changes affecting the power industry, the value of women in the workforce has never been higher".*Most studies of women in the workplace said that women are focus in higher-level roles, especially in executive positions and on corporate boards [8]. What is important for women are the value as role models and the economic value they bring to their organizations [9].

Figure 3 represents the educational background of the participants. It can be seen that 93.20% of the respondents are with Engineering Degree. Only 3.40% are High School (Technical) and same percentage for college graduate which is not Engineering Degree.

According to Ray [6] engineers of almost all disciplines can join the power industry by utilizing key skills gained during any engineering degree.

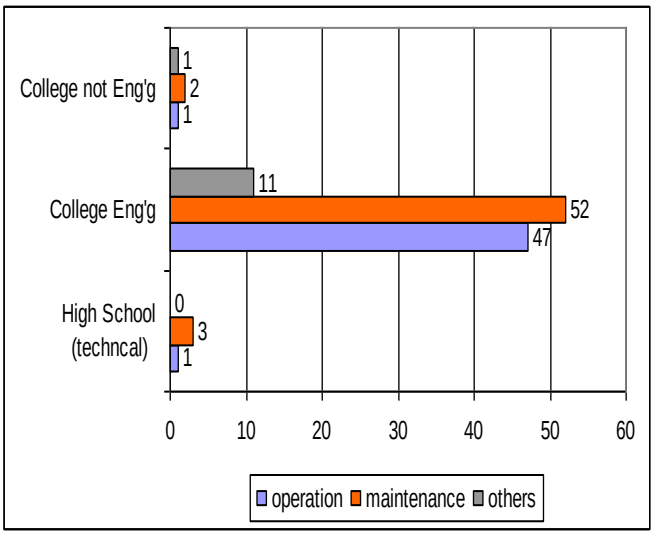

Figure 3. Educational Background of the Respondents

Also employers seek for "engineers that have a good understanding of engineering concepts as well as the ability to assess risks, be decisive, and manage projects and lead people. The power generation industry seeks graduates in Chemical, Civil/structural, Control, Electrical, Electronics, Environmental, Instruments, Manufacturing, Materials, Mathematics, Mechanical, Physics, Power systems and Software" [6]. Those that are High School (Technical) are the employees who have welding skills for example, and electricians. However, those who are not engineering graduates, are the experts in Risk Management hired by the company with the background in Project Management [10].

Fig. 4 shows the length of service in the power plant station. It shows that there are many young employees for operation and maintenance with a total of 40 or 33.90% or in service for 2 years and below. This is for the reason that new power stations are built in just recent years. It can be seen also that most of the employees who are in maintenance have the higher years of stay because in maintenance it requires more experience than in operation. From the survey conducted, one from the total of 10 power plants investigated started its operations in 2013, one started 2015 and two started 2016. Another observation is that, if a newly opened power plant stations, those currently employed are transferring due to higher compensations [11].

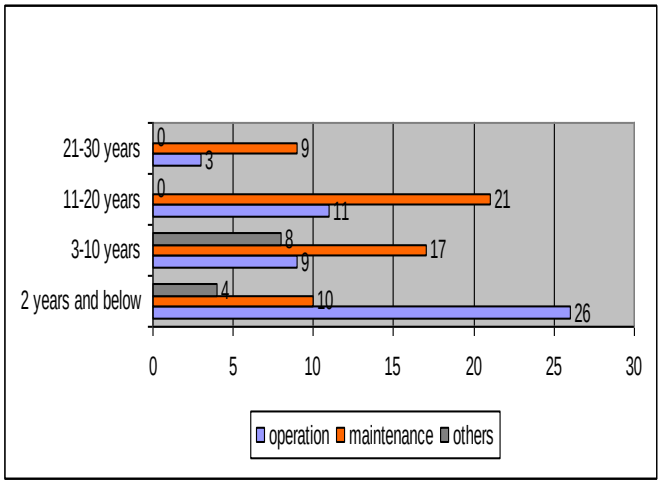

Figure 4. Length of Service in the Power Plant

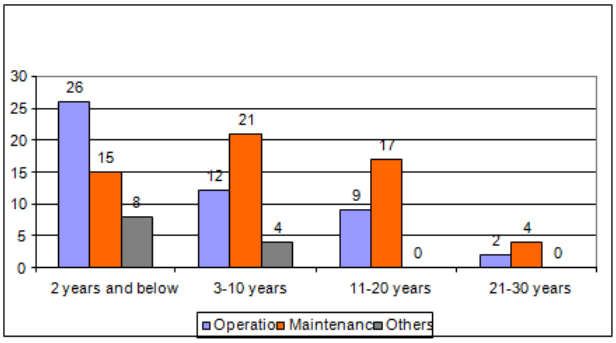

Figure 5. Distribution of Respondents as to number of Years in Present Work Division

Figure 5 represents the number of years in present work division. As observed in the number of years in service, most number of years are in their current division with a percentage of 41.52. This is definitely due to the fact that they are still new in the company. Thirty-one and 36/100 (31.36%) are in the range of 3 to

10 years [12]. There are also employees who are in the current division for 21 years and above. They are the employees who are in the maintenance division and possessing the managerial position. It is in the practice in the power plant sector that before a particular employee can have the supervisory and managerial positions, it is a requirement that they should have sufficient experiences and skills.

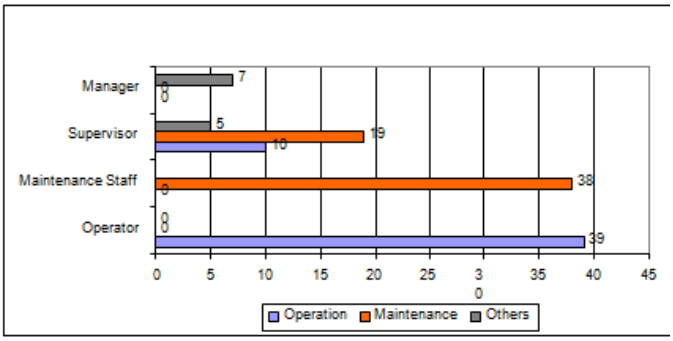

Figure 6. Respondents' Distribution as to Job Position

Figure 6 represents the distribution of respondents as to job position. In total, the operators have the higher number with a percentage of 33.10. It is followed by the maintenance staff at 32.20%, then supervisor at 28.80% and manager at 5.90%. As observed, the number of respondents for each group is balanced. In the operation of a power plant in the country, the staff in the operation and maintenance division ranges from the average of 20 to 25 people as the plant is producing only 7432MW in all operating power plants [12]. It means that the number of people employed depends upon the size of the plant.

Power plant operators are tasked to do the following: "Control power-generating equipment, such as boilers, turbines, generators, and reactors; read charts, meters, and gauges to monitor voltage and electricity flows; check equipment and indicators to detect evidence of operating problems; adjust controls to regulate the flow of power, start or stop generators, turbines, and other equipment as necessary" [13].

Figure 7 presents the distribution of respondents as to work division. These are namely the operation, maintenance and others. The Plant Maintenance is in charge to "attain maximum plant availability and equipment reliability, and to reduce forced outages, develops long-term custom maintenance programs that include: Preventive maintenance, Predictive maintenance procedures, Scheduled maintenance and Major refurbishments" [14]. It is 48.30% of the total respondents.

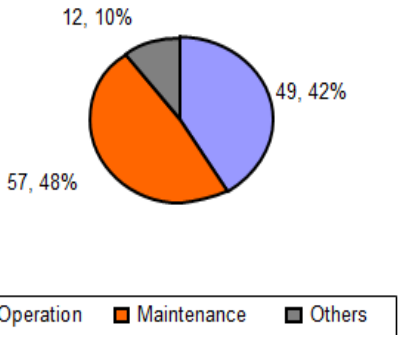

Figure 7. Distribution of Respondents as to Division

However, 41.50% is from operations division. The operational services are included and are designed to be implemented to achieve the safe, compliant to efficient manner working environment to ensure overall safety and control of the plant and site. However, 10.20% for others, this refers to the support services of the two divisions that requires also knowledge in power plant operations like Risk Management and Estimate Division that validate efficiency of the power plant.

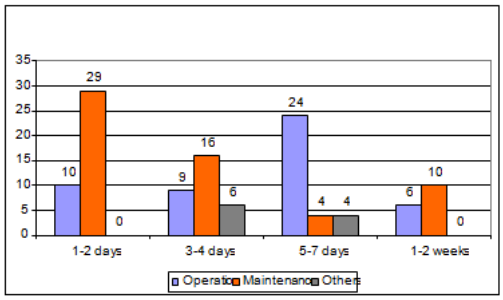

Figure 8. Distribution of Respondents as to Training Experience

Figure 8 shows the training experience of the personnel gained outside the company with a percentage of 67.80 percent. This refers to the trainings attended by employees conducted by the Engineering Professional Organizations, those sponsored by the Universities and Associations and the manufacturer. On the other hand, 38 or 32.20 percent are have no experience in attending training outside, what they attended are the in-house trainings conducted by the company. It can be observed that the training opportunity for this matter is very high for the reason that there is no training center for power stations in the Philippines. The GSC will provide training services to be facilitated by excellent technical skills from the local group of companies in Japan that aims to promote globalization and consideration will be given on the transfer of technology from Japan and the development

of new services designed to meet the needs of Southeast Asia [1].

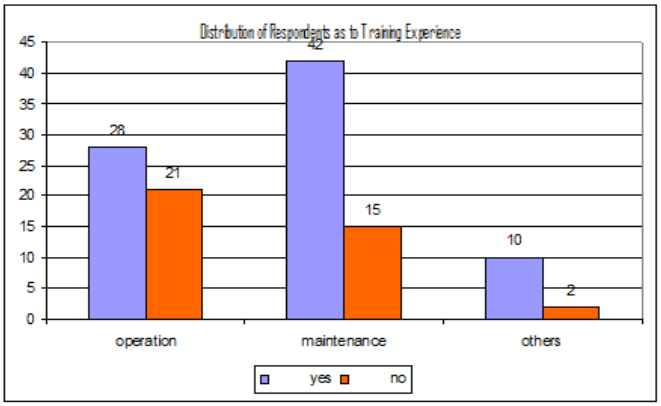

Figure 9. Preferred Training Period

This graph presents the preferred training period of the respondents. The most noted number of days is 1 to 2 days with the percentage of 33.05%, followed by 5 to 7 days at 27.12% and 26.27 % for 3 to 4 days. However, 13.56% or 16 preferred to have it for 1 to 2 weeks. The 1 to 2 days training period is ideal to the present set up as the operators and maintenance personnel as they cannot leave the company for several number of days. The nature of their work is technical and need to be present always in the plant site. On the other hand, according to several employees, they also would like to have the hands–on training and this will need 5 days. The GSC however is willing to accommodate the hands-on thru their MHPS-Phils Factory.

Table 2.Courses Preferred to Take by the Respondents

Course	f	%
Basic knowledge of boiler	62	52.54
Basic knowledge of turbine	66	55.93
Basic knowledge of generator	66	55.93
Operation of boiler using simulator	62	52.54
Operation of turbine using simulator	80	67.80
Operation of generator using simulator	76	64.41
Failure analysis of boiler	50	42.37
Failure analysis of turbine	60	50.85
Failure analysis of generator	49	41.53
Boiler Maintenance (RBM)	64	54.24
Turbine Maintenance	70	59.32
Generator Maintenance	70	59.32
Boiler Maintenance planning	28	23.73
Turbine Maintenance planning	32	27.12
Generator Maintenance planning	32	27.12

The Table 2 gives the multiple responses of the participants regarding their preferred courses to take. The top 5 courses are the Operation of Turbine and generator using simulator, followed by turbine and generator maintenance planning. As observed the training using simulator is the most noted with 80 and 76 respondents chosen to study these areas. It represents 67.80% and 64.41% respectively. Participants are interested because a "simulator is the fastest method of getting existing operators familiar with new procedures" [6]. For new plants, "simulators can give operators early hands-on "experience," or practice handling of the equipment. Simulators can also be used to let operators practice standard operations. This means faster and more reliable startups, shutdowns, and runbacks". With regards to turbine maintenance, this concentrates on how to repair, how to assess and find out the damage and repairs maintenance schedule. The basic knowledge in turbine and generator is the basic structure and function basic philosophy of design and their purpose.

In the survey conducted, the boiler, generator and turbine maintenance planning are the last three courses with least number of courses preferred by the participants. It is followed by failure analysis of boiler, turbine and generator. It can be inferred that these courses might be the least chosen because these are highly technical and highly concerned in supervisory and managerial level. The set of respondents are mostly new in the position and not yet in the 2nd level status.

Table 3.Preferred Training Method

Indicators	WM	VI	Rank
1. Classroom	2.53	VE	2
2. Video	2.35	E	3
3. Simulator	2.81	VE	1
4. Internet/Virtual	1.81	E	4
Composite Mean	**2.38**	**E**	

Table3 shows the preferred training method, as seen from the result, the respondents' considered simulator as the very effective method in the conduct of training program with the mean of 2.81. It is followed by classroom also noted to be very effective (2.53).Other items were assessed as effective only such as video and internet/ virtual with mean values of 2.35 and 1.81 respectively. According to PPTC [13], the simulator training technique is the "fastest method of getting existing operators familiar with the new procedures". This also means faster startups, shutdowns and runbacks and thus considered as the most effective training method. Also as explained by STEAG [15],

classroom "provides the ideal introduction of trainees into new concepts and updates". In the case of GSC, the newly constructed simulation room can accommodate 8 to 10 participants in a session; there is also classroom that can be used for the discussion. Several rooms with the state of the art facilities are installed thus can conduct the training simultaneously [17].

Table 4.Importance of the Training Courses

Indicators	WM	VI	Rank
1. Basic technical knowledge	4.86	VI	2
2. Maintenance Plan	4.67	VI	4
3. Maintenance Procedure	4.64	VI	5
4. Failure Analysis	4.89	VI	1
5. Operation	4.79	VI	3
Composite Mean	**4.77**	**VI**	

The Table 4 shows that among the five training courses mentioned failure analysis and basic technical knowledge ranked first and second respectively with the mean of 4.89 and 4.86. For the newly hired employees or those who are in the service for two years and below perceived the basic technical knowledge in power plant operation and maintenance of equipment. In view of the middle level employees, the failure analysis of boiler, turbine and generator is also considered very important, as their work is greatly focused on this area. On the other hand, the maintenance procedure and maintenance planning ranked last among the courses. This can be attributed to the fact that most number of the respondents are young and on their early years in stay in the office thus possessing the lower level rank. The concentration of their work is on operation and maintenance of the equipment and the planning and maintenance procedure is the work of supervisory and managerial level. Again to be in the position of supervisor and manager it requires longer period of experiences and practice of their expertise,

Table 5.1 shows the difference of responses on the preferred training method when grouped according to the profile of the respondents such as age, gender, and educational attainment, length of service in present plant station, job position, work division and training experience outside the company. As seen from the result, only educational attainment shows significant difference on the preferred training method since the obtained p-value of 0.018 is less than 0.05 alpha level. This means that the observation of the respondents on the effective training method needed in the training varies according to the degree that they earned.

Table 5.1.Difference of Responses on the Preferred Training Method When Grouped According to Profile of the Respondents

Profile Variables	F-value	p-value
Age	0.489	0.691
Gender	0.134	0.893
Educational Attainment	4.134*	0.018
Length of Service in the Power Plant Station	0.606	0.612
Job Position	0.077	0.972
Division	1.210	0.302
Attended training outside the company	1.651	0.101

*Legend: *Significant at p-value < 0.05*

Table 5.2.Difference of Responses on the Importance of the Training Courses When Grouped According to Profile of the Respondents

Profile Variables	F-value	p-value
Age	1.645	0.183
Gender	0.172	0.863
Educational Attainment	0.582	0.561
Length of Service in the Power Plant Station	0.496	0.686
Job Position	1.318	0.272
Division	2.571	0.081
Attended training in Power station before hired in the present company	0.398	0.691

*Legend: *Significant at p-value < 0.05*

It can be gleaned from the Table 5.2 that all computed p-values were all greater than 0.05 alpha level. This means that the respondents have the same assessment on the importance of the training courses. This situation validates the responses of the participants saying that all the training courses are considered very important regardless of their position whether maintenance staff or operation staff, supervisor or manager in all divisions under study. As validated on the training conducted by other training centers in Germany [15], the courses to be offered by GSC (Global Service Center) are the same. "STEAG is an officially authorized examiner for the German Chamber of Industry and Commerce and it supply the know-how on Made in Germany power generation", this is done through their local partners like PPTC [13].

Table 6 shows the summary of 25 suggestions given by the respondents on how the training can be conducted better. According to them, they also want to know knowledge of auxiliary equipment, latest technology, basis of each parameter's set point and hands-on approach, manual support and life extension advice on how can prolong the use of the equipment.

Table 6. Summary of Respondents' Suggestions in the conduct of Training

No.	Category of comments	f
1	Need to know latest technology of the product like boiler, turbine and generator	5
2	Hands-on training (actual use of the machine)	2
3	Other specific technology (welding, combustion, pump, AVR: Automatic Voltage Regulator)	6
4	Process, operation parameter and failure analysis in boiler, turbine and generator	5
5	Manual support, life extension of the product (broiler, turbine and generator) for longer use	7

Another suggestion is to provide manual support or referring to hand-outs that the participants may review or read from time to time, 28% suggested. The least is to have the hands on training, which means actual handling of the machine at 24%. According toGlobal Services Center [17], this suggestion can be materialized thru MHPS, Philippines that will provide the hands-on training.

Proposed Training Plan

Based on the findings of the training needs conducted, considering the demographic factors, the perceived teaching methods, the level of importance of each topic necessary in the operation and maintenance of BTG (boiler, turbine and generator) and the suggestions of the future trainees' themselves, the above table showing the course title, course contents and duration was able to identify. There are eight (8) courses to be offered, numbers one to six is for the personnel themselves, number 7 which is a special class is based on the suggestions that updates or current trends in BTG should be timely communicated thus come up with special course. The last or number 8 however is intended for the special lectures to be provided to visitors, students' plant tour and others. This is for free of charge and shall be part of its Corporate Social Responsibility.

Continuing these training to the personnel of power station and Filipino engineers, Japanese accumulated technology will be transferred to Philippines and it will contribute to the availability of coal power stations [17], and if it will be expanded to other countries, there will be overall reduction of CO_2 emission in earth.

CONCLUSION AND RECOMMENDATION

The coal fired power plant personnel are majority in ages 30 and below, male, with BS Engineering degree, less than 2 years in the power plant station, having the position of operator and maintenance staff and with trainings experiences attended outside the company, and willing to undergo training for one to two days duration. The preferred courses of the respondents to take are BTG (boiler, turbine and generator) operation using simulator, BTG maintenance and basic knowledge in BTG. The use of simulator is the most preferred teaching method preferred by the power plant personnel and they not so interested in e-learning or thru internet/virtual method. The training courses like basic technical knowledge, maintenance planning and procedure, failure analysis are considered very important courses that the power plant personnel should have. Educational attainment showed significant difference on the preferred training method, as to difference in responses on the importance of training courses when grouped according to profile, the respondents have the same level of assessment on the importance of training courses. The respondents suggested five areas on how the conduct of training can be best served such as manuals on how to prolong the use of BTG and its latest technology and to have hands-on training. The proposed training plan was formulated that can be used as the basis in the conduct of training in GSC.

It is recommended that the plant simulator may be fully utilized for each training course. Basic knowledge in BTG may be provided to the young Engineers of the power plant. Provide more detailed technical information like base of set point and mechanism or process for trainees that are well-experienced. Topic of latest technology may contain preventive maintenance, life extension and high efficiency operation etc. Delivery of training in the power plant site may be considered in the future. The Proposed Training Plan may be adopted by GSC in delivering their training for power plant personnel. This study may serve as a basis for future researchers in conducting similar studies that will utilize more respondents and more variables to further strengthen the results of the study.

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