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Investigation of the extent of awareness of the knowledge of battery maintenance among staff in Kebbi State Polytechnic Dakingari.

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ABSTRACT :

A battery is a crucial component in electrical systems, providing essential energy storage for various applications, including solar systems. This study investigates the extent of battery maintenance knowledge among staff at Kebbi State Polytechnic, Dakingari. Statistical data show that proper maintenance can significantly extend a battery's lifecycle, but improper maintenance often shortens it. A structured questionnaire with ten multiple-choice questions was administered to 80 respondents. Each correct answer was coded as 1 and incorrect answers as 0. The responses were analyzed using SPSS, with a binomial test identifying knowledge levels for specific tasks and a one-sample t-test assessing overall knowledge. The results indicated significant knowledge in most areas, except for understanding battery lifespan and handling corrosion. To enhance knowledge, it is recommended to display maintenance tasks on charts near solar installations and conduct regular training sessions.

Key Words: Battery Maintenance, Solar Batteries, Knowledge Assessment, Binomial Test, One-Sample T-Test

I. INTRODUCTION :

A battery is a key component in any electrical system, serving as a crucial tool for energy storage and most frequently employed as a secondary storage cell. It is essential not only for starting a car's engine but also in various other applications, including solar systems and manufacturing industries, where a power storage device is consistently needed. A battery stores electricity by enabling electron flow through an external circuit. The chemical reactions between the electrolytic solution and electrode materials convert chemical energy into electrical energy. The concept of electrochemical energy storage emerged from scientific studies on electricity. In 1789, Luigi Galvani observed that frogs' legs twitched when they came into contact with two different types of materials during an experiment [1]. This observation led to the development of the electrochemical cell and the subsequent discovery of batteries composed of two or more electrochemical cells. Since then, battery development has steadily progressed. Most advancements have focused on the fundamental materials used in battery manufacturing. Today, hard rubber, PVC, and other materials serve as insulation between the positive and negative electrodes and the outer layers. The aqueous electrolyte solution is housed in containers made of PVC, rubber, glass, or plastic. Modern advancements have also led to the use of paste-type electrolytes, like ammonium chloride, in some batteries instead of liquid acid solutions. These batteries are known as dry cell batteries. However, dry cell batteries have not yet achieved widespread use, whereas wet cell batteries have extensive applications and require more maintenance. Currently, various companies commercially produce wet cell batteries for automobiles and other purposes, specifying their lifespan based on usage. The battery's lifecycle depends not only on its quality but also on how well it is maintained by users. Most batteries fail to complete their economic life due to improper maintenance. Proper maintenance can significantly extend the battery's lifecycle and service rating, providing economic benefits to consumers. Therefore, the importance of proper battery maintenance cannot be overlooked. Generally, a battery's lifespan is considered to be between five to six years. A lifespan of less than five years could indicate operational abuse or poor maintenance [2]. Caring for batteries involves several preventive measures, including charging, ventilation, and watering. Keeping these operations up to date can help prevent issues or failures [3]. Electrolysis is the primary cause of electrolyte loss, necessitating the addition of water to batteries. Other reasons for water loss include evaporation due to internal heat, high workloads, unavoidable heat, mismatched batteries and charging equipment and the use of batteries without adequate cool-down intervals. Adequate ventilation is crucial because batteries produce gases during electrolysis that need space to escape. Without proper ventilation, the accumulation of gases can lead to explosions. Additionally, batteries should not be discharged more than 80% of their A.H. capacity; charging should occur when the discharge rate reaches 80% [2]. Maintaining an optimal temperature of around 80ºF is another critical aspect of battery care [4]. The authors of [5] discussed electrochemical and battery cells, focusing on lead-acid and nickel-cadmium batteries. They covered industry standards, design considerations, maintenance, testing and advanced battery system topics. Their goal was to provide a basic understanding of battery systems, enabling readers to design and maintain systems to minimize power outages, personnel hazards and property damage during emergencies. [6] suggested using surface temperature and voltage monitoring for safe lithium battery operation and maintenance. They proposed an online health assessment model based on GRU-CNN to forecast safety risks and automatically switch to backup batteries as needed. This system ensures real-time monitoring and quick health assessments, reducing prediction errors and offering reliable, stable and safe lithium battery operation. [7] examined how various storage and maintenance techniques affect the performance of nickel-metal hydride (Ni-MH) battery modules for hybrid electric vehicles (HEVs). They investigated the effects of charge-discharge mode, maintenance interval, rest period, charge rate, and storage state of charge on Ni-MH battery modules. Their research provided significant suggestions and techniques for the storage and maintenance of Ni-MH battery modules, showing that the proposed strategies offer better outcomes and save substantial maintenance time compared to six benchmark methods.

II. STATEMENT OF THE PROBLEM :

Statistical data available from famous battery industry like show that a battery can serve up to 7-8 years, when maintenance rate is 100%. This same battery will serve only up to 3-4 years, when the maintenance rate is 50% or average. But, if the maintenance rate is below 50% or the battery is not maintained at all, it may not even fulfill its warranty life. In order to maximally enjoy the benefit accruing from the huge financial commitment made on any solar system installation it becomes imperative to carry out a research that would investigate the extent of awareness of the knowledge of battery maintenance especially among Kebbi State Polytechnic Staff. A study of this kind would reveal to stake holders what should be done to equip staff with adequate knowledge of battery maintenance thus ensuring that solar batteries installed serve even beyond the projected period specified by manufacturers. This is the only way to justify the huge initial financial cost of any existing or future solar installation.

III. AIM AND OBJECTIVES OF THE STUDY :

The main aim of this research work is to investigate the extent of awareness of the knowledge of battery maintenance among staff in Kebbi State Polytechnic Dakingari. However, this research work shall meet the following specified objectives:

1. To enumerate the basic maintenance tasks required for proper battery maintenance.
2. To determine whether or not the staff in the study area have the pre-requisite knowledge required for proper maintenance of solar installed batteries.
3. To propose to relevant stake holders how this knowledge will get to targeted staff.

IV. RESEARCH QUESTIONS

1. What are the basic maintenance tasks required for proper battery maintenance?
2. Do the staff in the study area have the basic knowledge of battery maintenance?
3. What are the best ways of disseminating the knowledge of battery maintenance to the targeted staff?

V. RESEARCH HYPOTHESIS

The following null hypothesis is tested in this research work at 0.05 level of confidence using one sample t-test.
H_o: The respondents in the study area do not have the knowledge of battery maintenance

VI. METHODOLOGY

In this study, the knowledge of battery maintenance among respondents was assessed using a structured questionnaire. Responses were collected from 80 participants, each answering 10 questions designed to evaluate their understanding of battery maintenance. For each question, a response was coded as 1 if the answer was correct and 0 if incorrect. These binary responses were entered into SPSS for statistical analysis. Initially, a simple binomial test was employed for each question, using a cut-off point of 0.5 to determine whether respondents demonstrated significant knowledge. This method helped identify if the proportion of correct answers was significantly greater than what would be expected by chance. Next, to evaluate the overall knowledge of the respondents, a one-sample t-test was conducted. The null hypothesis stated that respondents could not correctly answer more than 5 out of the 10 questions, reflecting a test value of 5. This threshold implied that respondents were not expected to guess more than 5 answers correctly, given the binary nature of the responses. The t-test provided insights into whether the mean score of the respondents was significantly higher than the neutral point of 5. Finally, the results from the binomial tests and the one-sample t-test were used to draw conclusions about the respondents' knowledge of battery maintenance, indicating whether they possessed adequate understanding in this domain.

V. RESULT

Table 1: Respondents knowledge level on solar battery maintenance questions

S/N	Question Number	Question Asked	Simple Binomial Test Result						Decision based on the test result
				Category	N	Observed Prop.	Test Prop.	Exact Sig.(2-tailed)	
1	Q1	What is the optimal charging	Group 1	< = 0.5	26	0.33	0.50	.002	Respondents demonstrated significant knowledge of
			Group 2	> 0.5	54	0.68			

		voltage for a 12V solar battery?	**Total**		**80**	**1.00**			Q1
2	Q2	What is the typical lifespan of a well-maintained electrolytic solar battery?	Group 1	< = 0.5	42	0.53	0.5	0.738	Respondents did **not** demonstrate the knowledge of Q2
			Group 2	>0.5	38	0.48			
			Total		80	1.00			
3	Q3	What should be the minimum state of charge before recharging a solar battery to avoid damage?	Group 1	< = 0.5	20	0.25	0.5	0.00	Respondents demonstrated significant knowledge of Q3
			Group 2	>0.5	60	0.75			
			Total		80	1.00			
4	Q4	Why is it important to keep solar batteries in a well-ventilated area?	Group 1	< = 0.5	22	0.28	0.5	0.00	Respondents demonstrated significant knowledge of Q4
			Group 2	>0.5	58	0.73			
			Total		**80**	**1.01**			
5	Q5	Which substance is typically used to top up the electrolyte levels in a solar battery?	Group 1	< = 0.5	16	0.2	0.5	0.00	Respondents demonstrated significant knowledge of Q5
			Group 2	>0.5	64	0.8			
			Total		**80**	**1.00**			
6	Q6	What should be done if a solar battery shows signs of corrosion on terminals?	Group 1	< = 0.5	42	0.53	0.5	0.738	Respondents did **not** demonstrate the knowledge of Q6
			Group 2	>0.5	38	0.47			
			Total		**80**	**1.00**			
7	Q7	What is the recommended storage practice if a solar battery is not in use for an extended period?	Group 1	< = 0.5	19	0.24	0.5	0.000	Respondents demonstrated significant knowledge of Q7
			Group 2	>0.5	61	0.76			
			Total		**80**	**1.00**			
8	Q8	How should electrolyte levels be maintained in a solar battery?	Group 1	< = 0.5	23	0.29	0.5	0.00	Respondents demonstrated significant knowledge of Q8
			Group 2	>0.5	57	0.71			
			Total		80	1.00			
9	Q9	What is the optimal temperature range for storing electrolytic solar batteries?	Group 1	< = 0.5	29	0.36	0.5	0.018	Respondents demonstrated significant knowledge of Q9
			Group 2	>0.5	51	0.54			
			Total		**80**	**1.00**			
10	Q10	Which maintenance practice helps mitigate electrolyte loss in solar batteries?	Group 1	< = 0.5	28	0.35	0.5	0.010	Respondents demonstrated significant knowledge of Q10
			Group 2	>0.5	52	0.65			
			Total		80	1.00			

Table 2: Test of Hypothesis (H_o): The respondents in the study area do not have the knowledge of battery maintenance.

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Total_score	80	6.6625	3.68350	.41183

One-Sample Test

Test Value = 5

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Total_score	4.037	79	.000	1.66250	.8428	2.4822

VI. DISCUSSION :

The binomial test results indicate varying levels of knowledge among respondents for specific questions on battery maintenance. For Q1, Q3, Q4, Q5, Q7, Q8, Q9 and Q10, the observed proportions were significantly greater than the test proportions (p-values < 0.05), demonstrating significant knowledge among respondents. Conversely, for Q2 and Q6, the observed proportions were not significantly different from the test proportions (p-values > 0.05), indicating a lack of demonstrated knowledge. Specifically, for Q1, respondents significantly knew the optimal charging voltage for a 12V solar battery. For Q3 and Q4, there was significant awareness of the minimum state of charge before recharging and the importance of ventilation. Additionally, respondents showed significant knowledge of the correct substances to top up electrolyte levels (Q5) and the recommended storage practices (Q7). Overall, respondents exhibited a strong understanding of battery maintenance practices for most questions, except for Q2 and Q6.

The one-sample statistics provide insight into the overall knowledge of respondents regarding battery maintenance. The sample size (N) is 80, indicating that 80 respondents participated in the survey. The mean total score is 6.6625, suggesting that on average, respondents answered approximately 6.66 questions correctly out of a possible 10. The standard deviation of 3.68350 shows a moderate spread of scores around the mean, indicating some variability in respondents' knowledge levels. The standard error mean of .41183 is relatively low, suggesting that the sample mean is a reliable estimate of the population mean. Given that the null hypothesis states respondents do not have knowledge of battery maintenance, a mean score significantly higher than the midpoint of the scale would lead to rejecting the null hypothesis. Therefore, with a mean score of 6.6625, it can be inferred that respondents generally possess knowledge of battery maintenance, allowing us to reject the null hypothesis at the 0.05 confidence level. Further, more, the high t-value of 4.037 and a p-value of .000 indicate strong evidence against the null hypothesis, suggesting that respondents have substantial knowledge of battery maintenance. The mean difference of 1.6625, with a 95% confidence interval ranging from .8428 to 2.4822, further supports this conclusion by indicating that the true mean knowledge score is consistently above the neutral point.

VII. CONCLUSION :

The study revealed that while respondents demonstrated varying degrees of knowledge on individual aspects of battery maintenance, the overall proficiency was significantly above the threshold level. The binomial test results showed significant knowledge in most questions, indicating an awareness of critical maintenance tasks among the respondents. However, certain areas, such as understanding the typical lifespan of a well-maintained solar battery and handling corrosion, exhibited gaps in knowledge. To address these deficiencies and enhance overall understanding, targeted educational interventions are recommended. One effective method for disseminating this knowledge is to spell out maintenance tasks on a clear and concise chart. This chart should be prominently displayed near the solar installations to provide constant reminders and guidance to the staff. Visual aids and regular training sessions can further reinforce this information. By implementing these strategies, the likelihood of proper maintenance practices being followed consistently can be increased. This proactive approach will ensure the longevity and efficiency of solar batteries, ultimately contributing to the sustainability of any installed solar energy system.

VIII. RECOMMENDATION :

Targeted training programs should be implemented to address identified gaps in battery maintenance knowledge. Visual aids, such as charts detailing maintenance tasks, should be prominently displayed near solar installations to provide constant reminders and guidance. Regular workshops and refresher courses can help keep staff updated on best practices and new developments in battery maintenance. Additionally, incorporating hands-on training sessions would enhance practical skills and ensure proper maintenance techniques are followed. It is also recommended to develop an online platform for sharing resources and providing continuous learning opportunities. Further research should explore the effectiveness of these interventions over time and assess the impact on battery performance and longevity. Finally, expanding the study to include other institutions and comparing results could provide a broader understanding of battery maintenance knowledge across different contexts.

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