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Review and Application of the Analytic Hierarchy Process (AHP) for Maintenance Planning: A Case Study of Egbin Power Plant

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Abstract: *This study applies the Analytic Hierarchy Process (AHP) to optimize maintenance project selection at Egbin Power Plant, Nigeria. It addresses the need for a systematic approach beyond reactive methods by integrating four criteria—Economic, Performance, Technical, and Criticality—each with defined sub-criteria. Expert elicitation was conducted with eight professionals (Maintenance Managers, Operations Superintendents, Planning Engineers, and HSE Officers), and their judgments were aggregated using the geometric mean method. Validation through sensitivity analysis (weight perturbations, Monte Carlo simulations, tornado diagrams) and cross-method comparison with TOPSIS confirmed the robustness of results. Hydrogen Plant Overhaul (HPO) emerged consistently as the top priority, demonstrating novelty in contextual adaptation to Nigerian thermal power plant maintenance planning.*

Keywords: *Analytic Hierarchy Process, Consistency Ratio, Criteria, Decision Making, Eigen Factor, Project Selection*

1. INTRODUCTION

Effective equipment maintenance is crucial in ensuring the reliability, availability, and performance of critical assets within a thermal power generation facility [1]. Thermal power plants, characterized by complex systems comprising boilers, turbines, generators, and auxiliary facilities, are subject to wear and degradation over time. Consequently, the selection of maintenance projects becomes a critical decision-making process for plant managers and maintenance professionals [2]. Effective maintenance management results in beneficial outcomes for organizations, including improved operational costs and productivity and this is a critical way to ensure sustainability of any business [3]. Furthermore, safety of personnel and environment is also a critical reason enshrined in operating standards. Regulations that pertain to these must be well adhered to by process plants [4].

Traditionally, maintenance project selection in thermal power plants has been influenced by reactive responses to equipment failures and regulatory requirements. However, the dynamic and interconnected nature of modern power generation systems necessitates a more systematic and proactive approach to maintenance project selection. The lack of this systematic approach to maintenance project selection poses significant challenges to the long-term viability and competitiveness of thermal power plants. Consequently, there is a pressing need for research that investigates and proposes methodologies to optimize maintenance project selection, considering the diverse criteria influencing decision-making.

A more scientific approach is Multi-Criteria Decision Making (MCDM) process which can accommodate several criteria when considerations are made on selection of which project is best to execute at a given time. While it started as a simple process, decision making has metamorphosed over the years to the use of mathematical and computational analysis and oftentimes, involves comparison of several criteria that are important to the objective of a project [5].

Although earlier studies have demonstrated the value of structured frameworks in optimizing maintenance strategies—such as Pintelon's [4] seminal work on maintenance management decision-making—there is still a large gap in their actual implementation in particular operational contexts, such as thermal power plants. Comprehensive reviews of MCDM techniques, including AHP, have been presented in studies by Fatma et al. and Nurjaman & Listyantoko [6], [7], proving their theoretical efficacy in setting maintenance project priorities. These frameworks, however, frequently do not incorporate plant-specific elements that are essential for efficient decision-making in complex infrastructure, such as power plants, equipment criticality, safety, and operational constraints.

Furthermore, the majority of current research tends to focus on general methodological advancement rather than adequately addressing the particular difficulties that local or regional power systems face. Power plants in Nigeria and other comparable regions, for example, face particular problems such as restricted access to spare parts, a lack of qualified maintenance staff, logistical difficulties, and pressure to comply with regulations [2], [3]. Planning and carrying out maintenance is made more difficult by environmental factors like high temperatures, humidity, and resource constraints [1].

Therefore, in order to properly optimize the selection of maintenance projects, customized decision-making techniques that take these contextual factors into account are desperately needed. By applying the Analytic Hierarchy Process to the maintenance planning procedure at the Egbin Power Plant in Nigeria, this study seeks to close this gap and make maintenance decision-making more pragmatic and context-sensitive.

This study seeks to address the identified gaps by exploring the application of Analytic Hierarchy Process (AHP), one of the prominent MCDM methodologies, as a decision support tool for maintenance project selection in a thermal power plant. By doing so, the study intends to contribute valuable insights that can inform the development of more effective and proactive maintenance strategies, improving the reliability, availability, and performance of power generation facility. Owing to the simple and straightforward nature of Analytic Hierarchy Process, it has grown tremendously over the years to become the most prolific approach used in MCDM problems [6]. This is evidenced in the kind of acceptance it has gathered among business managers and strategic decision makers in organizations. It has been established as a sound and tested approach which can generate decisions that align with perceptions and expectations [8].

2. MATERIALS AND METHOD

The AHP process involves identifying the key criteria and sub-criteria that contribute to the overarching goal. AHP has found tremendous use in several fields ranging from management science, agriculture, construction, education, political science, and many other fields. As the heart of any research lies in the design which helps to understand the problem at hand, it is very critical to simplify it such that the process is well defined [9].

2.1 The Application of AHP Steps

Step 1 is developing the structure hierarchy. That is, where a goal has been set, then described in a systematic form into the structure that forms the series in the system, so that goals can be achieved rationally (Figure 1). The AHP as a multi-criteria analysis is capable of handling decision making problems whether it is quantitative or qualitative once the model has been designed in such a way to accommodate the analysis and determination of the comparison at each level [10].

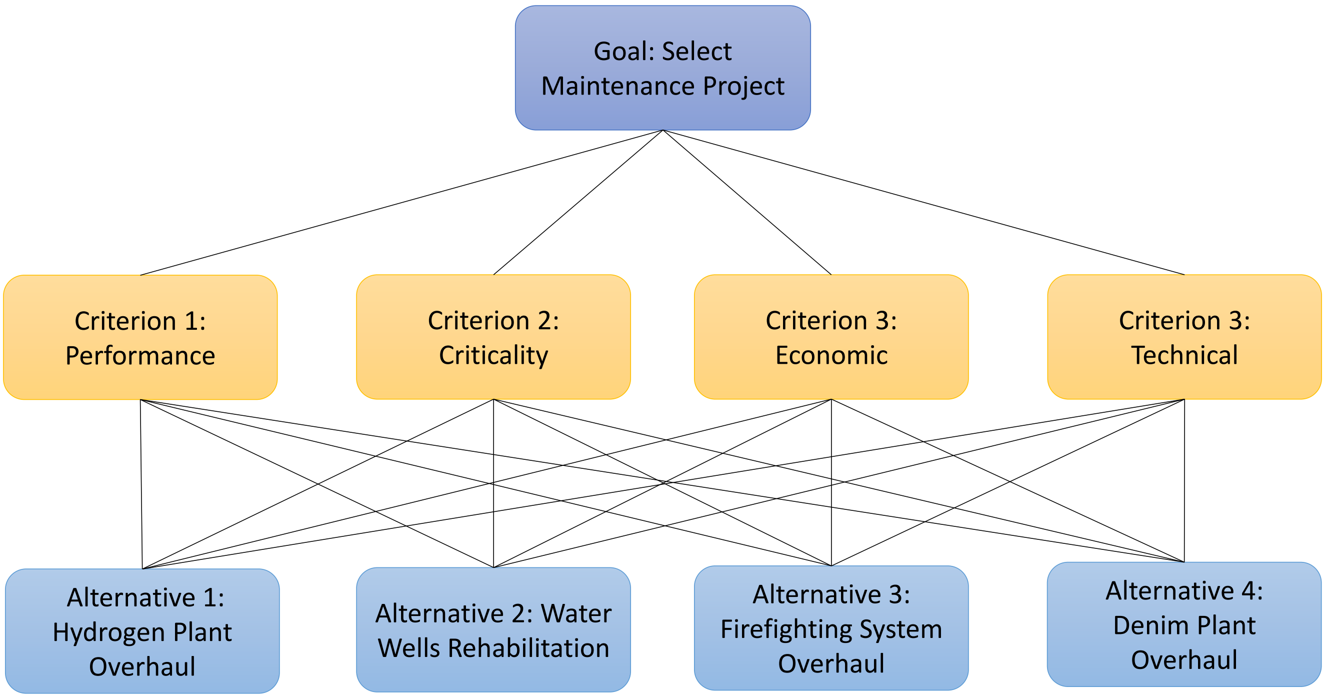

Figure 1: Hierarchy for AHP Level

Step 2 is to weigh elements comparison. This weighing procedure seeks to yield weights or priority that correspond to an underlying ratio scale [11]. The fundamental scale for paired judgement in the AHP is applied to pairs of homogeneous elements and the scale of values represents the intensities of judgements. This is provided by Saaty & Vargas [12] and presented in Table 1.

Step 3 is to prepare the matrix and calculate consistency. Initially, the pairwise comparisons between criteria and sub-criteria are conducted through a series of structured questionnaire or expert consultations. The collected data is then utilized to construct the pair-wise comparison matrices, capturing the relative importance of each element in relation to others. Subsequently, consistency checks were performed to ensure the reliability of the judgments provided by evaluating the consistency ratio. This iterative process of refining the matrices guarantees the accuracy and reliability of the data transformation from qualitative judgments to a structured hierarchy, setting the foundation for robust AHP analysis. The ensuing sections provide a detailed account of the matrix preparation methodology, emphasizing transparency, accuracy, and the steps taken to validate the resulting matrices as presented by Nurjaman & Listyantoko [7]. The standard comparison matrix is presented in Table 2.

Table 1: Scale of assessment of comparative pairs

Intensity	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2	Weak	Experience and judgment slightly favour one activity over
3	Moderate importance	another
4	Moderate plus	Experience and judgment strongly favour one activity
5	Strong importance	over another
6	Strong plus	An activity is favoured very strongly over another; its
7	Very strong	dominance
8	Very, very strong	The evidence favouring one activity over another is of the
9	Extreme importance	highest possible order of affirmation

Table 2: Standard comparison matrix

Criteria	1	2	3	n
1	*1*	*P12*	*P13*	*P1n*
2	*P21*	*1*	*P23*	*P2n*
3	*P31*	*P32*	*1*	*P3n*
N	*Pn1*	*Pn2*	*Pn3*	*1*
Total	T_1	T_2	T_3	*Tn*

The first step is to evaluate the total T across each column. This is derived by finding the sum of each column as shown in equation 1.

$$T = \sum_{i=1}^{n} P_{ij} \tag{1}$$

The second step is to create a normalization matrix. Each element in the matrix is being divided by its total to produce a matched matrix in normalization (see equation 2)

$$X_{ij} = \frac{P_{ij}}{\sum_{i=1}^{n} P_{ij}} \quad ;; \quad X_{ij} = \begin{bmatrix} X11 & X12 & X13 & X1n \\ X21 & X22 & X23 & X2n \\ X31 & X32 & X33 & X3n \\ X41 & X42 & X43 & Xnn \end{bmatrix} \tag{2}$$

To get the Eigen Factor, we find the summation of Eigen values and then divide the number of criteria used *(n)* to produce the weight matrix. This is represented in equation 3.

$$W_{ij} = \frac{\sum_{i=1}^{n} X_{ij}}{n} \tag{3}$$

The consistency must be calculated to verify the results of Eigen Factors are within reasonable judgment. The first step in doing this is by finding matrix multiplication of the comparison matrix with the Eigen Factor (see equation 4). The average is then derived as indicated in equation 5. The maximum value is used in equation 6 which gives a detailed breakdown of how the consistency ratio can be derived from the consistency index and index random consistency.

$$\begin{bmatrix} P11 & P12 & P13 & P1n \\ P21 & P22 & P23 & P2n \\ P31 & P32 & P33 & P3n \\ P41 & P42 & P43 & P4n \end{bmatrix} * \begin{vmatrix} W11 \\ W21 \\ W31 \\ Wn1 \end{vmatrix} = \begin{vmatrix} F11 \\ F21 \\ F31 \\ Fn1 \end{vmatrix} \tag{4}$$

$$\Lambda = \left(\frac{F11}{W11}; \frac{F12}{W21}; \ldots \ldots .. \frac{Fn1}{Wn1}\right) \tag{5}$$

$$\begin{cases} CI = \dfrac{(\Lambda_{max} - n)}{(n-1)} \\ \Lambda_{max} = Highest\ value\ (\Lambda) \\ IFR = \dfrac{1.98(n-2)}{n} \\ CR = \dfrac{CI}{RI} \end{cases} \tag{6}$$

where:
CI = Consistency Index
IR = Index Random Consistency
CR = Consistency Ratio
n = The number of criteria or sub criteria

If the consistency ratio is very large (> 0.10), then we are not consistent enough and the best thing to do is go back and revise the comparisons [7].

Step 4 requires determining the criterion comparison value on the alternatives involves repeating from Step 3 for each of the comparison matrix developed for each criterion by conducting pairwise comparison of the alternatives with respect to the criterion. The last step in the application of the AHP (Step 5) is choosing the best alternative by assessing the result of the analysis. To create a more reliable analysis, AHP are oftentimes integrated with other multi-attribute utility theories [13].

3. RESULTS AND DISCUSSION

Based on the data obtained, the Analytic Hierarchy Model was developed to identify the goal, criteria, and alternatives. Figure 2 shows the model with the interactions of the goal with the criteria and the alternatives. The model also accommodated the sub-criteria which forms input to the individual criteria. The criteria were selected from the company's risk management, redundancy plan, and the

1. Economy criterion: The economic criterion looks at the cost in the execution of a project. The two main sub criteria in this criterion are material cost and human resources.
   a) Capital Cost: The data for this comparison is largely derived from quoted cost by procurement team.
   b) Human Resource: This was accounted for by averaging emoluments for the workforce to be involved in the project work considering the different cadres of responsibility in the Engineering profession. This includes Engineers, Technicians, Craftsmen, and Labourers
2. Performance criterion: This criterion measure how the maintenance intervention will increase the plant performance.
   a) Generation: By what percentage will the generation capacity be increased upon completion of activity.
   b) Efficiency: Measure the efficiency of the steam turbine in converting thermal energy to mechanical energy.
3. Technical criterion: This outlook is the technology integration into the current framework available in the power plant. Criteria will be largely adjudged by technical experts in the subject area.
   a) Technology Suitability: Evaluate how well the maintenance fits the power plant's requirements.
   b) Compatibility: Assess the compatibility of the maintenance with other components of the power plant.
4. Criticality: This criterion is concerned with how important it is to carry a particular maintenance activity. It includes the following considerations.
   a) Dependency: If a particular process is heavily dependent on this maintenance intervention an if it is not carried out, it might lead to collapse of the critical system. An instance is a situation where the replacement of dryers is important to avoid compromise of instrument air flowing in the system.
   b) Safety: This speaks to activity that is needed to ensure safety of environment or compliance to certain regulatory standards.

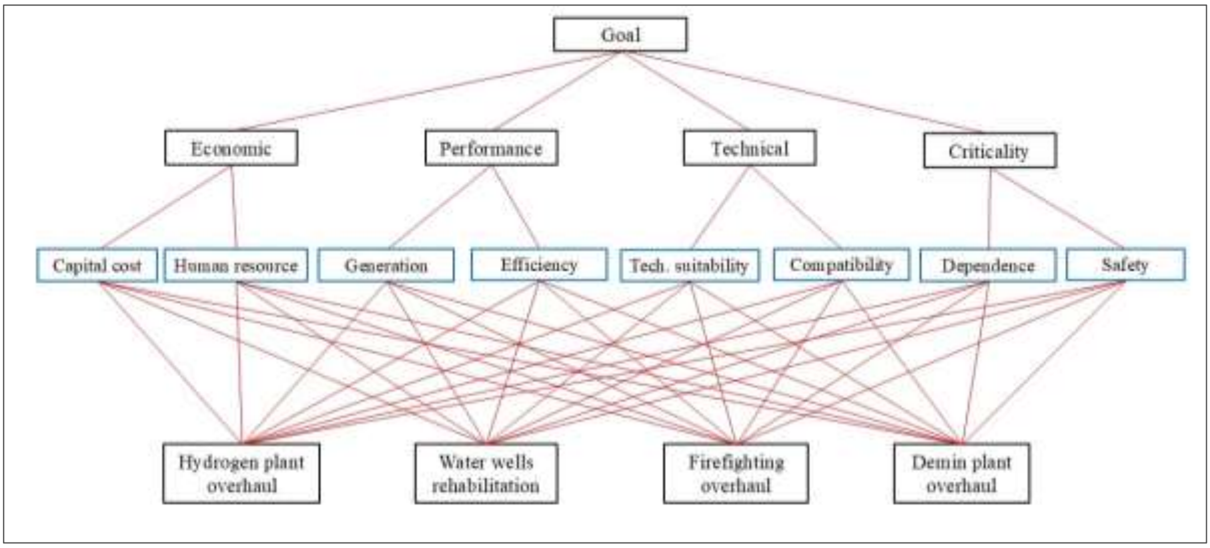

Figure 2: Structure hierarchy for selected maintenance projects

3.1 Weighted Matrix Matched Between Criteria

From the analysis as represented in Table 3 and 4, the indication of the survey conducted is that the most important criteria in selection of a maintenance project to be accommodated in the Annual Maintenance Plan is Performance (43%) followed closely by Criticality (41%). The third is Economic (11%) and the last is technical considerations which just accounts for 5% in decision making. What this implies is that the company places priority on projects that will increase the availability and reliability (performance) of the plant and, safety and sustainability (criticality) are almost equally important criteria when selecting the project. The management is not so concerned about the cost of the project, or the suitability of the technology being brought by any maintenance intervention plan. Therefore, projects that have enormous impact on the generation (performance of the plant) and projects that are geared towards safety of human, properties and environment will be favourably considered in the Maintenance plan.

Table 3: Weighted matrix between criteria

Criteria	Economy	Performance	Technical	Criticality	Total
Economy	1.00	0.20	3.00	0.25	4.45
Performance	5.00	1.00	7.00	1.00	14.00
Technical	0.33	0.14	1.00	0.13	1.60
Criticality	4.00	1.00	8.00	1.00	14.00
Total	10.33	2.34	19.00	2.38	

Table 4: Normalization of paired matrix between the criteria

Criteria	Economy	Performance	Technical	Criticality	Total	Eigen Factor
Economy	**0.10**	**0.09**	**0.16**	**0.11**	**0.45**	**0.11**
Performance	0.48	0.43	0.37	0.42	1.70	0.43
Technical	**0.03**	**0.06**	**0.05**	**0.05**	**0.20**	**0.05**
Criticality	0.39	0.43	0.42	0.42	1.66	0.41
Total	**1.00**	**1.00**	**1.00**	**1.00**	**4.00**	**1.00**

The Consistency ratio can thus be derived by following the steps in Equation 3 – 6 in the methodology. Doing this results in the following analysis (see Equation 7 – 8)

$$\begin{bmatrix} 1.00 & 0.20 & 3.00 & 0.25 \\ 5.00 & 1.00 & 7.00 & 1.00 \\ 0.33 & 0.14 & 1.00 & 0.13 \\ 4.00 & 1.00 & 8.00 & 1.00 \end{bmatrix} \times \begin{vmatrix} 0.11 \\ 0.43 \\ 0.05 \\ 0.41 \end{vmatrix} = \begin{vmatrix} 0.45 \\ 1.74 \\ 0.20 \\ 1.68 \end{vmatrix} \tag{7}$$

$$\begin{cases} \Lambda = \left(\frac{0.45}{0.11}; \frac{1.74}{0.43}; \frac{0.20}{0.05}; \frac{1.68}{0.41}\right) = (4.03, 4.10, 4.01, 4.06) \\ \Lambda_{max} = 4.10 \\ CI = \frac{(\Lambda_{max} - n)}{(n-1)} = \frac{(4.10-4)}{(4-1)} = 0.0336 \\ IR = \frac{1.98(n-2)}{n} = \frac{1.98(4-2)}{4} = 0.99 \\ CR = \frac{CI}{RI} = \frac{0.0336}{0.99} = 0.0340 \end{cases} \tag{8}$$

Based on the Consistent Ratio calculations, the weight data between the criteria is considered consistent because 0.0340 is less than 0.1.

3.2 Matrix Comparison of Projects

Economic criterion analysis on Table 4 shows the weights of the projects based on the economic outlooks for the company. From the table, it is evident that Demin Plant overhaul with 52% carries the largest weight here followed by Water Wells replacement (31%). The remaining two projects Hydrogen Plant and Firefighting systems overhaul have 13% and 4% weights, respectively. Therefore, if selection of projects is considered purely on economic criterion, Demin plant overhaul will deliver the best value to the plant. This can otherwise be interpreted that the Demin plant overhaul project will present the least challenge in terms of financing as compared with other projects. While water wall replacement also is critical, it should only be considered if there is enough budget to execute two projects. Based on economic criterion alone, Firefighting systems can be discarded as the value is exceptionally low.

Table 5: Economic weighted matrix between projects

PROJECTS	Hydrogen	Water	Firefighting	Demin	Total
Hydrogen Plant	1.00	0.33	5.00	0.20	6.53
Water Wells	3.00	1.00	8.00	0.50	12.50
Firefighting	0.20	0.13	1.00	0.11	1.44
Demin Plant	5.00	2.00	9.00	1.00	17.00
Total	9.20	3.46	23.00	1.81	

Table 6: Normalization of paired matrix between the alternatives

PROJECTS	Hydrogen Plant	Water Wells	Firefighting	Demin Plant	Total	Eigen Factor
Hydrogen Plant	0.11	0.10	0.22	0.11	0.53	0.13
Water Wells	0.33	0.29	0.35	0.28	1.24	0.31
Firefighting	0.02	0.04	0.04	0.06	0.16	0.04
Demin Plant	0.54	0.58	0.39	0.55	2.07	0.52
Total	1.00	1.00	1.00	1.00	4.00	1.00

$$\begin{bmatrix} 1.00 & 0.33 & 5.00 & 0.20 \\ 3.00 & 1.00 & 8.00 & 0.50 \\ 0.20 & 0.13 & 1.00 & 0.11 \\ 5.00 & 2.00 & 9.00 & 1.00 \end{bmatrix} * \begin{vmatrix} 0.13 \\ 0.31 \\ 0.04 \\ 0.52 \end{vmatrix} = \begin{vmatrix} 0.54 \\ 1.29 \\ 0.16 \\ 2.17 \end{vmatrix}$$

$$\Lambda = \left(\frac{0.54}{0.13}; \frac{1.29}{0.31}; \frac{0.16}{0.04}; \frac{2.17}{0.52}\right) = (4.08, 4.17, 4.02, 4.20)$$

$$\Lambda_{max} = 4.20$$

$$CI = \frac{(\Lambda_{max} - n)}{(n-1)} = \frac{(4.20 - 4)}{(4-1)} = 0.0664$$

$$IR = \frac{1.98(n-2)}{n} = \frac{1.98(4-2)}{4} = 0.99$$

$$CR = \frac{CI}{RI} = \frac{0.0664}{0.99} = 0.0671$$

Performance criterion captured on Table 5 shows the weights of the projects based on the performance outlooks for the company. From the table, Demin Plant overhaul with 40% still carries the largest weight here followed by Water Wells replacement (39%). The remaining two projects Hydrogen Plant and Firefighting systems overhaul correspond to 17% and 4% weights, respectively. If performance of the plant is being considered as the only goal, the Demin Plant overhaul will still deliver the best in terms of increasing the generation capacity and the efficiency of the plant. In essence, the upgrade that will be achieved by this project will streamline the plants inefficiencies and allow for a more optimal operation. When investigated further, the Demin Plant is strategically located in the entire plants operational process as it provides the prime mover of the steam turbine plant.

Table 7: Performance weighted matrix between projects and Eigen factor

PROJECTS	**Hydrogen**	**Water**	**Firefighting**	**Demin**	**Total**
Hydrogen Plant	1.00	0.33	7.00	0.33	8.67
Water Wells	3.00	1.00	8.00	1.00	13.00
Firefighting	0.14	0.13	1.00	0.11	1.38
Demin Plant	3.00	1.00	9.00	1.00	14.00
Total	7.14	2.46	25.00	2.44	

Table 8: Normalization of paired matrix between the alternatives

PROJECTS	**Hydrogen Plant**	**Water Wells**	**Firefighting**	**Demin Plant**	**Total**	**Eigen Factor**
Hydrogen Plant	0.14	0.14	0.28	0.14	0.69	0.17
Water Wells	0.42	0.41	0.32	0.41	1.56	0.39
Firefighting	0.02	0.05	0.04	0.05	0.16	0.04
Demin Plant	0.42	0.41	0.36	0.41	1.60	0.40
Total	1.00	1.00	1.00	1.00	4.00	1.00

$$\begin{bmatrix} 1.00 & 0.33 & 7.00 & 0.33 \\ 3.00 & 1.00 & 8.00 & 1.00 \\ 0.14 & 0.13 & 1.00 & 0.11 \\ 3.00 & 1.00 & 9.00 & 1.00 \end{bmatrix} * \begin{vmatrix} 0.17 \\ 0.39 \\ 0.04 \\ 0.40 \end{vmatrix} = \begin{vmatrix} 0.71 \\ 1.62 \\ 0.16 \\ 1.66 \end{vmatrix}$$

$$\Lambda = \left(\frac{0.71}{0.17}; \frac{1.62}{0.39}; \frac{0.16}{0.04}; \frac{1.66}{0.40}\right) = (4.10, 4.16, 4.01, 4.16)$$

$$\Lambda_{max} = 4.16$$

$$CI = \frac{(\Lambda_{max} - n)}{(n-1)} = \frac{(4.16 - 4)}{(4-1)} = 0.0545$$

$$IR = \frac{1.98(n-2)}{n} = \frac{1.98(4-2)}{4} = 0.99$$
$$CR = \frac{CI}{RI} = \frac{0.0545}{0.99} = 0.0551$$

Technical criterion detailed on Table 6 shows the weights of the projects based on the technical outlooks for the company. Here, Water Wells replacement and Firefighting systems overhaul both have equal weight of 40% followed by Hydrogen Plant and Demin plant overhaul both with 14% and 5% weights, respectively. The third consideration evaluates the technical suitability and compatibility of these projects with the current plant conditions, and the analysis shows that the Water Wells rehabilitation and Firefighting system will offer comparable value. In such cases as this, decisions cannot be made purely on this criterion alone especially if the budget can only accommodate one project. Therefore, it is imperative to engage an additional decision-making tool.

Table 9: Technical weighted matrix between projects and Eigen factor.

PROJECTS	**Hydrogen**	**Water**	**Firefighting**	**Demin**	**Total**
Hydrogen Plant	1.00	0.33	0.33	3.00	4.67
Water Wells	3.00	1.00	1.00	7.00	12.00
Firefighting	3.00	1.00	1.00	7.00	12.00
Demin Plant	0.33	0.14	0.14	1.00	1.62
Total	7.33	2.48	2.48	18.00	

Table 10: Normalization of paired matrix between the alternatives

PROJECTS	**Hydrogen Plant**	**Water Wells**	**Firefighting**	**Demin Plant**	**Total**	**Eigen Factor**
Hydrogen Plant	0.14	0.13	0.13	0.17	0.57	0.14
Water Wells	0.41	0.40	0.40	0.39	1.61	0.40
Firefighting	0.41	0.40	0.40	0.39	1.61	0.40
Demin Plant	0.05	0.06	0.06	0.06	0.22	0.05
Total	1.00	1.00	1.00	1.00	4.00	1.00

$$\begin{bmatrix} 1.00 & 0.33 & 0.33 & 3.00 \\ 3.00 & 1.00 & 1.00 & 7.00 \\ 1.00 & 1.00 & 1.00 & 7.00 \\ 0.33 & 0.14 & 0.14 & 1.00 \end{bmatrix} * \begin{vmatrix} 0.14 \\ 0.40 \\ 0.40 \\ 0.05 \end{vmatrix} = \begin{vmatrix} 0.57 \\ 1.61 \\ 1.61 \\ 0.22 \end{vmatrix}$$
$$\Lambda = \left(\frac{0.57}{0.14}; \frac{1.61}{0.40}; \frac{1.61}{0.40}; \frac{0.22}{0.05}\right) = (4.00, 4.01, 4.01, 4.00)$$
$$\Lambda_{max} = 4.01$$
$$CI = \frac{(\Lambda_{max} - n)}{(n-1)} = \frac{(4.01-4)}{(4-1)} = 0.0042$$
$$IR = \frac{1.98(n-2)}{n} = \frac{1.98(4-2)}{4} = 0.99$$
$$CR = \frac{CI}{RI} = \frac{0.0042}{0.99} = 0.0042$$

Criticality criterion analysed on Table 7 shows the weights of the projects based on the safety and sustainability outlooks for the company. From the table, Firefighting systems overhaul with 45% carries the largest weight here followed by Hydrogen Plant overhaul (41%). The remaining two projects Demin Plant Overhaul and Water Wells replacement have 7% and 6% weights, respectively. This last criterion measures the contribution of each project into the plant's sustainability and safety culture. It is evident that an upgrade of the Firefighting systems will offer the best value delivery and therefore, if the only criterion for the selection of a project is criticality, this is the project that will be selected.

Table 11: Criticality weighted matrix between projects and Eigen factor

PROJECTS	**Hydrogen**	**Water**	**Firefighting**	**Demin**	**Total**
Hydrogen Plant	1.00	7.00	1.00	5.00	14.00
Water Wells	0.14	1.00	0.14	1.00	2.29
Firefighting	1.00	7.00	1.00	7.00	16.00
Demin Plant	0.20	1.00	0.14	1.00	2.34
Total	2.34	16.00	2.29	14.00	

Table 12: Normalization of paired matrix between the alternatives

PROJECTS	Hydrogen Plant	Water Wells	Firefighting	Demin Plant	Total	Eigen Factor
Hydrogen Plant	0.43	0.44	0.44	0.36	1.66	0.41
Water Wells	0.06	0.06	0.06	0.07	0.26	0.06
Firefighting	0.43	0.44	0.44	0.50	1.80	0.45
Demin Plant	0.09	0.06	0.06	0.07	0.28	0.07
Total	1.00	1.00	1.00	1.00	4.00	1.00

$$\begin{bmatrix} 1.00 & 7.00 & 1.00 & 5.00 \\ 0.14 & 1.00 & 0.14 & 1.00 \\ 1.00 & 7.00 & 1.00 & 7.00 \\ 0.20 & 1.00 & 0.14 & 1.00 \end{bmatrix} * \begin{vmatrix} 0.41 \\ 0.06 \\ 0.45 \\ 0.07 \end{vmatrix} = \begin{vmatrix} 1.67 \\ 0.26 \\ 1.81 \\ 0.28 \end{vmatrix}$$

$$\Lambda = \left(\frac{1.67}{0.41}; \frac{0.26}{0.06}; \frac{1.81}{0.45}; \frac{0.28}{0.07}\right) = (4.02, 4.02, 4.02, 4.00)$$

$$\Lambda_{max} = 4.02$$

$$CI = \frac{(\Lambda_{max} - n)}{(n-1)} = \frac{(4.02 - 4)}{(4-1)} = 0.0072$$

$$IR = \frac{1.98(n-2)}{n} = \frac{1.98(4-2)}{4} = 0.99$$

$$CR = \frac{CI}{RI} = \frac{0.0072}{0.99} = 0.0073$$

3.3 Final Weight of Each Project

The final distribution is represented in Table 7 and equally on the Analytic Hierarchy diagram in Figure. The table shows the cross comparison of the weight of the criteria and the weight of the alternatives with respect to each criterion. Each project has been treated in isolation in the analysis above. However, the essence of multi-criteria analysis is to make a combinatorial/cross comparison of the projects with respect to the criteria (see Figure 3).

Table 13: Distribution of each criterion weight across the alternatives

	Economic	Performance	Technical	Criticality
Weights	0.11	0.43	0.05	0.41
Hydrogen Plant	0.13	0.17	0.14	0.41
Water Wells	0.31	0.39	0.40	0.06
Firefighting	0.04	0.04	0.40	0.45
Demin Plant	0.52	0.40	0.05	0.07

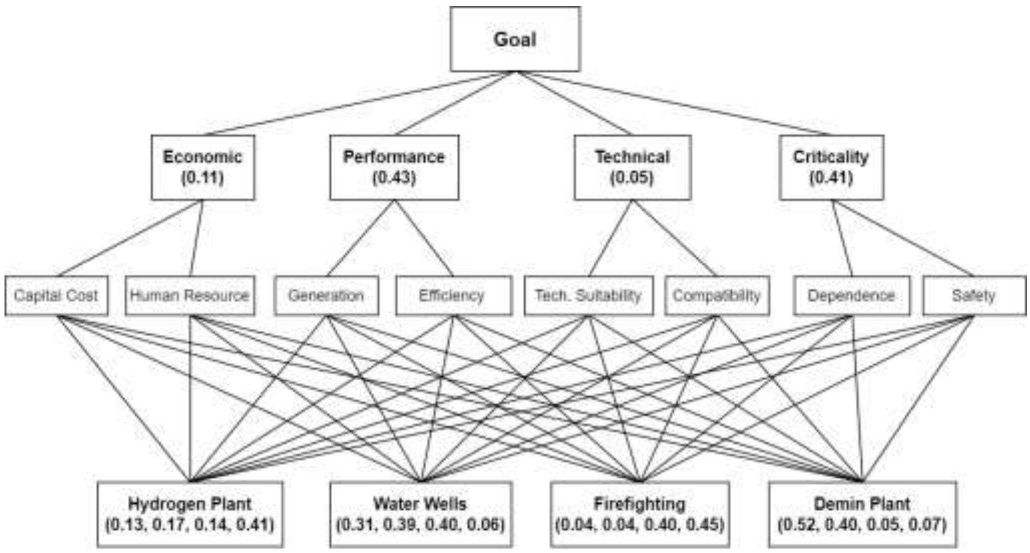

Figure 3: Analytic hierarchy model results

Table 14: Final weights of each alternative (projects)

	Economic	Performance	Technical	Criticality	Total
Hydrogen Plant	0.0148	0.0735	0.0071	0.1717	**0.2672**
Water Wells	0.0345	0.1653	0.0199	0.0266	**0.2464**
Firefighting	0.0045	0.0166	0.0199	0.1865	**0.2276**
Demin Plant	0.0575	0.1696	0.0027	0.0292	**0.2589**
Total					**1.0000**

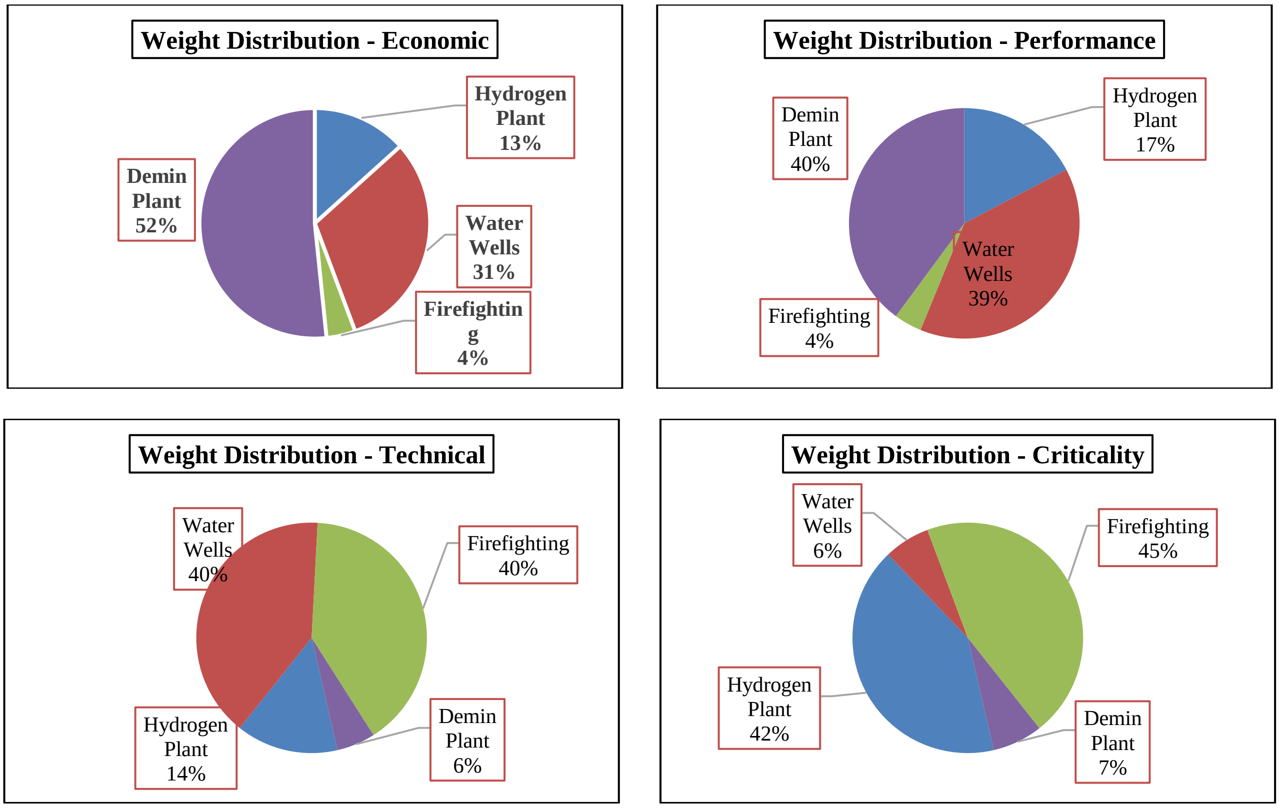

Figure 4: Weight distribution for each criterion

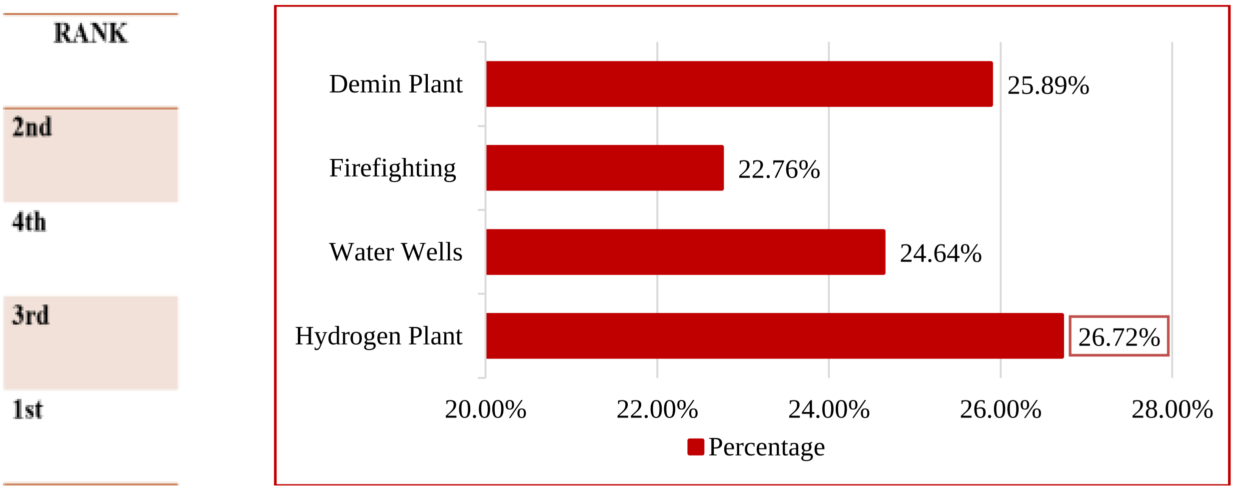

Figure 5: Final rank of Projects

The summary of the goal is presented in Table 14, whereas the weight distribution for each criterion as well as the final rank of projects are summarized in Figure 4 and Figure 5. Here, it can be inferred that the Hydrogen Plant Overhaul

(26.72%) will offer the best value to the company when considering the four criteria that are critical to selection of any project within the organization.

Drilling further down shows Demin plant overall is preferred when the consideration is just Economic or Performance. This can be attributed to the fact that few accessories of this plant need replacement during overall thereby reducing the cost when compared to other projects. Due to its strategic function as the purifier of water before introduction into the Boilers, it is also considered the most favourable when the criterion of Performance in considered. The quality of water goes a long way to determine the performance of the Boiler and Turbine.

It is also important to note that even though Water wells project have a sizable weight across Economic, Performance and Technical criterion, it still ended as the third preferable project. The goes to show the effect of the criteria weight as it influences project selection. The criteria with the highest weights from Table 12 are Performance and Criticality and while the other two hold little weights. Consequently, project that are highly relevant in Performance and Criticality lead the selection process as it is seen evidently in the emergence of Hydrogen plant project which has a significant weight in Criticality and Performance.

4. CONCLUSION

This study demonstrated that the AHP framework, validated with sensitivity analysis and cross-method comparisons, provides a robust decision-support tool for maintenance project prioritization at Egbin Power Plant. The novelty lies in contextual adaptation for Nigerian power infrastructure. Future applications can extend this framework to other power plants across sub-Saharan Africa, supporting sustainable and reliable energy systems.

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