

Exploring Issues and Problems towards Implementing Heating, Ventilation and Air Conditioning (HVAC) Maintenance in the Malaysian Oil and Gas Industry

Mohd Syafiq Syazwan Mustafa

Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia
Corresponding Author Email: mohdsyafiq@uthm.edu.my

Sri Sumarwati

Faculty of Technical and Vocational Education, Universiti Tun Hussein Onn Malaysia

Mohammad Ashraf Abdul Rahman

Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia

Anies Faziehan Zakaria

Faculty of Engineering & Built Environment, Universiti Kebangsaan Malaysia

Amir Abdullah Muhamad Damanhuri

Faculty of Mechanical Technology and Engineering, Universiti Teknikal Malaysia Melaka

Ummu Skainah Subri

School of education studies, Universiti Sains Malaysia

Abdul Muqsith Ahmad

Faculty of Tehcnical and Vocational, Universiti Pendidikan Sultan Idris

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Abstract

Heating, Ventilation, and Air-Conditioning (HVAC) systems are critical in the oil and gas industry. One of the most crucial functions is to help maintain acceptable indoor air quality through proper ventilation while also providing thermal comfort. The research aims to identify the issues and problems of the Malaysian HVAC maintenance O&G industry. This study used the Nominal Group Technique (NGT) to explore the issues and problems of the Malaysian HVAC maintenance O&G industry. The expert panel was chosen with purposive

sampling method. The expert chosen based on their knowledge, skill, and comprehension level of the subject area. NGT participants comprised nine expert panels, and they are knowledgeable and experienced in the HVAC Oil and Gas field. Data was analysed following the NGT process: silence, round robin, discussion, and voting. Results found that the four main HVAC maintenance issues in the Malaysian HVAC maintenance O&G industry are managerial, organizational, technical, and financial. These findings concluded that management, organization, technical and financial issues are all interrelated and have significant impacts on an organization's operations and success.

Keywords: Heating, Ventilation and Air-Conditioning (HVAC), Maintenance, Oil and Gas Industry, Nominal Group Technique (NGT)

Introduction

The oil and gas (O&G) industry is vital to the global economy and high capital-intensive industry. Malaysia's oil reserves are the fourth highest in the Asia-Pacific region. Malaysia become the fifth-largest exporter of liquefied natural gas (LNG) in the world and the second-largest producer of oil and natural gas in Southeast Asia. In addition, this industry has boosted socio-economic well-being by creating jobs, and entrepreneurs, fostering domestic growth, and increasing government revenue through the payment of taxes and royalties. The upstream consists of offshore exploration and hydrocarbon production, which can be either oil or gas production or a combination of the two. While downstream is the final stage, which includes refining, marketing, wholesaling, and retailing known as onshore (Álvarez et al., 2018). Midstream is a distribution system that contains pipelines and tankers for transporting crude oil to refinery plants (Kalita, 2020). The development of the O&G industry as a significant activity in Malaysia led to the enactment of the Petroleum Development Act in July 1974. The establishment of the Petroleum Regulations (1974 further amended in 1975, 1981, and 1991) set out the regulation and licensing of upstream and downstream activities to different entities. Under this Act, Petroleum Nasional Berhad (PETRONAS) oversees all upstream activities, including planning, investment, and regulation. Meanwhile, all downstream activities are regulated by the Ministries of International Trade and Industry (MITI) and Domestic Trade, Co-Operatives, and Consumerism (MDTCC).

All operations in the O&G industry need to be operated with high reliability and availability to sustain the upstream and downstream business of the O&G industry (Mahmood, et al., 2023; Al-Marri et al., 2020). Various machinery and equipment including heavy machinery need to be employed and utilized to create a good operation in the oil and gas business. Therefore, maintenance work is essential in the O&G industry (Mohamed, 2014). Maintenance work can be categorized into two parts, the first is planned maintenance and the second is unplanned maintenance. Industrial maintenance has two primary goals: high availability of production equipment and low maintenance costs (Wari, Zhu & Lim, 2023). An effective maintenance performance can be measured using related machines, costs, maintenance tasks, and customer satisfaction (Lundgren, Bokrantz & Skoogh, 2021). It is divided into two categories: internal factors and external factors. Internal factors are related to maintenance operations (Ngereja & Hussein, 2019), while external factors are related to customer satisfaction (Baquero, 2023). However, the nature and severity of equipment failures in plants is a significant impediment to achieving these goals.

Planned maintenance will also be carried out based on prior knowledge, control, and use of records following the plan that has been set, documented, monitored, and implemented regularly (Hosseinzadeh et al., 2023). Planned maintenance often has very challenging tasks in terms of labor costs as well as equipment replacement (Weidner, 2023). On the other hand, the second type of maintenance is unplanned maintenance. Generally, this planning is corrective in nature. This maintenance will be done if there is any damage or failure refers to work carried out on an emergency basis (Hamasha et al., 2023). Preventive maintenance also includes programs that have been planned and implemented to ensure that specific components are properly maintained. As a result, this type of maintenance can reduce unplanned work and, indirectly, overall costs (Hamasha et al., 2023; Hardt et al., 2021). In general, the equipment used in the oil and gas process is classified as static or rotating (Priyanta, Zaman, & Semin, 2021). Static equipment includes valves, heat exchangers, furnaces, boilers, and HVAC. Rotating equipment includes compressors, pumps, turbines, and induction motors (Das, Das, & Birant, 2023). Heating, Ventilation, and Air-Conditioning (HVAC) systems are critical in the oil and gas industry because they serve several crucial functions to maintain productive operations (Mustafa et al., 2023). This system is gathered by electrical and mechanical components and categorized as a high-end HVAC system: different control systems, materials, and explosion-proof components (Marshall et al., 2019). One of the most important functions is to help maintain acceptable indoor air quality through proper ventilation while also providing thermal comfort. Due to the scarcity of freshwater sources, air-cooled condensing units (ACCU), air-cooled chillers (ACC), and air-cooled split units (ACSU) are used widely in the oil and gas industry, particularly on offshore platforms. ACCU and ACC are linked to a fan coil unit (FCU) or an air handling unit (AHU) to provide cooled air into the living quarters (LQ). A pressurized fan is required to pressurize fresh air into the AHU to prevent toxicity gases from entering the LQ area on an offshore platform. Hydrogen Sulphide (H_2S) is an ordinary toxic gas in oil and gas, and high levels of H_2S can cause shock, convulsions, inability to breathe, extremely rapid unconsciousness, coma, and death.

The Heating, Ventilation, and Air-Conditioning (HVAC) systems are also necessary for serving rooms containing sensitive electrical equipment, such as battery rooms, radio equipment rooms, switchgear rooms, and central control rooms. Malfunction caused by a hot environment to sensitive electrical equipment can result in an electrical failure and the shutdown of the production offshore platform. The impact of an unexpected shutdown will result in massive losses for the oil and gas industry. The HVAC system maintenance in O&G is a crucial component that needs to be handled carefully, and these activities include technical and administrative actions such as planned, scheduled, and team mobilization to deliver maintenance activities efficiently (Mustafa et al., 2022). The maintenance strategies' performance is measured to describe the current performance levels and recommend any necessary action. This may assist in guaranteeing that the correct maintenance strategies are utilized correctly and optimized. Issues and problems encountered in implementing HVAC maintenance in the O&G industry need to be recognized and resolved to ensure an appropriate maintenance strategy. The research aims to identify the issues and problems of the Malaysian HVAC maintenance O&G industry. Besides, this study is made due to a lack of empirical data concerning to HVAC maintenance O&G industry. The issues and problems that have arisen should be identify and resolved to improve HVAC maintenance organization in the future.

Methodology

Nominal Group Technique (NGT) is a structured group process to achieve participant consensus (Parahoo, 2014; Vallabhaneni, 2013). NGT is used in group decision-making and problem-solving settings. Participants identify and contribute ideas to a topic or question that the facilitator specifies as part of the process. NGT is used to generate a large number of ideas and to promote equal involvement and input from all participants and prioritize those ideas. All ideas from participants are considered and evaluated by a majority of votes before decisions generate. The expert panel was chosen as participants based on their knowledge, skill, and level of comprehension of the subject area (McMillan et al., 2016), using purposive sampling. The criteria for selecting participants were critical for improving the Nominal Group Technique reliability and validity, as well as determining appropriate discussion questions. NGT participants comprised nine expert panels who are knowledgeable and experienced in the field of HVAC O&G. Table 1 shows the selected expert panels and the rationale of the experts’ selection is due to their duration of experience, qualification, and experience in handling HVAC operation and maintenance in O&G. At the beginning of an opening session, each participant had the chance to provide their background, current position, and role as well as numbers of experience. Following this, a brief of the topic regarding issues and problems implementing HVAC maintenance in O&G and instruction on the NGT process. The NGT process has four phases as shown in Figure 1.

Table 1
Selected Expert Panel in NGT

| Position | Duration of Experience | Qualification | Nos | Field experience |
|------------------------------------|------------------------|-------------------|-----|---|
| HVAC Specialist | > 15 years | Bachelor’s Degree | 2 | |
| Operation Manager | 10-15 years | Bachelor’s Degree | 2 | HVAC O&G |
| HVAC Engineer | 10-15 years | Bachelor’s Degree | 2 | |
| Group Technical Support Manager | > 15 years | Bachelor’s Degree | 1 | |
| Electrical and Instrument Engineer | 10-15 years | Bachelor’s Degree | 1 | Electrical and Instrumentation (HVAC) O&G |
| Head of Department | 10-15 years | Bachelor’s Degree | 1 | |

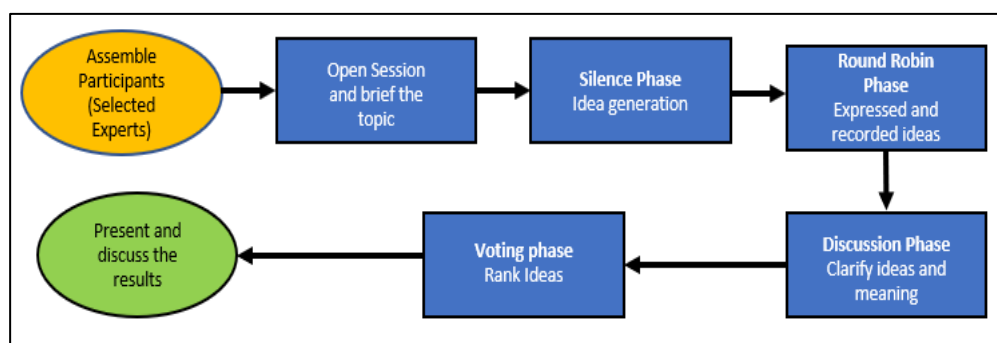


Figure 1. NGT phases to identify issues and problems in implementing HVAC maintenance in Malaysian O&G industry

Silence Phase

Participants have ten minutes to generate the idea silently and record all personal responses and relevant ideas to the topic given by the researcher. Participants are not allowed to have discussions during this phase. However, participants could raise their hands if any clarification about the topic.

Round Robin Phase

The recorded personal responses and ideas need to be expressed by participants. In this phase, no new ideas are generated, and discussions are not allowed among participants.

Discussion Phase

Participants listed all the ideas generated on the screen board. All participants need to clarify their ideas and provide additional information about their responses. At this phase, duplicate items may be removed, if having similar meanings.

Voting Phase

Based on agreed issues and problems, each participant is requested to rank the listed sub-construct in order of importance. The ranking used to be a good advantage on a scale of one to five, where one strongly disagrees and five strongly agree. The overall priority score for the subconstruct was then determined using the sum of votes allocated to each subcategory. The discussion among participants has been recorded to get more information and clarification on the listed category and subcategory.

Results and Discussion

In this research, the main issues in implementing HVAC maintenance for the Malaysian O&G industry have been identified based on the ideas of experts. Results found that the four main HVAC maintenance issues in the Malaysian HVAC maintenance O&G industry are management, organization, technical, and financial.

Management Issue

Based on Table 2, the NGT results show five problems regarding management issues agreed upon by experts in this study: lack of knowledge of technical, management, and commercial, lack of contract agreement understanding, improper plan, coordination, and delegation, change of company direction, and poor networking.

Table 2

Ranking Result for Management Issue and Problems

| Category | Problem | Summing by Votes | | | | | Total % | Priority Rank |
|------------------|--|------------------|---|---|---|---|---------|---------------|
| | | 5 | 4 | 3 | 2 | 1 | | |
| Management issue | Lack of knowledge of technical, management, and commercial | 5 | 3 | 1 | 0 | 0 | 89% | 1 |
| | Lack of contract agreement understanding | 5 | 2 | 2 | 0 | 0 | 87% | 2 |
| | Improper plan, coordination, and delegation | 3 | 5 | 1 | 0 | 0 | 84% | 3 |
| | Change of company direction | 1 | 5 | 3 | 0 | 0 | 76% | 4 |
| | Poor networking | 0 | 3 | 4 | 2 | 0 | 62% | 5 |

The biggest problem that has been ranked was the lack of knowledge in technical, management, and commercial with 89% of votes. Followed by the lack of contract agreement, improper planning, coordination, and delegation, change of company direction, and poor networking with votes of 87%, 84%, 76%, and 62%. All the issues and problems in the management are interconnected to the management team. The management team is essential to a maintenance management system's effectiveness. The management teams must have the ability to have a substantial impact on both organizations and individuals. In this view, the management team should play a crucial role in understanding the workflow in maintenance operations related to effective maintenance strategies and improving the system's reliability with the right maintenance activities that can be implemented for the O&G HVAC system. It includes the right decision in scheduling preventive maintenance, ordering spare parts, and prioritizing the repairs. In management, the lack of knowledge can hinder the ability to effectively lead a team and make strategic decisions, which can negatively impact the overall success of the maintenance organization. This result is supported by (Singh & Twalo, 2015), which shows that poor job behavior and performance of employees are due to the poor management system. The operation manager was responsible for improvement acting in maintenance management to overcome the management issues and problems. The operation manager shall understand contracts and agreements as critical documents that define the terms and conditions of a business relationship and provide legal protection for all parties involved. A manager who lacks an understanding of contracts may fail to identify crucial clauses or obligations, resulting in legal disputes, financial losses, and damaged business relationships (Jiang et al., 2022). Managers must thoroughly understand contract terms, conditions, and legal implications to ensure that they comply with the terms of the agreement and protect their company's interests.

Organization Issue

Six problems have been specified in organization issues as shown in table 3. The three highest-ranking problems, with the range of 98% to 94%, were unclear job scopes and descriptions, difficulty in finding and keeping skilled workers, shortage of skilled workers. Lack of proper training schemes and lack of cooperation and communication were indicated by < 80% and the lowest ranked was trust among organization at 76%.

An organization issue refers to the lack of skills, knowledge and experience among employees and leadership, which leads to poor performance and outcomes. It can stem from various factors such as inadequate training and development, poor hiring practices, or a lack of resources or support. Based on research findings by (Dunning et al., 2003; Carlton & Peszynski, 2018) shows that incompetence within an organization refers to a lack of skills and knowledge. The findings of the study (Deng et al., 2023) show that incompetence is a lack of experience that will tarnish an employee's professional image in the organization. An incompetent organization may struggle to innovate, adapt to change, or meet the needs of its customers, putting the company at a competitive disadvantage. To address incompetence, organizations must identify areas of weakness and invest in training, development, and support to build the necessary skills and expertise (Walters & Rodriguez, 2017). They must also ensure that hiring practices prioritize the recruitment of skilled and qualified employees and that performance management processes are in place to monitor and improve employee performance.

Table 3

Ranking Results for Organization Issues and Problems

| Category | Problem | Summing by Votes | | | | | Total % | Priority Rank |
|--------------------|---|------------------|---|---|---|---|---------|---------------|
| | | 5 | 4 | 3 | 2 | 1 | | |
| Organization issue | Unclear job scopes and descriptions | 8 | 1 | 0 | 0 | 0 | 98% | 1 |
| | Difficulty in finding and keeping skilled workers | 7 | 2 | 0 | 0 | 0 | 96% | 2 |
| | Shortage of skilled workers | 6 | 3 | 0 | 0 | 0 | 93% | 3 |
| | Lack of proper training schemes | 4 | 4 | 1 | 0 | 0 | 87% | 4 |
| | Lack of cooperation and communication | 1 | 8 | 0 | 0 | 0 | 82% | 5 |
| | Trust among organizations | 0 | 7 | 2 | 0 | 0 | 76% | 6 |

The shortage of skilled workers in HVAC maintenance in the oil and gas industry is a significant challenge faced by organizations worldwide (Poláková et al., 2023). One of the main reasons for this shortage is the lack of focus on technical education and training. With the changing needs of the industry, workers with technical skills are in high demand but in short supply. Furthermore, the oil and gas industry are known to be hazardous and requires specialized equipment. Therefore, the industry demands a specific skill set that is difficult to develop through traditional training methods. Another factor contributing to the shortage of skilled workers is an aging workforce. Many skilled workers in the industry are retiring, and there are not enough new workers to replace them. Additionally, the industry is facing fierce competition from other sectors that are also seeking workers with technical skills, such as technology and engineering (Poláková et al., 2023). This competition makes it challenging for the oil and gas industry to attract and retain skilled workers. To address this challenge, based on results by (Whitehead, 2022), organizations need to invest in training programs to develop and retain their workforce. They should also consider partnering with educational institutions to develop specialized training programs that meet industry needs. Additionally, companies could offer incentives to attract and retain skilled workers, such as competitive salaries and benefits packages, training opportunities, and opportunities for career advancement. These measures can help address the shortage of skilled workers and ensure that the industry has the talent it needs to continue to thrive.

Lack of cooperation and communication among HVAC maintenance organizations can lead to inefficiencies and reduced productivity. Without proper communication, workers may not have access to critical information, leading to delays in maintenance activities and potentially causing safety hazards (Campbell, Campbell-Phillips & Phillips, 2020). Additionally, lack of cooperation can lead to duplication of effort, wasted resources, and conflicts among team members. To address this issue, results by (Zirignon & Lindberg, 2020) found that organizations need to establish clear lines of communication and foster a culture of collaboration. Organizations can achieve clear communication by implementing regular meetings, clear reporting structures, and digital tools to share information and facilitate collaboration. Organizations can improve productivity, safety, and overall performance by fostering cooperation and communication.

Technical Issue

According to the result as shown in Table 4, there are seven problems ranking $\geq 80\%$ regarding technical issues: scheduling a person on board, the flammable refrigerant in the HVAC system, lack of maintenance data analysis, ineffective maintenance strategies, delivery spare parts, corrosion, shortage spare parts. However, logistic, evolution of technology, and lack of tools to execute maintenance work rank $< 80\%$.

Table 4
Ranking Results for Technical Issues and Problems

| Category | Problem | Summing by Votes | | | | | Total % | Priority Rank |
|---|------------------------------------|------------------|---|---|---|-----|---------|---------------|
| | | 5 | 4 | 3 | 2 | 1 | | |
| Technical issue | Scheduling a person on board | 4 | 4 | 1 | 0 | 0 | 87% | 1 |
| | The flammable refrigerant | 3 | 5 | 1 | 0 | 0 | 84% | 2 |
| | Lack of maintenance data analysis | 3 | 5 | 1 | 0 | 0 | 84% | 2 |
| | Ineffective maintenance strategies | 3 | 4 | 2 | 0 | 0 | 82% | 3 |
| | Delivery spare parts | 1 | 8 | 0 | 0 | 0 | 82% | 4 |
| | Corrosion | 2 | 5 | 2 | 0 | 0 | 80% | 5 |
| | Shortage spare parts | 1 | 7 | 1 | 0 | 0 | 80% | 6 |
| | Logistic | 1 | 6 | 2 | 0 | 0 | 78% | 7 |
| | Evolution of technology | 0 | 8 | 1 | 0 | 0 | 78% | 8 |
| Lack of tools to execute maintenance work | 0 | 7 | 2 | 0 | 0 | 76% | 9 | |

The HVAC maintenance in the oil and gas industry in Malaysia faces various technical issues and problems. The technical issue due to the dynamic, risky and hazardous which the equipment needs to be operated (Sehrawat et al., 2020). The equipment must endure extreme temperatures and corrosive conditions while maintaining efficiency and reliability. As result, issues such as corrosion, leakage, and equipment failure are common (Wasim & Djukic, 2022). Therefore, maintenance needs to be executed for all equipments and required maintenance woker to stay on board.

Another challenge is the need to comply with various regulatory requirements, particularly in terms of safety and environmental standards. The use of different types of equipment and the need for frequent maintenance and repair can also increase costs and downtime. Additionally, there is a shortage of skilled and experienced technicians in the

industry, leading to challenges in finding qualified personnel to perform maintenance tasks. To overcome these challenges, companies must invest in the training and development of their maintenance staff, utilize advanced technologies for maintenance, and implement robust safety and environmental management systems to ensure compliance with regulations.

Flammable refrigerants are a type of refrigerant used in HVAC systems that have a higher potential to ignite and cause a fire or explosion compared to non-flammable refrigerants. Flammable refrigerants are becoming increasingly popular due to their higher energy efficiency and lower environmental impact (Petersen et al., 2018). However, they require special handling and installation procedures to prevent fire hazards. According to findings by (Martinho et al., 2023) found that proper training of HVAC technicians is crucial in the safe handling and installation of these refrigerants. Additionally, building codes and regulations require specific safety measures to be in place for the use of flammable refrigerants in HVAC systems. It is crucial to follow building codes and regulations to ensure the safe use of flammable refrigerants in HVAC systems. Lack of maintenance data analysis refers to the failure to analyze and interpret the data collected from maintenance activities. This can result in missed opportunities to identify patterns, trends, and areas of improvement. Without analyzing the data, organizations may not be able to identify potential issues before they become major problems or take advantage of opportunities for cost savings and efficiency gains. Maintenance data analysis can provide valuable insights into equipment performance, maintenance costs, and overall operational efficiency (Hamasha et al., 2023). It can also help to identify areas where maintenance strategies can be improved, such as identifying which maintenance tasks are most effective in preventing failures and optimizing maintenance schedules. To address the lack of maintenance data analysis, organizations need to invest in tools and resources that allow them to collect, store, and analyze data effectively. They should also ensure that their maintenance personnel are trained in data analysis techniques and have access to the necessary tools and resources. By leveraging maintenance data analysis, organizations can improve their maintenance strategies, reduce costs, and optimize their operations.

Maintenance logistics are useful in ensuring reliability and overall operating costs within industries critical for advanced technical systems. This research found that HVAC maintenance in the oil and gas industry faces problems in logistics and the evolution of technology. This finding supports the study (Nowakowski, Tubis & Werbińska, 2019) and shows the importance of technical like logistics, and the evolution of technology to meet increasingly higher demands in the quality area. A responsive logistics network can lead to increased quality maintenance services (Manikas, Sundarakani & Iakimenko, 2019). In many companies, tools to execute maintenance work are not properly controlled and have an impact on the company's production capacity (García & García, 2018). This study shows that the problem regarding technical issues is the lack of tools to execute maintenance work. These results supporting research findings by (Hauashdh et al., 2020) that found the lack of tools to execute maintenance work causes difficulties in the decision-making process and can impact their work performance.

Financial Issue

This study found seven problems regarding financial issues: lack of budget and financial allocation, lack of maintenance operational expenditure analysis, cut-off budget in maintenance, company financial crisis, weakness of implementing payment procedure, inflation rate, economy fluctuation, and fluctuations in exchange rates as shown in table 5. Financial issues can also be a significant challenge for HVAC maintenance in the oil and gas industry in Malaysia. The cost of equipment, supplies, and personnel can be high, and maintenance activities can represent a significant portion of an organization's budget. Additionally, the industry can be subject to fluctuations in oil prices and market demand (Sun, Cai, & Huang, 2022), leading to budget cuts and financial constraints. These financial issues can impact the ability to invest in new technologies, training, and development, leading to a lack of innovation and competitiveness. To overcome these financial issues, organizations must adopt cost-effective maintenance strategies that focus on preventive maintenance and optimal resource utilization. They can also explore alternative financing models, such as leasing, to reduce upfront costs and manage cash flow. Additionally, (Soori, Arezoo & Dastres, 2023) concluded that investing in new technologies, such as IoT-enabled sensors and predictive maintenance software, can help optimize maintenance activities and reduce costs over time. Optimal maintenance and investment strategies of various aims to improve operations and to study the long-term effects of maintenance expenditures (Weidner, 2023). A cut-off budget is reduced from the previous period's budget, often as a result of cost-cutting measures. In HVAC maintenance in the oil and gas industry, a cut-off budget can have significant impacts on the maintenance operations. A reduction in the budget could mean a reduction in the resources available to conduct maintenance activities, leading to a potential increase in equipment failures, downtime, and safety hazards

Table 5

Ranking Result for Financial Issue and Problems

| Category | Problem | Summing by Votes | | | | | Total % | Priority Rank |
|-----------------|--|------------------|---|---|---|---|---------|---------------|
| | | 5 | 4 | 3 | 2 | 1 | | |
| Financial issue | Lack of budget and financial allocation | 4 | 4 | 1 | 0 | 0 | 87% | 1 |
| | Lack of maintenance operational expenditure analysis | 2 | 6 | 1 | 0 | 0 | 82% | 2 |
| | Cut-off budget in maintenance | 3 | 4 | 2 | 0 | 0 | 82% | 3 |
| | Company financial crisis | 2 | 5 | 2 | 0 | 0 | 80% | 4 |
| | Weakness of implementing payment procedure | 2 | 5 | 1 | 1 | 0 | 78% | 5 |
| | Inflation rate and economy fluctuation | 1 | 4 | 4 | 0 | 0 | 73% | 6 |
| | Fluctuations in exchange rates | 1 | 3 | 5 | 0 | 0 | 71% | 7 |

Cut-off budget can also lead to reduced maintenance activities (Barroy et al., 2021), such as a reduction in preventive maintenance, which can cause a decrease in the overall reliability of the equipment. Additionally, the cost of repair and replacement may increase if maintenance is deferred, leading to a potential increase in overall maintenance costs. Organizations should consider alternative maintenance strategies that can optimize maintenance activities with limited resources (Yıldız & Soylu, 2023). To address the impact of cut-off budgets in HVAC maintenance in the oil and gas industry, these strategies may include a focus on preventive maintenance, predictive maintenance, or prioritizing critical equipment

for maintenance activities. Organizations should also consider developing a contingency plan to address unexpected equipment failures and prioritize safety measures. By taking a proactive approach to address the impact of cut-off budgets on maintenance operations, organizations can improve equipment reliability, reduce costs, and maintain a safe working environment. Implementing a payment procedure in an organization is crucial to ensure that payment processes are streamlined, efficient, and accurate. However, some weaknesses can arise from implementing payment procedures. One common weakness is the potential for errors in the payment process, which can occur due to mistakes in data entry or processing. This can lead to delayed payments, incorrect payments, and even potential fraud. Another weakness is the potential for the payment process to become too rigid or inflexible, leading to delays or complications in processing payments. Additionally, implementing payment procedures can be time-consuming and costly, requiring resources for training and technology implementation. According to (Abei, 2021), to address these weaknesses, organizations should implement strong internal controls and checks to ensure accuracy and minimize the potential for errors or fraud. It is also important to regularly review and update payment procedures to ensure they remain efficient and effective in meeting the organization's needs.

A company financial crisis in a maintenance organization can occur when the organization is facing financial difficulties that may affect its ability to operate effectively. This can happen due to a variety of factors: economic downturns, increased competition, poor financial management, or unexpected expenses. In such situations, the maintenance organization may experience a reduction in funding and resources, can lead to delays in maintenance activities, reduced maintenance quality, and increased equipment downtime. The financial crisis may also lead to employee layoffs or reduced pay, affecting the morale and motivation of the workforce. Therefore, based on research findings (Mujtaba & Senathip, 2020) found that employee layoffs cause employees to have low morale because of fear of losing their jobs. To address a financial crisis, the maintenance organization needs to assess its financial situation, identify areas where cost savings, prioritize maintenance activities based on criticality, and seek alternative sources of funding or partnerships. The organization may also need to consider restructuring its operations or seeking expert financial advice to navigate through the crisis.

Inflation rates and economic fluctuation have a significant impact on the oil and gas industry. The result study (Choi et al., 2023) shows that the price of oil has received significant attention especially if linked to the impact of fluctuations in global oil prices on domestic inflation. Inflation can cause an increase in the cost of materials, labor, and services, which can increase the overall cost of production and impact profitability. Additionally, fluctuations in the economy can impact on the demand for oil and gas products, affecting revenue and profitability. The industry is also affected by global political and economic instability, which can result in supply disruptions and price fluctuations. The oil and gas industry must implement effective cost management strategies, including optimizing production and reducing waste, to ensure profitability and address the impact of inflation and economic fluctuations. The industry must also maintain flexibility and agility to respond to market fluctuations and seek new opportunities for growth and diversification. According to (Pinho, 2023), agility is a collective that involves opportunities for overcoming threats through flexible sourcing arrangements. Additionally, the industry must prioritize innovation and technology

development to improve efficiency, reduce costs, and remain competitive in a changing economic landscape.

Comparison for Overall Issue

Based on the findings in this study, the four main HVAC maintenance issues and problems in the Malaysian HVAC maintenance O&G industry are managerial, organizational, technical, and financial. The comparison of the overall issues of the Malaysian HVAC maintenance O&G industry is shown in Figure 2.

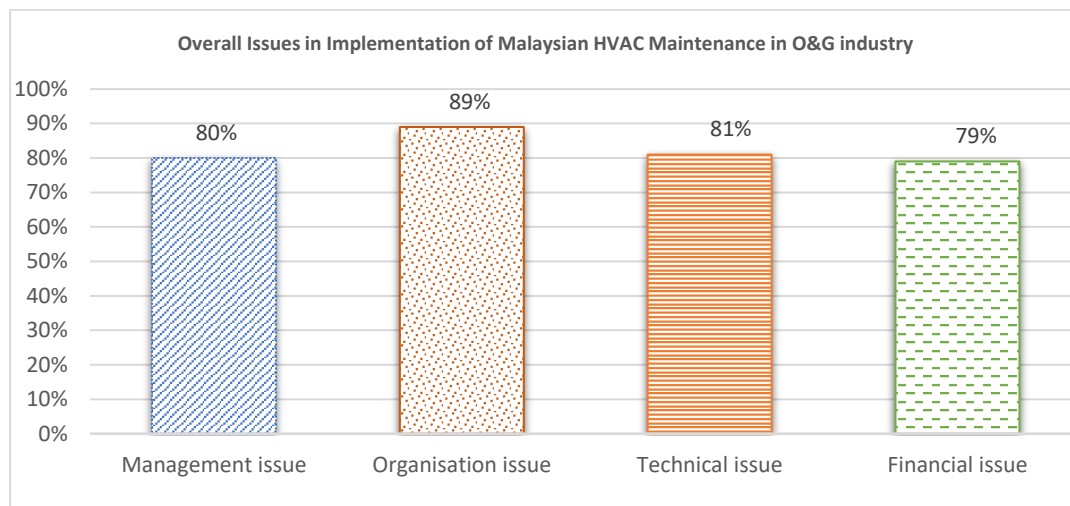


Figure 2. Overall Issues in implementation of Malaysian HVAC maintenance in the O&G

management, organization, technical and financial issues are all interrelated and have significant impacts on an organization's operations and success. Management issue leads to poor decision-making, lack of direction, and allocation of resources (Figuerola et al., 2019). organization issue can result in poor performance, decreased productivity, and increased costs. Technical issues can result in equipment failure, downtime, and increased repair costs. Financial issues can lead to budget constraints, limited resources, and an inability to invest in new technologies and development. In contrast, effective management can provide direction, clarity, and support for employees, leading to increased productivity and reduced costs. According to (Farida & Setiawan, 2022), a competent organization can improve performance, innovation, and competitiveness. Addressing technical issues can improve equipment reliability, reduce downtime, and optimize maintenance processes. Resolving financial issues can enable investment in new technologies, development, and innovation, improving competitiveness and financial stability. In summary, addressing these issues and promoting effective management, competence, technical expertise, and financial stability is crucial to achieving operational excellence and long-term success for an organization.

Conclusion

The study aims to identify the issues and problems of the Malaysian HVAC maintenance O&G industry. Results found that the four main HVAC maintenance issues in the Malaysian HVAC maintenance O&G industry are management, organizational, technical, and financial. Results in this study show four problems based on management issues: lack of knowledge of technical, management, and commercial, lack of contract agreements understanding, improper plan, coordination, and delegation, change of company direction, and poor

networking. This research found six problems regarding organization issues: unclear job scopes and descriptions, difficulty in finding and keeping skilled workers, shortage of skilled workers, lack of proper training schemes, lack of cooperation and communication, and trust among organizations. Besides, there are nine problems regarding technical issues: scheduling a person on board, the flammable refrigerant in the HVAC system, lack of maintenance data analysis, ineffective maintenance strategies, delivery of spare parts, corrosion, shortage of spare parts, logistics, evolution of technology, and lack of tools to execute maintenance work. This study also found seven problems regarding financial issues: lack of budget and financial allocation, lack of maintenance operational expenditure analysis, cut-off budget in maintenance, company financial crisis, weakness of implementing payment procedure, inflation rate, economy fluctuation, and fluctuations in exchange rates. In conclusion, ineffective management, incompetence organization, technical issues, and financial issues can all have significant negative impacts on an organization's operations, productivity, and success. Addressing these issues is crucial to achieving operational excellence and maintaining competitiveness in today's fast-paced business environment. Effective management can provide direction, support, and resources to employees, leading to increased productivity and reduced costs. A competent organization can improve performance, innovation, and competitiveness. Resolving technical issues can improve equipment reliability, reduce downtime, and optimize maintenance processes. Finally, resolving financial issues can enable investment in new technologies, development, and innovation, improving competitiveness and financial stability. By addressing these issues, organizations can build a strong foundation for growth, adapt to change, and achieve long-term success in their industry.

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