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WATER-FOOD-ENERGY NEXUS

**Embracing Nature:
Water Resilience Through
Nature-Based Solutions**

MARCH 2025

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BEYOND CONVENTIONAL METHODS:

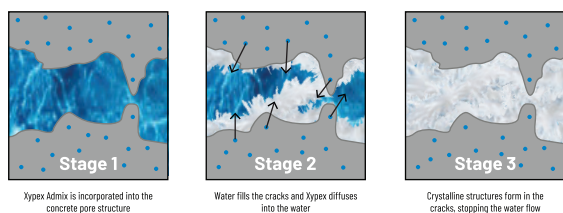
How Xypex Waterproofing Improves Below-Grade Concrete Performance

Concrete permeability critically affects structural integrity: water infiltration can lead to reinforcement corrosion, freeze-thaw damage, and chemical degradation. This article presents data-driven evidence of Xypex technology's efficacy.

A Superior Solution

Waterproofing membranes are prone to punctures, UV light, and mechanical stress. The ACI 212.3R-10 report notes that while hydrophobic admixtures (PRAN) repel water at the surface but fail under hydrostatic pressure, in contrast Xypex crystalline admixtures (PRAH) chemically react with water and cement by-products to form crystals that block pores, self-heal micro-cracks, and resist elevated hydrostatic pressure. The European regulation EAD 260026-00-0301 requires a "Waterproofing Admixture" withstand over 16,600 times the hydrostatic pressure of a "Water-Resistant Admixture." Xypex Admix was the first to achieve this certification and, over two years later, remains the only crystalline to do so, setting an industry benchmark.

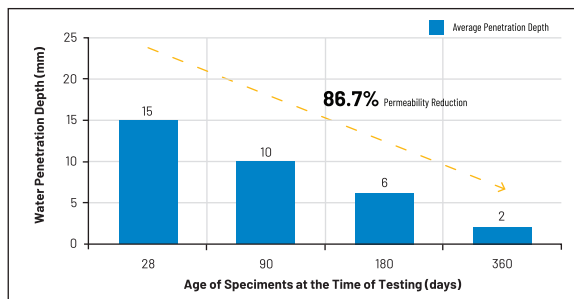
How Xypex Works



Performance Data

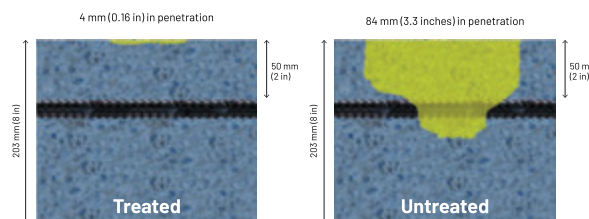
Independent testing (PERM-245) analyzed 225 test sets from 160 projects across 20 concrete batch plants in five countries. Over 360 days, Xypex-treated concrete showed an average water penetration reduction of 86.67%.

Depth of Penetration vs. Time (PERM-245)



Another independent study (PERM-200) using DIN 1048 standard found untreated control samples had 84 mm (3.3 in) water penetration under a 70 m (230 ft) hydraulic head, while Xypex-treated samples had only 4 mm (0.16 in), a 95% reduction.

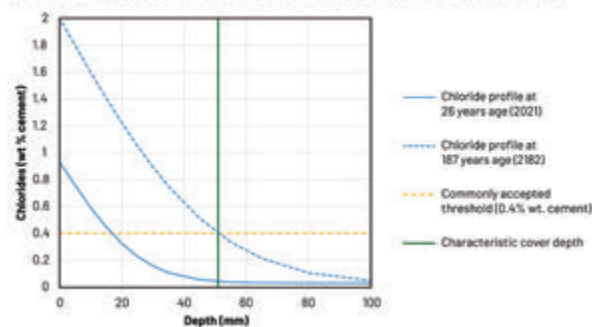
Crystalline Effect on Concrete (PERM-200)



Long-Term Performance Validation: Australian Case Study

Xypex-treated concrete improves over time. In 1995, Xypex Admix C-Series treated slabs were installed at Lascelles Wharf, Australia. Independent integrity tests in 2014 and 2021 (CHEM-155) used Fick's Second Law of Diffusion to predict lifespan. In 2014, tests showed low chloride penetration and no significant carbonation, indicating a 164-year lifespan. By 2021, zero carbonation and even lower chloride penetration extended the estimate to 187 years. This demonstrates Xypex's ability to enhance concrete durability over time.

Predicted Service Life: Chloride diffusion 2021 – 2182 (CHEM-155)



Conclusion

With over 55 years of proven performance in more than 90 countries, Xypex offers a durable, self-healing waterproofing and protection solution. Its exclusive crystalline approach ensures long-term structural integrity, reduced maintenance, and peace of mind for engineers, builders, developers and owners.



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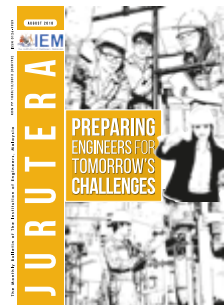
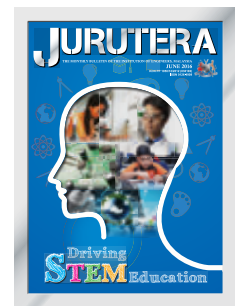
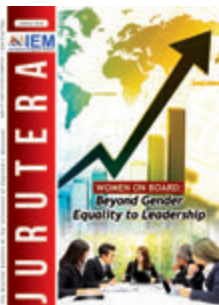
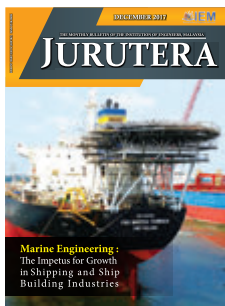
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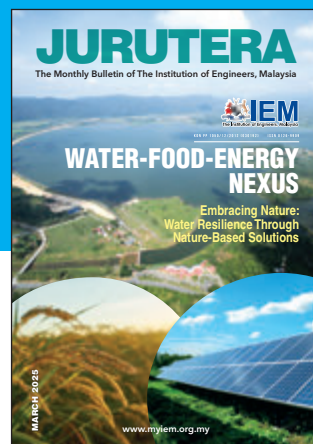
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COVER *Note*

by **Ir. Cheok Hou Seng**

Chairman, Water Resources Technical Division (WRTD)



Water-Food-Energy Nexus

It is my pleasure to introduce this month's bulletin, which explores the theme, Water-Food-Energy Nexus, a topic of paramount importance in today's world. As engineers, planners, policy makers, and industry leaders, we recognise that water, food, and energy are resources critical for the survival and sustenance of human civilisation. Water, food and energy are not isolated sectors but are deeply interdependent. Addressing challenges in one area inevitably affects the others and it is through integrated solutions that we can achieve sustainability.

Like many nations, Malaysia faces increasing pressure to balance water security, food production, and energy generation in the face of climate change, population growth, and urbanisation. The articles in this edition provide insights into innovative engineering solutions, policy recommendations, and case studies that highlight the importance of a holistic approach to managing these resources. From exploring more sustainable water resources and adapting an integrated water resources management approach to nature-based solutions and innovations that we can adopt in the food and energy sectors, our contributors offer perspectives that can inspire meaningful change.

IEM WRTD remains committed to fostering knowledge sharing and collaboration in these critical areas. We hope that this bulletin serves as a valuable resource to deepen our understanding and spark discussions on how we, as professionals, can contribute to a more resilient and sustainable future.

Thank you for your continued support. ■

EDITOR'S *Note*

by **Ir. Alex Looi Tink Huey**

Principal Bulletin Editor



Engineering the Lifelines: Water, Food & Energy in Balance

Water, food, and energy – the unbreakable triad that sustains civilisation. Yet, their delicate balance is increasingly under strain. In Malaysia, where our rainforests breathe life and our rivers carve history, engineers stand at the crossroads of innovation and necessity.

This month, *JURUTERA* explores the Water-Food-Energy Nexus, a puzzle where solutions in one sector ripple across the others. Can we harness hydro-powered agriculture? Will AI optimise irrigation for food security? How do we fuel industries while keeping our water sources pristine?

From cutting-edge desalination to smart grid resilience, our contributors dive into the heart of sustainable engineering. We also spotlight the role of policies, digitalisation, and bold engineering feats shaping Malaysia's future.

So, dear readers, let's engineer a world where every drop counts, every watt empowers, and every meal nourishes... without tipping the balance. Because in this nexus, the future isn't just built – it's carefully woven. ■

Water-Food-Energy Nexus



*The water-food-energy nexus is a critical framework for understanding the interdependent relationships between the three essential sectors. This nexus highlights the importance of integrated management to ensure sustainability and resilience across all three sectors. **YAB Dato' Sri Haji Fadillah Haji Yusof**, Deputy Prime Minister and Minister of Energy Transition & Water Transformation (PETRA), tells us more about the nexus.*



What challenges and opportunities should Malaysia address to achieve a more synergistic and integrated management of water that correlates to food and energy sectors?

The water-food-energy nexus is a vital framework for ensuring the sustainability, resilience, and security of Malaysia's essential resources. Water is needed for energy generation and agriculture; energy powers water treatment and food production, and food systems rely on both water and energy. This interconnection means that inefficiencies or disruptions in one sector can have severe cascading effects on the others, particularly in the face of climate change, population growth, and resource scarcity.

The Malaysian government has taken proactive steps to implement key policies which includes Integrated Water Resources Management (IWRM), National Food Security Policy and The Malaysia Renewable Energy Roadmap (MyRER). Each policy aims to optimise water use and protect our ecosystems, build a resilient and self-sufficient food system and transition towards 70% renewable energy capacity by 2050.

While these initiatives mark significant progress, we must go further to break down silos and facilitate interministerial co-operation and governance which are paramount in achieving actual policy alignment.

Synergy across ministries will be made possible by optimising data-sharing platforms.

The implementation of integrated planning and smart resource management, enhancing efficiency through innovation and circular solutions, and fostering collaboration between government, private sector, and communities are also crucial to ensure sustainability of the nexus.

The Ministry of Energy Transformation & Water Transformation (PETRA) is also progressively increasing data-driven and intelligent resource management, including AI-driven monitoring systems to optimise the allocation of water, energy, and food resources as well as real-time climate forecasting and early warning systems to lessen the effects of extreme weather.

Malaysia is endowed with abundant water resources. Paradoxically, while excessive water often leads to flooding, the agriculture sector still faces water shortages, preventing the nation from achieving its food security targets. This raises an essential question: What has gone wrong with our water management systems? What strategies and actions can be implemented to ensure effective water management to meet both immediate and long-term food security goals?

Water is the lifeblood of a nation. Malaysia has an average annual rainfall of 3,000 mm and 2,986 river basins, including 189 major river basins. Over 90% of the nation's water supply comes from these rivers. Yet, according to the Department of Irrigation & Drainage (DID), 13.4% of Malaysia is prone to flooding, impacting 32% of the population. However, while floods devastate communities, our farmers struggle with water shortage, and this hampers food security efforts.

Every Drop Matters: Holistic Water Management

To address these challenges, a paradigm shift towards integrated water resources management (IWRM) to balance flood mitigation, agriculture, and urban water supply needs is paramount in managing the challenges of divided authority to attain effective and resilient water management. Integrated River Basin Management (IRBM) plans, which are progressively prepared by the DID, aims to achieve four main objectives, including ensuring clean water and sufficient water supply, reduction of flood risk and protecting the environment. These plans and policies will enhance coordination, eliminate redundancies, and ensure a comprehensive, long-term strategy for sustainable water management.

Leveraging on Technology: National Water Balance Systems (NAWABS)

The Government, through DID, has embarked on the development of NAWABS, a state-of-the-art, comprehensive digital tool for integrated water resources management.

NAWABS utilises hydro-meteorological data combined with hydrological and hydraulic models to monitor and forecast water availability. The system offers real-time information on water resources, enabling early drought forecasts up to two months in advance and issuing drought warnings 14 days ahead. This early warning capability allows relevant agencies to implement timely mitigation measures, thereby reducing the impact of water-related disasters.

The system has been implemented in various river basins in Malaysia, including the Muda River Basin (Kedah), and the Perak, Kurau, and Kerian River Basins (Perak). In these regions, NAWABS helps to balance water supply and demand by assessing current and projected water availability, accounting for various uses such as domestic consumption, agriculture, industry, and environmental needs. It also evaluates operational strategies to ensure efficient water allocation and sustainability.

Thinking Out of the Box: Multi-purpose Storage

Multi-purpose storage ponds are an effective measure which can help capture and attenuate flood flows during wet seasons and, later, serve as water resources during dry seasons for potable and non-potable water supply. The government is

also promoting rainwater harvesting to capture stormwater for use as non-potable water, reducing the burden of using treated water in domestic, commercial and industrial sectors. The government also promotes the use of reclaimed water for non-potable usage to further reduce the demand for industrial treated water.

Agriculture is the cornerstone of food production and economic growth, but it is also a major consumer of water and a significant contributor to water quality degradation in river basins. What approaches and measures should be implemented to ensure sustainable management of water quantity and quality, balancing the needs of agricultural food production with the well-being of people and the environment?

Agriculture is not only the backbone of Malaysia's food security but is also a key driver of the economy. However, it is a major consumer of water, accounting for over 70% of national water use and a contributor to water pollution through excessive irrigation, chemical fertilisers, and improper land management. If left unaddressed, these issues threaten water availability, food security, and environmental sustainability.

To balance agricultural productivity with water conservation, the government is committed to implementing integrated water management strategies that support both farmers and ecosystems. Our approach is centred on 3 key pillars, namely:

- Efficient water use in agriculture
- Protecting water quality from agriculture pollution and
- Strengthening policy, governance, and climate adaptation.



Biodata of Interviewee

YAB Dato' Sri Haji Fadillah Haji Yusof is Deputy Prime Minister and Minister of Energy Transition & Water Transformation (PETRA). He has been a member of Parliament since 2004. His previous roles in the government included Minister of Plantation & Commodities (2022/2023), Senior Minister of Works (2021/2022), Senior Minister of Infrastructure & Minister of Works (2020/2021), Minister of Works (2013-2018) as well as Deputy Minister of Science, Technology & Innovation (2008-2013).





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These three pillars are supported by the strategies of leveraging technology in improving water availability and consumption, implementation of sustainable land management, and inclusivity of the stakeholders.

In Malaysia, energy generation is predominantly powered by thermal and hydropower sources. Thermal power plants, while essential, rely heavily on cooling processes, which can put a strain on local water resources, especially in our tropical climate. What strategies should we adopt to ensure the efficient management of both water and energy resources, maximising their potential while maintaining a sustainable balance with river basins and the environment?

Energy and water are deeply interconnected. Energy generation requires water and water management depends on energy. In Malaysia, thermal power accounts for 74% of installed capacity and hydropower plays a growing role.

Thermal power plants, particularly those using coal, natural gas, and oil, require substantial water for cooling. Meanwhile, large hydropower projects impact river ecosystems and water availability downstream. Without strategic management, these dependencies can strain our natural water resources, disrupt river basins, and compromise environmental sustainability.

To maximise energy potential while maintaining water sustainability, PETRA is adopting a Water-Energy Nexus approach, built on three key strategies:

1. Optimising water use in energy production
2. Sustainable hydropower development and
3. Advancing the energy-water transition.

Upgrading cooling systems in thermal plants, such as incorporating dry or hybrid cooling technologies and exploring alternative cooling methods, can significantly reduce water stress in critical areas. Integrating water recycling and water reuse systems within these

plants can further optimise water consumption by treating and reusing wastewater for cooling processes, reducing the reliance on freshwater sources.

Efforts to improve water usage efficiency in hydropower operations, including better reservoir management, can also optimise water and energy production. Investments in renewable energy sources, particularly solar and wind, should be prioritised to reduce dependence on water-intensive energy generation methods. Coupling these with energy storage solutions, such as battery systems or pumped hydro storage, can diversify Malaysia's energy mix while alleviating the pressure on freshwater resources.

The water sector is deeply intertwined with energy in Malaysia. Water treatment plants, pumping stations, and distribution networks consume substantial amounts of energy, particularly in urban areas with extensive water infrastructure. What challenges does the water sector face in energy management and what transformative measures are needed to ensure the sustainable management of water resources?

Water treatment plants, pumping stations, and distribution networks consume significant amounts of electricity, particularly in urban areas with complex water systems. This high energy demand not only increases operational costs but also contributes to carbon emissions and a larger environmental footprint. To ensure long-term sustainability, PETRA is committed to transforming the water industry through three overarching strategies:

1. Enhancing Efficiency & Reducing Energy Cost.

Implementing advanced energy management practices such as optimising pump scheduling, upgrading to high-efficiency motors and reducing water losses through better leak detection and maintenance programmes. Automation and control systems can further enhance operational efficiency.

2. Reducing dependence on fossil fuels and Integrating Renewable Energy Solutions.

Deploying solar power, hydropower, and biogas energy at water treatment plants and pumping stations to reduce reliance on conventional electricity. Solar panels can be installed on treatment plant rooftops, while micro-hydro systems can generate energy from water flows within the network.

3. Adopting Smart, Data-Driven Water-Energy Systems.

Utilising IoT sensors and AI analytics to detect non-revenue-water leakages and system inefficiencies, monitor energy consumption, and optimise system performance. Real-time data insights enable predictive





maintenance and informed decision-making, ensuring energy-efficient water operations.

Climate change causes irregular rainfall patterns, including prolonged dry spells and intense rainfall events. How has this impacted the water-food-energy nexus and what key strategies and initiatives should be implemented to transform the water sector to enhance sustainability while minimising negative impacts on the energy and food production sector?

Water is the lifeblood of energy and food production but climate change and population growth are placing unprecedented pressure on our water resources. Prolonged dry periods will lead to reduction in water availability for agriculture (which affects crop yields and productivity) and domestic use. Reduced water

availability limits the ability for hydropower energy generation and the water needs of thermoelectric plants while erratic rainfall leads to severe flood hazards. High non-revenue water (NRW), with losses exceeding 40% in some states, weakens supply reliability. All these impede the country's socio-economic and sustainable development goals.

So, ensuring water security while addressing water-related hazards has become a top priority. PETRA is committed to a holistic, integrated, and forward-looking approach to water management guided by these three objectives;

1. Ensuring water security and availability through the implementation of the National Water Policy (NWP)
2. Ensuring environmental conservation and water resource

sustainability through the implementation of IRBM and

3. Mainstreaming climate change adaptation for disaster risk reduction.

PETRA makes investments to improve climate resilience and water security by expanding water conservation and storage, such as underground water storage and rainwater harvesting. Multi-purpose reservoirs such as river off-storage are built to support water storage, hydropower, and flood mitigation. PETRA also promotes water recycling and reuse for non-potable purposes in industry and agriculture.

PETRA recognises the need to optimise efficiency in order to maintain food and energy production as water resources grow more limited. In order to reduce water waste in metropolitan settings, one of the most important initiatives is to modernise water distribution networks and improve leak detection systems. Adopting dry and hybrid cooling systems for thermal power plants to lessen water dependence is another crucial tactic for optimising water consumption in energy generation.

Industry Revolution 4.0 (IR4) refers to the integration of digital technologies such as the Internet of Things (IoT), artificial intelligence (AI), big data, and automation in various sectors, enhancing efficiency, productivity, and sustainability. How can the government, private sector, and general public embrace digital transformation to optimise and to promote the sustainable management of the water-food-energy nexus, referring particularly to the water sector?

The integration of IR4 technologies is revolutionising multiple sectors, including water management. Given that water is an essential component of food production and energy generation, any inefficiency in its management can significantly impact national sustainability. To address this challenge, the government, private sector, and general public must collaborate as follows:

1. Government Initiatives & Policy Support.

The National Water Policy is being strengthened to incorporate smart technologies that enhance efficiency, reduce waste, and ensure long-term sustainability. One of the major initiatives is the implementation of Smart Water Grid Systems, which employ IoT-based smart meters and real-time sensors to monitor water quality, detect leaks, and reduce NRW. With NRW currently at approximately 37%, such technological interventions can help minimise water losses and improve distribution efficiency.

Additionally, AI-driven predictive analytics and decision-making tools are being deployed to optimise reservoir management, improve flood forecasting, and develop better and more proactive drought mitigation strategies. Furthermore, the government is fostering Public-Private Partnerships (PPP) to accelerate digital transformation in water treatment and distribution. By collaborating with technology providers, Malaysia can integrate state-of-the-art solutions to improve water infrastructure resilience and sustainability.

2. Private Sector Involvement.

Water utilities and industry stakeholders are encouraged to invest in smart infrastructure, including digital twins, automation, and blockchain technology. Digital twins create virtual replicas of water systems, enabling real-time monitoring and predictive maintenance, while blockchain ensures transparency in water resource management and billing processes.

Moreover, industry players are adopting energy-efficient technologies in water treatment processes, such as solar-powered desalination and AI-driven wastewater recycling systems to reduce carbon footprints and operational costs. Water-energy integration is also being promoted, where AI-driven energy optimisation tools are deployed in water treatment plants. This integration helps reduce electricity consumption, enhance efficiency, and contribute to the

country's broader energy transition goals.

3. Public Engagement & Digital Literacy.

To empower individuals and businesses, the government and technology companies are promoting smart consumer applications which provide real-time water usage data. These mobile apps help users monitor consumption patterns, detect leaks, and adopt water-saving habits, leading to improved conservation efforts.

Smart irrigation systems are being promoted for urban farming, allowing the people to optimise water usage based on real-time weather data. Additionally, citizen science initiatives are being introduced, where individuals can participate in water quality monitoring using mobile-based community reporting tools. This collaborative approach ensures greater transparency and public involvement in maintaining water resources.

Environmental, Social, and Governance (ESG) practices have become increasingly important in driving sustainable development globally. How can the government, private sector, and general public adopt ESG practices to promote the sustainable management of the water-food-energy nexus and contribute to achieving the United Nations Sustainable Development Goals (UN SDGs) in Malaysia?

The Government is committed to integrating ESG principles into national policies and industry practices to ensure the sustainable management of the water-food-energy nexus. This aligns with the UN SDGs, particularly SDG 6 (Clean Water & Sanitation), SDG 7 (Affordable & Clean Energy), and SDG 13 (Climate Action). To achieve this, collaboration among the government, private sector, and the general public is crucial.

1. Government Initiatives: Strengthening ESG Policies and Regulations. In order to incorporate ESG compliance and sustainability goals, PETRA strengthens and regulates

framework and regulations, including the Circular Economy Roadmap, the National Water Policy, and the National Energy Policy (NEP). PETRA also encourage investments in low-carbon technologies, renewable energy projects, and water-efficient solutions through tax incentives, green bonds, and public-private partnerships (PPP). In order to increase resistance against climate change, PETRA focuses on adaptation and climate resilience strategies. AI-driven water management systems, flood mitigation programmes, and sustainable agriculture initiatives to enhance resilience against climate change are progressively implemented.

2. Private Sector: Driving ESG Innovation & Sustainable Practices.

Businesses can support long-term societal well-being, economic resilience, and environmental protection through sustainable business practices. ESG compliance and reporting, renewable energy integration, and sustainable water and energy management are three important areas where the business sector can propel ESG advancement.

3. Public Participation: Promoting ESG Awareness & Sustainable Lifestyles.

The general public plays an essential role in driving behavioural change and supporting ESG initiatives laid down by the Government through increasing water conservation and energy efficiency by encouraging the use of smart water meters, rainwater harvesting and energy-saving appliances in households. The general public is encouraged to practice sustainable consumption patterns. To guarantee a balanced water-food-energy nexus, urban farming, responsible food consumption, and waste reduction must be increased. Public involvement in water quality monitoring, environmental conservation programmes, and ESG education campaigns will result in increased awareness and accountability. ■



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Integrated Water Resources Management for Flood Mitigation & Food Security in Kota Belud, Sabah

by:



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Head of Upstream Water Resources & Digital Engineering at Ranhill Consulting Sdn. Bhd. and Chairman of IEM Water Resources Technical Division 2024/2025.



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The Kota Belud Granary Scheme is the main designated granary area (8,500ha) yielding most of the rice production for the state of Sabah. The main river basins within Kota Belud district are Sungai Kadamaian Basin, Sungai Kawang-Kawang Basin, Sungai Taburan Basin and Sungai Dudar Basin.

Kota Belud town is located in the Sungai Kadamaian basin, downstream of the Sungai Kadamaian and Sungai Wariu confluence. The main granary areas are located within Sungai Kadamaian and Sungai Kawang-Kawang Basin, which are connected via a dual-purpose irrigation and drainage canal called Sungai Jawi-Jawi.

The granary areas within Kota Belud are shown in Figure 1. Granary areas that are fully irrigated by the Department of Irrigation & Drainage (DID) are categorised as K1 while K2 indicates granary areas with poor or minimal irrigation system but near to a water source and K3 are granary areas that depend solely on rainwater (Table 2). About 46% of the granary areas are K1 schemes, where irrigation infrastructures are provided and operated by DID to enable double

cropping annually. The largest K1 scheme is the Tempasuk Utara Scheme, followed by the Tempasuk Selatan Scheme.

Impacts of Geohazard, Flood & Drought on Food Security

The natural topography and hydrological conditions at Kota Belud are quite challenging. Located adjacent to Mt Kinabalu, the highest mountain peak in South-East Asia, the average catchment slopes for the upstream and midstream sections of the catchment are very steep.

Kota Belud town is located at the inflexion point where the steep upstream river gradient suddenly becomes gentle and flat as it approaches the downstream granary areas. Coupled with the high annual average rainfall of about 2,800mm to 3,400mm, the town and the granary areas often face severe and extensive floods which can last from a few days to 2 weeks, due to the large volume and peaky flood flows coming from the steep upstream catchment during the wet monsoon season.

During the dry months, the flow of the rivers is low and due to the lack of water storage reservoirs, there aren't sufficient water resources to support double cropping for the 8,500 ha of paddy cultivation areas in Kota Belud. As this impedes the yield, Sabah cannot achieve its food security targets.

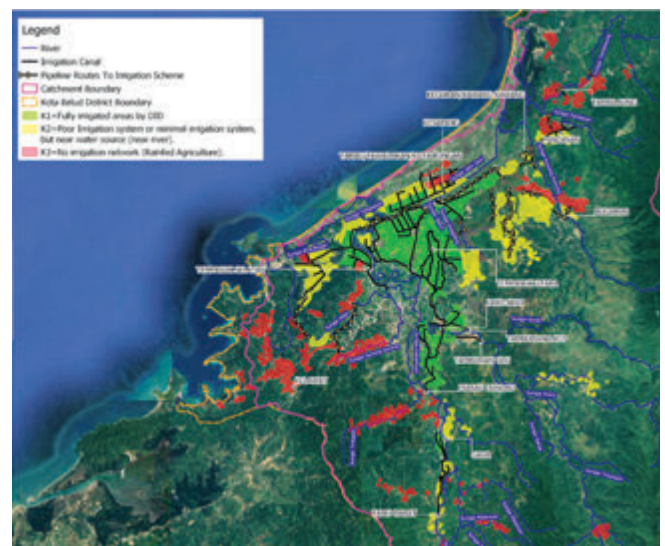


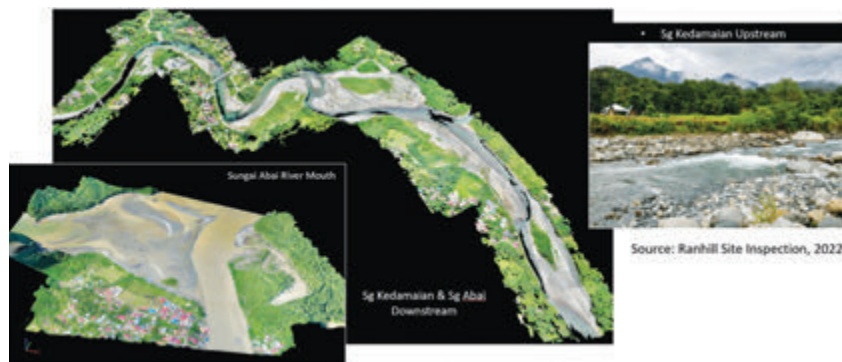
Figure 1: Granary and irrigation schemes in Kota Belud

Table 1: Categories of granary schemes in Kota Belud based on irrigation infrastructure

Category	Area (ha)	Infrastructure	Cropping Intensity	Yield Potential
K1	3,929 ha (46%)	Irrigated by DID	2 times/yr	Average Yield = 4.6mt/ha Yield Potential = 5.0-10.0 mt/ha
K2	2,136 ha (25%)	Poor / minimal irrigation system	Once a year	Average Yield = 3.5 mt/ha
K3	2,438 ha (29%)	No irrigation networks (Depends on rainfall)	Once a year	Average Yield = 1.5 mt/ha
Total	8,503 ha			

June 2015 Earthquake and Its Impact on Flooding

In June 2015, an earthquake at Mt Kinabalu caused severe erosion and sedimentation problems for the rivers downstream, significantly altering the river basin's geomorphological characteristics. Loosened boulders and sediments from the earthquake deposited along the river beds caused the rivers to become shallower, reducing their capacity and significantly increasing the frequency and severity of floods in Kota Belud.



Source: Ranhill 3D Drone Photogrammetry Reality Capture Model, 2022.

Figure 2: Significant geomorphological changes and severe sedimentation issues in Kota Belud after the June 2015 earthquake at Mt Kinabalu

After the earthquake, it was reported that Kota Belud faced 86 flood occurrences from 2015 to 2021, one of the highest flood occurrence statistics in the country. Extensive flooding occurred at Kota Belud town as well as villages and settlements along the rivers. There was severe and prolonged flooding (up to 1-2 weeks) in the flat downstream granary areas, causing major socio-economic disruption which significantly impeded the paddy fields and rice production in Kota Belud (Figure 3).



Figure 3: Severe flooding in Kota Belud town and granary areas after the 2015 earthquake

Potable & Irrigation Water Resources Scarcity

Apart from severe flooding which devastated the paddy fields, insufficient water resources also affected the paddy yield in Kota Belud. It was found that the water resources in Kota Belud within the natural rivers were sufficient to meet the projected potable water demand up to 2050 but were insufficient to meet irrigation water demand, especially for double cropping.

Currently, even for existing K1 and K2 schemes with irrigation infrastructures, water resources are only sufficient during the wet weather months but insufficient during the dry months because there are no existing water storage infrastructures in Kota Belud. Because of this, the average yield in Kota Belud is only 3.4 mt/ha and 54% of the granary area can only carry out single cropping.



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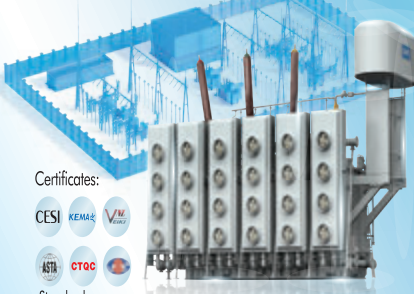
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At present, the Self Sufficiency Level (SSL) for paddy in Sabah is only 22.8% which is way below its food security target of 60% SSL by 2030. To achieve this target, the average granary yield at Kota Belud needs to be more than 6 mt/ha with an average of 1.5 times cropping intensity per year.

Use of Integrated Water Resources Management and IR4.0 Technologies for Sustainable Water Management & Food Security

To mitigate the geohazard and water hazards as well as to enable sustainable development in Kota Belud and food security for the state of Sabah, DID appointed Ranhill Consulting Sdn. Bhd. to carry out a feasibility study on Integrated Water Resources & Flood Mitigation in July 2021. This was the first all-encompassing water management study with more than 20 different scopes related to water hazards and disaster management (see list below) studied in a single integrated study in order to formulate a holistic and integrated masterplan to solve the multi-faceted water resources issues.

1. Integrated flood mitigation masterplan study
2. Integrated water resources masterplan study
3. Irrigation demand & scheme design
4. Groundwater study
5. Erosion & sedimentation study
6. Water quality improvement study
7. Integrated River Basin Management Plan
8. Flood damage assessment
9. Flood risk & evacuation mapping
10. Flood forecasting & warning system
11. Geohazard & seismic risk study
12. Multi-hazard analysis
13. Community-based disaster risk reduction study
14. River beautification & rehabilitation plan
15. Concept and preliminary design of proposed works
16. Quantity take-offs & cost estimation
17. Land acquisition study
18. Preliminary Environment Impact Assessment (EIA)
19. Preliminary Social Impact Assessment (SIA)
20. Preliminary Heritage Impact Assessment (HIA) study
21. Cost-Benefit Analysis
22. GIS asset inventory
23. 3D BIM Modelling

Another critical success factor to ensure that the project achieves its objectives within the stipulated timeline is the adoption of state-of-the-art IR4.0 digital engineering technologies below:

1. Use of Cloud-based Common Data Environment (CDE) in accordance with BIM ISO 19650, enabling the consultant team of 50 members in the Klang Valley, Sabah and Sarawak to digitally and remotely share data, collaborate, formulate plans and designs on a single platform in a systematic and coordinated manner.
2. Use of 3D drone reality capture and modelling to promptly and cost effectively obtain high resolution 3D data which is important to comprehensively study the complex rivers, irrigation and drainage network in Kota Belud.
3. Use of comprehensive Geographical Information System (GIS) to carry out asset inventory mapping, complex geospatial analysis and management of data required.
4. Use of catchment-wide integrated water modelling approach where water resources and flood issues can be studied in a single integrated model, enabling the design of multi-purpose water.
5. Use of workflow automation and programming which allows a large amount of data to be processed and analysed automatically with minimal human errors.

6. Use of 3D and 5D Building Information Modelling (BIM) to digitally model the existing river systems and the proposed engineering designs. Key benefits of using 3D and 5D BIM technologies include enabling multi-disciplinary design to be digitally coordinated, virtual digital iteration to obtain the best optimum design, accurate and fast extraction of quantities and cost estimation and to allow the proposed designs to be visualised in 3D which enhances stakeholder engagement and appreciation of complex engineering designs (Figure 4).

Figure 5 shows the flood inundation map of Kota Belud for October 2017 (5-17 years Average Recurrence Interval {ARI}) flood events simulated using a catchment-wide 1D/2D hydrodynamic model. Many areas in Kota Belud have a flood protection level of less than 2-year ARI.

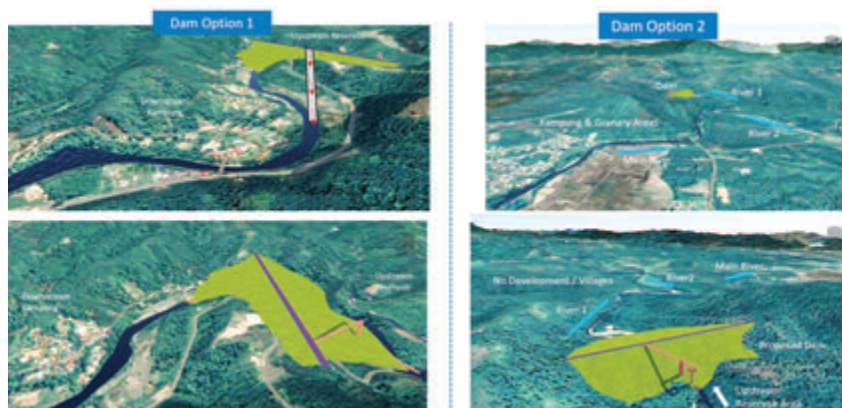


Figure 4: Visualising, testing and digitally refining the different dam designs in Kota Belud using 3D VR AR Technologies

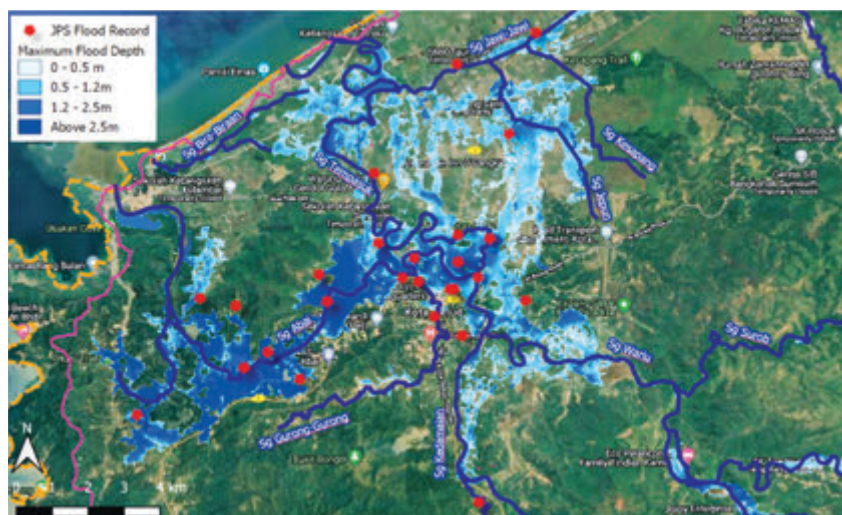


Figure 5: Simulated flood inundation map for the 17-22 October 2017 (5-17 years ARI) flood event

From the water balance study, it was found that only 3 out of the 16 granary schemes in Kota Belud had sufficient water resources while 13 faced water deficit. The total irrigation demand is 1,066.77 MLD or 387 MCM per year. The total maximum monthly irrigation water resources deficit for the entire Kota Belud Granary area is -621 MLD.

Formulation of Integrated Water Management Masterplan for Kota Belud

Utilising state-of-the-art digital engineering technologies coupled with an integrated multi-disciplinary approach, a comprehensive flood mitigation masterplan, potable and irrigation water resources masterplan, river basin management plan, geohazard management plan, erosion and sediment



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management plan, community-based disaster risk reduction plan, river rehabilitation plan were formulated in an integrated and holistic manner to help Kota Belud achieve its water resources sustainability objectives and food security targets moving towards 2050.

Key components of the formulated masterplan include:

1. River dredging and improvement works to reinstate the river conveyance capacities and reduce flood risks. Most of the river improvement works adopt a natural trapezoidal earth channel to maintain the green, nature-based aesthetics. Where required, sandfill mattress, gabion mattress and rock rick raps are provided to protect the river banks.
2. An erosion and sediment management plan consisting of upstream sabo structures to capture debris and attenuate flood flows at critical upstream rivers, sedimentation forebays incorporated into the multi-purpose ponds, sabo structures and sediment basin designed to trap sediment at the Sungai Wariu and Sungai Kadamaian confluence, just upstream of the Kota Belud town.
3. Multi-purpose water storage ponds which can attenuate and store flood water flows during the wet season to be used later as water resources for irrigation supply to paddy areas, especially during drought seasons. On top of that, the multi-purpose ponds also consist of sediment forebay to help trap sediments and to improve the quality of the river water that flows through the ponds. The ponds are also designed to incorporate landscaping amenities to enable the public to enjoy the water body for recreation and eco-tourism activities (Figure 6).
4. River trails have been proposed along the maintenance access of the ponds to connect from one eco-tourism site to the next eco-tourism site. The better accessibility and connectivity will enable the public to better enjoy, appreciate and conserve the ecological and recreational values of the river and water bodies, further elevating and unleashing the eco-tourism potential in Kota Belud.

5. A multi-purpose dam which functions as a flood control dam as well as to regulate water resources for potable and irrigation water demands. The proposed dam will play a critical role in alleviating floods in downstream Kota Belud town and the granary areas as well as ensure sufficient and sustainable water resources to enable double cropping in the granary areas and so increase paddy yields to meet the food SSL in Sabah.

Conclusion & Recommendations

Using a catchment-wide, integrated water resources management approach, the state government has formulated various masterplans for Kota Belud which can help achieve the objectives below to ensure water sustainability, considering all water hazards and disasters in a holistic manner.

- Geohazard management plan to mitigate landslides and riverbank erosion
- Water resources plan to meet potable and irrigation water demands
- Flood mitigation plan providing 100-year ARI flood protection
- Erosion and sedimentation management plan to mitigate debris flows and sedimentation problems.
- River basin management plan to conserve and enhance water resources and the environment, providing a roadmap for sustainable development in Kota Belud.
- Community-based disaster risk reduction plan.

This feasibility study was the first, most all-encompassing water and disaster management study in Malaysia, which allowed complex multi-hazard issues to be studied in a holistic and integrated manner (the study was completed in January 2023). It also created a unique opportunity that enabled the proposed water resources augmentation infrastructures to be multi-purpose and integrated across the various water resources, disaster management and river basin management plans formulated, achieving multiple objectives in one go with minimal cost, impacts

and maximum value. Coupled with the multi-purpose water infrastructure approach with green, nature-based solutions, the proposed works and schemes will not only preserve the natural ecology and beauty of Kota Belud but will also further elevate its already vibrant eco-tourism potential.

The formulated plans provide a roadmap and action plan to ensure water sustainability, enabling sustainable development for Kota Belud as well as achieving the food security targets for Sabah in a green and holistic manner. The unique approach of this study can be used as a role-model for future water management planning and design projects in Malaysia. ■



Figure 6: Green, nature-based approach with landscaped amenities, allowing the public to enjoy the proposed multi-purpose ponds

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Ir. Lim Sin Poh

Founder and Managing Director of Global Water Consultants Sdn. Bhd. and Joint Secretariat of IWA Specialist Group on Sustainable Coastal & Estuarine Development.

A Coastal Reservoir (CR) is a freshwater reservoir constructed in a coastal region to store runoff from the catchment before discharging to the sea. It can be sited at the river mouth or nearshore areas. This approach is not new and has been implemented in many countries, but it is still lacking exploration and consideration in Malaysia.

Based on the country's rainfall depth and land surface area, there is an annual rainfall volume of about 1,000 Bm³. Assuming 50% of the rainfall turns into surface runoff, the runoff volume is about 500 Bm³. The total water demand as of 2025 is estimated about 20 Bm³ or 4% of the runoff volume. Of course, this value is the average annual total; during drought, there will be very little water in the river

and many existing river water intakes will be affected. That is where raw water storage is needed to store sufficient water during wet seasons to cater to severe drought conditions. The size of the raw water storage depends on the upstream catchment inflow and water demand.

Raw Water Storage

Traditionally, a water supply dam was constructed upstream for this purpose. These includes the Sg. Selangor Dam, Sg. Langat Dam, Semenyih Dam, Bekok Dam, Sembrong Dam etc, just to name a few.

Off river storage (ORS) has been explored in recent years. One of the largest ORS schemes is the Selangor HORAS, which utilises existing ponds. The on-going Rasau ORS Scheme also utilises existing ponds as water supply storage. While utilising existing ponds is viable, acquiring existing land areas for construction of ORS purposes may not be viable, considering the high cost of land acquisition involved.

Lately, there are proposals for underground dams as water storage. In terms of quality, underground water may have higher mineral content (such as iron and manganese) and this may mean higher treatment costs. In addition, energy consumption will be higher as there is a need to pump the underground water to the surface constantly. This option should only be considered if there is insufficient water resource or storage options above ground.

CR offers many advantages (see Table 1). The most obvious is that CR not only does not require the acquisition of existing land, thus saving in land acquisition cost but it

Table 1: Advantages and disadvantages of downstream/coastal reservoir

		Advantages	Disadvantages
1.	Land Acquisition	- Minimal land acquisition required, using nearshore areas, etc. - Potentially creates a new land area for development and enhances surrounding property value with a significant water body.	Larger footprint in terms of area required.
2.	Environmental impact	- Creates man-made wetlands and new ecosystems. - Minimum impact.	Comparatively minimum, but still subject to impact assessment
3.	Social impact	Less social issues as site selection can be very flexible.	Minimum
4.	Heritage/ Historical site	This can be avoided as site selection is flexible.	Minimum
5.	Distance to demand point	- Site near demand points. - Low energy cost. - Fewer losses due to much shorter conveyance works.	None
6.	Catchment area	- Sited downstream, thus having much larger catchment areas. - Receive water even during low flows.	Downstream water quality is expected to be not as good as upstream
7.	Expandability	Can be easily expanded.	None
8.	Risk	Low risk.	Subjected to wave action but can be designed
9.	Construction	Simpler and faster.	Working in water
10.	Maintenance cost	Lower.	None
11.	Life span	Longer.	None

Source: Paradigm shifts from upstream reservoir to downstream/coastal reservoirs management in Malaysia to meet SDG6. Page 25

also has minimum social and environmental impact. It can potentially create new land area for development and it enhances surrounding property value with the presence of a significant water body.

The pros and cons of these options and the cost-benefit analysis should be conducted with a feasibility study to select the most suitable solution for a specific area to ensure the sustainability of the proposed scheme.

Advantages & Disadvantages of CR

CRs can be a feasible solution for many coastal areas in Malaysia. It is comparatively more straightforward to construct than the dam, ORS and underground dam. There are many apparent advantages of CR and some disadvantages, as listed in Table 1.

Global Applications of Coastal Reservoir

There are many successful examples of downstream/coastal reservoirs, as listed in the following table:

Name	Catchment (km ²)	Dam length (km)	Capacity (GL)	Year completed	Construction cost (US\$ B)	Country – River
Zuider Zee	170,000	33	5,600	1932	n.a.	Netherlands
Lakes Alexandrina and Albert	1.1 × 10 ⁶	7.6	1,600	1940	n.a.	Australia – Murray
Plover Cove	46	2	230	1968	0.07	Hong Kong
Baogang/Shanghai	1.8 × 10 ⁶	3.7	12	1985	n.a.	China – Yangtze
West Sea Barrage	20,000	7.8	2,700	1986	1.8	North Korea – Taedong
Cheng Hang/Shanghai	1.8 × 10 ⁶	4.7	8.0	1992	n.a.	China – Yangtze
Silwa	476	12.4	323	1994	0.3	South Korea
Yu Huan	170	1	64	1998	0.1	China – Zhejiang
Marina Barrage	110	0.35	2008	2008	0.2	Singapore
Qingcaoshu/Shanghai	1.8 × 10 ⁶	43	550	2011	2.8	China – Yangtze
Saemangeum	330	33	530	2011	2.1	South Korea

n.a. = not available.

Source: Sustainable Water Resource Development Using Coastal Reservoirs, Page 17

Two of the most successful CR implementations, i.e. Shanghai's Qing Cao Sha Reservoir and Singapore's Marina, are discussed herewith.

Qing Cao Sha Reservoir

The Shanghai Qing Cao Sha Reservoir is a very good example. The 7,190 MLD raw water development scheme started operations in 2011 with a reservoir area of 66 sq km and a water storage capacity of 527 MCM (Figure 3). More details and examples of coastal reservoirs are available in the book *Sustainable Water Resource Development using Coastal Reservoirs*, published by Elsevier in 2020.

Marina Bay, Singapore

In Singapore, the Marina Barrage, completed in 2008, is a multipurpose reservoir constructed across the Marina Channel. It serves as a freshwater reservoir, flood control mechanism, and recreational space. Since then, many barrages have been constructed at river mouths to create multipurpose reservoirs.



Figure 3: Layout plan of Qing Cao Sha 7,190 Mld Scheme in Shanghai

Another example of a nearshore reservoir was recently planned by the Singapore government which announced in November 2023 that the technical studies of this proposal would commence in 2024 and would be carried out over the next few years. It would involve land reclamation of 800 ha in size (roughly over 1,000 football fields), creating an enclosed water body and, eventually, a freshwater reservoir in front of East Coast Park. The new bund is expected to be an important adaptation against rising seawater and more substantial wave and erosion forces due to climate change.

Conclusion

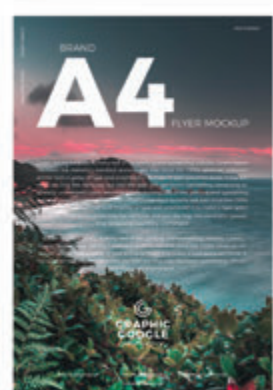
Malaysia is blessed with abundant water but we still need to store during the wet seasons for use during dry seasons. Before considering underground water, we should explore the possibility of using surface water as this is simpler and more sustainable. Similarly, before considering interstate transfers, we must first examine the possibility of using local water resources. Why buy from others when you have enough water for your use? At the very least, a comparison between these solutions in terms of cost-benefit analysis should be made.



Figure 4: Marina Barrage (completed in 2008) and the proposed Long Island⁵

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It is recommended that the government speed up water resource development, as cities are under pressure to secure sufficient water supplies for the many upcoming data centres that are “very hungry” for water.

CRs can be the solution in coastal areas such as Langkawi, Penang, Klang, Melaka, Johore, Bintulu, Kota Kinabalu, etc. In terms of implementation, as the land prices in urban areas are relatively high, the concept of Public Private Partnership (PPP) can be the way forward, allowing the private sector to carry out land development in exchange for offsetting the capex of the cost of water resources development. ■

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NOTICE OF IEM (PENANG BRANCH) OFFICE BEARERS 2025/2026

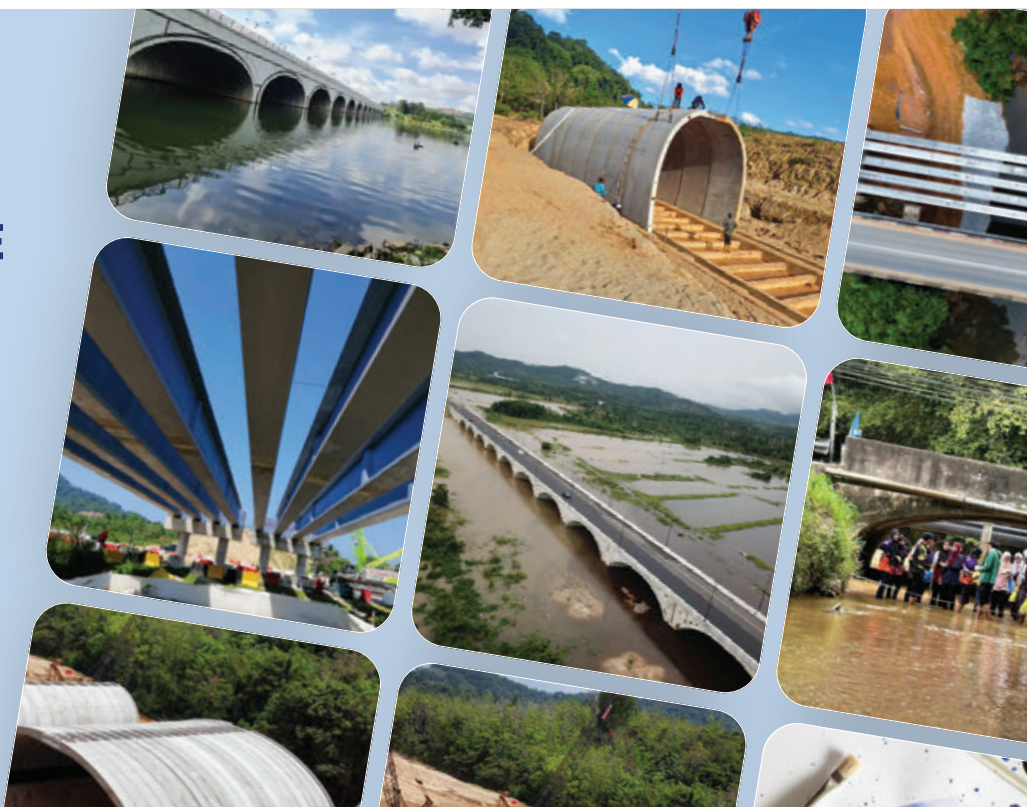
The Institution of Engineers, Malaysia (IEM) Penang Branch had its 58th Annual General Meeting on 8 March 2025 and we are pleased to introduce the new IEM Penang Branch Office Bearers for session 2025/2026:

IEM (Penang Branch) Office Bearers 2025/2026	
Chairman	Ir. Dr. Lee Choo Yong, PKT
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Embracing Nature: Water Resilience Through Nature-Based Solutions

by:



Ts. Dr. Azlinda Saadon



Ir. R. Sreedaran

The Water Resources Technical Division (WRTD) of the Institution of Engineers, Malaysia organised the International Symposium 2024, Embracing Nature: Water Resilience Through Nature-based Solutions (NbS), on 19 September 2024, at the Kuala Lumpur Convention Centre. The symposium was held in collaboration with the Humid Tropic Centre Kuala Lumpur (HTC KL) under the auspices of UNESCO, Department of Irrigation & Drainage Malaysia (DID).

It brought together global experts, policy makers, and industry leaders to address the pressing challenges of water management amid climate change and environmental degradation. The event underscored the transformative potential of NbS in strengthening water security by tackling issues such as flooding, water scarcity, and urban water pollution.

The symposium was aimed at fostering knowledge exchange, shaping policies, and enhancing climate resilience while improving community well-being by promoting the integration of NbS into environmental practices. As global climate continues to change and populations grow, the adoption of sustainable and innovative water management approaches becomes increasingly critical. NbS leverages on natural processes and ecosystems to address environmental challenges holistically while offering multiple co-benefits, including biodiversity conservation, improved water quality, and enhanced community resilience.

There were expert-led discussions on the integration of NbS into water management, climate adaptation strategies, and the application of Environmental, Social, and Governance principles. Technical presentations showcased 2 keynote papers and 8 technical papers highlighting case studies of effective NbS implementations in Malaysia, China, the Philippines, and Indonesia.

Major Dato' Ir. Dr. Hj. Ahmad Anuar Othman, the Director General of DID Malaysia, presented a notable keynote paper, Overview of the Implementation of NbS Programme in Malaysia's Water Sector. The event concluded with closing remarks by Dato' Ir. Ratna Rajah Sivapiragasam, the Director of HTC Kuala Lumpur.

One key takeaway was the emphasis on the importance of values, sustainability, and scalability of both the existing and new NbS projects. To achieve these objectives, several strategic recommendations were proposed, including strengthening policy and governance support, ensuring sustainable financing, enhancing capacity building, fostering community engagement, leveraging technology and innovation, valuing ecosystem services, implementing long-term monitoring and adaptation measures, and promoting public awareness and advocacy. The aim was to ensure the long-term success of NbS initiatives by aligning projects with national and local policies, securing diverse funding sources, providing training and knowledge-sharing opportunities, and actively involving local communities in planning and implementation.

Apart from technical presentations, collaborations between the private sector, non-governmental organisations, and government agencies in advancing water resilience and sustainability were also highlighted. The event received significant sponsorships from Nanning Jianning Water Investment Group (Platinum), Fibromat Sdn. Bhd. (Silver), and Lim Seong Hai Capital Berhad (Bronze), alongside participation from 8 other companies that showcased innovative solutions for sustainable water management.

In a show of strong governmental support, the Deputy Prime Minister of Malaysia, Y.B. Dato' Sri Haji Fadillah Haji Yusof, who is also Minister of Energy Transition & Water Transformation, visited exhibitors at the symposium during his tour of the Engineers Convention 2024. His presence underscored the government's commitment to promoting NbS and sustainable water management practices. Engaging with key exhibitors, he emphasised the crucial role of private-sector innovation in achieving Malaysia's water security and environmental resilience goals.

The symposium concluded with a resounding call to action, urging strengthened collaboration among the public and private sectors, academic institutions, and civil society in the implementation of NbS in Malaysia. By fostering partnerships and incorporating natural processes into water management strategies, Malaysia can build sustainable, resilient, and inclusive solutions to effectively address its water-related challenges. ■

OGMTD's First Oil & Gas Platform Design Competition 2024/2025

by:



Ir. Ts. Nur Azhani

The competition was held at Wisma IEM Petaling Jaya on 22 February 2025 and attended by 30 university students, lecturers, and professionals. Open to all engineering undergraduates in Malaysian universities, the aim was to spark creativity and innovation in the next generation in the oil and gas industry. The competition was sponsored by Hibiscus Petroleum Berhad, Malaysia's first listed independent oil and gas exploration and production company.

OGMTD hopes to establish the competition as an annual event with the assistance and support of our volunteers, industry partners, and universities. The effort is designed to ensure the industry remains relevant and competitive as we head towards the Energy Transition and Sustainable Energy eras, in line with the World Engineering Day (WED) 2025 theme, Shaping Our Sustainable Future Through Engineering.

The competition kicked off in early October 2024, with 14 team registrations received. All teams submitted their design proposals and, after careful and thorough evaluation by the judges, 5 teams were shortlisted to take part in the competition. These teams were ANDALAS and WINX from Universiti Kebangsaan Malaysia (UKM), Energising Future from Universiti Teknologi PETRONAS (UTP), Hornbill Venture from Universiti Teknologi MARA (UiTM) Shah Alam, and UTM-C from Universiti Teknologi Malaysia (UTM).

The competition timeline provided opportunities for students to explore and dive deep into the challenges of the industry, which required engineering multidisciplinary understanding and a broad range of engineering knowledge which were essential qualities for developing future engineers and leaders in the O&G Industry.



Group photo of students, lecturers, and professionals



The platform model on float test in a kiddie pool at Wisma IEM

It was a massive undertaking to build the platform model and visualise ideas, with sustainability integrated into the design. The competition enhanced the students' engineering innovation and contributed to the industry's advancement.

Petroleum Field Development Plan (FDP) is a comprehensive study outlining the technical, economic, environmental, social, and sustainability aspects of an oil and gas field that is appraised for potential development and operation. Exploration and production activities are the critical paths involving risks that must be managed and planned to sustain investment in an oil and gas field for 20-30 years of its operational life.



The shortlisted platform models ready for the grand final competition



The winning team with the sponsor and industry judges

As an exploration and production company, Hibiscus Petroleum Berhad is dedicated to expanding the company portfolio and expertise to address future challenges. This competition is part of the company's initiatives and contributions to the development of the next generation in the O&G industry.

Our special thanks go to Mr. Chong Chee Seong, Vice President of Strategic Ventures at Hibiscus Petroleum Berhad, for taking the time off on a Saturday to officiate at the competition finale and to present prizes to the winners, and to Ms. Adila Alias, Senior Corporate Development at Hibiscus Petroleum Berhad, for her unwavering support. The organising committee would also like to extend its gratitude to the IEM Vice President and OGMTD Chair for their support.

The competition featured a distinguished panel of industry judges who provided their expert assessment and evaluation. They include Mr. Chong Chee Seong & Dr. Judi Soetjahjo (Hibiscus Petroleum Berhad), Mr. Ahmad Mahmud (PETRONAS Carigali Sdn. Bhd.), and Ir. Rozali Ahmad (DAR Energy Sdn. Bhd.).

We thank all participants for their dedication and hard work and we hope this marks the beginning of your journey to compete at the ASEAN level and beyond. OGMTD looks forward to organising and hosting an even larger crowd in the next competition with continued partnerships and collaboration from the industry. Congratulations to the winners! ■



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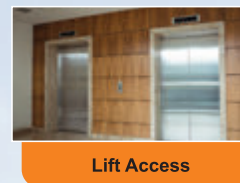
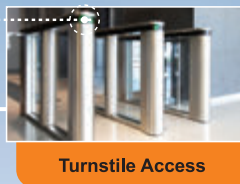
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Leading a Culture of Safety – Blueprint for Success

by:



Ir. Assoc. Prof. Dr.
Zaki Yamani Zakaria



Ir. Assoc. Prof. Dr.
Mazura Jusoh

The Occupational Safety & Health Administration's (OSHA) publication, *Leading a Culture of Safety: A Blueprint for Success*, is a comprehensive guide aimed at fostering a robust safety culture within organisations. The Blueprint emphasises the importance of leadership commitment, employee engagement and systematic approaches to safety. It serves as a valuable resource for industries looking to integrate safety practices into their organisational DNA.

The Blueprint is grounded in the principle that safety leadership is key to achieving a sustainable culture of safety. It outlines actionable

strategies and frameworks to guide leaders in creating an environment where safety is prioritised across all levels. It encourages organisations to shift from compliance-based safety practices to proactive, values-driven approaches that engage employees and promote continuous improvement.

The following are 4 key highlights from the Blueprint.

1. Leadership Commitment

A cornerstone of the Blueprint is the role of leadership in driving safety culture. Leaders are encouraged to model safety behaviours, allocate resources and demonstrate a genuine commitment to protecting workers. This commitment not only fosters trust but also aligns safety initiatives with organisational goals. The Blueprint emphasises that safety must be a visible priority, with leaders taking an active role in communication, training and evaluation of safety practices. This part is elaborated more in the beginning of The Six Domains Safety Culture framework.



2. Employee Engagement

The Blueprint highlights the importance of involving employees in safety programmes. Workers are more likely to adopt safe practices when they feel their input is valued. Encouraging employee participation in hazard identification, safety training and policy development helps create a sense of ownership. This aligns with findings from research on organisational safety, where participatory approaches are shown to significantly reduce workplace incidents (OSHA, 2024).

3. Structured Training Programmes

Training is central to the success of any safety initiative. The Blueprint provides practical guidance on designing effective training programmes tailored to organisational needs. It stresses the use of diverse training methods, such as interactive sessions, simulations and ongoing education, to keep employees informed and prepared. By prioritising training, organisations empower their workforce to recognise and respond to hazards effectively.

4. Continuous Improvement

Safety is a dynamic process and the Blueprint advocates for the regular review and improvement of safety programmes. Establishing metrics to evaluate safety performance ensures that organisations can identify gaps and make data-driven decisions. This focus on continuous improvement resonates with modern safety management practices, emphasising adaptability and resilience in evolving workplace environments.

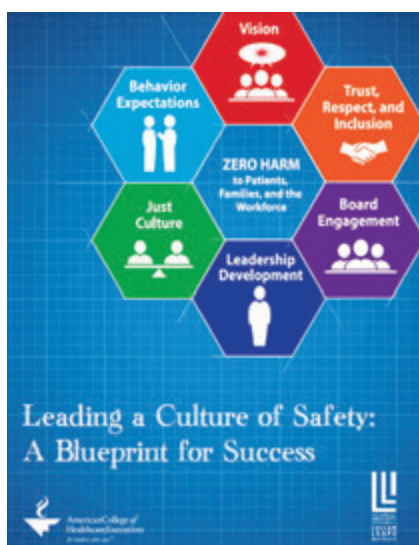


Figure 1: Cover of *Leading a Culture of Safety: A Blueprint for Success*



Figure 2: *A Culture of Safety: The Six Domains* is shown in page 5 of the blueprint

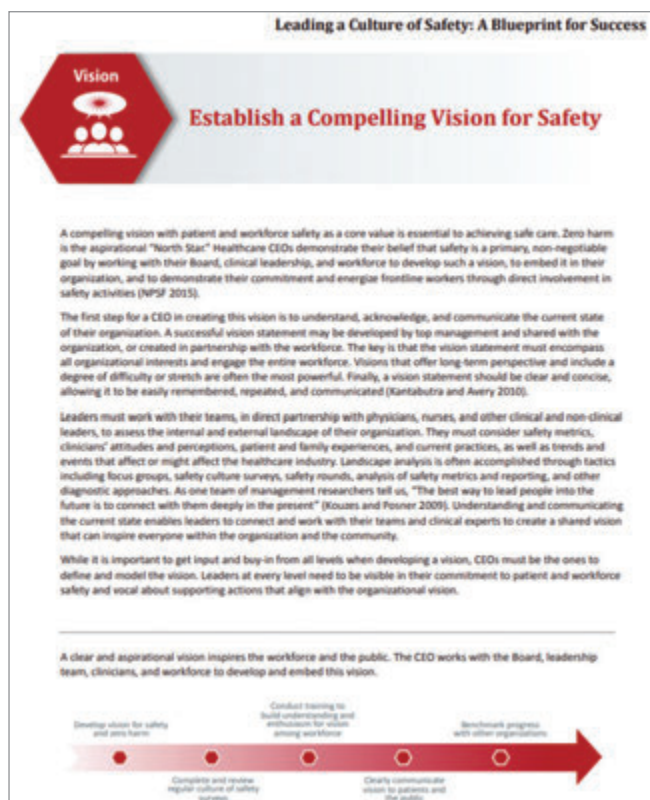


Figure 3: Establishing a compelling vision is critical for the success of the safety culture mission

Scoring:

1 – Never true for my organisation
2 – Rarely true for my organisation
3 – Sometimes true for my organisation
4 – Almost always true for my organisation
5 – Always true for my organisation
0 – Unsure of the response

Prioritize safety in the selection and development of leaders

MEASURABLE ELEMENTS	SCORE					OBSERVATIONS	
Key questions to ask about your organization's capabilities and processes.	1	2	3	4	5	Unsure 0	Please provide a brief description of why you chose this score, considering all parts of each question.
1. All leaders in my organization receive education and review opportunities in safety science and safety culture.							
2. My organization has defined roles, safety competencies, and development programs for leaders at all levels.							
3. My organization allows leaders opportunities for learning across departments and from outside organizations and industries.							

Total Score = _____

	Score: 0 – 4	Score: 5 – 9	Score: 10 – 15
Organizational State Brief description of current state of the organization	Organization's leaders are considered for development opportunities and promotion based on business and financial competencies. Leadership development programs focus on executive leadership. All leaders have semi-regular reviews that focus on financial performance.	Organization's executive leaders are provided basic safety science and culture educational opportunities. Leadership development programs are in place at all levels and throughout the organization. Both current and emerging leaders have access to peer coaching and mentoring programs.	Leaders at all levels of the organization are required to complete safety culture training. Regular reviews for all leaders include safety and culture metrics. Leaders are provided opportunities to learn from outside organizations and industries and are able to transfer among departments and units based on interest and organizational needs.
Recommended Next Steps Recommended next steps for improvement and implementation are based on domain and included in Leading a Culture of Safety: A Blueprint for Success	Begin with review of Foundational tactics Define required leadership competencies in culture and safety. Conduct regular gap analyses for CEO and senior leader competencies in safety culture. Develop and implement an organization-wide leadership development program.	Review Foundational and Sustaining tactics Provide continuing education opportunities in safety and culture for both new and emerging leaders. Develop systems that support leaders at all levels, including opportunities for cross-departmental training.	Review Foundational and Sustaining tactics Provide leaders at all levels opportunities for learning outside the organization. Define talent as an organizational resource. The performance on safety culture to leadership development priorities and promotional opportunities.

Figure 4: A series of self-assessment is provided at the end of the blueprint. In this context, an assessment to prioritise safety in the selection and development of leaders should be made

Practical Applications

Industries can leverage the Blueprint as a practical tool to integrate safety into their organisational culture. For example, construction firms can use it to implement behaviour-based safety programmes, while manufacturing plants may apply its principles to enhance compliance with safety protocols. The focus on leadership and employee involvement ensures that the strategies are scalable and applicable across sectors.

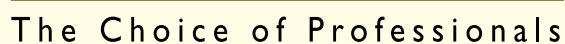
Conclusion

Without doubt it can be said that Leading a Culture of Safety: A Blueprint for Success is a vital resource for organisations committed to elevating their safety culture. By outlining actionable steps and fostering a shared responsibility for safety, the Blueprint provides a roadmap for sustainable success. Organisations which embrace its principles are likely to see enhanced employee well-being, operational efficiency and long-term growth. ■

NOTICE OF IEM (SARAWAK BRANCH) EXECUTIVE COMMITTEE MEMBER FOR SESSION 2025/2026

The 56th Annual General Meeting of The Institution of Engineers, Malaysia (Sarawak Branch) has been successfully conducted on 15th March 2025. The new office bearers for session 2025/2026 are as follows:

IEM (Sarawak Branch) Executive Committee Member 2025/2026	
Chairman	Ir. Dr. Liew San Chui, Angelia (M25519)
Immediate Past Chairman	Ir. Sim Hui Kheng, Stephanie (F19167)
Past Chairman	Dato Ir. Janang Anak Bungsu (F21883)
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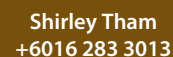
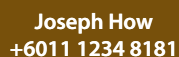
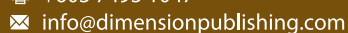
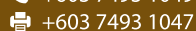
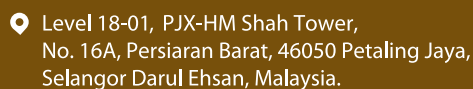
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IEM 2024 Employment Survey

by:



Ir. Prof. Dr. Tan Chee Fai

Honorary Secretary of IEM for Session 2024/2025 and Deputy Vice-Chancellor of Infrastructure University Kuala Lumpur.



Prof. Dr. Yong Chen Chen

Professor at Department of Economics, Faculty of Business and Economics, Universiti Malaya. Founder of IOMInsight, focused on Economic System modelling.



Ir. Prof. Dr. David Chuah Joon Huang

Vice President of IEM, Secretary-General of AFEO, Chairman of IET Malaysia Network, Board Member of BEM, President / CEO of Southern University College.



Ir. Assoc. Prof. Dr. Syuhaida Ismail

Director of Research at Maritime Institute Malaysia and recipient of MBOT Woman Leadership Award 2024 and APEC-Australia Women in Research Fellowship Award 2022.

Respondents' Profile

For the survey conducted from 1 January to 31 March 2024, there were 1,026 respondents. Table 1 shows that 59% of the respondents are ordinary members and 30% are Graduate members. There are 367/1026 (35.77%) respondents registered as Professional Engineer with Practising Certificate and 27.97% and 32.55% registered as Professional Engineer and Graduate Engineer respectively.

Table 2 shows that male engineers dominated the field by 75%. As Engineering remains the profession that is highly demanded due to industry and technology developments, return on education investment is observed where 96.87% of the respondents have a degree compared to 28.66% with Diploma level (Table 3).

The top 3 fields of study among the respondents are:

1. Civil (38.85%)
2. Mechanical (20.38%)
3. Electrical (16.15%) where most work in construction sectors and professional, scientific & technical activities industry (Table 5).

Table 1: Respondents distribution by membership type

Membership Type	Responses	
Honorary Fellow	0.19%	2
Fellow	3.31%	34
Senior Member	1.36%	14
Member	58.87%	604
Senior Graduate Member	2.63%	27
Graduate Member	29.92%	307
Engineering Technologist Member	0.10%	1
Engineering Technologist Graduate Member	1.27%	13
Engineering Technician Member	0.10%	1
Engineering Technician Graduate Member	0.00%	0
Incorporated Member	0.68%	7
Affiliate Member	0.39%	4
Associate Member	0.78%	8
Student Member	0.39%	4
Total	100%	1,026

Registration with the Board of Engineers Malaysia	Responses	
None of the above	1.85%	19
Professional Engineer with Practising Certificate	35.77%	367
Professional Engineer with Practising Certificate (RSA)	0.10%	1
Professional Engineer	27.97%	287
Accredited Checker	0.00%	0
Graduate Engineer	32.55%	334
Engineering Technologist	1.46%	15
Inspector of Works (IOW)	0.39%	4
Total	100%	1,026

Table 2: Respondents distribution by gender

Gender	Responses	
Female	12.96%	133
Male	87.04%	893
Total	100%	1,026

Table 3: Respondents distribution by education attainment level

	Responses	
College / Polytechnic (Diploma)	28.66%	284
University (Degree)	96.87%	960
University (Master)	34.51%	342
University (PhD)	8.07%	80
	Answered	991
	Skipped	35

Table 4: Respondents distribution by field of study

	Responses	
Aeronautical	0.50%	5
Building	0.30%	3
Civil	38.85%	385
Electrical	16.15%	160
Electronic	2.42%	24
Gas	0.10%	1
Highway	0.50%	5
Electromechanical	0.10%	1
Production	0.10%	1
Mechanical	20.38%	202
Marine	0.40%	4
Naval Architecture	0.20%	2
Mining	0.10%	1
Petroleum	0.40%	4
Industrial	0.20%	2
Environmental	0.71%	7
Structural	1.31%	13
Hydraulic	0.20%	2
Public Health	0.10%	1
Transport	0.10%	1
Chemical	4.14%	41
Agricultural	0.50%	5
Materials	0.10%	1
Instrumentation and Control	0.20%	2
Electrical and Electronic	1.61%	16
Civil and Structural	1.21%	12
Biochemical	0.10%	1
Instrumentation and System	0.20%	2
Mechanics	0.10%	1
Control System	0.10%	1
Water Resources	0.30%	3
Energy	0.10%	1
Manufacturing	1.11%	11
Aerospace	0.10%	1
Communication	0.20%	2
Construction	0.40%	4
Geotechnical	0.71%	7
Manufacturing System	0.10%	1
Bio-Medical	0.10%	1
Telecommunication	0.20%	2
Mechatronic	0.71%	7
Polymer	0.20%	2
Biology and Agricultural	0.10%	1
Biotechnology	0.10%	1
Microelectronic	0.20%	2
Other (please specify)	3.94%	39
	Answered	991
	Skipped	35

Table 5: Respondents distribution by working industry

	Responses	
Agriculture, forestry & fishing	0.89%	7
Mining & quarrying	1.14%	9
Manufacturing	9.49%	75
Electricity, gas, steam & air-conditioning supply	8.35%	66
Water supply, sewerage, waste management & remediation activities	5.32%	42
Construction	35.95%	284
Wholesale & retail trade, repair of motor vehicles & motorcycles	0.13%	1
Transportation & storage	1.39%	11
Accommodation & food service activities	0.00%	0
Information & communication	1.01%	8
Financial & insurance/takaful activities	0.13%	1
Real estate activities	2.41%	19
Professional, scientific & technical activities	19.62%	155
Administrative & support service activities	0.13%	1
Education	5.44%	43
Human health & social work activities	0.25%	2
Arts, entertainment & recreation	0.00%	0
Other service activities	8.35%	66
	Answered	790
	Skipped	236

Working Industry & Salary

Employment as an engineer does not seem to be a main challenge in Malaysia. However, long working hours with an average of 40-48 hours per week are required. Furthermore, 18.25% of the total respondents are working more than 48 hours per week.

Table 6: Duration taken to secure a job after graduation

	Responses	
Less than 1 month	48.38%	479
1 month	12.63%	125
2 months	7.78%	77
3 months	13.94%	138
More than 4 months	17.27%	171
	Answered	990
	Skipped	36

Table 7: Average working hours per week

	Responses	
Under 30 hours	6.34%	50
30 to 39 hours	11.53%	91
40 to 48 hours	63.88%	504
Over 48 hours	18.25%	144
	Answered	789
	Skipped	237

It is observed that salary is a main concern among engineers. Of 789 respondents, 35% reported that their current basic monthly salary is below RM7,000 (Table 8). Besides, 66.41% of 789 respondents reported that their monthly fixed allowance is below RM1,000 (Table 9). Furthermore, 63.03% of 725 respondents are not satisfied with their current salaries (Table 10). One reason may be due to not being paid for working overtime (Table 11) and having an increase in salary rate of just 1-5% for the past 5 years, in tandem with the inflation rate (Table 12). As such, most of the respondents feel they are underemployed. Table 13 shows 75.86% of 725 respondents feel their salary is not commensurate with skills and experience.

Table 8: Monthly basic salary range (in RM)

	Responses	
Under RM 3,000	5.70%	45
RM 3,000 - RM 6,999	29.40%	232
RM 7,000 - RM 10,999	27.25%	215
RM 11,000 - RM 14,999	13.94%	110
Over RM 15,000	23.70%	187
	Answered	789
	Skipped	237

Table 9: Monthly fixed allowance range (in RM)

	Responses	
Under RM 1,000	66.41%	524
RM 1,000 - RM 2,999	22.05%	174
RM 3,000 - RM 4,999	5.32%	42
RM 5,000 - RM 6,999	2.15%	17
Over RM 7,000	4.06%	32
	Answered	789
	Skipped	237

Table 10: Work satisfaction

Are you satisfied with your current salary?	Responses	
Yes	36.97%	268
No	63.03%	457
	Answered	725
	Skipped	301

Table 11: Overtime pays

Did you get paid for working overtime?	Responses	
Yes	9.24%	67
No	90.76%	658
	Answered	725
	Skipped	301

Table 12: Salary increment

What is your salary rate of increase for the past 5 years?	Responses	
Increase of between 1-5%	51.72%	375
Increase of between 6-10%	18.07%	131
Increase of between 11-15%	3.72%	27
Increase of over 15%	10.48%	76
Stagnant	16.00%	116
	Answered	725
	Skipped	301

Table 13: Opinion of salary pay

Do you think engineers are being paid a salary that commensurates with skills and experience?	Responses	
Yes	24.14%	175
No	75.86%	550
	Answered	725
	Skipped	301

Career Advancement & Skillsets

Although most of the respondents are not satisfied with their salaries, engineering remains their career choice (Table 14) and the majority have no intention to move away from engineering profession (Table 15).

Table 14: Career choice

Is engineering your career choice?	Responses	
Yes	95.03%	689
No	4.97%	36
	Answered	725
	Skipped	301

Table 15: Intention to leave the engineering profession

Do you intend to move away from the engineering profession?	Responses	
Yes	27.31%	198
No	72.69%	527
	Answered	725
	Skipped	301

Table 16 shows that many feel attaining Professional and IEM registration status will be an added advantage for career advancement and will bring them more job opportunities. Table 17 shows that perceived digital skills are more concentrated at the skilled and advanced levels while perceived ESG skills are more concentrated at the awareness, knowledgeable and skilled level.

Table 16: Opinion questions on career advancement and job opportunities

Do you agree that attaining Professional Registration status can help in your career advancement and job opportunities?	Responses	
Yes	81.52%	Yes
No	18.48%	No
	Answered	
	Skipped	
Do you agree that IEM can help in your career advancement and job opportunities?	Responses	
Yes	66.99%	485
No	33.01%	239
	Answered	724
	Skipped	302

Table 17: Digital & ESG skills

How would you rate the level of your digital skills?	Responses	
Awareness	4.55%	33
Knowledgeable	19.45%	141
Skilled	40.55%	294
Advanced	30.34%	220
Expert	5.10%	37
	Total	725
	Weighted Average	12
	Answered	725
	Skipped	301
How would you rate the level of your ESG skills?	Responses	
Awareness	17.10%	124
Knowledgeable	31.03%	225
Skilled	34.21%	248
Advanced	16.28%	118
Expert	1.38%	10
	Total	725
	Weighted Average	2.54
	Answered	725
	Skipped	301

Conclusion

From this survey, it can be observed that technology and ESG practices in transforming business and industry landscapes have changed the role of an engineer which, in turn, may cause wage stagnation. Due to uncertainty over how technology and ESG may disrupt and change the job roles, a way to move forward for a win-win situation between employer and employee, is to ensure business transformation plans are mapped with job re-design for an engineer based on the respective job role. The initiative of implementing multiskilling incentives as a variable allowance (instead relying on basic salary) to adjust the salary scheme should be considered by the employer during the transformation period. ■




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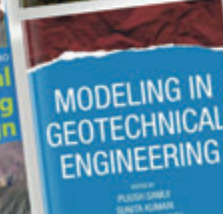

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STEM Robotic Workshop & Competition 2025

by:



Dr. Yip Bao Fang
YES Chairman, IEM Southern Branch

The STEM Robotic Workshop & Competition 2025 held on 16 January 2025 at AEON Bandar Dato Onn, Johor Bahru, was organised by the Young Engineers Section (YES) of The Institution of Engineers, Malaysia (Southern Branch), in collaboration with the Faculty of Electrical Engineering, Universiti Teknologi Malaysia (FKE UTM). The aim was to foster greater interest in science, technology, engineering and mathematics (STEM) through an engaging and hands-on learning experience. The event was organised by facilitators from FKE UTM and representatives from the IEM UTM Student Section, with support from YB Tuan Jimmy Puah Wee Tse, Member of Parliament for Tebrau.

Objective & Participation

The main objectives of the workshop were to inspire and engage students in STEM and robotics education, to provide a platform for hands-on learning and to increase awareness of electronics, IoT, AI and engineering knowledge. Taking part were 30 students and 15 teachers from 15 secondary schools across Tebrau, Pasir Gudang, Johor Bahru, Kota Tinggi and Batu Pahat. The organisers comprised members from IEM SB YES, lecturers and student facilitators from FKE UTM, student committees from the IEM-UTM Student Section and teachers from external schools.



The organising committee with Tuan Jimmy Puah Wee Tse



Students assembling the robotic kits



Robotics competition in progress

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Programme Highlights

There were structured sessions designed to enhance the participants' understanding of robotics and AI. The event commenced with registration and an ice-breaking session, followed by orientation and software verification to ensure the students had access to necessary tools such as Tinkercode, Tinkerbot and Arduino IDE.

A key component of the workshop was a hands-on session in which students learnt to create mobile applications using Blynk. They explored the integration of AI with Tinkercode and Blynk, which enabled them to build interactive and intelligent systems. Facilitators provided guidance throughout, ensuring an interactive and educational experience for all.

The highlight of the day was a mini competition, where students applied their newly acquired knowledge in a friendly yet competitive environment. They worked in teams to develop functional robotic solutions, demonstrating creativity, problem-solving skills and teamwork. The competition served as an excellent opportunity for students to showcase their abilities and innovative spirit.

Closing Ceremony

The event was graced by several distinguished guests, including Tuan Jimmy Puah, who attended the mini-competition and closing ceremony. Also present were Ir. David Puen Ming Shen (Chairman of IEM SB), Ir. Juraimi Masood (Treasurer of IEM SB) and Prof. Ir. Dr. Rubita Sudirman (FKE UTM).

The closing ceremony celebrated the achievements of all participants, with speeches highlighting the significance of STEM in driving technological advancement. Certificates of participation were presented and a group photo session marked the conclusion of the event.

Impact & Conclusion

The STEM Robotic Workshop & Competition 2025 had achieved its goals to promote STEM education, to foster innovation and to encourage students to explore the world of robotics. Participants gained valuable hands-on experience with state-of-the-art technologies such as Tinkercode, Blynk and ESP32 microcontrollers, equipping them with essential skills for future technological advancements.

The event also highlighted the significance of collaboration between academia, industry and government in advancing STEM initiatives. By providing students with the opportunity to apply their knowledge in a real-world setting, the workshop not only strengthened their technical skills but also inspired many of them to want to pursue a career in STEM fields. It definitely left a lasting impact on participants, facilitators and all stakeholders. ■

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- Pavement Foundation
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- Full papers must be written in English and submitted in Microsoft Word and PDF file format.
- All submissions must be original and not previously published or under consideration for publication elsewhere.
- Papers will be peer-reviewed and accepted papers will be published in the conference proceedings.

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An Outstanding Paper Award will be presented to the best paper submitted to the conference. The award will recognize exceptional research, innovation, and contribution to the field of geotechnical engineering. The winning paper will be selected by a panel of experts and announced during the conference. The selected paper will also be considered to be published under an International indexed publications, subject to approval by the panel of experts.

Important Dates

Abstract submission deadline	: 28th February 2025
Notification of abstract acceptance	: 31st March 2025
Full paper submission deadline	: 1st July 2025
Notification of paper acceptance	: 15th September 2025
Submission of the presentation slide	: 15th October 2025
Conference day	: 3rd & 4th December 2025

Submission of abstracts/full papers and enquiries:

All abstracts and full papers shall be submitted to the Organising Committee via email to, Ms Aisyah at: mgc2025@gmail.com or Tel: [03-7890 0132](tel:03-78900132).

*We look forward to your contributions and to welcoming you
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Overview

The primary objective of JURUTERA is to publish articles of general interest to IEM members. JURUTERA provides reports and news on professional activities, branch activities, and current issues of interest. It also serves as one of the medium of communication between the Institution and its members, providing notices and announcements of IEM.

Articles submitted for publication in JURUTERA must be original, light reading material, unpublished elsewhere, and of interest to IEM members. Technical content should be presented in a readable and accessible style. JURUTERA is published Monthly, and can be viewed in the IEM website.

Technical Articles

1. Since JURUTERA is not a peer-reviewed publication, research articles can be forwarded to the Editor of IEM Journal. However, articles based on research conducted are welcome.
2. A technical article are limited to **2,400 words**. The word count must be reduced appropriately with each additional figure or diagram or photo.
3. The author may be requested to modify the article or to clarify certain points in the article. The Editorial Board reserves the right to edit manuscripts for clarity, readability, length and content.
4. An article should communicate information efficiently and effectively to readers. The prose should follow a coherent line of thought. Sidebars, tables and figures may be used where appropriate. All mathematical equations must be properly checked by the authors themselves, using MS Excel formulae format. It is suggested that all articles have a summary or conclusion. Technical or formal articles may list the references cited using the IEE style.
5. The actual publication of an article is at the sole discretion of the Editorial Board.

Reports on Activities

1. **Each report shall be limited to 800 words:** All reports should be concise and precise in view of the limited publication space. The word count must be reduced appropriately with each additional figure or diagram or photo. As the sizes of such insertions affect their word-countequivalent, it will be left to the judgement of the authors on the number of words to cut. The Bulletin Editor retains the right to edit or further reduce the number of words.
2. **All reports are subjected to selection for publication by the Editorial Board:** To better determine themselves on the suitability of the reports, the Editorial Board is free to seek further advice from parties deemed fit to do so, while avoiding conflict of interest such as asking the same Technical Division to vet their own reports.
3. **Reports on activities should be value-adding to the readership:** For example, reports on talks should be akin to an extended abstract from which readers could get the gist of the talk and the subsequent Q&A. Reports on visits, forums and others shall serve a similar purpose, e.g. highlighting critical observations, issues, resolutions that will be of interest to the readers. Other than the basic information such as title, venue, name and affiliation of the speaker, details which are of little interest to most readers (such as the time of arrival at a destination, presentation of a token of souvenir etc) should be excluded.
4. **A report should preferably be submitted within a month from the date of activity:** Considering that some Technical Divisions have internal vetting process prior to submission, the Editorial Board will not be unreasonably strict with this requirement.

5. Although the Editorial Board will strive to publish the reports in a timely manner, the Editorial Board reserves the right to Schedule to a later date, e.g. to provide room to clear the backlog, or to better fit the theme of the month. Until the backlog is cleared, each issue of JURUTERA will contain a mix of earlier submitted and relatively current reports.
6. It is also the discretion of the Bulletin Editor to decide on the reports to be uploaded in the IEM webportal "Jurutera Online".

Writing Style

1. It is recommended that authors peruse published articles in past issues of JURUTERA to get a feel for the style, format and nature of the articles. A technical article may use a formal style, while an opinion piece may be written in a very casual style. The Editorial Board prefers to refrain from imposing particular styles.
2. Articles should be in U.K. English. Submitted material is expected to be of a high standard.
3. Since articles submitted for JURUTERA are not peer-reviewed, the onus is on the author to ensure that the article is factually correct and the arguments are sound.
4. An article should be written in a clear and direct style. Paragraphs and sentences should be short and easily digestible. Long-winded and tedious technical writing styles must be avoided. Writing is a two-way street; remember that you are writing for an audience that consists largely of both technically-minded trained professionals and budding engineers. The reader should be moved along briskly; reading JURUTERA ought to be an enjoyable and satisfying activity.

Authors

Authors are requested to submit a recent passport-sized photograph together with a brief profile of themselves. Authors are also encouraged to provide keywords for articles submitted.

Submission of Materials

Electronic copies of articles may be sent as attachments to the following e-mail address: pub@iem.org.my. Your documents should have meaningful and unambiguous names. Large documents may be sent compressed using the ZIP archive format and should be sent as separate attachments.

Photographs and Illustrations

All photographs should be of high quality, ready for typesetting. Image files should be in JPG/JPEG format, and of a high resolution (at least 300 DPI.) Drawn illustrations must be of high quality, as they will be used "as is". All figures, tables, graphs and photographs must be rightly captioned.

Fair Use of Copyrighted Material

It is necessary to adopt a conservative policy on the fair use of copyrighted material. The Editorial Board reserves the right to reject articles that exercises the doctrine of fair use in an excessive manner. It is up to the author to obtain permission, if necessary, for the use of copyrighted material.

Use of Proprietary Material

An article must not overtly promote a proprietary or commercial product. Such articles will be immediately rejected. Proprietary material such as trade names and proprietary terms should be avoided. Prose that seems advertorial in nature is unwelcome. An objective and balanced technical discussion involving commercial products is acceptable.

Date: 22 February 2025

To all Members,

**LIST OF CANDIDATES ELIGIBLE TO SIT FOR
THE PROFESSIONAL INTERVIEW FOR THE YEAR 2025**

The following is a list of candidates who are eligible to sit for the Professional Interview for the year 2025.

According to the IEM Bylaws, Section 3.8, the names listed below are published as eligible candidates to become Institution Members, provided that they pass the Professional Interview in 2025.

If there are any Corporate Members who have objections against any candidate deemed unsuitable to sit for the Professional Interview, a letter of objection can be submitted to the Honorary Secretary, IEM. A letter of objection must be submitted within one month from the date of publication.

Ir. Prof. Dr. Tan Chee Fai
IEM Honorary Secretary

NEW APPLICATION

NAME	QUALIFICATION
CIVIL ENGINEERING	
NURFAIZAN BIN NASIR	BE HONS (UMS) (CIVIL, 2016)
IBRAHIM HANIF BIN MD GHAZALI	BE (UITM) (CIVIL, 2010)
ELECTRICAL ENGINEERING	
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PANG SIEW YONG	BE HONS (UNITEN) (ELECTRICAL & ELECTRONIC, 2013) ME HONS (UNITEN) (ELECTRICAL, 2018)
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Fire Safety Systems

Guidelines for Hydrogen Refuelling Stations

Hydrogen energy is a potential substitute for conventional oil and gas. Hydrogen research and development in Malaysia started in 2001. However, hydrogen production development was kickstarted only in 2023, in pursuant to the country's Hydrogen Economy & Technology Roadmap establishment.

However, despite the huge potential of hydrogen, challenges remain when it comes to safety, with regards to its production, storage, and utilisation. To date, there are no fire safety guidelines established in Malaysia for safe hydrogen operation.

Thus, this document was crafted to provide comprehensive guidelines and reference pertaining to fire safety requirements for Hydrogen Refuelling Stations (HRS) in Malaysia. It encompasses all pertinent aspects, including applicable codes and standards, hazards identification and risk assessment, fire prevention and protection management as well as the human factor.

Objectives

This document is developed as a technical guidance to ensure:

- Adequacy of fire prevention and protection design for HRS facilities in Malaysia
- Compliance with Regulatory, Codes & Standards

Terms & Definitions

CAS	Chemical Abstracts Service
CGA	Compressed Gas Association
CHSV	Compressed Hydrogen Service Vehicle
ERP	Emergency Response Plan
ESS	Emergency Shutdown System
GH2	Gaseous hydrogen
H-Code	Hazard statements code
Hazard Identification	Identification of possible hazards and their sources which may result in a fire risk resulting from the proposed project storage, processes, and production
HRS	Hydrogen Refuelling System
ICOP	Industry Code of Practice
IEC	International Electrotechnical Commission
ISO	International Organisation for Standardisation
JBPM	Jabatan Bomba & Penyelamat Malaysia
LH2	Liquified Hydrogen gas
LFL	Lower Flammability Limit
LOPC	Loss of Primary Containment
LPS	Low Pressure Storage
NFPA	National Fire Protection Association
SMR	Steam Methane Reforming
UBBL	Uniform Building By-Laws
UFL	Upper Flammability Limit

Overview of Hydrogen Refuelling Station

Hydrogen gas can be generated on-site via electrolysis or delivered through tube trailers and metal hydride storage trailers. A typical HRS, which is an integration of On-site Hydrogen Generators, Hydrogen Gas Supply via trailers and Hydrogen Dispensing facilities is illustrated in Figures 2.1 and 2.2.

Hydrogen Gas Supply via On-Site Hydrogen Generator: On-site hydrogen production is typically established through water electrolysis. The equipment required for this includes the cell(s), electrical, gas processing, ventilation, cooling, monitoring equipment, and controls.

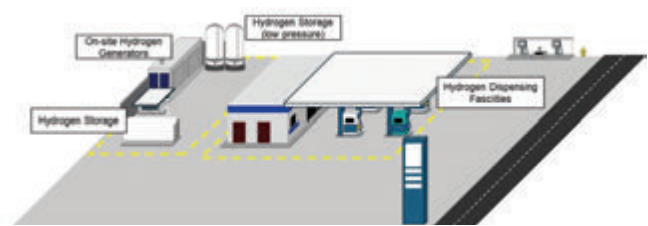


Figure 2.1: Typical arrangement of On-site Hydrogen Generator with Hydrogen Dispensing Facilities

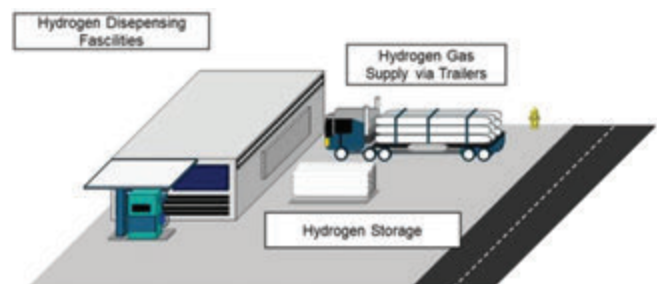


Figure 2.2: Typical arrangements of Hydrogen Gas Supply via Trailer with Hydrogen Dispensing Facilities

Hydrogen generators consist of the following process/facilities:

- Water purification
- Electrolysis
- Hydrogen (H_2) and Oxygen (O_2) separation
- Low pressure storage (LPS)
- Compression (if required)
- High pressure storage (if required)
- Utilities and offsite facilities

Hydrogen Gas Supply via Trailers: If not produced on-site, hydrogen gas can be supplied to the HRS externally via tube trailers and metal hydride storage trailers in the form of compressed gas. Trailers can either deliver to on-site hydrogen storage vessels at the HRS or remain at the site and are replaced when the inventory of the hydrogen product in the trailer is low.

Hydrogen Dispensing Facilities: Hydrogen gas dispensing facilities may be used to receive hydrogen supplied by on-site hydrogen generators or via trailers. These facilities consist mainly of following:

- Low pressure hydrogen gas storage
- Compressors
- High Pressure Hydrogen gas storage
- Chilling system
- Dispenser

The low-pressure gaseous hydrogen supply is compressed and stored at pressures above the maximum vehicle pressure (either 350 or 700 bar). When a vehicle is to be filled, the high-pressure hydrogen gas flows into the vehicle through a dispenser. To ensure safety and efficiency, a chiller is typically used to pre-chill the high-pressure gas before it is dispensed. Figures 2.1 and 2.2 show the typical arrangements for hydrogen dispensing facilities.

Scope

This document provides technical guidance on the requirements of fire safety systems for the following:

1. On-site hydrogen generators
2. Hydrogen dispensing facilities
3. Hydrogen gas supply via trailers

The following process or systems are not covered:

1. Liquified hydrogen gas system (LH₂)
2. Vehicle/ truck refuelling receptacle
3. Other types of hydrogen generation e.g. SMR, ammonia
4. Hydrogen gas supply transportation e.g. tube trailers, tankers

Regulatory Compliance

Applicable Regulatory requirements, Codes & Standards. Applicable Malaysian Laws and Regulations are as follows:

1. Akta Perkhidmatan BOMBA 1988 (Akta 341)
 2. Uniform Building By-Law (UBBL)1984
 3. Sarawak Building Ordinance 1994
 4. Occupational Safety and Health Act 1994 (Act 514)
 5. Other Regulations approved by JBPM.
- Other recognised Codes & Standard applicable for hydrogen production and dispensing facilities:
1. NFPA 2 Hydrogen Technologies Code
 2. NFPA 55 Compressed Gases & Cryogenic Fluids Code
 3. ISO 22734 Hydrogen generators using water electrolysis — industrial, commercial, and residential applications.
 4. ISO 19880-1 Gaseous hydrogen – Fuelling Stations
 5. ISO/Technical Report 15916 Basic Considerations for the Safety of Hydrogen Systems
 6. CGA G-5.5 Hydrogen Vent Systems
 7. IEC 60079-10-1, Explosive atmospheres- Part 10.1: Classification of areas - Explosive gas atmospheres
 8. MS 2558:2022 – Safety and health signage used in the workplace – Specification
 9. SAE J2600, SAE J2601, SAE J2601-2, SAE J 2799

Other acceptable Codes & Standards. The project team (comprising Submitting Person, Manufacturer, Owner and PMT) is advised to present the Project Brief and justification to obtain JBPM feedback and directions on fire protection and prevention system requirement.

Hydrogen Hazards

Hydrogen Properties: Hydrogen Properties and ICOP classification are summarised in Table 5.1 and Table 5.2.

Risk Management

Appropriate hazard identification and risk assessment shall be conducted to evaluate the design of the HRS and adequacy of barriers, in accordance with Codes & Standard in Section 4 e.g. ISO 19880, NFPA 2.

A risk assessment shall be performed except when the stations comply with prescriptive regulations which address relevant risks.

Table 5.3 tabulates the typical hazards associated with components of HRS facilities, as a reference during a hazard identification and risk assessment exercise. It also shows typical hazards and operating parameters for each component in HRS.

Table 5.1: Hydrogen Properties

Property	Criteria
General Characteristic	• Colourless, odourless and tasteless gas • Non-toxic • Non-corrosive • Does not support life (asphyxiant)
Density	0.0838 kg/m ³ Note: 1. 14 times lighter than air 2. Rises quickly under atmospheric conditions
Specific Gravity	0.0696 Note: Air Specific Gravity is 1.0
Auto-ignition Temperature	585°C
Flammable Range	LFL: 4%; UFL: 75%
Minimum Ignition Energy	0.02 mJ Note: Minimum ignition energy in air (one of the lowest among substances)
Size/Diffusivity	1.697 m ² /hour Note: 1. 4x smaller than Natural Gas 2. Diffuses through many "gas tight" or "impermeable" materials. 3. Smallest molecule

Table 5.2: Hydrogen ICOP Classification⁽¹⁾

CAS No	Classification		Labelling		
	Classification Code	H-Code	Signal Word	H-Code	Hazard Pictogram
1333-74-0	Flam. Gas 1 Press. Gas	H220	Danger	H220 H280/281	

(1) Industry Code of Practice on Chemical Classification and Hazard Communication (Amendment) 2019

Table 5.3

Components	Example of Hazards	Example Operating Parameters (System Pressure/ Temperature)
On-site hydrogen generator	• Hydrogen gas • Oxygen gas • High pressure/ temperature • Flammable mixture in enclosures	Up to 25 MPa/ -18°C to +40 °C
Hydrogen delivery via trailers including mobile storage and remote fill points	• Flammable mixture in atmosphere	Up to 25 MPa/ -18°C to +40°C
Low pressure storage	• High pressure/ temperature • Flammable mixture in atmosphere/ enclosure	Up to 25 MPa/ -18°C to +40°C
Compressors	• High pressure/ temperature • Flammable mixture in atmosphere/ enclosure	Up to 97.5 MPa/ -18°C to +40°C
High Pressure Storage	• High pressure/ temperature • Flammable mixture in atmosphere/ enclosure	Up to 97.5 MPa/ -18°C to +40°C
Pre-cooling	• High pressure/ temperature • Flammable mixture in atmosphere/ enclosure	Up to 97.5 MPa/ -18°C to +40°C
Dispensers	• High pressure/ temperature • Flammable mixture in atmosphere	Up to 97.5 MPa/ -18°C to +40°C

Fire Prevention Management

By addressing fire prevention requirements during the design phase, HRS facilities can minimise the risk of fire incidents and ensure the safety of personnel, vehicles, and surrounding properties. This section describes some of the fire prevention features to be considered in the design. Fire prevention measures shall form an integral part of the design, engineering, and construction of the HRS.

- 1. Separation distance requirements.** These shall be in accordance with applicable Codes & Standards, e.g. NFPA 2 and ISO 19880, for the types of hydrogen storage handled by the facility. Adequate separation distance shall be provided to minimise the impact of fire or an explosion to the surrounding facilities which can cause escalation and harm to the public.
- 2. Ignition Control.** Equipment shall be classified in accordance with IEC 60079-10-1. An average hydrogen gas concentration in enclosed areas within the enclosure shall be maintained below the LFL level of hydrogen. Design requirements for HRS involve implementing measures to prevent the accidental ignition of the highly flammable hydrogen gas. This includes selecting equipment and materials which minimise the risk of electric sparking or heat generation, selection of explosion-proof electrical equipment, ensuring proper ventilation to disperse hydrogen leaks, and implementing safety protocols such as bonding and grounding to prevent static electricity buildup. According to NFPA 2, paved surfaces shall have a resistance of 1 megohm or less to allow static charge to safely dissipate, preventing buildup before refuelling begins.
- 3. Emergency Shutdown System (ESS).** The main approach to extinguish hydrogen fire is through isolation and pressurisation. The ESS plays an important role in preventing fire hazards for hydrogen facilities. The ESS shall operate upon activation of a manual or automatic emergency shutdown device (ESD). The detailed requirement of ESS shall be in accordance to Codes & Standards at section 4.0 e.g. ISO 19880, NFPA 2.
- 4. Means for emergency venting of hydrogen storage vessel.** Relief of hydrogen from the depressurisation system shall be routed to a safe location. Means to extinguish vent fire and flash back into the system may be provided.
- 5. Pressure Relief Device.** All pressurised systems and equipment shall be protected from overpressure by means of one or more pressure relief devices (PRD) or pressure safety system. Hydrogen vents shall be designed in accordance with the Codes & Standards at section 4 e.g. ISO 19880, NFPA 2.
- 6. Isolation or shut-off valve.** This shall be provided for equipment and systems where the isolation of process flow is necessary during emergency conditions. Requirements for the isolation valve shall be in accordance with the Codes & Standards in Section 4 e.g. ISO 19880, NFPA 2.
- 7. Ventilation.** For enclosures or buildings containing hydrogen equipment (with hydrogen concentrations at or below 25% of the Lower Flammable Limit), ventilation shall be achieved either through natural ventilation or mechanical ventilation e.g. blower, extractor as per Codes & Standards in Section 4, e.g. ISO 19880, NFPA 2.
- 8. Oxygen Venting for On-site Hydrogen Generator.** Oxygen can be vented either indoors or outside of the enclosure. If oxygen is vented outdoors, it shall be done in a way that will not create a hazardous condition, i.e. vented at a safe location. If it is vented indoors, the enclosure should be diluted by a ventilation air stream to a volume fraction of oxygen less than 23.5% before being exhausted from the enclosure. The design of oxygen venting shall be in accordance with ISO 22734.

Fire Protection Management

- 1. Passive Fire Protection.** Passive fire protection prevents the spread of fire and protects structure integrity. Consideration shall be given to passive fire protection to protect critical structures, equipment, and people against direct fire impact.

- A fire wall shall be provided at strategic locations at the hydrogen generation and storage areas to prevent direct impact on the surroundings such as dispensing unit and public areas. The requirement of a fire wall can be further justified through consequence modelling or Fire & Explosion Risk Assessment (FERA) in accordance with the Codes & Standards in Section 4 e.g. ISO 19880.

Note:

- Based on industrial practices, emergency procedures/mitigation are focused on isolation of hydrogen release through emergency shutdown system.*
- The likelihood of emergencies comes from tubing & piping leaks and are unlikely for tank incidents.*

- 2. Active Fire Protection.** Design, siting and installation requirements for applicable active fire protection for HRS e.g. fire hydrant and portable fire extinguisher (ABC type) shall be in accordance with MS1489 and MS1539 as shown in Appendix 1. Fire protection for buildings shall comply with UBBL requirement.

Detection. A leak detection system shall be provided and shall cause the hydrogen generator to alarm where possible and, where possible, to change the operating parameters to minimise the inventory of release.

The hydrogen fire and gas detector(s) shall be installed at optimum location(s) e.g. hydrogen generator enclosure, compressor skid, etc. to provide the earliest detection of the presence of hydrogen gas and fire.

The alarm set points are:

- A lower activation limit set at maximum value of 10% of the LFL (0.4% by volume) for a high-level alarm.
- A higher activation limit, set at maximum value of 25% of the LFL (1.0% by volume) for a high-high level alarm, indicating a more urgent danger.

The 25% LFL threshold is a precaution, as hydrogen levels at this point pose a high risk of becoming flammable if they continue to rise.

Communication and alarm system. This should be installed at appropriate location(s) in accordance with the Codes & Standards at Section 4 with distinctive audible and/or visual to give notification as to the status of the facilities and emergency responses.

People Safety Management

This section describes the safety precautions and considerations to ensure the safe operation of the HRS facility as well as timely and effective responses during an emergency.

Emergency Response Plan (ERP). A dedicated ERP shall be established and shall be readily available to operations personnel. The ERP shall include the information below in accordance with the Codes & Standards in Section 4.

- Type of emergency scenario
- Type of emergency equipment available and its location
- Brief description of any testing or maintenance done
- Maintenance programmes for the available emergency equipment
- Indication that hazard identification labelling is provided for each storage area
- Safety data sheet (SDS) or equivalent to be stored for use on the site
- Site emergency response team
- List of emergency contacts, emergency services and phone numbers

- Emergency chain of command
- Duty list
- Site plan and equipment operating manuals.

Escape Route and Muster Area. An escape route for the HRS facility shall be designed in accordance with UBBL requirements. Safe areas shall be identified and located outside of hazardous areas (i.e. fire exposure) and provide adequate occupancy requirements, such as accessibility and space of the facility.

Suitable roadways or other means of access for emergency equipment, such as fire department apparatus shall be provided in accordance with UBBL 1984.

Safety Signage. Safety signages shall be provided for HRS facilities in accordance with MS 2558, NFPA 55, NFPA 2, ISO 3864-1, and ANSI Z535.1 including the shape, colour, size and position of the signage. Safety signages are used for warning against hazards and for providing safety-related information. Table 8.1 shows examples of safety signages that can be used for HRS facilities.

Table 8.1: Examples of Safety Signage

Example of safety signs from MS 2558	Description
	• No open flame. • Fire • Open ignition source and smoking prohibited
	• Personal protective equipment required. • Keep well ventilated
	• Warning: Explosive • Hydrogen Flammable Gas
	• Fire Exit • Assembly area
	• Firefighting equipment • Fire extinguisher • Fire alarm call point

Ignition Control. The facility must be designed, constructed, and maintained in a way that prevents unintended explosions and fires that can damage adjacent compartments, emergency life safety systems, adjacent properties, adjacent outside storage, and the facility's structural elements. Additionally, operations associated with the facility must also be conducted in a way that prevents such incidents. This can be achieved through the prevention of ignition. Potential ignition sources include the following:

- Mechanical electrical sparks
- Hot surfaces, flames
- Frictional heating
- Adiabatic compression and shock wave
- Electrical equipment, especially non-flameproof motors
- Static electricity
- Radio waves

These ignition sources shall be identified and prohibited from being located within the refuelling area. Ignition control for HRS facilities shall be in accordance with the applicable standards.

Vehicular Impact Protection Measures. The site layout and the selection for the vehicular impact protection shall be taken into account as part of the HRS facility. Protection measures shall be in accordance with ISO19880 to prevent vehicles from potentially colliding into the dispenser at the facility.

Operation Procedures. Operating procedures shall be developed for managing the HRS facilities. As a minimum, the following procedures shall be developed and training provided for the operator:

- Startup and Shutdown procedure
- Normal operating procedure
- Emergency/Abnormal procedure.

Hydrogen Fuelling Protocol

Hydrogen dispensing protocol and process limit for gaseous hydrogen dispensers intended to fuel light-duty and heavy-duty hydrogen motor vehicles shall be in accordance with the acceptable standard for safe dispensing protocol of hydrogen powered vehicles e.g. SAE J2600, SAE J2601, SAE J2601-2, SAE J 2799.

The manufacturer shall ensure that the pressure drop between the dispenser fuel pressure sensor, which monitors vehicle pressure, and the nozzle, stays within the limits defined in the fuelling protocol during hydrogen flow, as outlined in ISO 19880- 1:2020. The system must detect potentially hazardous leaks, such as hose failures, and limit the volume of leaked flammable gas. Possible methods for detecting leaks include:

- Detecting low dispenser fuel pressure and triggering an emergency shutdown
- Identifying an unexpected drop in fuel pressure and activating the shutdown.
- Detecting a higher-than-expected flow and initiating the emergency shutdown.

Inspection, Testing & Maintenance

Inspection, testing and maintenance programmes shall be established to ensure the integrity of the HRS facility. The programme shall focus on safety critical equipment such as safety interlock system, pressure safety valves, high pressure piping and vessels containing hydrogen, fire detection and protection system, etc.

Procedures shall be established for the expected service and maintenance activities. These procedures shall address proper isolation of the system, worker safety, measures required during the maintenance or service activity, and steps required to return the system to operation. The procedures are meant to prevent contamination or air ingestion into the dispensing system.

Frequency of the periodic inspection, testing and maintenance shall be established in accordance with Codes & Standard in Section 4 e.g. ISO 19880 and shall comply with recommendations from the manufacturer. ■

Appendix 1: Active fire protection for HRS facilities

Facility	Components	Type of Firefighting	
		Fire Extinguisher (ABC Type)	Hydrant
Hydrogen Onsite Generator and Dispensing Facilities	On-site hydrogen generator	X	X Note 1
	Hydrogen mobile storage and fill points	X	
	Low/High pressure storage	X	
	Compressors	X	
	Dispensers	X	

Note 1: Hydrant provided for overall fire protection coverage to Hydrogen Refuelling Station facilities