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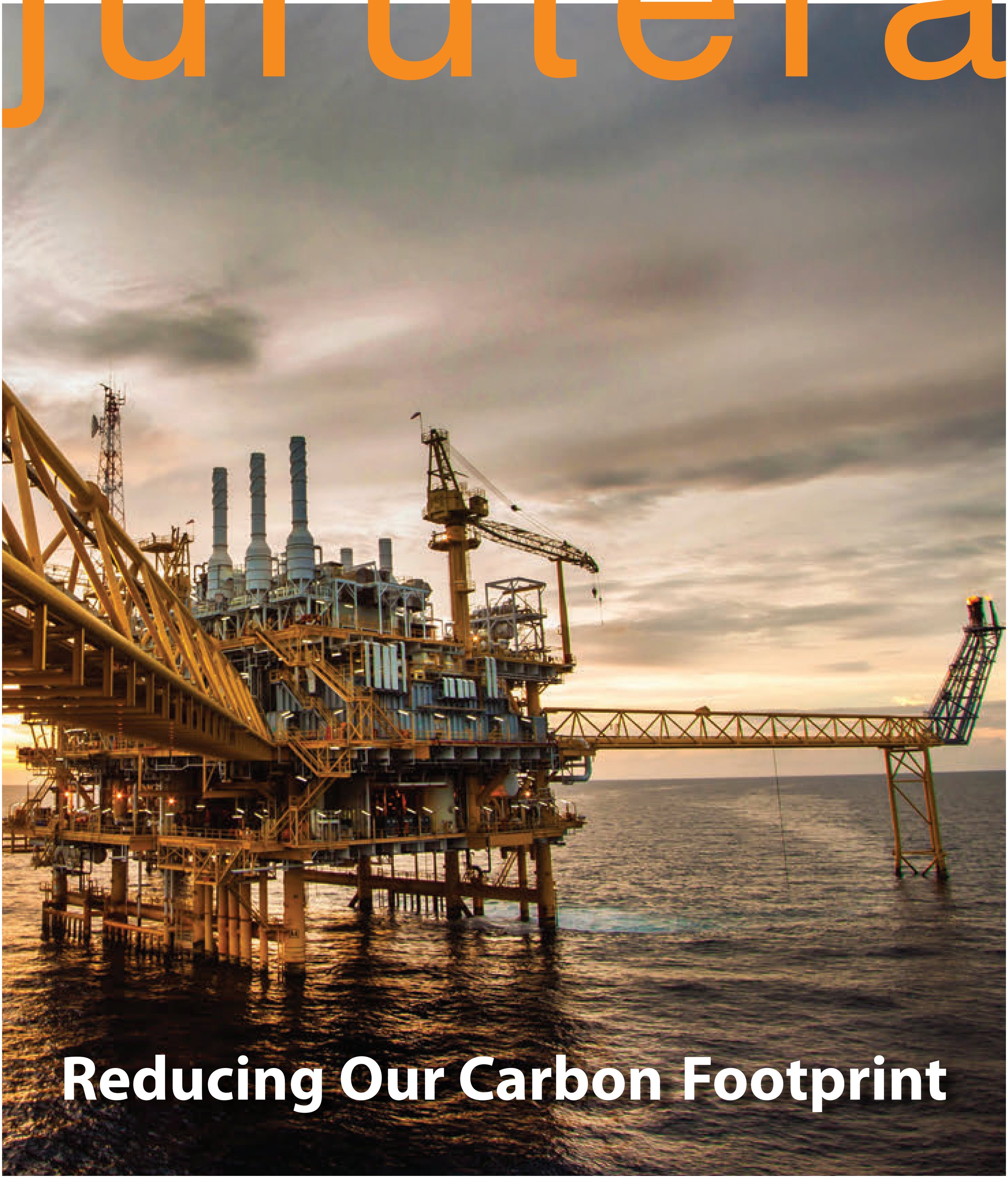

Reducing Our Carbon Footprint

NOVEMBER 2021 THE MONTHLY BULLETIN OF THE INSTITUTION OF ENGINEERS, MALAYSIA

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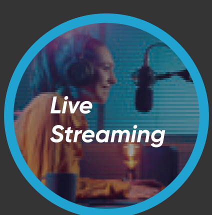

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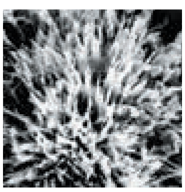

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COVER NOTE

OVERCOMING CHALLENGES IN REDUCING CARBON FOOTPRINT

by Ir. Abdul Razak bin Yakob
Chairman, Oil, Gas & Mining Technical Division

The Oil, Gas & Mining Technical Division (OGMTD) is proud to champion this month's bulletin which focuses on an important issue and talks to industry players about their challenges in the effort to reduce the carbon footprint. Sustainability goes hand in hand with efforts to reduce the carbon footprint in all industry sectors and this includes Oil & Gas.

Carbon neutral, carbon positive, carbon negative, climate positive, climate neutral, net-zero emission, net-zero carbon emission and greenhouse gas are terms related to efforts to reduce carbon footprint. On 17 January 2020, Brad Smith of Microsoft announced that it will become carbon negative by 2030 and will remove historical carbon emissions by 2050. Though many people may question the achievability and even what this really means, this is a corporate commitment that the world needs to ensure the destruction we have caused is balanced with healing efforts.

While we question the Oil & Gas industry about its contributions to heal Earth, we may want to look closer at our own backyard. What have we, as individuals, done to take care of and protect the ground we stand on? Every tiny effort counts. Bringing your own bag when out shopping and switching off the home air-conditioning before you sleep can help reduce your own carbon footprint. So let's contribute to this effort and continue to engineer our country to greater heights! ■

EDITOR'S NOTE

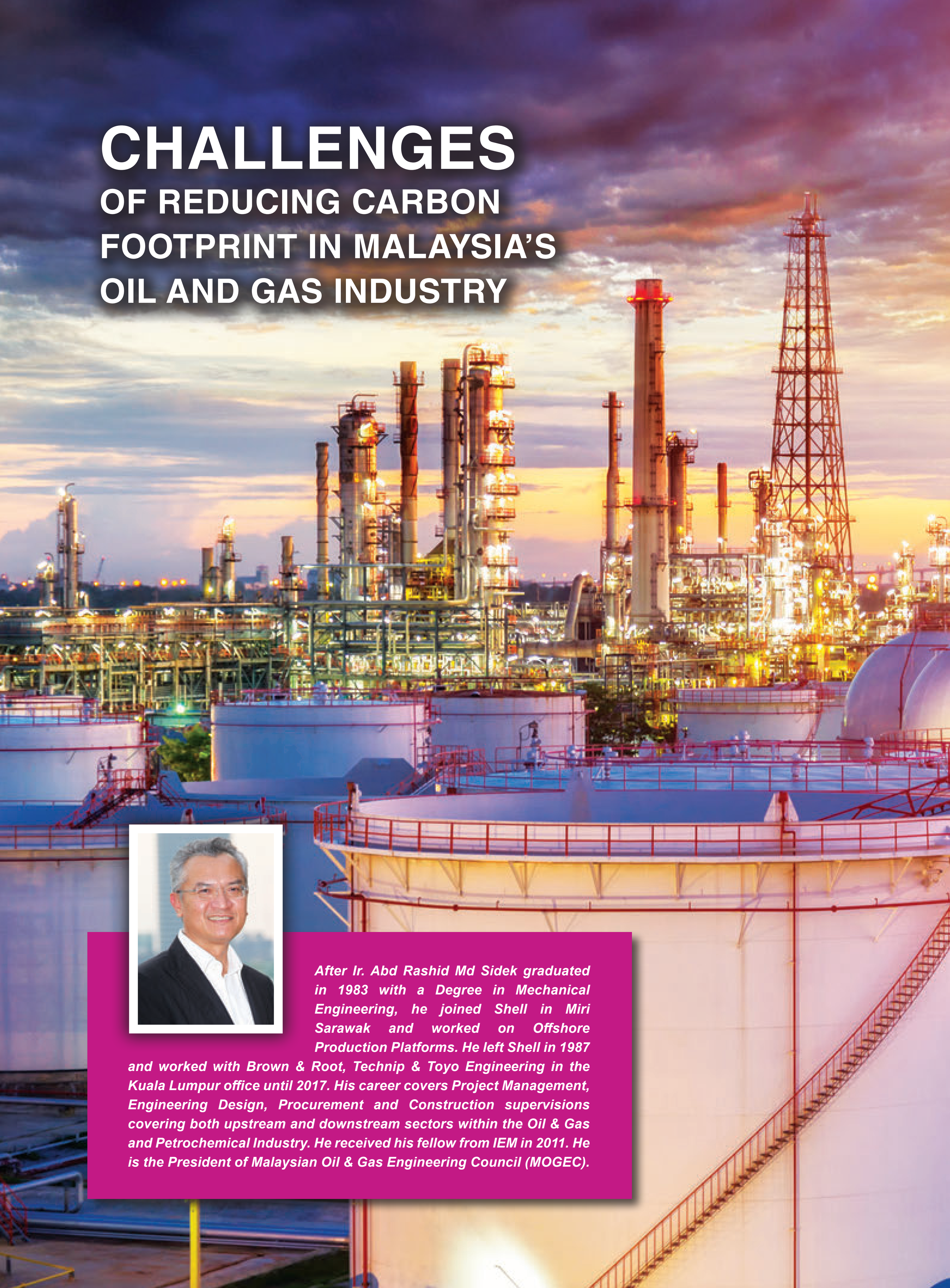
COLLECTIVE EFFORT FOR BIG RESULTS

by Ir. Prof. Dr Zuhaina binti Zakaria
Principal Bulletin Editor

This month, *JURUTERA* focuses on the challenges in reducing our carbon footprint. With the COVID-19 pandemic, global economic and social activities almost came to a standstill. One positive side effect was a reduction in global carbon dioxide emissions by 6.4% (or 2.3 billion tonnes) in 2020 as reported in Nature. In Malaysia, based on the air quality index as recorded by the Department of Environment, our air was cleaner during the Movement Control Order. However, this may prove temporary as many countries move into the endemic phase and economic activities start to recover.

As individuals, we can estimate our personal carbon footprint from our daily activities such as travel, use of electricity and waste disposal. This will help us understand the amount of CO_2 generated in our own households and so, take steps to reduce it. It may seem like a small contribution but a collective effort will lead to big results in reducing greenhouse gas emissions.

On another note, the editorial board would like to wish all Hindu readers, "Happy Deepavali", the festival of lights. May the beauty of Deepavali fill your home with happiness, and may the coming year provide you with everything that brings you joy. ■



CHALLENGES
OF REDUCING CARBON FOOTPRINT IN MALAYSIA'S OIL AND GAS INDUSTRY

After Ir. Abd Rashid Md Sidek graduated in 1983 with a Degree in Mechanical Engineering, he joined Shell in Miri Sarawak and worked on Offshore Production Platforms. He left Shell in 1987 and worked with Brown & Root, Technip & Toyo Engineering in the Kuala Lumpur office until 2017. His career covers Project Management, Engineering Design, Procurement and Construction supervisions covering both upstream and downstream sectors within the Oil & Gas and Petrochemical Industry. He received his fellow from IEM in 2011. He is the President of Malaysian Oil & Gas Engineering Council (MOGEC).

The Oil & Gas industry has a big part to play in meeting climate change goals. Efforts to achieve these goals come with many challenges, as discussed by Ir. Abd Rashid Md Sidek, President of Malaysian Oil & Gas Engineering Council (MOGEC), with IEM Oil, Gas & Mining Technical Division (OGMTD) Chairman Ir. Abdul Razak Yakob, Deputy Chairman Ir. Lee Chang Quan and Secretary/Treasurer Ir. Muhamad Her Jantan.

More than 70 countries, including major greenhouse gases (GHG) emitters such as China, United States of America and nations that make up the European Union, have pledged to achieve net-zero carbon emissions/carbon neutrality by 2050 or earlier. This pledge complies with the Paris Climate Agreement signed during the United Nations Framework Convention on Climate Change's 21st Conference of the Parties (COP21) in 2015. More developing countries, including Malaysia, have also set policies and plans in line with the global carbon neutrality target.

Malaysia pledged to reduce greenhouse gases by 45% by 2030, relative to the emissions intensity of GDP in 2005. Looking at the latest developments on climate change in the Intergovernmental Panel on Climate Change (IPCC) report, pressure is growing for countries to increase their efforts and to push for carbon neutrality within a certain timeframe. The outcome is expected to be known during the 26th UN Climate Change Conference (COP26) which will be held in Glasgow in November 2021.

According to global management consulting firm McKinsey & Company, if the world aims to meet its climate change goals, the Oil & Gas (O&G) industry will have to play a big part. O&G operations account for 9% of all human-made GHG emissions and in addition, it produces fuels which create another 33% of global emissions.

Commenting on the global scenario, Ir. Abd Rashid Md Sidek, President of the Malaysian Oil & Gas Engineering Council (MOGEC), says the total world emissions of carbon dioxide (CO_2) today is approximately 40 Gtpa (gigatons per annum) CO_2. Currently, 30 operational projects are injecting 0.04 Gtpa CO_2.

"To keep to 1.5°C, by 2050, the world needs to inject 5 Gtpa CO_2 for fossil fuel power generation (coal, natural gas), industry (cement, iron/steel, alumina, petrochemicals), energy from waste (EfW, W2E) and CO_2 capture (bio-energy with carbon capture and storage or BECCS)," he says.

He notes that today, there is an increase in the number of companies, organisations and jurisdictions announcing net-zero climate target. This is because most have realised the urgency to save our planet and that people must act now.

"From the economic perspective, we should be able to find the right balance in our act to reduce the carbon footprint. From an engineering viewpoint, in keeping with the laws of thermodynamics, the sectors which contribute more towards GHG should make every effort to reduce the impacts. For example, many regard the O&G industry as the main contributor to the carbon footprint since fossil fuel burning is the major GHG contributor. This is arguably true in the Malaysian context, given that O&G is a key economic driver for our country," he says, adding that those in the O&G industry are also nevertheless the ones leading the technology to reduce the carbon footprint with Carbon Capture, Low to Zero Carbon LNG, Green/Blue Hydrogen, Biomass replacing fossil feedstock, and/or Sustainable Chemistry in recycling for sustainable use of resources (i.e., recycling plastics to monomers to create another environmentally friendly product).

These are among the existing technologies which can be applied to existing or new product lines and this application should offer more opportunities to grow Malaysia's economy. Efforts to reduce our carbon footprint should be viewed as an opportunity to optimise the cost of running businesses.

"With the current environment that we are living in, our carbon footprint reduction efforts include cutback in travel, as quite a bit of our work can now be done via virtual platforms, and improvement in energy efficiency as more people are working from home," he says.

ENERGY MIX

Some 80% of the country's GHG emissions is from the energy sector. Further, 71% of the energy mix comes from fossil fuels and of this, 41% is from gas. On the other hand, coal takes up 22% of the energy mix. There has been a substantial growth in coal consumption in recent years, driven by the demand in the power generation sector, placing Malaysia in an almost unique position of being a major importer of coal, while being a major exporter of natural gas.

Ir. Abd Rashid also says that while renewable energy (RE) capacity is growing steadily, conventional energy will still play a significant role in our energy supply for the coming decades, even as we move from a position of baseload security to ensuring supply stability.

For conventional fuels, he says the choice is essentially between coal and natural gas. Coal is cheaper but it is also twice as polluting. Combined-cycle gas fired plants are

MOGEC Council Members with En. Zainul Rahim Mohd Zain at MOGEC Live Webinar jointly organised with Hibiscus Petroleum held on 19 Nov 2020

also far more efficient than coal-fired plants. Moreover, natural gas is better suited to play the supporting role to intermittent renewables since it is cheaper to cycle (ramp up and down) gas power plants than coal-fired plants.

"Malaysia imports most of its coal and there are no socio-economic benefits for the country. Conversely the increase in consumption of natural gas, particularly if it drives renewed efforts in local exploration and production, will result in a commensurate increase in the economic footprint of the industry, with associated socio-economic benefits. Therefore, replacing coal from retiring power plants with natural gas is a low hanging fruit for Malaysia to strive towards our decarbonisation goals," he says.

COMMITMENT OF MOGEC

In helping the country fulfill its pledge to reduce the carbon footprint and develop alternative energy resources, Ir. Abd Rashid says all O&G players are committed in one way or another to reduce their carbon footprint. He adds that the recent groundswell of support for climate action that has arisen across the globe has reinforced this commitment.

MOGEC members who provide the full spectrum of engineering services to the O&G industry, support their clients through engineering, project delivery and technical expertise to enable the industry to reduce its carbon footprint. Their ultimate clients are generally oil companies and plant owner-operators.

Elaborating, he says: "In general, MOGEC members are collaborating with many O&G companies to work on energy transition offerings, which are ways that we can reduce carbon footprints. These include integrating complex technologies, including proprietary technologies, to meet project specificities and economic hurdles."

There are many technologies, know-hows and solutions being offered for different type of industry needs. Teams of specialists are involved to support companies such as PETRONAS, to work on technologies in particular, including Carbon Capture and Sequestration, cleaner solutions for brownfield and greenfield LNG projects, offerings for the generation of sustainable and recyclable products, optimising petrochemical assets with greener and circular solutions as well as decarbonising ethylene to reduce environmental footprint to meet the net-zero carbon emission goals.

"MOGEC is in assent with oil producing companies to develop alternative energy resources to reduce the carbon footprint, as many of our members are also making the same pledge. We have also observed that it is a trend in the energy industry, especially among the O&G majors, to make a commitment to address global climate change issues," says Ir. Abd Rashid.

Reducing the carbon footprint is becoming mainstream and investment in renewable and alternative energies are accelerating. MOGEC is responding to this and is anticipating to support this effort, working alongside O&G companies from the engineering perspective in the design of new/alternative technology and applying risk mitigation in existing facilities to improve energy efficiencies.

Ir. Abd Rashid says MOGEC will continue to play its role from the engineering standpoint in contributing to sustainability and carbon reduction initiatives. This includes contribution to technology in carbon footprint reduction.

"MOGEC envisages better collaboration with leading O&G players which have demonstrated early success for a greener future. No one should be left out of the race, in particular smaller companies which may not have the resources or adequate capacity to embark on their own initiatives. As an association that seeks to advocate the needs of local O&G players, MOGEC is well-

positioned to provide a platform for effective and efficient knowledge and know-how sharing," he says.

Ir. Abd Rashid credits PETRONAS with taking the leadership position in contributing towards the nation's efforts to achieve net-zero carbon emissions.

"Ever since PETRONAS announced net-zero carbon emissions target by 2050, it has intensified efforts toward reducing GHG emissions from its assets. Naturally, its contractors will also have to work hand-in-hand to deliver and deploy innovative operations and technologies to meet these requirements," he says.

DEVELOPMENT OF ALTERNATIVE ENERGY

On the type of alternative resources which Malaysian companies can venture into to support carbon reduction, Ir. Abd Rashid says solar energy (photovoltaic solutions) is the most popular as a carbon-free energy solution because of our strategic location near the equator which means 12 hours of sunlight daily. Other than solar power, many are talking about green or blue hydrogen as another carbon-free solution. Green hydrogen typically can be produced through electrolysis of water and most parts of our country are blessed with good annual rainfall which means a sustainable stream of water; blue hydrogen is produced by using the technology offered by oil & gas companies on steam methane reforming through extraction of natural gas.

While the alternative energy solutions represent business opportunities that come with implementation, Ir. Abd Rashid says these are still in the infant stage here, adding that such opportunities lie in the supply-chain for the industry. It can be from technology providers, product or raw material suppliers or even experts in installation at field. However, in developing alternative energy, he points out that the use of fossil fuels will still continue to be strong.

"When we look at the projections for developing alternative energy, fossil fuels will still dominate as a source of energy. A study shows that even at the peak of alternative energy implementation, it will be only 40% of energy consumed. O&G and petroleum products will still dominate the raw materials required for energy and the manufacture of most of the products we use in our daily lives. Demands for O&G and petrochemical products will continue to rise, especially when we consider the growing global population. This means engineering support to ensure the upstream and downstream activities will continue to operate and it will always be there," he says.

However, the continued reliance on conventional fuels should not hinder the tapping of opportunities in developing alternative energy. Commenting on this, OGMTD Chairman Ir. Abdul Razak Yakob says: "Business is business. If a business idea is feasible to be monetised, then it should be monetised. There should not be restrictions imposed on such opportunities. Bigger companies have the budget to go into research should they want to diversify their businesses.

"We can understand when smaller businesses, which have the expertise, may have reservations over this market liberation but collaboration with other industry players can be one of the ways that they can work together. Great ideas and development funding can go together. At the end of the day, businesses revolve around solving problems which is what we engineers do essentially, to provide solutions at a cost to clients. Regardless of whether it is a product or service, O&G companies should consider diversifying their businesses into alternative energy if the idea meets their companies' visions of the future and is feasible within the structure of their companies. "

OGMTD Deputy Chairman Ir. Lee Chang Quan concurs with the need to diversify into the business of developing alternative energy. He says: "First, we all know that natural resources have a finite life. Second, this is not an engineering question but rather, a business survival question. Does an O&G company want to exist only till the end of the finite life of the resources? This may be 10-30 years down the road depending on where you operate. To survive, sustain or even grow the business, companies have no choice but to explore every business opportunity. Instead of merely joining the bandwagon into alternative energy, a company should evaluate its business position and think really hard about what and how additional value can be brought into the business."

When making the evaluation, Ir. Lee suggests several questions which companies must answer, such as "What is the company's strategic competitive advantage in developing the alternative energy or serving the existing market?", "Are you be able to offer a better solution to the customer when developing the alternative energy?", "Can you offer solutions which can add to the value chain in alternative energy, for example in terms of asset management solution instead of being the energy generator itself?" and "Is there any opportunity or new solution that can still provide business value by staying core to O&G?".

MANPOWER EVOLVEMENT & CONCERNS

Another challenge in alternative energy development involves the question of manpower. Ir. Abd Rashid says in looking at this aspect, it is important to know how Malaysia's engineering service providers and the industry's supply chain have evolved over the past four decades.

"In Malaysia, most engineers started by working under expats from all over the world, carrying out projects for international oil companies and subsequently for our national oil company, PETRONAS. This was how it started. Now we have thousands of experienced Malaysian design and site engineers. We can proudly claim to be a hub for design engineers in Southeast Asia. We have seen the growth of locally-established engineering firms working alongside and sometimes even competing with multinational engineering design firms and most of these are MOGEC members," he says.

The O&G industry was an early adopter of computer-aided design. Most veteran engineers have seen the introduction of key engineering and drafting software, for instance 3D Smart Plant and PDMS design tools, which are familiar to most engineers in this industry.

He says: "IR4.0 and the Big Data era pushed design engineers into a new way of thinking about doing their work more efficiently, especially as more advanced countries started to consider autonomous operations and robotics to further enhance their Health, Safety & Environment (HSE) requirements. Malaysia is following suit very closely. Pressure to bring down costs (CAPEX and OPEX) have also encouraged engineering design houses to look at more efficient and productive ways to improve their project execution flow.

"We are also adapting to Virtual Reality (VR), Machine Learning (ML), Artificial Intelligence (AI) and and Digital Twins (DT) into our engineering design process flows. We take pride in the fact that our members are working to introduce VR and DT to their core clients while others are working on developing ML to capture engineering data collected over two decades of project works to eventually automate part of their engineering workflows. These evolutions mean engineers are always expected to develop or adapt to technologies. Unfortunately, technology alone is insufficient. Experience is still paramount," he says, adding that even the most sophisticated engineering software depends on the quality of input and the ability to interpret the output to get the best results. Passing down the knowledge is crucial as there is a wide gap in experience due to engineers leaving the industry during downturns.

"We do not have a solution to resolve this gap but the COVID-19 pandemic that has resulted in many people working from home, may indirectly provide the way forward. The services of well experienced technical professionals should also be tapped should they choose to work, without being directly hired on a fulltime basis and instead of retiring or moving to other professions. They will also have the option to provide their services to several companies and that will allow them to form their own independent enterprises. In the longer term, we should develop versatile and digitally literate problem-solvers who are ready to be lifelong learners in a rapidly changing environment," says Ir. Abd Rashid.

> **MOGEC will continue to play its role from the engineering standpoint in contributing to sustainability and carbon reduction initiatives. This also includes contribution to technology in carbon footprint reduction.**

He also holds the view that multilingual-disciplinary skills and knowledge, including those related to sustainability, energy systems and behavioral science alongside traditional engineering and science disciplines should be a central part of future skill pathways for O&G engineers.

HEALTH, SAFETY & ENVIRONMENT

Some of the solutions to reduce the carbon footprint may lead to safety and environmental issues which pose major challenges to O&G industry players. Therefore, the management of risks to Health, Safety, Security & Environment (HSSE) is paramount. Ir. Abd Rashid says it is the key strength of the industry, which manages major hazards risks such as fire and explosion.

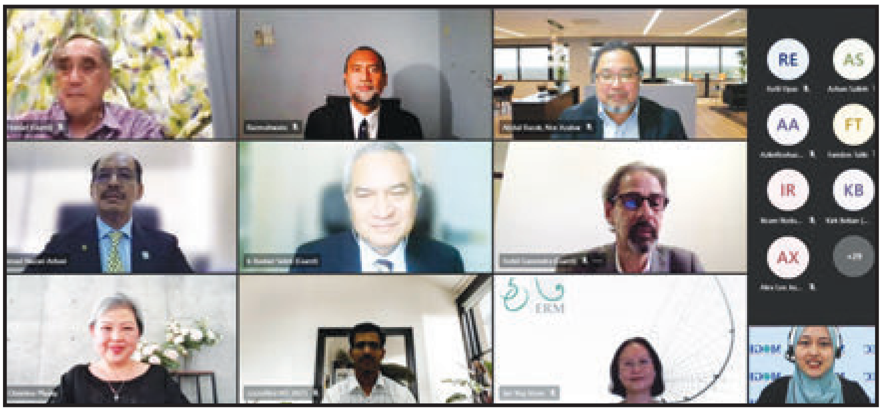
"The HSSE requirements are stringent; the approaches and methodologies are well established. Such technical knowledge and skills sets are transferrable to the new and alternative energy technologies. The principles of managing safety hazards in the solar, wind or hydro energies are essentially not any different to the O&G sector," he says.

He adds that environmental concerns specifically have always been part of proper safety evaluation, the most visual product being the Environmental Impact Assessment. The management of the environment is a path taken by both legislation and the private sector.

"It is important that the safety culture of ensuring all hazards is recognised and evaluated and that the risks managed to as low as reasonably practicable to become an integral part of the business," he says.

"Every industry will have its own challenges in managing safety and environment but the goal should be the same, which is to bring the risk level to as low as reasonably practical. The advantage for O&G players is that we can use our experience in managing safety, health and environment risks in this new area, as we are dealing with risks all the time in the industry," says Ir. Lee.

"In offshore exploration and production, for example, we have to consider the marine environment and we take necessary action from design, operation and decommissioning or in short, the whole asset life, to minimise impact on the marine environment. Throughout the years, not only do we have a rigorous system and procedures in



MOGEC Annual General Meeting 2021 held on 24 June 2021 via MS Teams

place to manage the risks, be it on safety or environment, but we also work together with key stakeholders – the government, environment experts and locals – to manage the risks. This is what we have learnt and improved with years of experience. So, while we are exploring alternative energy sources such as wind, solar or hydro, I believe O&G players are well positioned to manage the risks."

INVESTMENT ALTERNATIVES IN O&G

Besides giving priority to HSSE by investing in various methodologies and approaches as well as developing technical knowledge and skills, O&G players have other worthy investments to consider. These encompass the lowering of costs and risks as well as lowering carbon emissions.

On this aspect, Ir. Muhamad Her Jantan of OGMTD says it is very clear that O&G companies will continue to lower costs, lower carbon emissions and lower risks. Lowering cost requires continuous improvement and efficiencies in every aspect of the value chain. Digitalisation is expected to play an important role in effective energy transition strategies, enabling remote operations and driving human-machine collaboration. It plays in setting near-term emissions targets, using standardised and credible reporting and tracking accountability across the hierarchy.

On the lowering of carbon emissions, he says this can be carried out best in class operational practices as well as continued research and technology development and deployment. This is associated with the Cap-and-Trade approach policy that has already been adopted by some countries, in which entities receive shares, which are like permits for emitting a certain amount of carbon. They can sell these shares to others in the industry.

He adds that O&G companies can also invest in searching for lower technical risks with better reservoir models, better visualisation and more. This ensures guarding against downside risks and readiness for any potential upside. Investment tasks should consider accelerating digital transformation to reduce operating costs, variabilities in fixed costs of support functions (i.e., supplier to being business partners), maintaining flexibility in their operations and optimising the capital allocation for their projects.

In addition to investing in hard skills as mentioned above, O&G companies need to continually invest in the softer skills of communication, collaboration and innovation.

"There is no doubt that the continued development and successful implementation of soft skills is the hardest part of all, yet these are paramount for success. The world will still be dependent on O&G for decades to come in which the demand does not only involve access to energy but also ensures that it is clean, affordable and reliable. The O&G industry can meet these challenges and must do that in partnership with customers, governments and universities so as to ensure that net-zero emissions by 2050 will be possible," says Ir. Muhamad Her.

CREATING AWARENESS & SUPPORTING NATIONAL PLAN

As for the suggestion that the O&G industry embarks on partnerships to surmount challenges in reducing the carbon footprint, Ir. Razak singles out one important aspect.

"Awareness. This is the most important keyword that we all must understand because it is only after obtaining awareness that we can start doing something, actions to help reduce the carbon footprint. Awareness is not only for the industry players but it's also for the public," he says, adding that, on this note, IEM does organise "meet the public" events.

"At every event, we include the idea of environmental and sustainability awareness. Avoiding wastage is one of the biggest ways to reduce the carbon footprint. During the current pandemic, IEM conducts most of its activities, such as talks, courses, meetings and administration via virtual platforms. This is part of our efforts to help reduce the carbon footprint as participants don't have to travel to the events location."

In addition, IEM and MOGEC will continue to support the national development plan, in particular the implementation of Sustainable Development Goals (SDGs) which must be aligned with future policies development. Both IEM and MOGEC agree that there is a further need to conduct comprehensive analysis of GHG emissions from the energy sector in Malaysia and to provide an insight for our policymakers to evaluate the effectiveness of past policies and the measures to be taken in future. ■

MOVING TOWARDS HYDROGEN ECONOMY FOR DECARBONISATION



by Ir. Dr Tan Lian See *Ir. Ts. Dr Liew Peng Yen* *Ir. Lee Chang Quan*

Hydrogen economy started in the 1970s as a move to shift from fossil fuel economy to clean energy. Since then, there have been increasing research activities in efforts to enable a significant shift towards hydrogen economy (Dawood *et al.,* 2020). Over the years, hydrogen has been utilised in transportation, buildings (residential and commercial) and industry.

Fossil fuel vehicles have contributed largely to air pollution in major cities and emission of greenhouse gas, i.e. carbon dioxide. So hydrogen-fuelled vehicles or hydrogen fuel cell electric vehicles are as a cleaner alternative since they do not contribute to carbon emission at the point of use. Hydrogen has made considerable progress in this field, with the successful roll-out of hydrogen fuel cell trucks in Europe.

Meanwhile, in countries with 4 seasons, heat consumption in residential and building sectors depends largely on fossil fuel energy sources. Its replacement with hydrogen-based technologies will decarbonise heat consumption in this sector. Fuel cell-based combined heating and power (CHP) system and hydrogen boilers can be employed to replace conventional energy conversion technologies. Hydrogen and natural gas blend boilers are also suitable during the transition for lowering emission from this sector (Hydrogen Council, 2020).

Industries commonly rely on fossil fuel for heat and power generation for the operation of processes. To mitigate the impact on environment and finances, there are various researches done to reduce the power and heat consumption for industries, such as total site heat integration for maximising energy recovery across multiple processes (Liew *et al.,* 2017).

There are also extensive works on fuel replacement with renewable energy sources such as using solar photovoltaic, solar thermal, wind, biomass and biogas. Fuel cell-based backup generator, hydrogen furnace, simple cycle hydrogen turbine and combine cycle hydrogen cycle are among examples of hydrogen energy supply technologies which can be used to produce power and heat for industries (Hydrogen Council, 2020). However, decarbonisation of industries through the realisation of hydrogen economy is still limited by the requirement of large-scale infrastructure investment for hydrogen production, storage, transportation and distribution. The hydrogen compression and purification process are also among challenges which require improvement from energy consumption perspective.

In addition, the actual environmental impact of hydrogen vehicles is highly dependent on the source used to produce hydrogen. Clean production of hydrogen is essentially important for maintaining a low carbon footprint and environmental impact at every stage of the hydrogen life-cycle. Hydrogen can be produced through various production pathways, such as thermochemical processes from fossil fuels and biomass, electrolytic processes from electricity and photolytic processes from solar (Brandon & Kurban, 2017).

To date, most hydrogen production available is grey hydrogen which is produced from fossil-based raw materials through thermochemical processes and where the carbon emission is high. Steam-methane reforming is the most stable and scalable process for supporting the development of hydrogen economy. To support the low carbon energy system transition through hydrogen economy, carbon capture and sequestration (CCS) can be included in the grey hydrogen production. The integration of CCS will divert the carbon dioxide from being released into the atmosphere and the hydrogen produced from such a process is labelled blue hydrogen. However, the implementation of CCS comes with its own enormous challenges, making blue hydrogen a rare item.

Ideally, the hydrogen economy should be based on green hydrogen. Green hydrogen is produced from renewable sources and it poses significantly low environmental impacts, making it fit for sustainable and circular economy development (Brandon & Kurban, 2017).

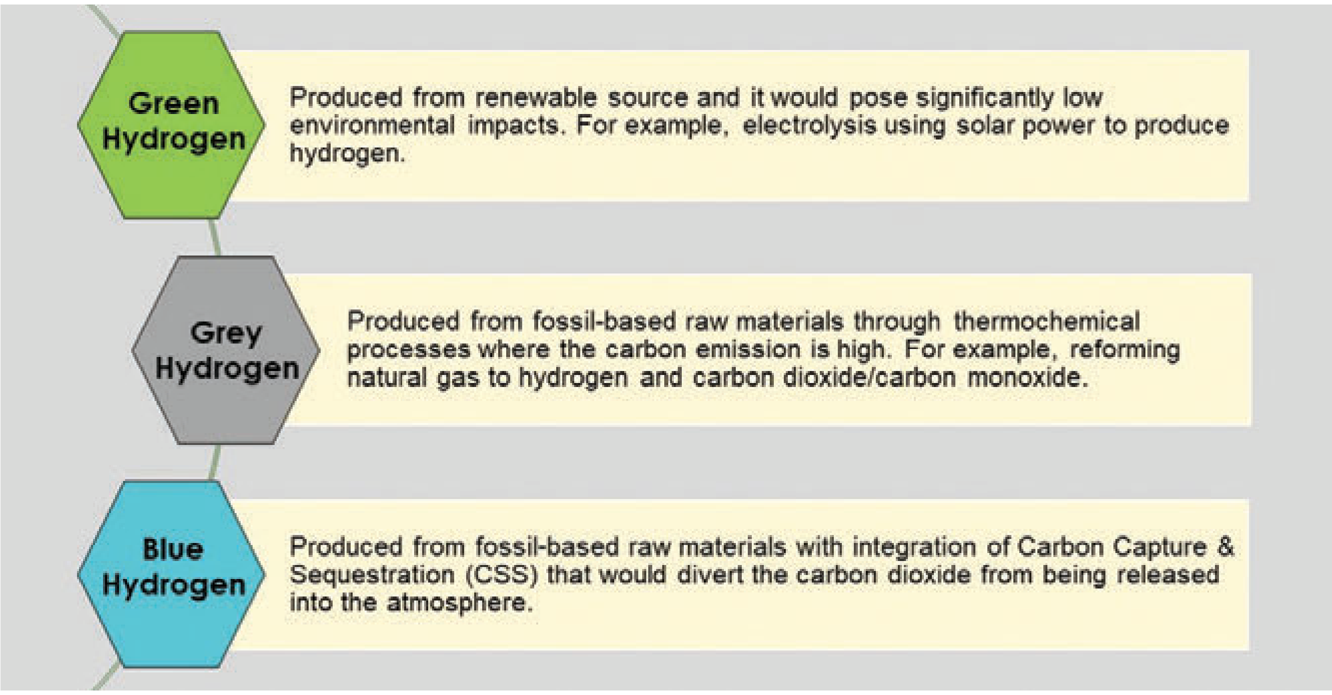


Figure 1: Hydrogen production pathways

The green hydrogen utilisation in the supply chain will ensure low emission for the whole life-cycle of the product.

CONVENTIONAL GREY HYDROGEN

Currently, steam reforming of natural gas is an established and favourable route for the large scale production of hydrogen. It involves the following reactions:

$CH_4 + H_2O \rightleftharpoons CO + 3\,H_2$ (Reaction 1)

$CO + H_2O \rightleftharpoons CO_2 + H_2$ (Reaction 2)

Reaction 1 shows the steam reforming of methane in natural gas. It is a reversible reaction process. Theoretically, it must be carried out at a high temperature (800°-950°C) and high steam to methane ratio (4 to 5 mol H_2O/C-atom) to achieve maximum conversion. However, in practice, a low steam to carbon ratio (typically 2.5 or lower) is employed to reduce the mass flow through the plant and hence, reduce the size of equipment. In addition, a low steam to carbon ratio results in a more energy efficient plant which means lower operating costs (Rostrup-Nielsen & Rostrup-Nielsen, 2002). The reformed gas will go through further conversion of carbon monoxide and steam to carbon dioxide and hydrogen (Reaction 2). This process results in formation of 0.25 vol. CO_2 per vol. H_2.

Coal gasification and oil/naphtha reforming are alternative viable processes for hydrogen production. Catalysts play a very important role in these reforming processes. As shown in Figure 2, 96% of hydrogen production relies on using fossil fuel as raw material. This indicates the relevancy and importance of fossil fuel in supporting the hydrogen economy.

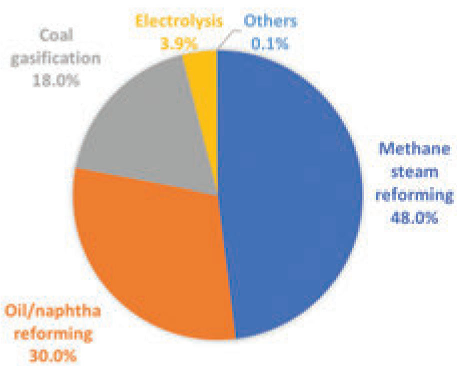


Figure 2: Primary routes for hydrogen production (da Silva Veras et al., 2017)

CHALLENGES IN PRODUCING GREEN HYDROGEN

The production of hydrogen through electrolysis is in place commercially. This process employs an electrical current passing through two electrodes to split water into hydrogen and oxygen. This process can occur at ambient temperature and pressure. Although the production of hydrogen this way is a clean process, its expansion for large scale production is constrained by the need for a consistent and stable electricity supply. This in itself raises issues on the "greenness" of the process, depending on the source of the electricity power. To qualify as green hydrogen, the electricity should be generated from renewable resources.

On the other hand, the generation of green hydrogen directly from sunlight is a promising solution for sustainable and clean energy. Figure 3 shows the formation of hydrogen and oxygen from the photo-excited charge carriers in photocatalytic water splitting process.

Figure 3: Photocatalytic water splitting on semiconductor with the presence of co-catalyst (Osterloh & Parkinson, 2011)

The mechanism of reaction leading towards the formation of hydrogen from water in the presence of light, is shown from Reaction 3 to Reaction 5. In the presence of light, ground-state electrons of photocatalyst are photoexcited to form proton (h^+) and electron (e^-) pair (as shown in Reaction 3). The nucleophilic nature of water molecules (H_2O) tends to oxidise with proton on the photocatalyst surface, generating oxygen (O_2) and H^+ (Reaction 4). The H^+ions from Reaction 4 will undergo reduction at certain conduction band to form hydrogen (H_2) (Reaction 5). The overall reaction is represented by Reaction 6.

Reaction mechanism in photocatalytic water splitting:

$Photocatalyst \rightarrow h^+ + e^-$ (Reaction 3)
$4\,h^+ + 2\,H_2O \rightarrow 2\,O_2 + H_4^+$ (Reaction 4)
$4\,e^- + 4\,H^+ \rightarrow 2\,H_2$ (Reaction 5)
Overall reaction: $2\,H_2O \rightarrow O_2 + 2\,H_2$ (Reaction 6)

However, despite some success in the ideal setting of laboratory-scale studies, it is extremely challenging to turn the process into actual large-scale operation as this is hampered by both technical and economical hurdles. From a technical point of view, upon scaling-up, non-idealities such as reduced light absorption and sluggish diffusional transport, will reduce the solar-to-hydrogen (STH) efficiency from a practical threshold of STH > 10% to STH < 1.0%. The cost of producing hydrogen through photocatalytic water splitting is estimated at US$10.36/kg, far more than the practicable price range of US$2-4/kg (Ng *et al.*, 2021). As such, fossil fuel is expected to remain a reliable raw material for hydrogen production, at least in the near future.

CONCLUSION

Hydrogen economy can facilitate a more cost-effective transition towards low carbon and cleaner energy systems. If carbon capture and sequestration can be widely practised, the carbon footprint of natural gas and other fossil fuels in the production of hydrogen (via blue hydrogen production pathway) can be further reduced. Fossil fuel is expected to continue to play an important role in the future hydrogen economy, until a viable technology for large-scale green hydrogen production is available for roll-out. Collaboration of university-industry-government through the Triplex Helix model is critical to expedite a large-scale green hydrogen realisation and to substantiate low carbon economy through hydrogen energy. Curating strategy of hydrogen economy for Malaysia by the tripartite will be necessary and timely as an inclusive blueprint for the nation, not only to meet the carbon reduction target pledged at the Paris Agreement, but also as a bolder step in the move towards a carbon-neutrality economy. ■

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NON RARE EARTH ELEMENTS (NREE): POTENTIAL INDUSTRY IN MALAYSIA

by Dr Ismail bin Ibrahim

Rare earth elements (REE) are relatively abundant in the earth's crust, with cerium being the 25th most abundant element at 68 parts per million (ppm). Because of their geochemical properties, REE are typically dispersed. This means they are not often found in concentrated clusters, which is why they are called rare earth. Rare earth is categorised into light rare earth elements (i.e. lanthanum and europium) and heavy rare earth elements (i.e. gadolinium, lutetium and yttrium); scandium is unclassified. The latter are less common and consequently more expensive [1].

Ion-adsorption clays, also commonly known as weathered clays, are non-radioactive REE (NR-REE) [2]. Extraction methods such as leaching, are performed to extract the rare earth elements from ore bodies; further separation into individual elements is done via processes such as solvent extraction. In-situ leaching process of ion-adsorption rare earth ore, also known as weathering shell leaching rare earth ore, involves ion exchange reaction between leaching solution (i.e. ammonium sulfate or magnesium sulfate) and ore body that occurs during the seepage process, recovering rare earth cations, thereby extracting REE. The pregnant solution obtained is then precipitated using oxalic acid or ammonium bicarbonate, forming rare earth oxalates or carbonates [3].

Produced RE oxalates or RE carbonates are further purified into pure REE for use in various industries as components in high technology devices including smart phones, digital cameras, computer hard disks etc. [4].

Malaysia is rich in rare earth oxide (REO) ion-adsorption resources estimated at 15.18 million metric tonnes as reported in the media, and worth RM742.7 billion [5]. However, mineral resources and their subsequent conversion to REO reserves are of key importance to mining companies. Their reliable estimation is critical to both the confidence in a feasibility study and to the day-to-day operation in a mine. If it proves feasible to carry out mining, Malaysia should take the opportunity to be among the global players in developing REE. It is subjected to the new global interest and demand for RE minerals, especially the metals, are increasing.

In on-going efforts to sustain the nation's economy, Malaysia is always on the lookout for new business opportunities and economic growth areas. As the world struggles to embrace green technology, the role of rare earth has become increasingly significant in the global economy. REE has wide usage in a range of products and gadgets as well as the manufacturing of more effective renewable energy technologies such as wind power and solar photo-voltaic. The establishment of the REE processing plant by Lynas Corporation has prompted a more detailed evaluation of RE business opportunities and how Malaysia can best participate as a country [6].

As the world struggles to avert the negative consequences of climate change and global warming, the demand for REE is predicted to rise in the coming years. The global demand for REO is projected to reach 315,000 tonnes by 2030, driven by the increasing uptake in green technologies and advanced electronics. Most of the demand will come from the developed economies, especially EU, USA, Japan and South Korea [7]. The downstream manufacture of REE based products is now mainly centred in these countries. For years, China was the leading producer and supplier of REE to the world. They are still very much in control and account for more than 90% of global production. A few years back, China took a decision to rationalise the country's REE production [8].

TYPES OF RARE EARTH ELEMENTS

REE is often sub-divided according to their atomic numbers. Light Rare Earth Elements (LREE), which are commonly REE with atomic numbers 57-64, include cerium, lanthanum, praseodymium, neodymium, promethium, samarium and europium. Among LREE,

neodymium has the widest usage in modern products such as mobile phones, electric cars and medical equipment. It is also used in permanent magnet manufacture.

Heavy Rare Earth Elements (HREE) are those with atomic numbers greater than 64 (corresponding to europium). These are less common and some elements within the group are facing shortages as demand outpaces supply. Because of this, they are more valuable than LREE, though they also have a smaller market. Dysprosium, yttrium and terbium are considered critical elements in HREE as they face low supply and increasing importance in the development of clean energy technologies [9].

NON REE: ION-ADSORPTION CLAYS

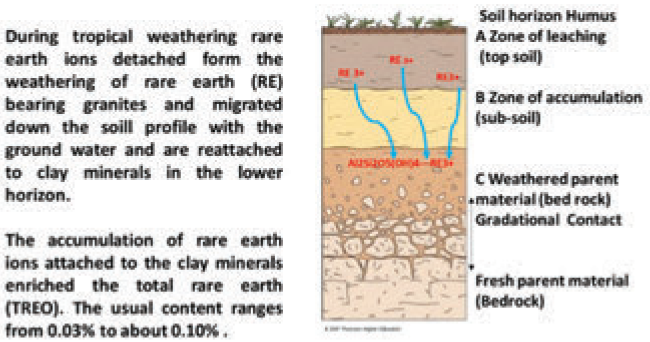

Figure 1: The formation of ion clay rare earth deposit

Due to its geological formation, REE can be categorised into two types: Primary ore (mineral type) and ion-adsorption rare earth ore. Primary ore is REE that occurs in mineral mixtures. These are bastnaesite (carbonate type), monazite and xenotime (both minerals are phosphates), the 3 most significant minerals that contain REE [10].

Ion-adsorption RE ore is the source of non REE which generally occurs in granite weathering crust and is easy to mine as well as convenient to extract with little impact on the environment (Figure 1). The characteristics of Ion-adsorption REE are:

- REE released from the granite is adsorbed to clay minerals
- Low REE grade (<0.05 – 0.20%) but some are enriched in HREE
- Free from radioactivity
- Easy REE extraction [11].

ION-ADSORPTION IN-SITU LEACHING MINING & PROCESSING

Ion-adsorption rare earth ore, also known as weathering shell leaching rare earth ore, was first discovered in a foot cave in China's Longnan County, Jiangxi Province, in the late 1960s. Ion-adsorption rare earth ore is found in shallow, weathered rock formations. Currently, mining is conducted through a relatively matured process known as in-situ leaching and mining. This process is governed by ion exchange between leaching solution and ore bodies. The reaction occurs through seepage process of a leaching solution into the ore body which recovers rare earth cations, thereby extracting rare earth elements. The rare earth leaching rate depends on the degree of ion exchange reaction and the seepage of the rare earth mother liquor in the ore body. This ion-adsorption rare earth leaching process includes both analytical and anti-adsorption processes. The exchange of rare earth cations is performed under dynamic equilibrium conditions. Furthermore, various parameters of the leaching ore body, including the concentration of the leaching solution, the cation activity and the temperature, are positively related to the intensity of the ion exchange reaction. The mineral leaching rate, which indicates the extent to which a metal is leached, represents one of the criteria for the leaching processes of various metals [3,11,12].

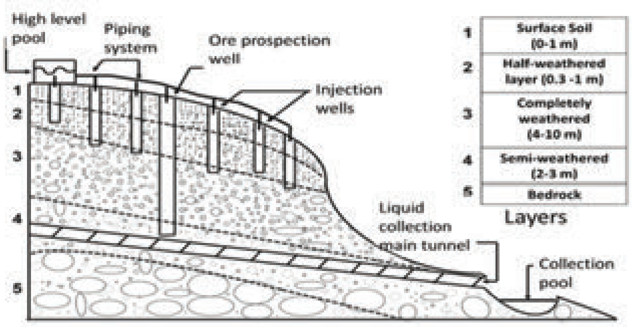

Figure 2: Schematic in-situ leaching of ionic clay rare earth deposits

For in-situ leaching (Figure 2), the ore leaching solution is continuously injected into the ore body through a liquid injection hole under a certain head pressure and the cation with higher exchange potential in the solution will be exchanged with adsorbed REE ions, so that the REE ions will enter the leaching solution. The process of this multidirectional solid-liquid exchange system is as follows: Infiltration diffusion → exchange → rediffusion → reinfiltration and the diffusion force is the concentration difference. The solution (under screen water) will be continuously injected into the ore body, extruding the REE leaching solution which has been exchanged. The pregnant solution is collected in tanks and oxalic acid or ammonium bicarbonate is added to precipitate REE, either as rare earth oxalates or carbonates. Precipitated RE carbonates or RE oxalate products are further purified into pure REE for use in various industries [10,11,12].

USAGE OF RARE EARTH ELEMENTS

In the downstream sector, REE is used as components in high technology devices, including smart phones, digital cameras, computer hard disks, fluorescent and light-emitting-diode (LED) lights, flat screen televisions,

Table 1: Applications of REE

Applications	Examples	Rare Earth Elements
Light weight magnet	Cars: Light weight magnets in motors for windows, windscreen wipers, starter motors, alternators, etc. Electronics, magnets in disc drives for computers, data storage, portable music players, video recorders, consoles, video cameras, speakers, wind turbine	Dd, Pr, Sm, Dy, Tb
Catalyst	Automotive catalyst, Clean diesel, Oil refining	La, Ce, Nd, Pr, Sc
Hybrid vehicles	Electric motors and generators, Hybrid batteries	Nd, Pr, Dy, Tb, La, Nd, Ce
Polishing powder	Compact fluorescent lights, energy saving	Eu, Tb, Y, Sc
Glass additive	CRT screens to stabilise glass from cathode ray, small optical lenses, phosphors	Ce, Er, Gd, Tb, La, Nd, Yb, Pm, Sc
Ceramics	Advanced ceramics	Dy, Er, Pr, Gd, Ho, Ce, La

computer monitors and electronic displays. It is also used in defence applications for jet fighter engines, missile guidance systems, anti-missile defence, space-based satellites and communication systems [9]. For each industry, investments can involve hundreds of million ringgit. Table 1 shows examples of REE usage in various applications.

MALAYSIA AND THE REE INDUSTRY

Malaysia is expected to be the second Asian country after China, to enter the global supply chain for rare earth metals. Malaysia could contribute towards a global effort to break China's global chokehold on rare earth metals, securing supply in the global rare earth industry.

We are blessed with a significant amount of non-radioactive rare earth deposits. Although this represents less than 1% of the world's total deposits, it is more than enough for us to be a major regional player in the supply of rare earth minerals. Ion-adsorption clay deposit is currently the focus source of REE in the country because it is non-radioactive REE (NR-REE). If Malaysia has been identified to be rich in rare earth oxide (REO), especially ion-adsorption resources, how far can that mining activity be carried out potentially?

Hopefully the Government will rationalise the planning process to make it more reflective in terms of scope, functions and visions of the REE industry. It involves collaboration between state agencies and industries, each with its own role in regulating the mining industry. The establishment of regulations for REE industries depends on:

(a) Reviewing available information on REE reserves
(b) Identifying critical research and development needs related to exploration, mining and processing of REE minerals and metals and
(c) Examining the federal contribution to research and development in mining processes.

Hence the REE production chain is complex and often involves a number of stakeholders but in short, it can be divided into 4 phases: Mining, mineral processing, cracking and REE separation. All these should take into account environmentally friendly and green capabilities factors. Basically, an in-situ leaching mining method will produce RE carbonates or RE oxalate as the final product which will then be further purified into pure REE. Initiation of REE leaching mines locally will provide opportunities for local industries to venture into the downstream sectors. Ultimately, this chain will establish holistic local REE industries cycles and a dependable income for the nation.

This learning case is developed based on research using publicly available information. Views and opinions are based on the research and consultancy by the individual authors and do not necessarily reflect that of any organisation. Despite compliance with the requirements set out in the laws and regulations, it shall fulfill the obligations of the stakeholders which comprise the tenement holder, mine operator and the authorities.

CONCLUSION

Rare earth elements are relatively plentiful which makes them as abundant as copper but because of their geochemical properties, they are typically dispersed and do not exist in concentrated clusters which would make them viable for mining. The global demand for

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REO is projected to reach more than 300,000 tonnes in 2030. Most of the demands are from downstream manufacturers of REE based products from countries with developed economies.

Malaysia is blessed with a decent amount REE resources and therefore, should be taking advantage of current high demand of REE. Malaysian REE resources have been identified to contain a high amount of highly in-demand HREE and our nation has the ability to attract specialised refining. A pilot programme should be initiated and funded immediately and the Rare Earths Blueprint details how the establishment of local rare earth industries can be achieved. ■

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FEATURE

IMPACT OF GRID-CONNECTED SOLAR PHOTOVOLTAICS ON POWER FACTOR

by Mr. Alex Looi Tink Huey

Ir. Tay Siang Hui

Ir. Mohammad Rhaiz bin Abdul Aziz

In 2001, Malaysia introduced the Fifth Fuel Policy by adding Renewable Energy (RE) to oil, gas, coal and hydro. With the ever-increasing demand for energy, it was essential to have strategic planning for sustainability and to supplement the supply from conventional energy sources [1]. The introduction of the Feed-in Tariff (FiT) mechanism under the Renewable Energy Act (REA) in 2011 spurred RE development and the Malaysian Government made it mandatory for Distribution Licensees (DLs) such as Tenaga Nasional Berhad, NUR Distribution Sdn. Bhd. and Sabah Electricity Sdn. Bhd. to buy electricity from Feed-in Approval Holders (FIAHs) at a predetermined tariff rate and duration of 16-21 years.

Today, solar energy generation is no longer available under the FiT mechanism as it has achieved grid parity with the more matured solar Photovoltaic (PV) technology and more competitive cost [2]. The FiT mechanism has been replaced with the Net Energy Metering (NEM) scheme which allows prosumers (consumers who both produce and consume electricity) to sell excess solar energy produced to DLs on a one-on-one offset basis. Prosumers will be given credit for every 1kWh of solar energy exported to the utility grid. This credit will be offset against the electricity consumed by the prosumer. For commercial, industrial and agricultural consumers, the allowable maximum capacity of the solar PV system installed shall be 75% of the Maximum Demand (MD) or 60% of the fuse rating or 60% of the Current Transformer (CT) rating of their existing installation [3].

For the NEM scheme, the solar PV system has the option to connect direct and indirect feed to the utility grid. Typically, it is connected as indirect feed on the prosumer's side (load side). To ensure maximum solar energy generation which also leads to maximum savings, most inverters are configured to run at unity Power Factor (PF=1). This means the inverter only exports active power as a form of active energy (kWh) to fully offset the electricity bill and doesn't supply reactive energy (kVARh).

POWER FACTOR (PF)

In layman's terms, PF can be described as the ratio of "useful" over the total energy drawn. Total energy comprises active [Wh] ("useful") and reactive energy [VARh]. The index is measured from 0 to 1. A higher index simply means less reactive power consumed than active power and a lower index means vice versa. In Malaysia, non-domestic consumers are required to have a PF higher than 0.90 (for electricity supply of 132kV and above) or higher than 0.85 (for electricity supply below 132kV) to avoid PF penalty charges from the DLs. PF penalty charges for non-domestic consumers with electricity supply below 132kV is calculated as follows [4]:

- 1.5% surcharge of the current bill – for every 0.01 less than 0.85 power factor.
- 3% surcharge of the current bill – for every 0.01 less than 0.75 power factor.

Example:
Current bill: RM 10,000.00 (based on kWh consumed)
Recorded PF = 0.65
Calculated Surcharge from low PF = [((0.85-0.75)/0.01) x 1.5% x RM 10,000.00] + [((0.75-0.65)/0.01) x 3.0% x RM 10,000.00] = RM 4,500.00

HOW PF IS CALCULATED

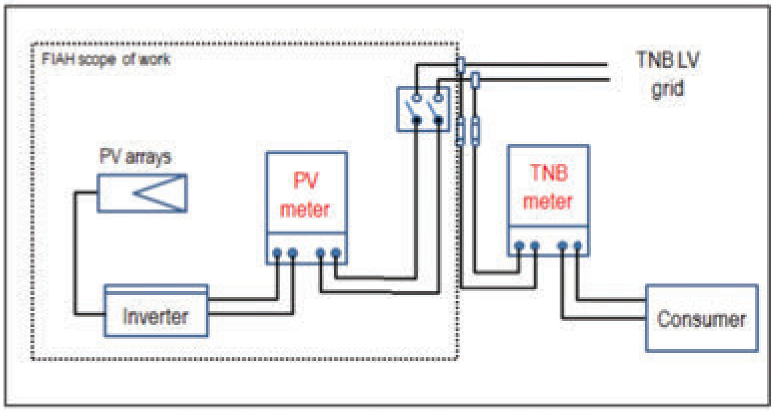
DLs use accumulative readings from the meter to calculate the PF by using the formula below:

$$PF = \frac{kWh}{\sqrt{kWh^2 + kvarh^2}}$$

- kWh is the real power multiplied by the usage hours
- kVARh is the reactive power multiplied by the usage hours.

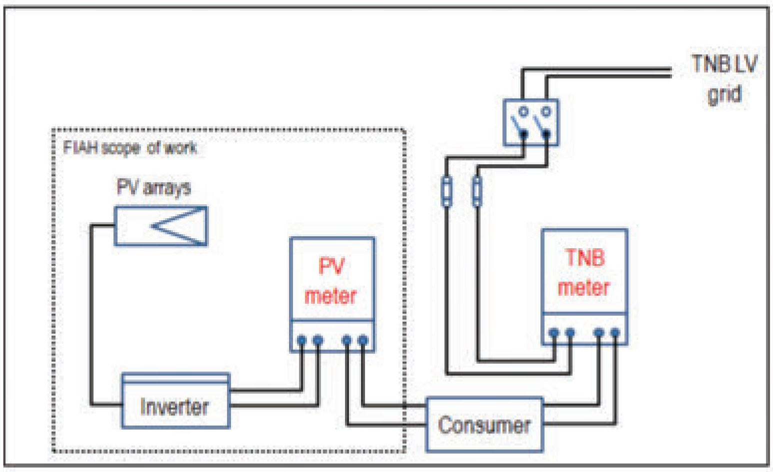
CONNECTION SCHEMES OF SOLAR PV SYSTEM

According to *TNB Technical Guidebook on Grid-interconnection of Photovoltaic Power Generation System to LV and MV Networks* [5], for Type 1 (Single Phase) or Type 2 (Three Phase) of the Low Voltage (LV) system, the utility allows 2 types of connection method: Direct Feed (direct connection to utility grid) and Indirect Feed (connection point at prosumer's load) as illustrated in Figures 1 and 2.



PV direct connections diagram for LV

Figure 1: Direct Connection of Solar PV System. Source: TNB Technical Guidebook on Grid-interconnection of Photovoltaic Power Generation System to LV and MV Networks



PV indirect connections diagram for LV

Figure 2: Indirect Connection of Solar PV System. Source: TNB Technical Guidebook on Grid-interconnection of Photovoltaic Power Generation System to LV and MV Networks

There is a trade-off between direct connection and indirect connection. The advantages of direct connection are that the solar PV system is seen as an independent alternative source of supply which can complement the utility supply and has the least impact on the sizing of existing reactive compensation system. The issues and impact of the solar PV system on the PF penalty on the prosumer's side does not arise from this configuration. However, the main disadvantage of grid-connected solar PV system is that during a power outage (loss of mains) on the utility side, the prosumer will also experience an outage on the solar PV side as the grid-connected solar inverters have to operate in anti-islanding mode [5].

For reasons of economy and convenience, the indirect connection method is commonly implemented where the solar PV system is connected at one of the spare outgoing circuits (see Figure 3). This connection method utilises the spare circuit breaker for the solar energy to feed to the prosumer's main switchboard, thus saving installation cost and space. However, this connection method may have a few consequences which we will discuss in the following sections.

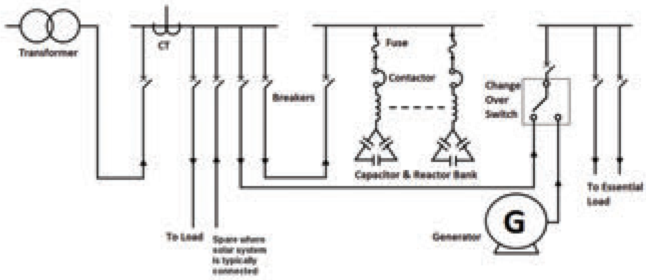


Figure 3: Electrical Single-Line-Diagram of a Grid-Connected Solar PV System

IMPACT OF GRID-CONNECTED SOLAR PV SYSTEM ON PF

Now that we understand what PF is and how the solar PV system is connected, the next question is, how does grid-connected solar PV impact our PF?

In Figure 4, we can see that the consumer is consuming or importing 1,000kWh of active energy and 500kvarh of reactive energy before the installation of the solar PV system. By using the PF formula, we can calculate the PF and the resulting PF is 0.89 lagging.

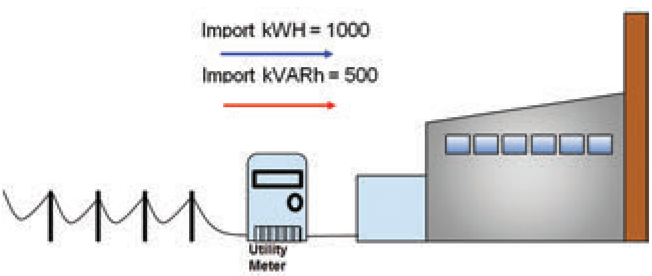


Figure 4: Active and Reactive Energy Consumption Before Solar PV

When the solar PV system is installed (see Figure 5), we can see that the solar PV is generating 40% of the required active energy (kWh) and 60% is imported from the grid. To maximise the Return on Investment (ROI), solar inverters are set to only produce active power which is used to offset the electricity bill at unity PF. In effect, this will reduce the active energy (kWh) drawn or imported from the utility. On a side note, reactive energy (kVARh) is still required to support inductive loads such as motors (fans, pumps, etc.), fluorescent ballasts, transformers, arc welders, induction heaters, etc. The reactive energy of 500 kVARh is still being imported from the utility. Hence, the PF factor value decreases as a result. By using the PF formula, we can derive that the PF is 0.76 lagging and the prosumer will be charged by the DLs for PF penalty.

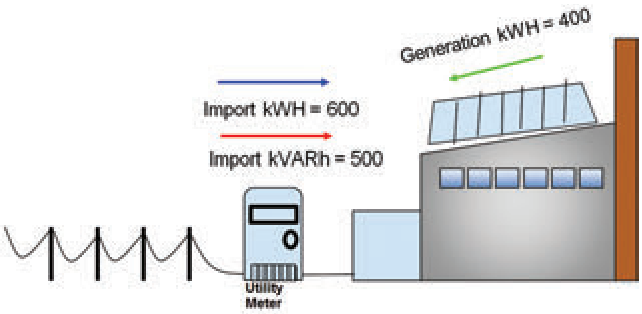


Figure 5: Active and Reactive Energy Consumption After Solar PV

This is one of the reasons why a premise that does not have a PF problem prior to the installation of a solar PV system, may encounter problems after the installation of the solar PV system through indirect connection method. The dynamic range of the operating active power (kW) drawn from the utility decreases during peak solar energy generation. This means less active power will be drawn from the utility, causing the existing sizing of the electrical equipment such as transformers, CTs, cables and perhaps capacitor banks to be oversized during that period.

Secondly, the PF correction panel which is supposed to provide reactive power compensation may not be able to function as required because the premise now imports and exports electrical energy. Thirdly, the impact of Power Quality (PQ) due to harmonics injection from solar inverters may cause parallel resonance with the PF capacitor bank or sensitive residual current devices (RCDs) to mal-operate.

RECOMMENDATIONS WHEN INTEGRATING SOLAR ENERGY GENERATION WITH EXISTING REACTIVE POWER COMPENSATION FOR INDIRECT CONNECTION METHOD

1. Ensure that the Power Factor Regulator (PFR) is set to 4-Quadrant operational mode as the PFR now needs to control the PF correction panel at both import and export power quadrant with CT installed in the correct position and correct polarity.
    a. Configure the solar inverters to either not regulate the reactive power (recommended for maximum ROI) or regulate the PF (setting above the PF penalty level of 0.85) and coordinate it to have the same target PF as the PF correction panel. Users will also need to check the sensitivity timing of both PFR and solar inverters to avoid a race condition or race hazard.
2. Ensure that during peak solar energy generation and trough load condition, the CT is able to accurately sense the reactive power (var) drawn by the load and that the smallest capacitor size at the PF correction panel is able to adequately compensate the reactive power.

3. Check if the harmonics interfere with the electrical system from the solar inverters (especially to the PF capacitor banks). If so, mitigate harmonics with the installation of active or passive harmonic filters due to the solar inverter harmonics emission. Note: To conduct proper PQ modelling and analysis of harmonic distortion from grid-connected solar PV inverters to select the most suitable and effective harmonics filter solution. ■

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UPCOMING ACTIVITIES

WEBINAR Talk on "Energy Efficiency Initiatives In Malaysia"

Date	: 10 November 2021 (Wednesday)
Time	: 10.00 a.m. – 12.00 p.m.
Venue	: Digital Platform
Approved CPD	: Applying
Speaker	: Mr. Zulkiflee Umar

BUILDING ORGANISATIONAL EXCELLENCE VIA A SUSTAINABLE ENERGY MANAGEMENT PROGRAMME

by Ir. Al-Khairi Mohd Daud

On 12 June 2021, OGMTD organised a 2-hour webinar where Prof. Ir. Ts. Zainuddin Manan, past Deputy Vice Chancellor of UTM, talked about the success and challenges of working with the Universiti Teknologi Malaysia (UTM) community to drive the 6P Energy STAR (Sustainability Transformation Programme). He described how each P-element had helped to transform UTM into an energy sustainability living lab to achieve impactful outcomes. The P-elements are as follows:

P1: PAIN & PURPOSE

To act, we must personally feel the intense **Pain** and be convinced of the clear and strong **Purpose** of our roles. There is no doubt that UTM staff and students are concerned about issues of energy and climate change but the fact remains that they do not pay UTM's electricity bills, so energy issues may not touch them in a personal way. On the contrary, the pain of not having labs to work in and journal papers to publish can be unbearable.

Prof. Zainuddin's strategy was to capitalise on UTM's brand as a "living lab". The idea was to create a desirable purpose for its community members to unleash their creativity and innovation via research and publications related to the campus-wide implementation of SEMP. After his team spearheaded research to transform UTM into an energy sustainability living lab and published the research impacts widely, the campus community naturally jumped on the bandwagon.

P2: PRODUCTS & PROGRAMME

The advantage of using the campus grounds as a living lab enabled UTM to craft a purpose-driven niche in energy sustainability research but more importantly, it help the UTM community develop and market its home-grown **Products** and innovations. Among others, the UTM SEM Programme catalysed the development and commercialisation of its innovative 4IR-driven software products such as Optimal-Audit, Optimal Heat, e-SMART and SEDAR for thermal and electrical energy savings.

P3: EMPOWERING THE PEOPLE & INNOVATION TEAM

Without dedicated **People**, it would be challenging to sustain a programme like SEMS. To develop staff competency, UTM invested in the training of its first batch of 30 staff members who obtained recognition as certified energy managers. These then formed the energy management team and drafted an energy management policy to drive the SEM initiative across UTM. The strategy was to continuously motivate the team by maintaining a constant communication channel among the energy managers to promote their success stories and to reward them accordingly.

P4: PERFORMANCE DELIVERY

In 2012, UTM won the ASEAN Energy Award after it managed to save RM5 million in less than 3 years. After 6 years of SEMS implementation, UTM became the first organisation to be certified a 3-star energy-efficient organisation under the ASEAN Energy Management Accreditation Scheme (AEMAS) and it amassed energy savings of over RM26 million between 2011 and 2018, with proven **Performance** as the showcase for SEMP in ASEAN. To date, it is still the only organisation in Malaysia and the region with over 40 Certified Energy Managers and 10 Registered Electrical Energy Managers (REEM).

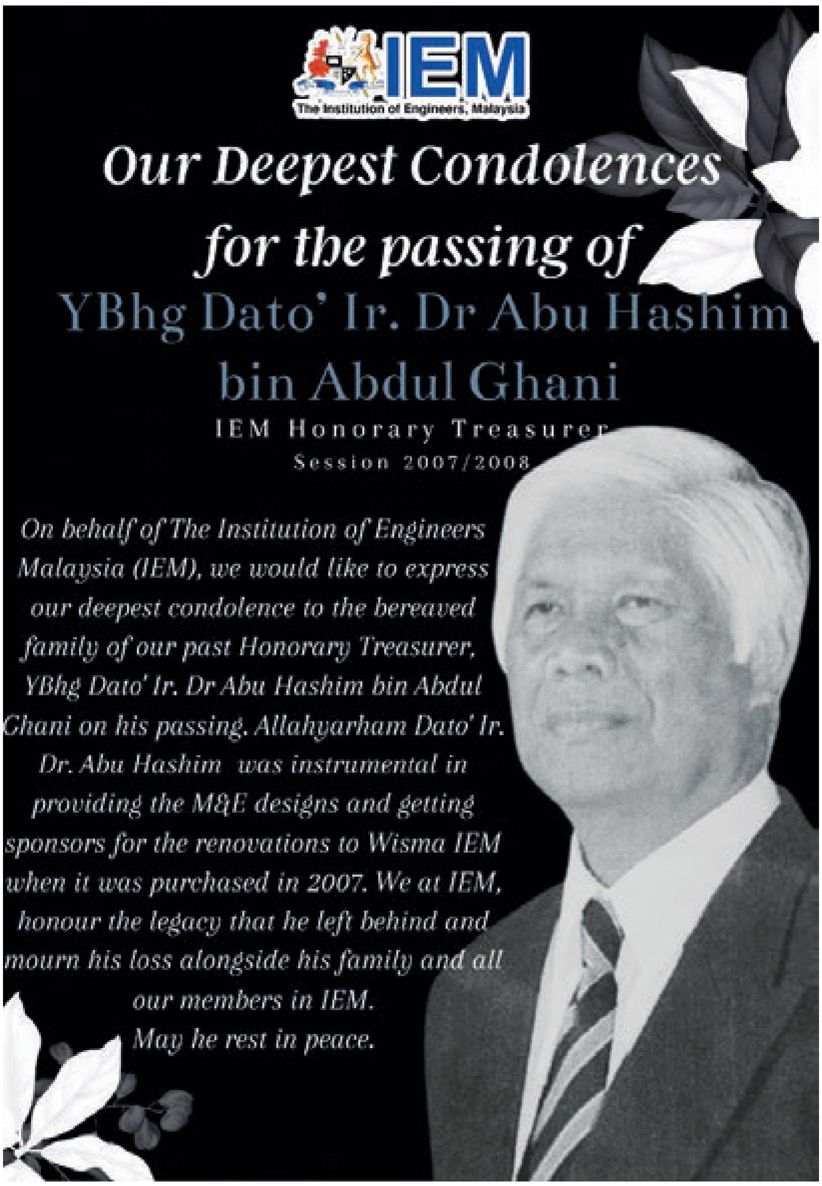
P5: PARTNERSHIP

A critical success factor in the UTM SEM programme is its quadruple-helix **Partnership**, with stakeholders from the community, other universities, industry and policy makers. With team success and dedication, UTM also gained the trust of the Ministry of Energy and agencies such as the Energy Commission, Sustainable Energy Development Agency (SEDA) and Malaysia Green Technology Corporation (MGTC). UTM has signed an MOU and MOA with Green Tech Malaysia as the national centre for Certification of Energy Managers in the Southern Region.

P6: PROMOTION

The successful results of the UTM SEM programme initiative have been continuously **Promoted** widely to over 1,000 organisations nationally and internationally.

The webinar session, attended by 95 participants, ended in a lively discussion. OGTMD wishes to thank Prof. Zainuddin for sharing his experiences in driving SEMP in UTM. ■



ENQUEST-IEM SCIENCE SPEAK OUT 2021

by Ir. Danaraj

One creative way to improve English and STEM literacy is to encourage students to read up and speak on various interesting contents. This year, the Oil, Gas & Mining Technical Division (OGMTD) held an inaugural online public speaking contest for school children aged 9-12 in the Klang Valley.

For the EnQuest-IEM Science Speak Out 2021 contest, the students were required to submit a short video of themselves speaking on selected STEM topics. The initiative, led by Ir. Danaraj and supported by IEM Toastmasters Club, received 21 entries which were assessed independently by a group of judges from IEM Toastmasters Club.

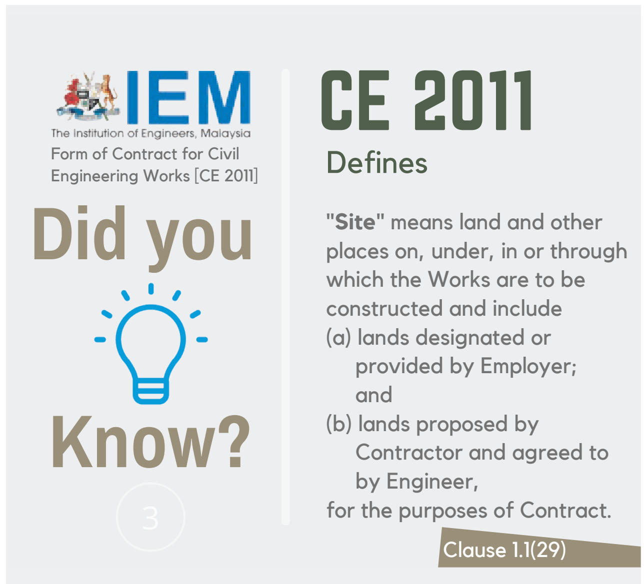
Mr. Isaac Tan (Grand Prize Winner)

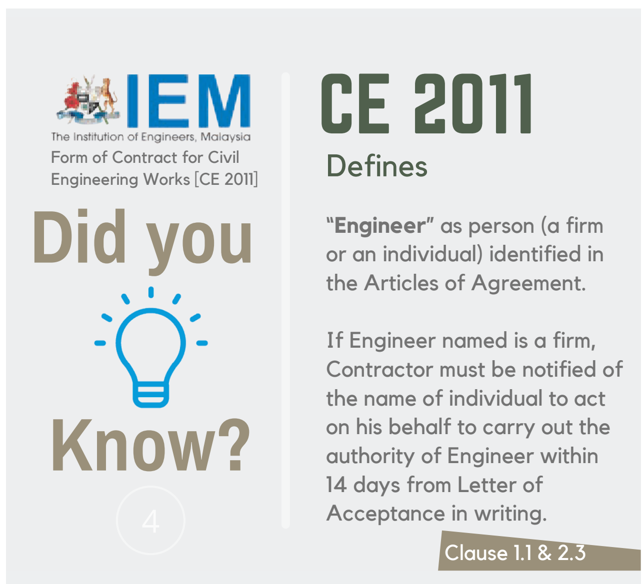
Ms. Rayna Imani (Runner-Up)

In their videos, the children brilliantly and creatively touched on the various STEM topics. There were 10 finalists. Of these, Mr. Isaac Tan of SJKC Kuen Cheng 1 and Ms. Rayna Imani Raymond of SK Alam Damai were named grand prize winner and runner-up respectively. The online prize giving ceremony was held on 22 July 2021.

The contest was sponsored by EnQuest Petroleum Malaysia and supported by the Ministry of Education, Malaysia. All winners received cash prizes and gifts presented by Dato' Ruslan Ibrahim, Head of Organisational & Business Services, Human Resources, EnQuest Petroleum. OGMTD chairman Ir. Abdul Razak Yakob said that, in view of the encouraging response to the contest despite the challenges of the pandemic, there were plans to make this as annual event.

A special note of thanks to EnQuest Petroleum for supporting and sponsoring this event. ■





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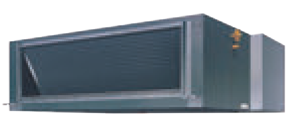

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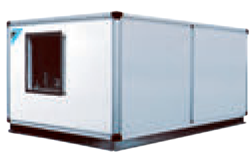

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VIRTUAL ENGINEERING AT NATIONAL SUMMIT 2021

by Chen Ching Yin

The Institution of Engineers, Malaysia (Southern Branch) - Young Engineers Section (IEM SB-YES) organised the National Summit 2021 (NATSUM 2021) from 5 August to 7 August 2021. This grand annual event is organised in rotation by the YES of the respective branches.

It is a platform for all Malaysian engineers and engineering students to gather and discuss issues related to career, professional development, education, technical site visits, technical information exchange and networking activities.

Due to the Covid-19 situation in the country, NATSUM 2021 was held as a virtual event for the very first time with Virtual Engineering as the theme. IEM SB-YES is proud to be the pioneer for this milestone virtual event. All activities were conducted via the ZOOM application. The organising chairman and YES Chairman (2021/2022), Mr. Kenneth Chaw, was pleased at the enthusiasm and teamwork shown by the organising committee.

Ir. Wong Yee Foong, IEM SB Chairman (2021/2022), officiated at the event which was attended by 174 engineers and engineering students from around the country.

In conjunction with NATSUM 2021, IEM SB-YES also organised the Engineers' Virtual Run 2021 aimed at promoting work-life balance and health consciousness among engineers and students, especially during the pandemic; 285 IEM members took part.

NATSUM 2021 participants also attended the mid-term Young Engineers ASEAN Federation of Engineering Organisation (YEAFEO) board meeting to understand more about the latest issues and developments in engineering in the ASEAN region.

There were various webinars conducted during the event. The first, Formula to Success/Land the Offer/Transform Underdogs into Winners by Mr. Jonathan Javier, was followed by The Successful Engineer Workshop by Ms. Vanee Sivasamy. The third and fourth webinars were Application of Neuro Linguistic Programming (NLP) in Day-to-Day Engineering Works by Ir. Ang Pey Char on the first day and The Rise of AI-Driven Drones that are Disrupting the World by Mr. Richard Ker on the last day.

Mr. Kenneth Chaw

One significant event was a forum on Building Information Modelling (BIM). Three prominent individuals in the industry – Ir. Ts. Choo Kok Beng, Ir. Ts. Edward Han Liang Kwang and Ts. Louis Tay Chee Siong – were invited as speakers and they shared with forum participants insights into the BIM application and its role in digital transformation within the engineering field.

Because of restrictions due to the MCO but yet keeping to the tradition of technical visits to factories as an event highlight, NATSUM 2021 participants went on virtual visits to the following factories: Turcomp BMB Sdn. Bhd., Duopharma Biotech Berhad and Top Glove Corporation Berhad. They were able to gain valuable knowledge, exposure and insights on the virtual tours.

IEM SB-YES would like to express gratitude to the following sponsors: Chuan Luck Piling & Construction Sdn. Bhd., Geolab (M) Sdn. Bhd., Antara Koh (M) Sdn. Bhd., Industrial Concrete Products Sdn. Bhd., Malpakat Leisure Group Sdn. Bhd., Mapei Malaysia Sdn. Bhd., Panaron Sdn. Bhd., Guanlite Sdn. Bhd., Jurutera Uji Tatah Sdn. Bhd., Aurum Precast Sdn. Bhd., Dataran Tenaga (M) Sdn. Bhd., Johmanco Sdn. Bhd., Jurutera JRK Sdn. Bhd., Leviat and Victaulic Malaysia Sdn. Bhd.

A big thank you too to the IEM SB Committee for guiding us in this Virtual Milestone Event. Congratulations to IEM YES Sabah Branch who will be hosting NATSUM 2022. ■

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LITTLE YELLOW TRAIN IN THE PYRENEES

Ir. Chin Mee Poon

***Ir. Chin Mee Poon** is a retired civil engineer who derives a great deal of joy and satisfaction from travelling to different parts of the globe, capturing fascinating insights of the places and people he encounters and sharing his experiences with others through his photographs and writing.*

Villefranche-de-Conflent is noted for its fortified village and its little yellow train. Situated 45km east of Andorra as the crow flies, this medieval garrison station was established in 1092. It was remodelled by King Louis XIV's military engineer, Vauban, in 17th century after France annexed the site. Together with a castle on top of an adjacent hill, the village was added to UNESCO's list of World Heritage Sites in 2008.

After spending 2 nights in the tiny principality of Andorra which is sandwiched between France and Spain in the Pyrenees, my wife and I departed for Villefranche-de-Conflent in a rented car, passing through Bourg Madame, Saillagouse, Mont-Louis and Olette; on the way, we caught sight during of a little yellow train twisting and winding its way through the picturesque mountainous terrain.

After checking into a nice *auberge* (hostel) besides the Têt River, we walked to the fortified village in the late afternoon and had a great time exploring its labyrinthine alleyways and byways while enjoying its serene ambience. It is no wonder that Villefranche-de-Conflent is often touted as one of the prettiest villages in France. Unfortunately, we could not climb to the castle for an overview of the village as it was closed.

The next morning, we went to the railway station, a short walking distance from our hostel. When we arrived, a busload of tourists had already beaten us to the ticket counter.

The Little Yellow Train (*Le Petit Train Jaune*) departed at 9.45 a.m. Its ultimate destination was La Tour de Carol, 63km away at the Spanish border. There would be 20 halts along the way but 14 were optional, meaning the train would only stop upon request.

Construction of the 1,000mm gauge railway line started in 1903 and took 24 years to complete, but part of the line commenced operations in 1909.The line climbs from 427m above sea level to the highest point of 1,593m at Bolquére-Eyne, the highest railway station in France. From here, it descends to 1,247m at the terminal station, passing through 19 tunnels and crossing 2 bridges along the entire route. One of the bridges, Pont Gisclard, is a suspension bridge with a rather unusual design.

These little yellow trains are powered by electricity produced by turbine-coupled generators installed on the Tét River and supplied to the trains via a third rail. Since it has lost its commercial value, the little yellow trains are now mainly a tourist attraction.

With the train chugging along at a maximum speed of 55kph, we had ample time to enjoy the charming Pyrenean scenery along the way. Unfortunately, this particular train did not have an open carriage. After 2 hours and 45 minutes, we disembarked at the little frontier village of Bourg Madame, 7km away from the terminal station.

The village was a 3-minute walk from the station. To our great disappointment, it had nothing to offer tourists. A Spanish village, Puigcerdà, is right across the border and also a short walk from the station, but since we only had a little more than one hour left after lunch before the return train was due to arrive from La Tour de Carol, we could not pay it a visit.

On hindsight, it would have been much better to alight at Mont Louis at 10.50 a.m. We would then have 5 hours to visit its citadel and city wall, both UNESCO World Heritage Sites, as well as its pioneering solar furnace. But alas, we've had to bear with this regret due to our failure to carry out adequate research before embarking on this train journey.

TEMUDUGA PROFESSIONAL

Tarikh: 13 Oktober 2021

Kepada Semua Ahli,

SENARAI CALON-CALON YANG LAYAK MENDUDUKI TEMUDUGA PROFESIONAL TAHUN 2021

Berikut adalah senarai calon yang layak untuk menduduki Temuduga Profesional bagi tahun 2021.

Mengikut Undang-Undang Kecil IEM, Seksyen 3.8, nama-nama seperti tersenarai berikut diterbitkan sebagai calon-calon yang layak untuk menjadi Ahli Institusi, dengan syarat bahawa mereka lulus Temuduga Profesional tahun 2021.

Sekiranya terdapat Ahli Korporat yang mempunyai bantahan terhadap mana-mana calon yang didapati tidak sesuai untuk menduduki Temuduga Profesional, surat bantahan boleh dikemukakan kepada Setiausaha Kehormat, IEM. Surat bantahan hendaklah dikemukakan sebulan dari tarikh penerbitan dikeluarkan.

Ir. Dr David Chuah Joon Huang
Setiausaha Kehormat, IEM
(Sessi 2020/2021)

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UPCOMING ACTIVITIES

Virtual Course on "Marine Project Management – Balancing Strategy to complete projects under severe constraints"

Date : 17 November 2021 (Wednesday)
Time : 9.00 a.m. – 5.00 p.m.
Venue : Digital Platform
Approved CPD : Applying
Speakers : First Admiral (Retired) Dato' Ir. Ahmad Murad B Omar
: Ir. Ts Abdul Malik Hussein bin Abdul Jalil

Virtual Half Day Course on Ethics for Marine Professionals

Date : 23 November 2021 (Tuesday)
Time : 1.30 p.m. – 5.30 p.m.
Venue : Digital Platform
Approved CPD : 3.5
Speaker : Ir. Prof Ab Saman bin Abd Kader

WEBINAR TALK on Value Engineering in Mining with Geosynthetics

Date : 24 November 2021 (Wednesday)
Time : 10.00 a.m. – 12.00 p.m.
Venue : Digital Platform
Approved CPD : 2
Speakers : Mr. Brendan Swifte
: Mr. Norhisam Omar

Webinar Talk on "Eliminate Aedes Mosquito Breeding Ground in Built Environment"

Date : 24 November 2021 (Wednesday)
Time : 5.00 p.m. – 7.00 p.m.
Venue : Digital Platform
Approved CPD : 2
Speaker : Ir. Gary Lim Eng Hwa

KEAHLIAN

CONTINUATION FROM JULY ISSUE 2021

PERMOHONAN MENJADI AHLI SISWAZAH

No. Ahli	Nama	Kelayakan
KEJURUTERAAN ELEKTRIKAL		
112460	LEE KAI SHEN	BE HONS (UNSW) (ELECTRICAL, 2010)
112619	LIM YEN YAO	BE HONS (UTAR) (ELECTRICAL & ELECTRONIC, 2019)
112642	MOHD FAIRUS BIN ABD RAHMAN	BE HONS (UiTM) (ELECTRICAL, 2012)
112487	MUHAMMAD HAFRIZ AIZAT BIN M.BAKRI	BE HONS (UniKL) (ELECTRICAL, 2018)
112482	MUHAMMAD HAZIQ BIN AHMAD TARMIZI	BE HONS (UPNM) (ELECTRICAL & ELECTRONICS - POWER, 2016)
112635	NAZLIN BINTI AB.ALIM SIDIKI	BE HONS (UPM)(ELECTRICAL & ELECTRONIC, 2001)
112622	NEEREINDAR A/L Y RAO	BE HONS (UniMAP) (ELECTRICAL ENERGY SYSTEM, 2015)
112448	NUR ARINA BINTI AWANG	BE HONS (UNITEN) (ELECTRICAL POWER, 2015)
112463	OOI CHUN YONG	BE HONS (THE UNI. OF NOTTINGHAM)(ELECTRICAL & ELECTRONIC, 2014) MSc (TH EUNI. OF BATH) (ELECTRICLA POWER SYSTEMS, 2019)
112451	PUTERI NUR JASHENA BINTI JEFRY	BE HONS (THE UNI. OF SYDNEY)(ELECTRICAL-POWER, 2019)
112469	SHESARUBEN YUTHAYA SURIAN	BE HONS (UTP)(ELECTRICAL & ELECTRONIC, 2019)
112634	SOLEHIN BIN BAKRIN	BE HONS (UTM) (ELECTRICAL, 2010)
112484	SYAFIQ AIMAN BIN SAAD	BE HONS (UiTM) (ELECTRICAL, 2017)
114748	FAN CHIN WEI	BE HONS (UTAR SG LONG) (ELECTRICAL, 2020)
114753	TAN BOON HONG, PHILIP	BE HONS (UTAR SG LONG) (ELECTRICAL, 2020)
KEJURUTERAAN ELEKTRONIK		
114745	HEAW ZI BIN	BE HONS (UTAR KAMPAR) (ELECTRONIC, 2020)
112621	LIEW BO YUAN	ME HONS (ICL)(ELECTRICAL & ELECTRONIC, 2014)
112613	MOHAMMAD HASBULLAH BIN MAZLAN	BE HONS (UTM) (ELECTRICAL-TELECOMMUNICATION, 2011)
112611	MOHD HAZIM BIN MOHAMED HARITH	BE HONS (UiTM) (ELECTRONIC-COMMUNICATION, 2012)
112590	NG BOON KHAI	BE HONS (UMP) (ELECTRICAL-ELECTRONICS, 2017) ME (UTM)(COMPUTER AND MICROELECTRONICS, 2019)
112629	NORAINI BINTI HARUN	BE HONS (UiTM) (ELECTRICAL, 2005)
112456	NUR FARAH AIN BINTI KAMARUZAMAN	BE HONS (UniMAP) (BIOMEDICAL-ELECTRONICS, 2016)
114740	TAN XIN YEE	BE HONS (UTAR KAMPAR) (ELECTRONIC, 2020)
115443	WONG JUN YONG	BE HONS (UTAR SG LONG)(ELECTRONIC AND COMMUNICATION, 2020)
114739	WONG VIN YEAN	BE HONS (UTAR KAMPAR) (ELECTRONIC, 2020)
112356	ZARITH ZULAIKHA BINTI ZULKFLEE	BE HONS (UTeM) (ELECTRONIC-TELECOMMUNICATION-ELECTRONICS, 2013)
KEJURUTERAAN ALAM SEKITAR		
115444	VITHYAMUGILAN S/O SUBRAMANIAM	BE HONS (UTAR KAMPAR) (ENVIRONMENTAL, 2020)
114744	LOH XIANG RU	BE HONS (UTAR KAMPAR) (ENVIRONMENTAL, 2020)
114741	SIAH WEELIAM	BE HONS (UTAR KAMPAR) (ENVIRONMENTAL, 2020)
KEJURUTERAAN PEMBUATAN		
112612	AHMAD NABIL BIN ROSLI	BE HONS (UKM) (MANUFACTURING, 2016)
112473	IZHAM REZA BIN ZAINAL ABIDIN	BE HONS (LOUGHBOROUGH UNI. OF TECH.) (MANUFACTURING ENGINEERING & MANAGEMENT, 1991)
112606	MUHAMMAD REDUAN BIN HASHIM	BE HONS (USM) (MANUFACTURING ENGINEERING WITH MANAGEMENT, 2017)
114754	SHIM YI HENG	BE HONS (UTAR SG LONG) (MATERIALS, 2020)
112485	YONG ZHEN PHUAH	BE HONS (UniMAP) (MANUFACTURING, 2016)
KEJURUTERAAN MEKANIKAL		
112483	AB AZIZ BIN MOHD YUSOF	BE HONS (UTM) (MECHANICAL, 2010) ME (UTM)(BIOMEDICAL, 2013) PhD (UTM)(BIOMEDICAL, 2017)
112620	AHMAD NUR IKRAM BIN MANSOR	BE HONS (UKM) (MECHANICAL, 2015)
112643	CHE GHANI BIN CHE KOB	BSc (UTM)(MECHANICAL, 1997)
115445	CHEE KIT MUN	BE HONS (UTAR SG LONG) (MECHANICAL, 2020)
112616	CHIN HONG SHENG	BE HONS (UNITEN) (MECHANICAL, 2010)
112360	CHOON CHIN AUNN, DANIEL	BE HONS (UNITEN) (MECHANICAL, 2015)
114764	CHOW GENG YONG	BE HONS (UTAR SG LONG) (MECHANICAL, 2020)
112474	DHARMARRAJ A/L JAYABALAN	BE HONS (MMU) (MECHANICAL, 2016)
112598	EDWIN RAKESH CHELLIAH	BE HONS (UTP) (MECHANICAL, 2018)
112644	FATIN ALIAA KHAIZAN	BE HONS (UNITEN) (MECHANICAL, 2015)
112594	FIELZA NABILA BINTI MOHD FEISAL	BE HONS (UNITEN) (MECHANICAL, 2019)
112599	HELMI MUZAFFAR SHAH BIN ABD HALIM	BE HONS (UNITEN) (MECHANICAL, 2009)
112617	HERMENTH RAJ A/L GUNASEGARAN	BE HONS (UCSI) (MECHANICAL, 2020)
112454	JEVARAJAN A/L GANASAN	BE HONS (UNITEN) (MECHANICAL, 2018)
112472	KOSHELLAYOGAN A/L MUTHUVALLI	BE HONS (MMU) (MECHANICAL, 2016)
112481	LEE YEONG SHENG, JAMES	BE HONS (UNITEN) (MECHANICAL, 2015)
114756	LIM CHUN YING	BE HONS (UTAR SG LONG) (MECHANICAL, 2020)
112639	MOHD HASIF ARIFF B HALIM	BE HONS (UPM) (MECHANICAL, 2008)
112592	MOHD MAZLAN BIN MASJAYA	BE HONS (UiTM) (MECHANICAL, 2019)
112630	MUHAMMAD FIRDAUS BIN MOHD IRWAN KUAN	BSc (STATE UNI. OF NEW YORK at BUFFALO) (MECHANICAL, 2017)
112452	MUHAMMAD HAZIM BIN ANUAR	BE HONS (TAYLO'R'S UNI.) (MECHANICAL, 2015)
112471	MUHAMMAD NAZMI HANIS BIN MOHD FAISUL	BSc (THE PENNSYLVANIA STATE UNI.)(MECHANICAL, 2019)
112625	MUHAMMAD SYAFIQ BIN SHAMSUDIN	BE HONS (UTP) (MECHANICAL, 2012)
112632	NURSYAHBANI BINTI EVI SUKARDI	BE HONS (UTHM) (MECHANICAL, 2015)
112615	OOI PEI JUN	BE HONS (INTI INT. UNI.) (MECHANICAL, 2019)
112618	SAIFUL AZHAR BIN MASRI	BE HONS (UiTM) (MECHANICAL, 2018)
112624	SIAW WEI YAH, VICTORIA	BE HONS (CURTIN UNI.) (MECHANICAL, 2018)
112491	SURINJEET SINGH A/L HARBHAJAN SINGH	BE HONS (UTM) (MECHANICAL-AERONAUTICS, 2000)
112628	TAY YUNG HUI	BE HONS (SWINBURNE UNI. OF TECH.)(MECHANICAL, 2016)
112358	VIKNESHWARAN S/O KELUAN SINGH	BE HONS (NILAI UNI.) (MECHANICAL, 2017)
114750	YAP KAH YEE	BE HONS (UTAR SG LONG) (MECHANICAL, 2020)
114749	YEOH KEAT JIN	BE HONS (UTAR SG LONG) (MECHANICAL, 2020)
112478	ZULKEFLEE BIN ZAKARIA	BE HONS (UTM) (MECHANICAL, 2014)
KEJURUTERAAN MEKATRONIK		
112466	CHAI TONG YUEN	BE HONS (UniMAP) (MECHATRONICS, 2007) MSc (UniMAP) (MECHATRONICS, 2009)
112486	YEOH RU SERN	BE HONS (UNI. OF NORTHUMBRIA at NEWCASTLE) (MECHANICAL, 2016) ME (UNI. OF MALAYA) (MECHATRONICS, 2019)
KEJURUTERAAN PETROLEUM		
112627	JEYEDESWARAN A/L GANASAN	BE HONS (UTP) (PETROLEUM, 2017)

PERMOHONAN MENJADI AHLI 'INCORPORATED'

No. Ahli	Nama	Kelayakan
KEJURUTERAAN ELEKTRIKAL		
37239	RAJAKUMAR A/L RAJARATNAM	BE HONS (THE NOTTINGHAM TRENT UNI.)(ELECTRICAL & ELECTRONIC, 2002)
KEJURUTERAAN ELEKTRONIK		
112602	LIM HOCK HENG, ADRIAN	BE HONS (THE UNI. OF SHEFFIELD)(ELECTRONIC-COMMUNICATIONS, 2003)

UPCOMING ACTIVITIES

Webinar Talk on "How to get an advanced RM 1 million++ UPS at RM 200k++ through innovative designs"

Date : 25 November 2021 (Thursday)
Time : 5.30 p.m. – 7.30 p.m.
Venue : Digital Platform
Approved CPD : 2
Speaker : Ir. Vignaeswaran Shanmugananthan

Webinar Talk on "Introduction to Welding Engineering"

Date : 27 November 2021 (Saturday)
Time : 11.30 a.m. – 1.30 p.m.
Venue : Digital Platform
Approved CPD : Applying
Speaker : Ir. Ts. Pragash Krishnasamy

PERMOHONAN BARU / PEMINDAHAN AHLI

Persidangan Majlis IEM yang ke-**424** pada **18 Januari 2021** telah meluluskan sebanyak **1,998** ahli untuk permohonan baru dan permindahan ahli. Berikut adalah senarai ahli mengikut disiplin kejuruteraan:

DISIPLIN	GRED KEAHLIAN									
	FELO	SENIOR	AHLI	SENIOR GRADUATE	SISWAZAH	"INCORPORATED"	"AFFILIATE"	"ASSOCIATE"	SISWA	JUMLAH
Aeronautikal						1				1
Aeroangkasa					1				1	2
Pertanian					1					1
Automotif									1	1
Biokimia					1					1
Bioperubatan	1		1		1					3
Biologi & Pertanian									1	1
Kimia			1	2	21				150	174
Awam	1		32	9	72	2		2	448	566
Komunikasi			2	1	1					4
Komputer									3	3
Sistem Komputer									2	2
Pembinaan									1	1
Elektrikal & Elektronik									311	311
Elektrikal	1		23	6	56	2			54	142
Elektronik	1		9	3	17		1		134	165
Alam Sekitar					3					3
Geoteknik			1							1
Industri									8	8
Maklumat Teknologi									1	1
Kawalan & Instrumentasi			1							1
Pembuatan			1		5				29	35
Bahan			1		1					2
Mekanikal	1	2	16	8	69				452	548
Mekatronik			2		2				10	14
Arkitek Naval						1				1
Petroleum					2					2
Polimer					1					1
Struktur			1							1
Pengangkutan			1							1
Sistem Mekanikal									1	1
JUMLAH	5	2	92	29	254	6	1	2	1607	1998

Senarai nama ahli dan kelayakan adalah seperti di bawah. Institusi mengucapkan tahniah kepada ahli yang telah berjaya.

Ir. Dr David Chuah Joon Huang

Setiausaha Kehormat, Institusi Jurutera Malaysia, Sesi 2020/2021

PERMINDAHAN AHLI KEPADA AHLI FELLOW

No. Ahli	Nama	Kelayakan
KEJURUTERAAN AWAM		
16340	NEO BOON KHENG	BSc (OUTHERN ILLINOIS) (CIVIL, 1987) MSc (SOUTHERN ILLINOIS) (1990)
KEJURUTERAAN BIO-PERUBATAN		
54322	LAI KHIN WEE	BE HONS (UTM) (BIOMEDICAL, 2009) PhD (UTM) (BIOMEDICAL, 2012)
KEJURUTERAAN ELEKTRIKAL		
05899	CHIEW LIK ING, PAUL	BSc HONS (MANCHESTER) (ELECTRICAL & ELECTRONIC, 1979) MSc (HERIOT-WATT) (DIGITAL TECHNOLOGIES, 1982)
KEJURUTERAAN ELEKTRONIK		
25647	HARIKRISHNAN RAMIAH	BE HONS (USM) (ELECTRICAL & ELECTRONIC, 2000) MSc (USM) (ELECTRICAL & ELECTRONIC, 2003) PhD (USM) (2009)
KEJURUTERAAN MEKANIKAL		
29070	MUHAMMAD AZMI BIN AYUB	BE (NEW SOUTH WALES) (MECHANICAL, 1990) MSc (LOUGHBOROUGH) (MECHATRONICS, & OPTICAL, 1996) PhD (LOUGHBOROGH) (2004)

PEMINDAHAN AHLI KEPADA AHLI KORPORAT

No. Ahli	Nama	Kelayakan
KEJURUTERAAN AWAM		
94021	AMNORZAHIRA BINTI AMIR	BE HONS (MALAYA) (CIVIL, 2003) MSc (UPM) (ENVIRONMENTAL, 2007). PhD (KAIST) (CIVIL & ENVIRONMENTAL, 2012)
34867	CHAN PUI KHUAN	BE HONS (MALAYA) (CVIL, 2007)
52845	CHEAH SHENG HONG	BE HONS (UTHM) (CIVIL, 2013)
104306	CHEN CHO' LIN, JOSEPH	BE HONS (SWINBURNE) (CIVIL, 2014)
26380	FAUZI	BE HONS (UiTM) (CIVIL, 2003)
53739	FAUZIAH BINTI MOHD SAID	BE HONS (UTM) (CIVIL, 2000)
38584	HERMANIZAH BINTI SA'ADON	BE HONS (UTM) (CIVIL, 2010)
105663	LEONG KAH HON	BE HONS (UTHM) (CIVIL, 2009)
17731	LIEW KIT HONG	BE HONS (MALAYA) (CIVIL, 1999)
50703	MUHAMMAD MAAMIN BIN ABDUL MALIK	BE HONS (MALAYA) (CIVIL, 2011) ME (UTM) (CIVIL-STRUCTURE, 2014)
30525	NG KOK SHIEN	BE HONS (UTM) (CIVIL, 2004) ME (UTM) (CIVIL-GEOTECHNIC, 2005) PhD (NUS) (2013)
37235	NOR ASHIKIN BINTI MUHAMAD KHAIRUSSALEH	BE HONS (UKM) (CIVIL & STRUCTURAL, 2004) MSc (USM) (STRUCTURAL, 2006) PhD (SURREY) (2016)
53610	NOR AZRA BTE AB. WAHAB	BE HONS (UKM) (CIVIL & STRUCTURAL, 2013)
21173	REDZUAN BIN MD YUNUS	BE HONS (UTM) (CIVIL, 2003)
18937	SII HIE ING	BSc HONS (MISSISSIPPI) (CIVIL, 1992) MSc (MISSISSIPPI) (CIVIL, 1993)
76050	TAN KEN HENG	BE HONS (MALAYA) (CIVIL, 2003) MSc (UPM) (ENVIRONMENTAL, 2007). PhD (KAIST) (CIVIL+D34 & ENVIRONMENTAL, 2012)
51625	TAN SIANG LOONG	BE HONS (UTM) (CIVIL, 2012)
61170	WAN MUHAMAD FAHMI BIN WAN ZAKI	BE HONS (UiTM) (CIVIL, 2007)
41226	ZAHARI BIN MOHD NOR	BE HONS (UTM) (CIVIL, 2007)
KEJURUTERAAN BAHAN		
77459	TAN KIM SEAH	BE HONS (UniMAP) (MATERIALS, 2011)
KEJURUTERAAN BIOPERUBATAN		
90350	HAW YU HONG	BE HONS (MALAYA) (BIOMEDICAL, 2016)
KEJURUTERAAN ELEKTRIKAL		
58722	ALIAS BIN KHAMIS	BE HONS (UiTM) (ELECTRICAL, 2003) MSc (UPM) (ELECTRICAL POWER, 2007)
80547	AMIR ANWAR BIN SHABUDIN	BE HONS (UNITEN) (ELECTRICAL POWER, 2012)
91034	ANG KUAN SIM	BE HONS (NEWCASTLE) (ELECTRICAL, 2016)
93670	JAGDESH RAO A/L KRISHNAN	BE HONS (UTM) (ELECTRICAL, 2016)
87396	LEE YUAN GENG	BE HONS (USM) (ELECTRICAL, 2013)
29109	LIM KHONG HEAN	BE HONS (UNITEN) (ELECTRICAL POWER, 2006)

105764	MOHD HAFIZZUDIN BIN ISMAIL	BE HONS (UTeM) (ELECTRONIC POWER & DRIVE, 2012)
51316	MUHAMMAD ZULKIFLI BIN ABD HAMID	BE HONS (UiTM) (ELECTRICAL, 2009) ME (MALAYA) (POWER SYSTEM, 2018)
87441	MUTHU KUMARAN A/L GUNASEGARAN	BE HONS (UNITEN) (ELECTRICAL POWER, 2013)
90761	NAJLAN BIN ISMAIL	BE HONS (UNITEN) (ELECTRICAL POWER, 2014)
47160	QUAH CHEE HEAN	BE HONS (UniMAP) (ELECTRICAL SYSTEM, 2011)
43090	TEO SIN TIONG	BE HONS (UNIVERSITY OF LONDON) (ELECTRICAL & ELECTRONIC, 2003)
87364	VIGNES A/L KANNESAN	BE HONS (UNITEN) (ELECTRICAL POWER, 2015) ME (UPM) (ENGINEERING MANAGEMENT, 2018)
84942	WEE CHAI SIANG	BE HONS (MMU) (ELECTRONICS MAJORING IN ROBOTICS AND AUTOMATION, 2012)

KEJURUTERAAN ELEKTRONIK

88959	AZRULAZHAR BIN JAMALUDIN	ME (SURREY) (ELECTRONIC, 2007)
89532	LEE CHER CHIA	BSc HONS (STATE UNIVERSITY OF NEW YORK AT BUFFALO) (ELECTRICAL, 2002) ME (UTeM) (MANUFACTURING SYSTEM, 2017)
43556	NORFAIZA BINTI FUAD	BE HONS (UTM) (COMPUTER, 2003) MSC (UPM) (COMPUTER SYSTEMS, 2007) PhD (UiTM) (ELECTRICAL, 2017)
51683	SITI AISYAH BINTI ANAS	BE HONS (UTeM) (ELECTRONIC - COMPUTER, 2008) ME (UKM) (COMMUNICATION & COMPUTER, 2011)
99363	TAY LEE CHOO	MSC (UPM) (COMPUTER SYSTEMS, 2007) PhD (UiTM) (ELECTRICAL, 2017)

KEJURUTERAAN KAWALAN & INSTRUMENTASI

73382	ONG BOON LEONG	BE HONS (NORTHUMBRIA) (ELECTRICAL & ELECTRONIC, 1997)

KEJURUTERAAN KOMUNIKASI

24438	SURESH KUMAR A/L KANDASAMY	BE HONS (USM) (ELECTRICAL & ELECTRONIC, 2000) MSc (UKM) (ELECTRICAL, ELECTRONIC & SYSTEM, 2005)

KEJURUTERAAN MEKANIKAL

109219	CHONG KOK HONG	BE HONS (UPM) (MECHANICAL, 2008)
66379	FAIZ AZMI BIN SUTARJI	BE HONS (UTM) (MECHANICAL-MARINE TECHNOLOGY, 2013)
86891	KHAW YAO SHUN	BE HONS (UTP) (MECHANICAL, 2015)
94378	MOHD RIDZUAN BIN SUID	BE HONS (MALAYA) (MECHANICAL, 2010)
36888	MOHD RUZAINI BIN MOHAMAD NOOR	BE HONS (ESSEX) (COMPUTER & COMMUNICATIONS, 1990) ME (UNITEN) (ELECTRICAL, 2017)
42456	MURTHY A/L RAMARAO	BE HONS (UNISEL) (MECHANICAL, 2007)
59039	NG TZE TAT	BE HONS (UKM) (MECHANICAL, 2011)
50882	OOI TZE HOONG	BE HONS (USM) (MECHANICAL, 2015)
50184	SIM SOO CHOON	BE HONS (UTP) (MECHANICAL, 2009)

KEJURUTERAAN PENGANGKUTAN

46756	WONG CHANG YAU, SANDRA	BE HONS (UNITEN) (CIVIL, 2005)

KEJURUTERAAN STRUKTUR

53628	WONG LUNG FEI	BE HONS (UKM) 9CIVIL & STRUCTURAL, 2013) BSc (DUISBERG-ESSEN) CIVIL, 2013)

PEMINDAHAN KEPADA AHLI (MELALUI PEPERIKSAAN PENILAIAN PROFESIONAL)

KEJURUTERAAN AWAM

No. Ahli	Nama	Kelayakan
37046	ELAINE KUSON	BE HONS (UTP) (CIVIL, 2007)
108127	MOHD ZULHAIRI BIN SOBRI	BE HONS (UTP) (CIVIL, 2008)
70277	NGIAM KEE HWEE	Sc HONS (OKLAHOMA) (CIVIL, 1996)

KEJURUTERAAN ELEKTRIKAL

87360	CHAN JEE HENG	BE HONS (MMU) (ELECTRICAL, 2013)
72220	KOO LI CHIAT	BE HONS (UNITEN) (ELECTRICAL & ELECTRONICS, 2010)
27977	KWOK YEW HOE	BE HONS (MALAYA) (ELECTRICAL, 1998)
66526	MOHAMMED REYASUDIN BIN BASIR KHAN	BE HONS (UNITEN) (ELECTRICAL & ELECTRONICS, 2011) PhD (UNITEN) (2016)
52820	MUHAMMAD NURZUHAILI BIN ZAINUDI	BE (UMP) (POWER SYSTEM, 2012) ME (MALAYA) (2017)

KEJURUTERAAN MEKANIKAL

42437	JARONIE BIN MOHD JANI	MIED (UPM) (2008) PhD (RMIT) (2016)
66705	LAU CHIN SHENG	BE HONS (NUS) (MECHANICAL, 2008)
64837	MOHD HAZWAN BIN MOHAMED HANIFFA	BE HONS (MALAYA) (MECHANICAL, 2007)

KEJURUTERAAN MEKATRONIK

58103	SALMIAH BINTI AHMAD	BE HONS (IIUM) (MECHATRONICS, 2001) ME (CURTIN) (ELECTRICAL, 2005) PhD (SHEFFIELD) (2010)

PEMINDAHAN AHLI KEPADA AHLI KORPORAT

KEJURUTERAAN AWAM

No. Ahli	Nama	Kelayakan
94021	AMNORZAHIRA BINTI AMIR	BE HONS (MALAYA) (CIVIL, 2003) MSc (UPM) (ENVIRONMENTAL, 2007). PhD (KAIST) (CIVIL & ENVIRONMENTAL, 2012)
34867	CHAN PUI KHUAN	BE HONS (MALAYA) (CVIL, 2007)
52845	CHEAH SHENG HONG	BE HONS (UTHM) (CIVIL, 2013)
104306	CHEN CHO' LIN, JOSEPH	BE HONS (SWINBURNE) (CIVIL, 2014)
26380	FAUZI	BE HONS (UiTM) (CIVIL, 2003)
53739	FAUZIAH BINTI MOHD SAID	BE HONS (UTM) (CIVIL, 2000)
38584	HERMANIZAH BINTI SA'ADON	BE HONS (UTM) (CIVIL, 2010)
105663	LEONG KAH HON	BE HONS (UTHM) (CIVIL, 2009)
17731	LIEW KIT HONG	BE HONS (MALAYA) (CIVIL, 1999)
50703	MUHAMMAD MAAMIN BIN ABDUL MALIK	BE HONS (MALAYA) (CIVIL, 2011) ME (UTM) (CIVIL-STRUCTURE, 2014)
30525	NG KOK SHIEN	BE HONS (UTM) (CIVIL, 2004) ME (UTM) (CIVIL-GEOTECHNIC, 2005) PhD (NUS) (2013)
37235	NOR ASHIKIN BINTI MUHAMAD KHAIRUSSALEH	BE HONS (UKM) (CIVIL & STRUCTURAL, 2004) MSc (USM) (STRUCTURAL, 2006) PhD (SURREY) (2016)
53610	NOR AZRA BTE AB. WAHAB	BE HONS (UKM) (CIVIL & STRUCTURAL, 2013)
21173	REDZUAN BIN MD YUNUS	BE HONS (UTM) (CIVIL, 2003)
18937	SII HIE ING	BSc HONS (MISSISSIPPI) (CIVIL, 1992) MSc (MISSISSIPPI) (CIVIL, 1993)
76050	TAN KEN HENG	BE HONS (MALAYA) (CIVIL, 2003) MSc (UPM) (ENVIRONMENTAL, 2007). PhD (KAIST) (CIVIL+D34 & ENVIRONMENTAL, 2012)
51625	TAN SIANG LOONG	BE HONS (UTM) (CIVIL, 2012)
61170	WAN MUHAMAD FAHMI BIN WAN ZAKI	BE HONS (UiTM) (CIVIL, 2007)
41226	ZAHARI BIN MOHD NOR	BE HONS (UTM) (CIVIL, 2007)

KEJURUTERAAN BAHAN

77459	TAN KIM SEAH	BE HONS (UniMAP) (MATERIALS, 2011)

KEJURUTERAAN BIOPERUBATAN

90350	HAW YU HONG	BE HONS (MALAYA) (BIOMEDICAL, 2016)

KEJURUTERAAN ELEKTRIKAL

58722	ALIAS BIN KHAMIS	BE HONS (UiTM) (ELECTRICAL, 2003) MSc (UPM) (ELECTRICAL POWER, 2007)
80547	AMIR ANWAR BIN SHABUDIN	BE HONS (UNITEN) (ELECTRICAL POWER, 2012)
91034	ANG KUAN SIM	BE HONS (NEWCASTLE) (ELECTRICAL, 2016)
93670	JAGDESH RAO A/L KRISHNAN	BE HONS (UTM) (ELECTRICAL, 2016)
87396	LEE YUAN GENG	BE HONS (USM) (ELECTRICAL, 2013)
29109	LIM KHONG HEAN	BE HONS (UNITEN) (ELECTRICAL POWER, 2006)
105764	MOHD HAFIZZUDIN BIN ISMAIL	BE HONS (UTeM) (ELECTRONIC POWER & DRIVE, 2012)
51316	MUHAMMAD ZULKIFLI BIN ABD HAMID	BE HONS (UiTM) (ELECTRICAL, 2009) ME (MALAYA) (POWER SYSTEM, 2018)
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