

KDN PP 11720/4/2013 (032270)



LEMBAGA JURUTERA MALAYSIA
BOARD OF ENGINEERS MALAYSIA

THE
VOL.106
APRIL-JUNE 2026

INGENIEUR

MAGAZINE OF THE BOARD OF ENGINEERS MALAYSIA

Engineering the *ENERGY TRANSITION*





A member of UEM

EMPOWERING ENGINEERS, BUILDING THE FUTURE

At PLUS, with a dedicated team of 3,800 personnel, we are committed to providing world-class facilities and services that prioritise the safety and comfort of our highway users. PLUS offers a dynamic platform for our engineers to develop their expertise, advance their careers, and shape the future of highway management through innovative solutions and cutting-edge practices.

Ir. Ts. Noordini Harliyati Ramli
(PE P117506)
Traffic Safety

Every individual, regardless of gender, possesses a distinctive spark that drives innovation in engineering. Your unique perspective is not merely valuable, it is crucial for the advancement and transformation of our industry. A diversity of thought stimulates creativity and propels progress, enabling us to develop effective solutions for the challenges we encounter.

Ir. Maizatul Zaila Kamarol Zaman
(PEPC C110553)
Strategic Planning
and Development

I am honored to be part of the backbone that supports Malaysia's transportation infrastructure. My 30 years at PLUS have not only enriched my engineering expertise but also allowed me to contribute to enhancing the efficiency and safety of our nation's mobility network.

Ir. Ts. Adam Junid
(PEPC C113254)
Mechanical, Electrical and Electronic

Engineers carry a vital responsibility and commitment to public safety throughout design, construction, testing, installation, operations, maintenance and decommissioning phases. Beyond this fundamental duty, our team embodies MyPLUS Culture Practices of 'I Constantly Learn, I Collaborate, I Am Accountable, I Build Trust, I Care, and I Embrace Change'. These MyPLUS Culture Practices support professional growth, preparing them for long-term success in their careers.

EUR ING Ir. Ts.
Azizul Faiz Abdul Aziz
(PE P123178)
Maintenance and
Asset management

PLUS promotes the value of constantly learning with great appreciation for those who are willing to put their best efforts in gaining knowledge. I have obtained my Professional Technologist, my Chartered Professional Civil Engineer, my Professional Engineer and most recently the accreditation as Professional European Engineer from Engineers Europe Engineering Council. The accreditation received would be crucial in promoting the drive for PLUS in being the best in Highway and Transportation Asset Management within a fast-moving Malaysia's transportation infrastructure industry.

Follow us on social media



www.plus.com.my

PLUS App

PLUSLine 1800-88-0000

PUTRI



LEMBAGA JURUTERA MALAYSIA
BOARD OF ENGINEERS MALAYSIA

BOARD MEMBERS 2025-2026

PRESIDENT

YBhg. Dato' Sri Ir. Roslan bin Ismail

BOARD MEMBERS

YBhg. Dato' Indera Ir. Dr Ahmad Sabirin bin Arshad

YBhg. Datuk Ir. Mohamad Radzi bin Abdul Talib

YBhg. Datu Ir. Dr Cassidy Anak Morris

Ir. Haji Mohd Hatta bin Zakaria

Ir. Mohd Shahrom bin Ahmad Saman

Ir. Dr Sherliza binti Zaini Sooria

Ir. Haji Mohd Jalaludin bin Sulaiman

Prof. Ir. Dr David Chuah Joon Huang

Ir. Megat Johari bin Megat Mohd Noor

Ir. Sharifah Azlina binti Raja Kamal Pasmah

Ir. Yau Chau Fong

Ir. Dr Bernard Lim Kee Weng

Ir. Chen Harn Shean

Ir. Abdul Razak bin Yakob

Ar. Abd Shukor bin Ismail

Sr Dr Azmi bin Mohamed @ Mohd Adnan

REGISTRAR

Ir. Dr Megat Zuhairy bin Megat Tajuddin

SECRETARY

Ir. Khairul Nizan bin Khairudin

EDITORIAL BOARD

ADVISOR

YBhg. Dato' Sri Ir. Roslan bin Ismail

CHAIRMAN

Ir. Dr Sherliza binti Zaini Sooria

EDITOR

YBhg. Dato' Ir. Fong Tian Yong

EDITORIAL MEMBERS

Prof. Emeritus Ir. Dr K S Kannan

Ir. Prem Kumar

Ir. Anuar bin Mohd Aris

YBhg. Dato' Prof. Ir. Dr Eric KH Goh

PUBLISHER

Lembaga Jurutera Malaysia

Tingkat 17 Blok F, Ibu Pejabat JKR,

Jalan Sultan Salahuddin,

50580 Kuala Lumpur.

Tel: 03-2698 0590, 03-2691 2090 Fax: 03-2692 5017

E-mail: publication@bem.org.my

Website: www.bem.org.my

DESIGN AND PRODUCTION

Dimension Publishing Sdn Bhd

PRINTER

Sky Press Sdn Bhd

No.8, Jalan PBS 14/10,

Taman Perindustrian Bukit Serdang,

43300 Seri Kembangan, Selangor.

The Ingenieur is published quarterly by the Board of Engineers Malaysia (Lembaga Jurutera Malaysia) and is distributed free to registered Professional Engineers. The statements and opinions expressed in this publication are those of the writers. BEM invites all engineers and readers to contribute relevant articles and views to the Publisher.

CONTENTS

Announcement

- 4** Call for Articles
- 5** President's Message

Cover Feature

- 6** Engineering with Purpose: Nation-Building Beyond Technology
- 9** Young Icon with National Mission: To Reignite Engineering in Malaysia
- 12** AI-enabled Engineering for Energy Transition & Economic Success: Smart Heavy Equipment Design towards ESG Net Zero Status
- 17** Engineering ESG into Practice: The HSS Experience

- 23** Implementation of Large-Scale Solar Photovoltaic Systems in Malaysia
- 27** Engineering Bioenergy for a Low-Carbon Future: From Biomass Conversion to Grid Integration

Feature

- 33** Intelligent Solution to Malaysia's Waste-to-Energy Incinerator Dilemma
- 38** Renewable Energy as Cornerstone of Energy Transition - The Way Forward for ASEAN Decarbonisation Towards 2030
- 41** Energy the Currency of Digital Age: Rising Electricity Appetite of AI & Data Centres
- 46** Ultra-High Voltage Transmission: The Backbone of Long-Distance Power Delivery
- 49** Electrical Safety Standards for Rooftop PV & Battery Energy Storage Systems in ASEAN
- 53** Dealing with Spent Batteries: Green Industrial Recycling at Crossroads of the Green Economy & E-Waste Management

6



12



56 Extending UN Decade of Sustainable Energy to 2030: Engineering the Path Towards SDG 7 in ASEAN & Beyond

59 Just & Inclusive Energy Transition in APAEC 2026-2030 - Powering progress

62 Role of Carbon Data Open Protocol in Modern Carbon Markets: Engineering the Future of Carbon Integrity

65 Grid Code Strengthening Roadmap for ASEAN in the Era of Data Centres: Securing the digital future ultimately begins with securing the grid

Do You Know?

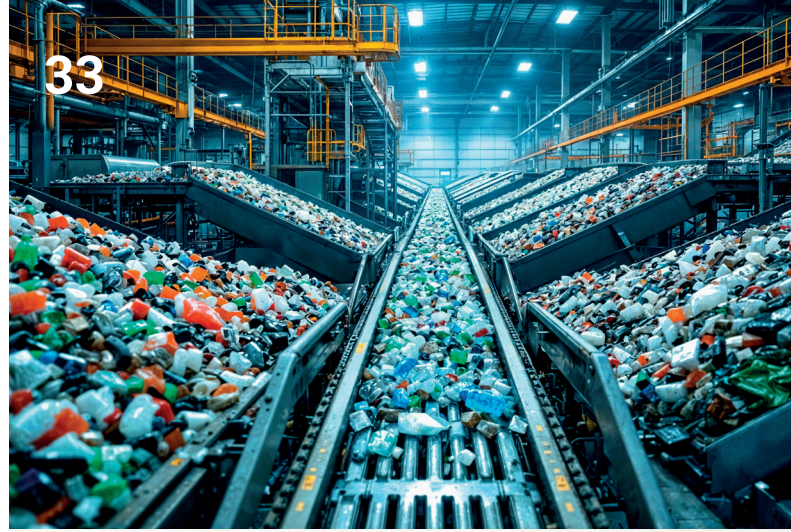
69 Engineering Energy Transition

Engineering Feature

74 Melbourne Kokoda Memorial Walk: Engineering, Memory & Spirit of Kokoda Trail

Engineering Nostalgia

80 Ringlet to Habu, Cameron Highlands Road Construction, 1962





CALL FOR ARTICLES

The Ingenieur is published quarterly by the Board of Engineers Malaysia. The following are the themes for the coming issues.

Vol. 107 Jul-Sept 2026

Engineering Physical Connectivity

Vol. 108 Oct-Dec 2026

Building Lifeline

Vol. 109 Jan-Mar 2027

Circularity and Resource Engineering

Articles and other contributions relevant to the themes are welcomed, but the decision to publish rests with the Editorial Board.

Advertising inquiries are also welcomed. Please refer to the BEM advertisement on Page 36 for the latest rate card and booking form.

The Ingenieur e-Magazine on **SMARTPHONES & IPADS**

THE INGENIEUR can now be read on smartphones as well as iPads. Read anywhere, anytime and share with your colleagues and friends.

How to get the e-magazine?

Mobile Version -
Scan the QR Code



The Ingenieur
Vol. 105
Jan-Mar 2026



The Ingenieur
Vol. 106
Apr-Jun 2026

Native iPad/iPhone Version -
Get the free Apps



The e-magazine may be viewed natively on iPads and iPhones using the Joomag Apps. Download for free.

Engineering the Energy Transition



Dato' Sri Ir. Roslan bin Ismail
President
Board of Engineers Malaysia

The global energy transition is no longer optional; it is an engineering imperative. Worldwide energy consumption continues to rise, driven by population growth, electrification, digitalisation and the rapid expansion of data-intensive technologies. International energy outlooks consistently highlight data centres as one of the fastest-growing sources of electricity demand, alongside electric mobility and industrial electrification.

Malaysia is experiencing the same upward pressure on its power system. The increase in the number of data centres and digital infrastructure developments will significantly raise electricity demand in the coming decades, requiring careful system planning, efficiency improvements and diversification of energy sources. This evolving reality places engineers firmly at the centre of national and global energy solutions.

As engineers, our responsibility extends beyond increasing generation capacity. We must innovate to improve energy efficiency, integrate renewable and low-carbon technologies, enhance grid resilience and develop smarter energy management systems. Engineering solutions in areas such as advanced cooling, power electronics, energy storage and demand-side optimisation will be essential to meeting future demand sustainability and reliability.

The engineering profession has always adapted to change, guided by science, ethics and public interest. By nurturing innovative thinking and embracing new technologies, engineers will continue to play a decisive role in balancing energy security, economic development and environmental stewardship in ensuring a sustainable and resilient energy future for Malaysia and beyond. 🌱

Engineering with Purpose: Nation-Building Beyond Technology

Engineer, academic, public administrator, environmental steward, author and intellectual activist Emeritus Professor Dato' Seri Ir. Dr. Zaini Ujang represents a generation of engineers who sees the profession as not merely a technical discipline but also as a moral calling. Recipient of the BEM Anugerah Tokoh Kejuruteraan Negara 2025, his journey reflects how engineering, when guided by purpose, can shape policy, protect nature and elevate society.

When Dato' Seri Ir. Dr. Zaini Ujang, 61, received news that he had been selected as the recipient of the Anugerah Tokoh Kejuruteraan Negara 2025 (National Engineering Icon Award, 2025), the moment arrived not at the height of professional ambition but at a time of personal reflection. Retirement from public service was imminent and his attention had turned to sharing knowledge globally.

"It surprised me," he recalls candidly. "At that time, my focus was mainly on my post-retirement plans. That's why I went abroad for an epic world tour of 100 days, delivering 40 lectures in 15 countries. Suddenly, in between the trip, I received this surprise. But it was a very good surprise."

The recognition, conferred by the Board of Engineers Malaysia (BEM), honours not just technical excellence but also integrity, leadership and societal impact. In Dr. Zaini's case, it acknowledges a career that has spanned academia, engineering practice, national policy-making and international diplomacy - each reinforcing the other.

Roots in Rivers: Calling Shaped by Nature

Long before he became a national figure, water shaped Dr. Zaini's worldview. Growing up near rivers and experiencing floods during monsoon seasons instilled both familiarity and respect for the power of Nature.

"Water has always been close to my heart," he says. "Living near rivers, understanding floods, experiencing monsoons in both Kelantan and Terengganu... these things stay with you."

Born on 3 March 1965, Dr. Zaini began his higher education in Chemical Engineering at Universiti Teknologi Malaysia (UTM) but his curiosity soon drew him towards environmental and water engineering, fields that directly addressed the challenges he had witnessed firsthand. In Malaysia, environmental engineering sits within the broader civil engineering ecosystem, particularly in relation to water resources, sanitation and sustainable infrastructure - an integration that suited his interdisciplinary instincts.



Dr. Zaini believes that engineering education theory must be constantly tested against reality

Postgraduate studies at Newcastle University, United Kingdom, culminating in a PhD and later an Honorary Doctor of Science, gave him not only technical depth but also exposure to global perspectives in water research, regulation and governance. Later, his participation in the Advanced Management Programme (AMP) at Harvard Business School further equipped him with leadership and strategic capabilities, skills that would prove invaluable in public administration.

Academia with a Difference: Learning from the Field

Unlike many academics whose early careers were dominated by teaching schedules, Dr. Zaini's return to Malaysia had an unconventional beginning. "When I came back from England as a lecturer, I didn't get a teaching assignment. Instead, I received consultancy assignments," he says. "Most of my work was attached to universities, agencies or companies."

He began his professional career in August 1988 as an assistant lecturer at UTM. Demonstrating an exceptional blend of academic rigour, applied research and leadership, he rose steadily through the academic ranks and was appointed Professor in Environmental Engineering & Water Sustainability in 2002. His leadership qualities culminated in his appointment as Vice-Chancellor of UTM (2008-2013), making him the youngest Vice-Chancellor of a Malaysian public university at the age of 43.

In 2011, Dr. Zaini entered the Administrative & Diplomatic Officer (PTD) service, marking a pivotal transition from academia to national governance. Beginning in 2013, he was entrusted with the role of Secretary-General across six ministries, a rare distinction that underscored the confidence placed in his leadership and policy acumen. His ministerial portfolios spanned higher education, human resources, energy, water, green technology, environment, climate change and health, positioning him at the nexus of Malaysia's sustainable development and nation-building agenda.

His final posting was as Secretary-General of the Ministry of Higher Education (Kementerian Pendidikan Tinggi, KPT) for the second time, from 13 February 2024 until 2 March 2025, coinciding with his compulsory retirement from the civil service. After departing from public service, he served concurrently as Chairman of the Malaysian Qualifications Agency (MQA), Pro-Chancellor of Management & Science University (MSU), Professor Fellow at the International Islamic University Malaysia (IIUM) and as a Member of the Board of Directors of Universiti Tenaga Nasional (UNITEN), Universiti Tun Abdul Razak (UNIRAZAK) and UNICIEF University. He also advises many corporate entities on SDG, ESG, climate strategy, river sustainability, water and wastewater engineering.

Throughout his career and involvement in various bodies, Dr. Zaini prioritised understanding and appreciation of knowledge culture, sustainable and healthy lifestyles and leadership by example.

His deep immersion in real-world problem-solving shaped his philosophy of engineering education. Theory, he believed, must be constantly tested against reality. Consulting on river classification, water quality standards and infrastructure planning gave him a practical understanding of governance complexities which textbooks alone could not provide.

This dual identity of scholar and practitioner became the hallmark of his career. It also influenced generations of students who encountered an academic who was equally comfortable at discussing membrane filtration systems, policy frameworks and institutional reform.

Knowledge as Legacy: Writing, Teaching & Public Engagement

Dr. Zaini feels that knowledge is not complete until it is shared. Writing has been his most enduring tool for dissemination. "I write a lot; that's how we transfer knowledge," he says simply. "Distributing knowledge is one of my key roles and my passion."

To date, he has authored or co-authored more than 53 books, covering water management, sewerage systems, flooding, sustainability, governance and even poetry rooted in environmental consciousness. His seminal works, such as *Water & Sewerage Management in Malaysia and Banjir*, are more than academic texts. They are repositories of institutional memory, documenting how our water sector has evolved over decades. He is about to complete his memoirs on the epic 100 days world tour, titled *World Tour: 100 Days, 40 Lectures & 15 Countries* in both Malay and English.

"If you master a subject, it grows with you," he says. "When I talk about water management in Malaysia, I was involved from the early years. Many technologies we have today exist because of collective contributions made over time."

Beyond books, Dr. Zaini has written thousands of articles in mainstream media and delivered countless public lectures (he gave 100 public lectures in 2025). He also gave media interviews and remained an active presence on social platforms, using language accessible to both professionals and the general public.

Understanding Water as a Governance Challenge

One of Dr. Zaini's most consistent messages is that water problems are rarely just engineering problems. They are governance challenges involving multiple agencies, overlapping mandates and long-term trade-offs.

His early consultancy work on river classification required the development of standards that balanced ecological health, sewage effluent quality standards, drinking water safety, flood mitigation and economic activity. Later, his involvement in national institutions such as the National Water Services Commission (SPAN) and the National Water Council, gave him a system-wide view of how policies are negotiated and implemented.

"To really understand water, you must engage in all the various aspects," he explains. "Water resources, water services, water security and water governance. Teaching about water requires experience in consulting water projects and managing water issues."

This breadth of exposure allowed him to champion innovations such as off-river storage (ORS). It was first implemented successfully with the ORS Labu project between Selangor and Negeri Sembilan and later with Hybrid Off-River Augmentation System (HORAS)

along Sungai Selangor, which demonstrated that infrastructure could deliver multiple benefits such as flood mitigation, improved water quality and recreational spaces for communities.

Technology, Data & Limits of Prediction

While deeply grounded in local contexts, Dr. Zaini has consistently embraced technology as an enabler of better decisions. Satellite imagery, hydrological modelling and data analytics now play critical roles in flood prediction and river basin management.

Yet he remains cautious about over-reliance on tools without understanding. “Technology must serve local solutions,” he stresses. “We cannot import models blindly. We must understand our rivers, our rainfall and our people.”

This balanced perspective reflects his broader advocacy for nature-based solutions, planetary health and an eco-shift framework - approaches that integrate engineering with environmental ethics and long-term sustainability.

Ikigai: Reclaiming Purpose in Engineering

As his career progressed, Dr. Zaini became increasingly concerned with a question often overlooked in technical professions: Why do we do what we do?

He found resonance in the Japanese concept of Ikigai - the idea of a reason for being, located at the intersection of passion, skill, societal need and livelihood.

“Engineers must have Ikigai,” he says. “Not just to focus on professional practice, but also to see the bigger picture - what you love, what you can produce, what the world needs.”

For him, engineering devoid of life purpose risks becoming transactional and uninspired. “Look beyond technicalities,” he urges. “Look for your purpose in life beyond your salary, beyond your assignments.”

This philosophy is now taking form in a forthcoming book on Ikigai, aimed at professionals who seek meaning in a rapidly changing world.

Reforming Engineering Education for a Global Future

As Chairman of MQA, Dr. Zaini is now influencing how future engineers are trained and recognised. His vision challenges conventional academic structures.

“A four-year programme (two years in university and two years at work in places such as engineering companies) would be ideal,” he suggests. “Design should not be taught only in classrooms.”

He advocates stronger industry-academia partnerships, micro-credentialing, structured workplace learning and rigorous quality assurance. Central to

this vision is the proposed MQA Academy, intended to standardise training, evaluation and professional readiness.

“What we are missing is structured training programmes for life-long learning,” he says. “We have conceptual frameworks. Now we must start implementing and keep on improving, consistently.”

This approach is also driven by global realities. Malaysian engineers are increasingly sought after abroad, including in developed countries such as Japan, Australia and Singapore.

“From one perspective, we are losing engineers,” he acknowledges. “From another, it shows that our qualifications are well recognised. That is something we must be proud of and which we must continue to improve.”

From National Policy to Global Platforms

Dr. Zaini’s influence extends well beyond Malaysia’s borders. He has played key roles in international climate negotiations, serving as Head of the Malaysian delegation at COP26 and COP27 and presenting national reports at the United Nations Framework Convention on Climate Change (UNFCCC).

His leadership within the International Water Association (IWA) as Vice President (2004-2006), as ASEAN Chair of Senior Official on Environment and as a contributor in various environmental forums and global academic networks has positioned him as a respected voice in water governance and sustainability.

Yet, he remains equally committed to grassroots engagement, promoting river clean-ups, cycling, kudah (kutip sampah sambil riadah), poetry and public discourse as tools for cultural transformation.

Engineering as a Moral & Civilisational Endeavour

The story of Dato’ Seri Ir. Dr. Zaini Ujang is not merely a chronicle of positions he has held or honours he has received though these are many and distinguished. It is the story of an engineer who understands his profession as a civilisational responsibility.

From rivers and laboratories to ministries and global forums, his career demonstrates that engineering, at its best, is about service - to the people, to knowledge and to the future.

As Malaysia honours him with the Anugerah Tokoh Kejuruteraan Negara 2025 (previously as the first recipient of Merdeka Award 2009 for scholastic achievements and Tokoh Maal Hijrah Kebangsaan 2019), his message to the profession is both timely and timeless: Engineering must move beyond problem-solving to purpose-finding.

“We must always continue learning,” he says. “We are part of civilisation and our duty is to serve it well.” 🌱

Young Icon with National Mission: To Reignite Engineering in Malaysia

The recipient of the BEM Anugerah Tokoh Muda Kejuruteraan Negara 2025, Ir. Alex Looi Tink Huey, represents a new generation of Malaysian engineers – technically accomplished, globally engaged and deeply committed to strengthening the engineering ecosystem. For him, the future of engineering depends on not only innovation but also on mentorship, localisation, policy reform and passion-driven leadership.



Proud moment for Ir. Alex at the presentation of the BEM Tokoh Muda Kejuruteraan 2025 Award

When Ir. Alex Looi Tink Huey was named recipient of the BEM Anugerah Tokoh Muda Kejuruteraan Negara 2025 (National Young Engineering Icon Award, 2025), the recognition affirmed more than his technical credentials. Conferred by the Board of Engineers Malaysia (BEM), the award honours young engineers whose work demonstrates integrity, leadership and meaningful societal impact.

For Ir. Alex, engineering is not merely a career but also a responsibility.

Currently the General Manager of Malim Consulting Engineers, Ir. Alex has led significant renewable energy initiatives aligned with Malaysia's sustainability goals. The holder of dual degrees

- Bachelor of Engineering (Hons) in Electrical & Electronic Engineering and Bachelor of Science (Hons) in Software Engineering - he represents the multi-disciplinary engineer increasingly required in a digital and energy-transition era.

A Professional Engineer, ASEAN Chartered Professional Engineer, Registered Energy Manager Type 1 & 2, APEC & International Professional Engineer (IntPE) and Certified Infrared Thermographer, he is also an Honorary Member of the ASEAN Federation of Engineering Organisations and a Young Professional with the International Electrotechnical Commission (IEC). His professional journey reflects both depth and diversity but his concerns about the future of engineering in Malaysia reveal a broader mission.

Ir. Alex observes a worrying trend: Despite technological advancement and expanding sectors such as renewable energy and electric vehicles, fewer engineering graduates remain in the profession.

“Even among my generation (from 2005 to 2010), the number of graduates who actually ventured into engineering was not more than 30%,” he says. “The rest went into sales, marketing, financial institutions or started businesses not related to engineering.”

This migration away from engineering is influenced by economic pressures and perceptions about income stability.

“Often, parents feel it is more profitable for their children to go into higher-paying jobs, especially when they have financial loans to repay,” explains Ir. Alex. The result is a disconnect between engineering education and career pathways, a gap that requires systemic intervention.

Government's Role in Engineering Ecosystem Growth

For Ir. Alex, the solution cannot rest solely with universities or professional bodies. Government policy, he says, plays a decisive role.

"If you look at China, they produce 1.3 million engineers a year," he notes. "To do that, you need the government to pump in innovative projects that are right for the ecosystem. Only then will you create the demand."

He believes Malaysia must align the supply side (education) with the demand side (industry and economic opportunity).

"If you create high-paying, innovative engineering opportunities, then you attract the right group of people," he says.

Encouraging signs exist. The rise of EV manufacturing, expansion of data centres, MRT development and large-scale renewable energy programmes, including the upcoming battery energy storage system (BESS) and new solar initiatives, are steps in the right direction.

However, he believes progress must accelerate. "Perhaps it is not fast enough because once production cycles increase, that's when engineers are required."

Renewable Energy: Opportunity & Localisation Challenge

As a leader in renewable energy projects, Ir. Alex sees enormous potential in the nation's green transition. Large-scale solar programmes and energy efficiency initiatives are creating momentum.

However, he raises a critical concern: Localisation. "If you look at solar panels, we are still relying heavily on products from China. Inverters are still from China. After so many years, we have to look at how to localise it."

He suggests introducing localisation conditions -perhaps requiring 20-30% local participation - to strengthen domestic capability.

"We are importing foreign equipment and foreign specialists. Local engineers have minimal involvement. But this could be the initial stage. We need mentors first who can train locals in technical design and know-how," he says.

For him, foreign expertise should serve as a bridge rather than as a permanent dependency.

BEM, IEM & the Power of Professional Engagement

Ir. Alex's own professional growth has been shaped by active involvement in institutions such as BEM and IEM. "I first joined IEM and attended CPD courses on electrical design. Later, I had the opportunity to serve as a committee member under BEM's Corporate Communication Working Group," he recalls.

He has contributed to initiatives such as BEM Open Day and social media engagement, guiding students and young engineers. He has also benefited from specialised programmes such as the FIDIC course, substantially funded by BEM and administered by ACEM as the only FIDIC certified body in Malaysia. This has strengthened his understanding of contracts and international standards. "These courses are very valuable to me in understanding the terms in FIDIC," he says.

Today, he chairs the Information & Communication Technology Working Group for the ASEAN Engineering Register and the International Professional Engineers Agreement, further reinforcing his belief that engineers must engage beyond their immediate workplaces.

"By interacting through professional institutions and standards development, we indirectly benefit from opportunities and mentorship," he explains. "That's also how we can grow professionally."

Industry 4.0 to Industry 5.0: Staying Ahead of Global Trends

Asked about global trends that Malaysian engineers must align with, Ir. Alex points to the shift from Industry 4.0 to Industry 5.0.

"Industry 4.0 was about automation and digitalisation. Industry 5.0 is more people-centric," he says.

He encourages engineers to develop skills in not only hardware systems, but also in software, artificial intelligence and augmented reality. Climate change and ESG considerations are equally urgent.

"Climate change is very real. It impacts not only Malaysia but also the whole Asia-Pacific region. So how do we mitigate it? By implementing renewable energy - but more importantly, through energy efficiency. That's the low-hanging fruit," he says.

Energy conservation, he stresses, is often more impactful than simply generating more power.

Human Element: Passion, Mentorship & EQ



Ir. Alex on job site

Beyond policy and technology, Ir. Alex believes personal passion is what drives excellence. “Young engineers should look into their hearts and minds. Look for what you’re passionate about. If you’re passionate, you drive your commitment and energy toward that goal,” he says, adding that his own passion lies in solving engineering challenges within renewable energy and energy efficiency.

Equally important is mentorship. “Have mentors guide you throughout your journey,” he advises. “I’m very grateful to have had many mentors who trained and guided me.”

Interestingly, Ir. Alex credits his engineer father, Ir. Looi Huat Chuan, as an early source of inspiration. “My father is a Professional Engineer in the electrical discipline. The electrical spark came from there,” he says with a smile.

Technical Skills Are Not Enough

While technical competence remains foundational, Ir. Alex emphasises the importance of soft skills. “You may have a fantastic idea, but if you don’t know how to put it across, you may not be able to get it accepted.”

Public speaking, stakeholder engagement and emotional intelligence (EQ) are often underdeveloped in engineering training. He says: “Engineers are strong in technical skills, but sometimes they lack soft skills. They should learn from lawyers or economists on broad-based thinking, communication.”

His advice is practical: “You must practice speaking in public. Organise conferences and lead activities to help reduce your nervousness and to learn to communicate clearly.”

Advice to Aspiring Engineers

When asked for some final advice, Ir. Alex has these messages:

- Be passionate in what you do.
- Engage actively in professional institutions.
- Volunteer and give back to the community.
- Participate in standards development.
- Seek mentors.
- Engage with stakeholders and build networks.

“Don’t be afraid to voice your opinion,” he adds. “Engagement brings opportunities.”

Recharging Our Engineering Future

Ir. Alex represents more than just a successful young professional. He also embodies a generation that understands engineering must evolve - technically, economically and socially.

His concerns about declining engineering participation, over-reliance on foreign expertise and gaps between education and industry reflect a deeper commitment to national development. At the same time, his advocacy for mentorship, communication skills and professional engagement signals a human-centred approach to leadership.

As Malaysia navigates renewable energy transitions, digital transformation and global competitiveness, engineers like Ir. Alex remind us that infrastructure alone does not define progress. People do.

The future of Malaysian engineering, he suggests, will depend on passion, policy alignment, professional solidarity, the courage of young engineers willing to step forward and perhaps, as he puts it simply: “Look into your passion. That’s what drives you”. 🙏

AI-enabled Engineering for Energy Transition & Economic Success: Smart Heavy Equipment Design towards ESG Net Zero Status

by
Dato' Ir. Dr. Eric KH Goh
Dato' Ir. Fong Tian Yong

Board of Engineers Malaysia



Source: Modified from caterpillar.com

With the recent quantum leap into the vibrant and exciting tech-era of Artificial Intelligence (AI) and smart engineering digital transformations worldwide, the resourceful engineering fraternity and heavy equipment manufacturers are diligently progressing toward attaining responsible International Net Zero Industrial Sustainability Status.

Energy Transition (ET) is concisely defined as the positive global shift from fossil fuels (such as coal, oil & gas) to sustainable and low-carbon energy sources. The initiative is driven by climate change goals to achieve Net Zero emissions, to improve energy usage efficiency and to actively promote economic growth through cleaner industrial

production and responsible consumption patterns. Likewise, ESG Net Zero Status is concisely termed as Environmental, Social & Governance (ESG) stage where the amount of Greenhouse Gases (GHGs) produced by industrial activities are balanced by the amount removed from the atmosphere, resulting in net zero emissions.

This principled initiative can be achieved through the incorporation of AI-engineered Energy Transition Systems and the reduction of unhealthy emissions. Heavy equipment manufacturers also try to accommodate global expectations by incorporating the latest top-trending technologies to enhance energy efficiency usage while maintaining improved production, optimised operating costs and enhanced occupational safety.

Heavy equipment is classified as large, power-driven machinery, specially designed for heavy-duty tasks in construction, mining and quarrying, earth moving and agricultural projects. These include excavators, bulldozers, loaders, trucks and backhoes and are crucial for intense digging, hauling, paving and lifting industrial-centred tasks. Heavy equipment used for construction, mining and quarrying and agriculture industries in Malaysia ranges from compact machinery weighing 3 tonnes to massive mining dump trucks weighing more than 500 tonnes. In Malaysia, highlights of specific heavy equipment weights depend mainly on the machine type and designated site applications:

- **Construction Heavy Equipment (5t-30+ tonnes)**

Excavators (medium to large): Ranging from 12t to over 30t.

Wheel Loaders: Ranging from 5t compact models to 17t heavy-duty designs.

Backhoe Loaders: Normally 8.6t-8.8t.

- **Mining & Quarrying Heavy Equipment (70t-500+ tonnes)**

Trucks (medium-large): 70t-85t class dump trucks for normal operations.

Excavators: Large excavators can reach up to 800t for ultra-large projects.

- **Agricultural & Plantation Heavy Equipment (0.5-7+ tonnes)**

Tractors: General 4WD designs have an operating weight of not more than 3t while larger industrial-agricultural tractors weigh about 7t.

Tipping trailers: Specialised site equipment have capacities of 3t-8t.

AI-enabled technologies include the development or simulation of human intelligence for machines which are programmed to learn, think and offer constructive problem-solving outcomes at the respective industrial sites worldwide. Smart AI-engineering tech and their respective applications thus need to be ingenious, effective and task achievable to produce positive results.

Pro-active global heavy equipment manufacturers are diligently contributing towards the successful incorporation of AI-smart technologies, energy transition concepts and ESG principles in their updated designs of smart, efficient, sustainability-focused and energy efficient cost-saving measures to accomplish challenging tasks effectively while still trying to minimise equipment owning and operating costs.

Here, we comprehensively assess the various innovations in heavy equipment design, smart applications of AI, operational logistic benefits and conclude with potential % in cost savings these offer compared to traditional equipment set-ups. Operational advantages of these high-tech smart heavy equipment designs include innovative engineering transformation features, improved energy transition elements, enhanced confident rapid decision-making options, increased productivity opportunities, better occupational safety components and responsible ESG setups. It's definitely a win-win scenario for all engineering professionals and responsible Net Zero-focused industries worldwide.

Effective Criteria For Optimum Heavy Equipment Selection



Source: modified from cceonlinenews.com

Key criteria to be considered for the optimum and economic selection of appropriate heavy equipment specifications suitable for any industrial project worldwide include:

Site requirements

- Site layout consisting of multiple site material collection and loading areas.
- Blending requirements based on customers' specifications.
- Loading area support equipment requirements.
- Site topography/presence of uneven or unstable land surfaces.
- Environmental conditions of worksite and manoeuvring space.
- Material type/characteristics for task to be carried out efficiently.

Equipment performance

- Productivity (tonnes/day).
- Cycle time/Speed.
- Power required and Reliability.

Equipment Design

- Quality and Efficiency.
- Competency of Equipment Operator.
- Control System set-up.

Effectiveness of Equipment Maintenance/Service

- Quality of maintenance service.
- Ready availability of Spare Parts.
- Level of Technical Competency from Maintenance/Service Team.

Economic Cost Factors

- Capital, Operating and Fuel Costs.
- Maintenance and Spare Parts costs.
- Salaries of skilled operators to confidently operate heavy equipment.

Decision-making on the selection of smart and effective heavy equipment will require valuable input from site work experience and the availability of in-depth AI-enabled database on equipment performance, job efficiency, worksite characteristics, economics of fleet optimisation, application of the latest state-of-the-art technologies in the market, equipment life and finally, efficient on-site equipment maintenance options.

New Frontiers In Ai-Engineered Heavy Equipment Design & Operations

Highlights of major AI-enabled engineering marvels in heavy equipment design and operations aimed at Energy Transition success, positive Economic Cost Savings, attainment of ESG Net Zero status, improved productivity complemented with positive Return of Investment (ROI) outcomes are as follows:

• Generative Heavy Equipment Design & Manufacturing Material Selection

Innovative Generative-AI gives engineers a powerful option to input numerous variables/constraints (such as material strength, weight and production costs) during the equipment design phase to rapidly produce thousands of variation outcomes. Some manufacturers have successfully used AI-enabled smart tools to achieve a 40% equipment weight reduction or even 20% reduction in material usage in their final equipment product fabrication/manufacturing phase while still maintaining equipment functions, strength and performance.

The prime advantage of using Generative-AI in heavy equipment design iterations is the smart option to confidently use lightweight materials without compromising on material strength. On a positive note, industrial case studies have shown that the positive optimisation of energy usage and up to a 20% minimisation of equipment manufacturing costs are feasible using AI-enabled technology.

• Incorporation of AI-driven Hydraulics Systems

The installation of AI-driven Hydraulic-efficient Systems such as the 'Triad of Three (T3)' set-up, especially in excavators, have resulted in better energy savings through high-precision (1mm) accuracy motion control. Another supplementary outcome advantage in the incorporation of AI-enabled Hydraulic Systems is the outcome of zero-emission operations... definitely a big bonus towards

industrial Net Zero Status success. Key benefits include hierarchical energy optimisation via high-precision equipment control. From excavator operational records, the ROI Cost for incorporating AI Systems offers energy savings of up to 62% compared to traditional equipment set-up.

- **AI-enabled Fleet Equipment On-line Link-up and Smart Productivity Monitoring**

The aim of effective AI-assisted on-line real time fleet management is to provide instantaneous detailed asset information for any selected/remote site operation so that the top management overview can be strategically carried out instantaneously from the head office located in any city worldwide. This unique link-up solution enables top management the option to control the production process in real-time to meet the specifications requested by the respective market clients.

Heavy equipment productivity is thus defined as the smart monitoring of on-going equipment performance and allocated task accomplished at site, complemented with the evaluation of the corresponding jobsite efficiency. The benefit in the improvement of real time equipment performance and operator efficiency can be achieved successfully via 2-way real-time digital parallel communications to multiple operating heavy equipment at site.

The relevant site productivity data can be collected from on-line interactive user-friendly operator interfaces and smart sensors installed on the respective heavy equipment used. This novel digital linkup is most advantageous for the continuous monitoring, database creation and task assessment of the respective operator efficiency and site equipment work performance. Some of the benefits for on-line real-time smart productivity monitoring are:

- o Access option to precious and accurate real-time site productivity information.

- o Rubrics indicators on whether the assigned task targets are being achieved consistently.
- o Ability to boost production with faster equipment cycle time.
- o Compliance to tyre load rating with the aim to extend tyre life.
- o Option to use analysed productivity data to design future equipment specifications.

- **Holistic Operational Productivity**

AI-powered holistic equipment and manpower resource productivity management have resulted in the successful 41.2% reduction in equipment idle time leading to an overall 34.8% improvement in industrial productivity and eventually company profits.

The unique articulated haulage truck design, another creative engineering feature, incorporates a small turning circle set-up that allows it the option to turn easily at sharp corners. The advantages of articulated trucks are unsurpassed manoeuvrability in adverse worksite road conditions, automatic traction control and the incorporation of hydro-mechanical self-adjusting steering system in the vehicle design.

Other operator benefits in the utilisation of this novel truck design includes ease of usage, extended equipment service intervals, benefit of advanced combustion technology component with 5% more power output and up to 20% more torque in operational performance. The installed Automatic Traction Control (ATC) system for articulated trucks provides a seamless transition which reduce fuel consumption by up to 6%, extends tyre life by 10% and protects the driveline system from unnecessary wear and tear. Usage of articulated trucks offer benefits in fuel efficiency, low maintenance costs, overall improved efficiency, increased productivity, resulting in improved efficiency of energy usage and achieving ESG Net Zero status.

• Predictive Maintenance Economics

Traditional Scheduled Maintenance practices add up to about 30-40% of overall total production costs. The economic application of AI-smart internet link-up technology for the respective heavy equipment is most useful for on-line predictive maintenance. The on-board tracking system installed within all equipment at site is useful for transmitting continuous data on cumulative hours of machine usage and is complemented by the operating conditions or mechanical health of the vehicles. The creation of databases for carrying out efficient maintenance service for all heavy vehicle types is useful to reduce equipment and production downtime. This distinctive set-up also helps to minimise repair costs through optimum preventive maintenance with the timely replacement of equipment spare parts. This will improve work efficiency, increase production, minimise downtime events, reduce fleet idle time and result in rapid response to safety warnings. AI-enabled technology can help to reduce existing industrial maintenance costs by up to 30% and extend equipment life by about 20-40%.

A summary of the other practical AI-engineered applications and key benefits in Heavy Equipment Design & Operations, with their corresponding Cost Savings is included in the table below.

The Way Forward

The strategic convergence of AI-enabled technologies integrated with Energy Transition initiatives and smart Heavy Equipment designs is transforming industrial operations based on reducing carbon footprints, increasing energy efficiency as well as enhancing asset longevity and increased productivity.

AI, through ingenious Heavy Equipment designs, is definitely driving the transition towards a decentralised, digitalised and cleaner energy system by primarily optimising the performance of industrial equipment worldwide. Appreciating the impressive global progress of AI-Smart top-trending technologies, engineers need to seize this golden opportunity to collaborate with equipment manufacturers to exponentially evolve existing heavy equipment designs to be more energy efficient, user-friendly, economic and productive while diligently working together towards responsible Net Zero status. 🌱

	AI-engineered Applications for Equipment Design & Operations	Key Benefits during Equipment Operations	Cost/Energy Savings compared to Traditional Equipment Designs
1.	AI-Regenerative Energy Mangt.	Dual-path recovery of kinetic and gravitational energy during usage	Up to 80% efficiency in energy regeneration
2.	Fuel Optimisation AI-algorithms	Real-time adjustment of engine settings based on work conditions	Up to 29.1% in fuel/energy savings per hour
3.	Powertrain Optimisation	Smart AI-enabled calibration of electric/hybrid powertrains to match duty work cycles	Able to achieve 5-7% in improved equipment energy efficiency
4.	Digital Twin Simulations	Virtual replicas of worksite for 'what-if' scenario simulations from real-time on-line monitoring	Capable of achieving 23% better energy efficiency and 19% lower operating costs
5.	AI-Smart Worksite Simulations	AI-enabled planning for optimum equipment usage, cut idle time	Reduction of Equipment Idle Time cuts down excess fuel usage and carbon emissions, production increase (6-16%)
6.	Smart Inventory Management	AI-procurement analytics helps to reduce excessive stock/parts	Savings of up to 37.9% in storage costs budget
7.	AI-powered Manufacturing Defect Detection	Early detection of Structural Failures/ Flaws during Heavy Equipment Manufacturing phase	Ability to achieve 27.4% reduction in Equipment Manufacturing Faults
8.	Renewable Energy Integration Mangt.	AI-driven Smart Mangt. of on-site solar/hybrid Charging Facilities	Capable of savings up to 25% reduction in energy costs for RE projects

Engineering ESG into Practice: The HSS Experience

by
Ir. Sharifah Azlina Raja
Kamal,
Ir. Sri Kanthan Veeramuthu,
Anand Sharvanandan

HSS Group Sustainability
Committee

Environmental, Social & Governance (ESG) considerations have become integral to engineering practice today, particularly in infrastructure development where decisions have long-term environmental, social and economic implications. Engineering consultancies are increasingly expected to demonstrate accountability beyond regulatory compliance by embedding sustainability, ethical conduct and governance throughout project delivery.

HSS Integrated Sdn. Bhd. (HSSI), a wholly-owned subsidiary of HSS Engineers Berhad (HEB), operates within this evolving landscape. Guided by the Group's sustainability commitments, governance framework and professional standards, HSSI integrates ESG principles into its engineering design and supervision, project management and advisory services, contributing meaningfully to sustainable infrastructure development in Malaysia.

ESG/Sustainability Initiatives

Malaysia has made significant progress in embedding ESG and sustainability into national policies, reporting frameworks and regulatory requirements, particularly for listed entities. These requirements have cascading effects on micro, small and medium enterprises (MSMEs) and sole proprietors, many of whom operate as vendors or suppliers within the infrastructure value chain.

Rancangan Malaysia Ketiga Belas (RMK13) 2026-2030, the Government's latest five-year development blueprint, places sustainable

development and resilient growth at the core of the national policy. RMK13 aligns with global climate goals and domestic socio-economic priorities, emphasising the environment, social inclusion and governance reforms as part of Malaysia's transition to a more sustainable and socially-just economy.

The blueprint calls for enhanced policy, regulatory consistency and strategic investment to address climate risks, reduce emissions and support green growth in engineering, procurement and construction project.

Governance and institutional integrity are also emphasised, with a renewed focus on transparency, accountability and effective public-private collaboration, which underpin strong ESG performance.

Several regulatory initiatives shape how ESG principles are implemented across industries, including engineering consultancy. They include:

- Mandatory ESG reporting requirements for listed companies under Bursa Malaysia, including climate-related

SUSTAINABLE DEVELOPMENT GOALS



Note:

- The term Environmental, Social & Governance (ESG) & Sustainability are used interchangeably.
- HSS Integrated Sdn. Bhd. is a subsidiary of HSS Engineers Bhd. HSSI, HEB & HSS are used interchangeably.

disclosures from the 2025 financial year, set a benchmark for sustainability transparency across supply chains.

- MITI's National i-ESG Framework encourages phased ESG implementation and provides practical tools for MSMEs to begin ESG reporting and stakeholder engagement. This is relevant for firms supplying services to large infrastructure projects.
- Government tax incentives and policy support are available for ESG-related expenditures, including green technology investments and sustainability certification costs.

On a broader sustainability landscape, several notable policy initiatives that influence infrastructure and engineering practices are:

- The National Energy Transition Roadmap (NETR) and RMK13 support for Carbon Capture, Utilisation & Storage (CCUS) and low-carbon energy investments emphasise decarbonisation pathways which are relevant to major project planning and design.
- Government programmes such as the National Low Carbon Cities Masterplan and Circular Economy Blueprint support urban sustainability and resource-efficient infrastructure planning, reinforcing environmental stewardship and lifecycle thinking in engineering design.

Why ESG Matters for Engineering Consultancy Practices

ESG considerations are important for Engineering Consultancy Practices (ECP) as infrastructure projects especially large-scale and mega developments have profound and lasting impacts on climate and the natural environment, resource utilisation and efficiency as well as public safety, health and community well-being.

ECP must integrate ESG not only as a compliance requirement but as a core operational strategy as:

- Projects have significant environmental impacts (e.g., emissions, land disturbance, energy use) requiring alignment with the national carbon and environmental targets set under RMK13 and other related frameworks.
- Resource efficiency and life-cycle optimisation are central to sustainability and cost effectiveness.
- Social and community outcomes, such as public safety, equitable access to benefits and stakeholder engagement, are now embedded in how sustainability performance is assessed.
- Governance expectations, including transparency, risk management and ethical procurement, influence both public and private sector contracting standards.

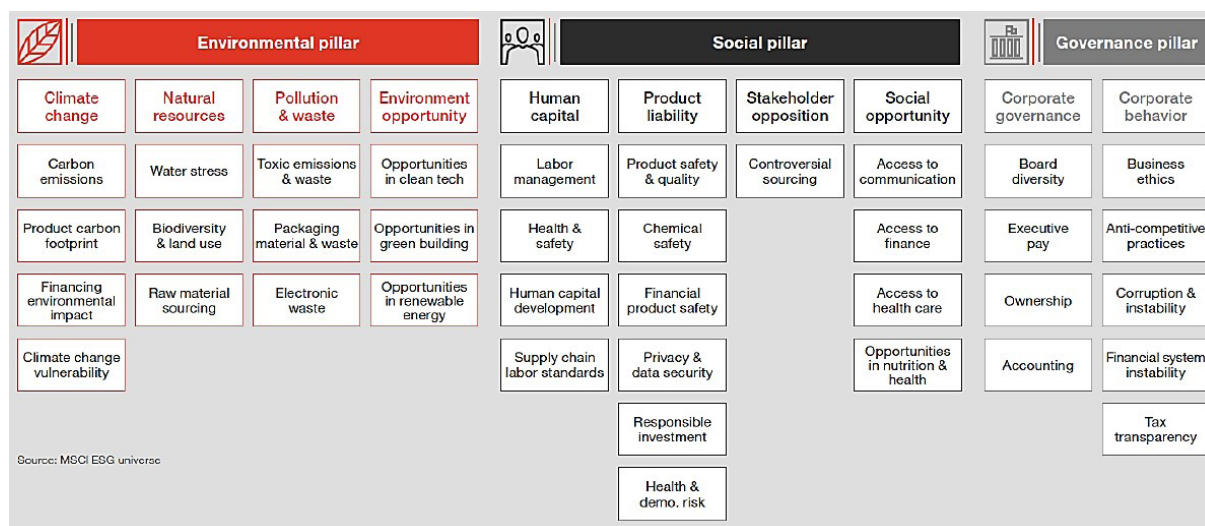


Figure 1: ESG Pillars

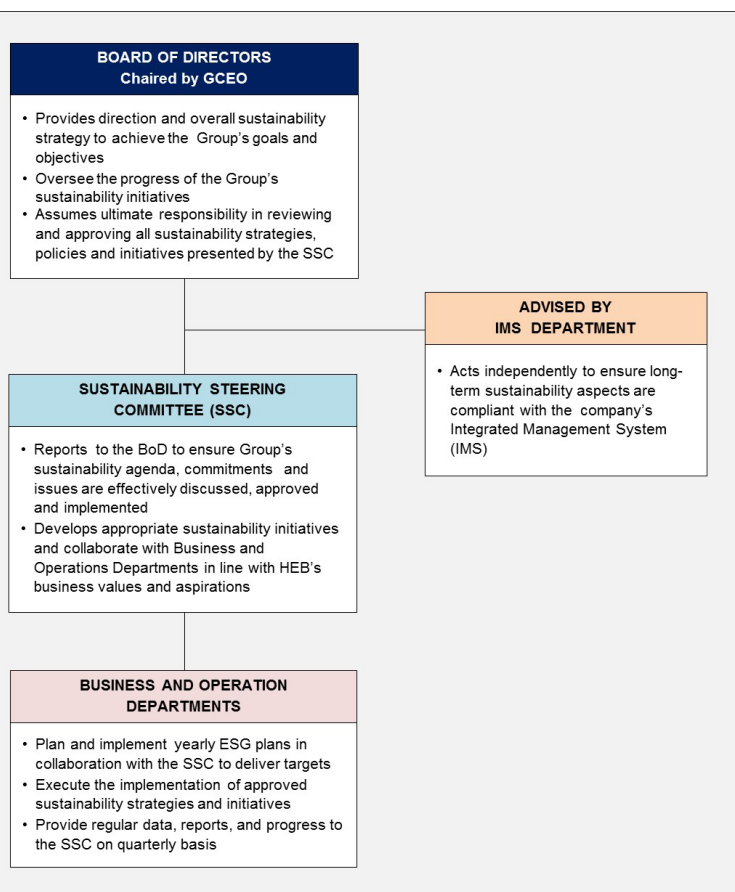


Figure 2: HSS Sustainability Governance Structure

By aligning with government-led ESG priorities, from policy frameworks to reporting standards and sustainable financing incentives, ECP can enhance project resilience, market competitiveness and stakeholder trust in a rapidly evolving regulatory and sustainability landscape.

HSS's ESG Culture in Shaping Sustainable Infrastructure

HSS plays a pivotal role in shaping sustainable infrastructure through its engineering consultancy services, supporting the modernisation of Malaysia's built environment while simultaneously integrating ESG considerations across project life-cycles. HSS aligns closely with the Group's sustainability commitments, embedding ESG principles in governance, risk management, decision-making and project delivery processes. Through the provision of competent professional expertise,

HSS proactively incorporates environmental and social risk considerations into planning, design, implementation and management, aligning project outcomes with clients' sustainability objectives and regulatory expectations. This integrated, value-driven approach reflects HSS's belief that ESG is fundamental to resilient infrastructure, responsible development and long-term business sustainability, rather than a compliance-only obligation.

Sustainability Governance

As a subsidiary of a listed company, HSSI adopts the Group-wide policies of HSS Engineers Berhad, including anti-bribery and corruption, occupational safety and health, ethical conduct and professional standards. Sustainability governance is overseen by the Group's Sustainability Steering Committee (SSC), which provides strategic direction and oversight to ensure ESG priorities are consistently implemented across the Group and its subsidiaries. Independent assurance is provided by the Management System Compliance (MSC) Department, which ensures alignment with the Group's Integrated Management System and long-term sustainability objectives. Performance monitoring, internal audits and management reviews are used to identify gaps, track progress and drive continual improvement. ESG considerations are also incorporated into risk management processes to support long-term resilience and sustainability.

Stewardship in Practice

HSS recognises environmental sustainability as a fundamental responsibility in safeguarding the health and well-being of communities and the natural environment, while supporting economic development and social progress. Within the Group, continuous innovation in engineering tools and solutions is prioritised to contribute towards environmental preservation and protection. Processes are established to include sustainability into its operations as well as to strengthen internal capability and foster a shared ESG culture across the organisation.



Figure 3: HSS Sustainability Framework

HSS's Sustainability Framework is anchored on 4 key pillars (Figure 3) which encompass the way it conducts business, innovative and sustainable practices in its operations, as well as its roles in communities. They are:

Pillar 1: Valuing & Developing Human Capital.

Pillar 2: Connecting Community.

Pillar 3: Transforming the Nation.

Pillar 4: Sustaining the Environment.

As effective ESG implementation requires competent and informed personnel, the initial steps taken include:

- Involving all employees in the sustainability agenda.
- Introducing and continuously providing group-wide training and awareness programmes on ESG and sustainability.
- Sharing best practices across the Group of companies.
- Encouraging multi-disciplinary collaboration to address ESG challenges.

Sustainability is also consciously embedded in every project undertaken with its steadfast commitment to sustainable solutions, ensuring that projects not only meet present-day needs but also deliver positive environmental outcomes for future generations.

Through innovative design approaches, energy-efficient technologies and responsible resource management, HSS strives to contribute to a greener and more sustainable built environment, connecting community and transforming the nation.

Embedding ESG Initiatives at HSS

HSS has adopted a structured and phased approach to embedding ESG into its operations and project delivery, aligned with the sustainability governance framework of the Group. The methodology is outlined in Figure 4 and several pertinent elements discussed thereafter.

Embedding ESG - Leadership Commitment and Governance Alignment:

The foundation of the HSS ESG journey is strong leadership commitment from its Board and Management. Oversight is provided through the Group's Sustainability Steering Committee (SSC), which sets sustainability priorities, reviews ESG risks and opportunities and guides implementation across subsidiaries. This ensures ESG considerations are embedded into strategic planning, decision-making and operational oversight at HSS.

Setting Goals and Targets	- Once material issues are identified, the firm sets specific goals and targets to address these issues and improve the ESG performance - These goals relate to reducing environmental impacts, enhancing social responsibility, improving governance practices and achieving sustainability certifications and standards
Data Collection and Measurement	- The firm collects relevant data and metrics to track sustainability goals and targets - This includes information on energy consumption, greenhouse gas emissions, waste generation, diversity and inclusion metrics, health and safety performance and other key performance indicators (KPIs) related to ESG/sustainability
Reporting Frameworks	- The firm uses established ESG/sustainability reporting frameworks and standards to structure the ESG/sustainability disclosures - Common frameworks include the Global Reporting Initiative (GRI), the Sustainability Accounting Standards Board (SASB) and the Task Force on Climate-related Financial Disclosures (TCFD) - These frameworks provide guidance on reporting ESG performance in a standardized and transparent manner
Preparing Sustainability Reports	- The firm compiles the collected data and information into comprehensive sustainability reports that communicate its ESG performance to stakeholders - Sustainability reports typically include an overview of the firm's sustainability strategy, highlights of key achievements and initiatives, performance data and metrics, and insights into future sustainability priorities and plans
Stakeholder Engagement	- Sustainability reporting involves engaging with stakeholders to understand their information needs and interests, as well as soliciting feedback on the firm's sustainability performance and reporting practices - The firm may conduct stakeholder consultations, surveys, or focus groups to gather input for its sustainability reports and ensure they are relevant and meaningful to stakeholders
External Assurance	- The firm also undergo external assurance and verification of their sustainability reports to enhance credibility and transparency - External assurance involves independent review or audit of the firm's sustainability data, processes, and reporting practices by a third-party assurance provider

Figure 4: Key Steps in the adoption of ESG

Embedding ESG - Policy Adoption and Framework Integration: HSS adopts Group-wide policies that support ESG implementation, including:

- Anti-bribery and corruption policy.
- Occupational safety and health policy.
- Code of conduct and ethical practices.
- Environmental, safety & health and quality management policies.

These policies are integrated into HSS's Integrated Management System (IMS), providing a formal structure for ESG implementation, monitoring and continual improvement across projects and internal operations. Relevant ESG-related laws and regulations were also identified and adopted for compliance.



Figure 5: ESG-related Laws and Regulations

Embedding ESG - Identification of Material

ESG Areas: A materiality assessment provides information that may positively or negatively influence the ability to deliver. HSS started by identifying material ESG areas most relevant to its operation and engineering consultancy and project management deliveries. This includes assessing ESG risks and opportunities arising from:

- Project scope and scale.
- Regulatory and client requirements.
- Stakeholder expectations.
- Industry and national sustainability priorities.

Sustainability matters are considered from both internal and external perspectives, i.e. from the organisation's point of view and that of stakeholders. Applying materiality helps HSS identify what is most important to act on and to report.

Key material focus areas include environmental and local communities' impact management, occupational safety, ethical and business governance, digitalisation and technology, data privacy, talent management and social responsibility in project delivery. Materiality assessment is reviewed annually to keep abreast with the internal and external stakeholders' evolving priorities as well as to consider changing external factors.

Embedding ESG - Integration into Project Delivery and Services: ESG considerations are systematically embedded into its engineering and consultancy services through:

- Incorporation of environmental and social risk assessments in project scopes.
- Advisory on sustainable design, resource efficiency and life-cycle considerations.
- Support for client compliance with sustainability and reporting requirements.

Continued in the next issue

Implementation of Large-Scale Solar Photovoltaic Systems in Malaysia

by
Dato' (Dr.) Ir. Muhamad
Guntor Mansor Tobeng,
Mohamad Amirul Hanif
Shuib,
Muhammad Nazrul
Kamarul Bahrin,
Nurul Fadhilah Mohd Ridza,
Mohd Amir Sharifuddin
Mohd Ridzuan (Gading
Kencana Sdn. Bhd.),
Ir. Prof. K.S. Kannan

Development of 29.9 MW Solar PV Plant Under New Enhanced Dispatch Arrangement (NEDA) in Bidor, Perak for Sand Town Solar Sdn. Bhd.

The New Enhanced Dispatch Arrangement (NEDA), an initiative by the Energy Commission (EC), is aimed at improving efficiency in short-run electricity generation competition and promoting cost-effective electricity pricing. The programme also provides opportunities for businesses to participate in the adoption and utilisation of renewable energy (RE) within their operations, supporting the increasing demand from electricity consumers to meet Environmental, Social & Governance (ESG) objectives.

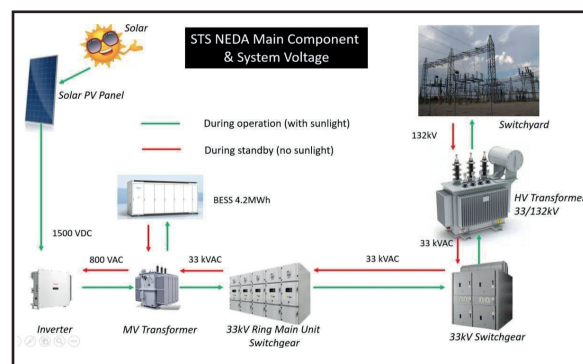
In alignment with the Government's green power agenda, Sand Town Solar Sdn. Bhd. undertook the development of a Solar Photovoltaic (PV) system as a power producer and developer, encompassing project financing, operation and maintenance as well as to supply electricity to corporate consumers.

This article presents development insights from a 29.9 MWac solar farm implemented in Mukim Bidor, Perak, under the NEDA framework. The discussion focuses on key engineering implementation challenges and practical lessons relevant to Professional Engineers involved in the planning, design and delivery of utility-scale renewable energy projects.

Overview of Large-Scale Solar PV Systems

PV systems use the high-power rating PV panel of 605 watt, totalling 56,820 panels to produce 34.3761 MWp of power. The 82 numbers of

string inverter with the capacity of 385 kW each and 4 numbers of 8,500 kVA medium voltage stations will be used to convert from DC to AC power. The voltage will then step up to 33 kV connected in ring-circuit within the solar plant facility and then a final step-up via main step-up power transformer of 45 MVA to 132 kV which will be injected to the TNB transmission grid line.



Site Selection & Feasibility Considerations

Site suitability plays a decisive role in determining the technical viability of an LSSPV project. The NEDA site covers approximately 77.7 acres and is located adjacent to the existing grid infrastructure, which significantly reduces transmission line distance and interconnection complexity. The site consists largely of former mining land and vacant agricultural areas, minimising social displacement.

Key feasibility parameters evaluated include annual solar irradiation of approximately 1,700 kWh/m²/year, predominantly flat to gently sloping terrain (0°-15°), reducing earthworks complexity, proximity to a 132 kV switching station, enabling efficient grid evacuation, drainage and flood risk assessment due to nearby river systems. Comprehensive site investigations allowed early identification of engineering risks, particularly related to earthworks balance, drainage design and long-term site stability.

Engineering Design Considerations

Electrical System Design: Electrical design is a key point to the plant performance and grid compliance. Key considerations include DC/AC ratio optimisation, inverter topology selection, MV cable sizing, power transformer selection, power plant controller, protection coordination and earthing design. For the NEDA project, string inverters with a combined rated capacity of 31.57 MW_{ac} were adopted to optimise efficiency and to simplify operational control.

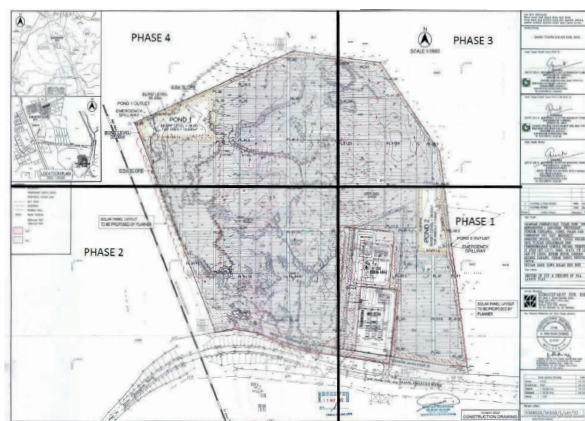
Protection schemes were designed in accordance with the Malaysia Grid Code and Suruhanjaya Tenaga requirements, ensuring fault clearance, system stability and personnel safety during both normal and abnormal operating conditions.

Civil & Structural Design: Civil and structural works represent a significant portion of LSSPV project costs and risks. Earthworks design focused on achieving balanced cut-and-fill volumes while maintaining adequate platform levels above flood-prone areas. Drainage systems were designed to accommodate monsoon rainfall and to prevent ponding within PV array zones.

Ground-mounted fixed-tilt structures were selected for their robustness and suitability to local soil conditions, with structural design accounting for wind loading, corrosion protection and long-term durability.

Grid Interconnection & Regulatory Compliance

Grid interconnection is one of the most critical aspects of LSSPV implementation. Projects must comply with requirements imposed by



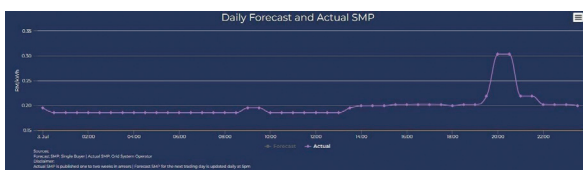
Project and Design Overview	
Installed Capacity	34.3761 MWp
Export Capacity	29.9 MW _{ac}
Energy Production	51,462,523 kWh/year
Site Location	Bidor, Perak, Malaysia
GPS Location	4.08 °N 101.28°E
PV Panel Rating	605 Wp
Nos. of PV Panel in series	30 nos.
Nos. of PV Panel	56,820 nos.
Total PV panel surface area	153,482 m ²
Mounting Structure	Ground Mounted
Specific Yield	1,497 kWh/kWp/year
Inverter Rating	385kW
Number of Inverter	82 nos.
MV Station Capacity	8,500kVA
Number of MV Station	4 nos.
Power Transformer Rating	45MVA



The completed LSSPV project

the Suruhanjaya Tenaga (ST), Tenaga Nasional Berhad (TNB), the Grid System Operator (GSO) and the Single Buyer. Under the NEDA framework, the project operates as a merchant generator, dispatching energy based on System Marginal Price (SMP).

SMP refers to the electricity price determined by the last generating unit required to meet system demand at a particular time. Under an economic dispatch arrangement, power generators are scheduled in order of increasing operating cost and the generator with the highest cost that is still needed to satisfy demand sets the SMP. All dispatched generators are then paid based on this price, regardless of their individual generation costs.



This pricing mechanism encourages efficient system operation and provides a transparent price signal for electricity markets, including merchant market frameworks such as NEDA.

This requires full compliance with Grid Code provisions, protection coordination studies, SCADA integration and successful completion of Grid Compliance Tests (GCT) and Established Capacity Tests (ECT).

Early engagement with utility stakeholders is essential in aligning design assumptions and avoiding delays during approval and commissioning stages.

Construction, Testing & Commissioning

Construction of LSSPV projects in Malaysia is significantly influenced by weather conditions, logistics and coordination among multiple parties. Prolonged rainfall may affect earthworks, piling and cable installation, while delays in the delivery of critical equipment can disrupt installation sequencing and downstream activities. As LSSPV construction involves various subcontractors across civil, structural and electrical disciplines, effective interface management, material readiness and clear work sequencing are essential to maintain progress, quality and safety.

Testing and commissioning activities typically comprise insulation resistance and Tan Delta testing for medium-voltage cables, protection relay testing, inverter functional and performance tests, as well as comprehensive verification of the Power Plant Controller (PPC). PPC testing focuses on configuration, controls logic validation and interface performance with inverters, protection systems, SCADA and the Energy Management System (EMS). Commissioning also includes SCADA point-to-point testing, EMS offline and online testing and Grid Code-related tests covering capacity, protection performance, ramp rate, frequency and voltage response, reactive power capability and quality of service. Experience from utility-scale projects indicates

that operational issues are more commonly associated with interface coordination and commissioning readiness, particularly PPC integration, rather than fundamental design shortcomings.

Project Management & Risk Mitigation

Effective project management integrates engineering design, cost control, schedule management and risk mitigation. Key risks identified in the project included grid approval timelines, flooding events and coordination between multiple stakeholders.

Project Timeline Overview	
Concession Type	NEDA
Earthwork Commencement	1 January 2022
Construction Work Commencement	9 December 2023
Commercial Operation Date (COD)	14 February 2025

Clear Owner's Requirements, robust documentation and continuous involvement of Professional Engineers throughout design review, construction supervision and commissioning have been identified as critical success factors in managing these risks.

Role of Professional Engineers

Professional Engineers play a pivotal role by providing technical assurance, ethical oversight and regulatory compliance. Their responsibilities extend beyond design calculations to include verification of safety, interface with authorities and protection of public interest.

As RE penetration increases, the demand for competent local engineers with multi-disciplinary expertise in electrical, civil and power system engineering will continue to grow.

Technical Challenges

From a technical standpoint, the construction of LSSPV projects involves a range of challenges extending from the PV generation field to the 132 kV grid interconnection. At the solar field level, key issues include achieving consistent screw pile depth and alignment for PV mounting structures under variable soil conditions, maintaining earthing continuity across extensive array areas and ensuring proper DC string routing, segregation and labelling to reduce losses and fault risks.

Installation quality of mounting structures and PV modules requires close supervision to avoid long-term mechanical and electrical performance issues. On the AC and medium-voltage side, effective coordination is required for inverter installation, transformer placement and MV cable routing and jointing, where construction sequencing and workmanship quality directly influence system reliability and test readiness.

At the high-voltage interface, construction of the step-up substation and 132 kV bay extension demands strict adherence to utility standards, precise coordination with existing live systems and careful integration of protection, control and SCADA functions. In addition, works within TNB's PMU environment are subjected to stringent approval of Method of Statement (MoS), which must accurately define construction sequences, safety controls and the use of plant and machinery.

Any deficiency in MoS preparation or execution may result in access restrictions, rework or delays during testing and commissioning. These challenges underscore the importance of strong engineering oversight, disciplined construction planning and early engagement with utility stakeholders to ensure safe, compliant and efficient project delivery.

Lessons Learnt

Key lessons from the project include the importance of early design freeze, comprehensive site assessment, proactive utility engagement and disciplined commissioning management. Looking ahead, the integration of battery energy storage systems, grid-forming inverters and advanced monitoring platforms is expected to further increase the complexity and importance of engineering governance in LSSPV projects.

Social Benefits

The project is expected to boost potential economic sector and social benefits to Bidor and its surroundings such as:

1. **Job creation and skills development.** The project creates employment opportunities for local communities during construction,

commissioning and operation, while supporting skills transfer in RE and electrical engineering works.

2. **Support for national energy transition.** The development contributes to Malaysia's RE targets by increasing clean energy generation and reducing reliance on fossil fuels.
3. **Environmental and public health benefits.** Solar PV generation reduces greenhouse gas emissions and air pollutants, contributing to improved environmental quality and public health outcomes.
4. **Local economic stimulation.** Engagement of local contractors, suppliers and service providers supports regional economic activity and strengthens the local supply chain.
5. **Energy cost competitiveness for consumers.** Participation in market-based mechanisms such as NEDA promotes efficient electricity pricing, benefiting corporate consumers and supporting broader ESG objectives.
6. **Infrastructure and site improvement.** Site development works, including access roads, drainage and utilities, may improve local infrastructure and land usability.
7. **Knowledge and technology transfer.** The project enhances local technical capability through exposure to utility-scale solar PV systems, grid integration and modern power system practices.

Conclusion

The implementation of LSSPV projects requires a coordinated approach encompassing engineering design, regulatory compliance, construction management and grid integration. Experience from the project demonstrates that effective interface coordination, disciplined construction sequencing and structured testing and commissioning are critical to achieving safe and reliable operation.

The active involvement of Professional Engineers throughout the project life-cycle remains essential in ensuring technical integrity, system performance and compliance with utility and regulatory requirements as utility-scale solar deployment continues to expand. 🌞

Engineering Bioenergy for a Low-Carbon Future: From Biomass Conversion to Grid Integration

by
Dr. Tan Jian Ping
Malvin Ma

Xiamen University Malaysia



Malaysia's bioenergy development is closely tied to its renewable energy policy framework. The Renewable Energy Act 2011 and the Sustainable Energy Development Authority (SEDA) Act 2011 established the legal foundation for renewable deployment through the Feed-in Tariff (FiT) mechanism.

Administered by SEDA, the FiT scheme catalysed early-stage investment in biogas, biomass and small hydro projects by guaranteeing long-term tariff structures and grid access for qualified producers. This regulatory certainty enabled the first wave of bioenergy infrastructure to be built across the country.

Today, Malaysia has 95 biogas plants in operation with 47 additional plants under construction, as well as 8 biomass power plants in operation and nine more under construction^[1]. While this progress reflects meaningful deployment momentum, bioenergy remains under-utilised relative to national resource availability.

Under the National Energy Transition Roadmap (NETR), bioenergy capacity is targeted to reach 1.4 GW by 2050. Concurrently, renewable energy is projected to constitute 70% of installed capacity by 2050, reflecting a structural transformation of Malaysia's power generation mix^[2].

Bioenergy occupies a unique position within this transition. Unlike intermittent renewables such as solar and wind, bioenergy provides dispatchable and grid-stable generation. It can serve both baseload and industrial heat demand while mitigating methane emissions from organic waste. Therefore, engineering bioenergy infrastructure effectively contributes to not only decarbonisation targets but also to grid reliability and industrial resilience. Beyond power generation, bioenergy pathways are also expanding into renewable gas and hydrogen production, positioning biomass not only as a grid-stabilising resource but as a feedstock for future low-carbon fuels.

Biomass Advantage

Malaysia produces approximately 182.6 million tonnes (MT) of biomass annually, with over 85% derived from palm oil residues^[3] such as empty fruit bunches (EFB), palm kernel shells (PKS), mesocarp fibre and palm oil mill effluent (POME). This resource concentration presents a significant engineering opportunity: Mill-level residues are geographically clustered around processing facilities, enabling co-located energy conversion and reducing aggregation costs.

While plantation residues such as fronds and trunks offer theoretical potential, their dispersed distribution, low bulk density and high collection costs constrain large-scale utilisation. As a result, mill-based residues remain the most economically and logistically viable foundation for Malaysia's biomass energy development. That said, the scale of palm oil residue alone positions Malaysia as one of South-East Asia's most structurally advantaged nations for bioenergy development.

Anaerobic Digestion: Engineering Biogas Systems

Anaerobic digestion (AD) remains the most mature and commercially deployed bioenergy technology in Malaysia, particularly within the palm oil sector. The process converts organic waste into biogas under oxygen-free conditions through a multi-stage biological reaction. The resulting biogas typically contains 50-70% methane, alongside carbon dioxide and trace contaminants^[4].

From an engineering standpoint, system performance is governed by hydraulic retention time (HRT), organic loading rate (OLR), temperature regime and reactor configuration. Mesophilic digesters operating at approximately 35°C are widely adopted due to process stability and lower energy requirements, while thermophilic systems (~55°C) offer faster reaction kinetics but demand tighter operational control. Reactor configurations in Malaysia commonly include continuous stirred tank reactors (CSTR) and covered anaerobic lagoons. CSTR systems provide superior mixing, consistent gas yield and better process optimisation, whereas lagoons offer lower capital expenditure but reduced control over methane capture efficiency^[5].

Malaysia has strong biomethane fundamentals, particularly from POME, with national technical potential exceeding 500 MW^[6]. To date, approximately 95 operational biogas plants have been deployed^[1]. However, only around 35% of palm oil mills have installed methane capture systems^[6]. The majority still rely on conventional open ponding systems with long retention times, resulting in significant fugitive methane emissions. While technical upgrades toward closed anaerobic digesters, CSTR systems, membrane-based upgrading technologies achieving >92% methane purity and integrated combined heat and power (CHP) systems are underway, deployment remains uneven^[6,7].

Biogas upgrading requires the removal of hydrogen sulfide, moisture and carbon dioxide to meet biomethane specifications. Technologies such as pressure swing adsorption (PSA), membrane separation and water scrubbing enable upgrading for compression or potential grid injection. Engineering optimisation increasingly focuses on gas purity monitoring, corrosion mitigation, energy-efficient upgrading systems and integration with CHP for enhanced system efficiency.

Despite technical maturity, economic barriers continue to slow scale-up. High capital expenditure requirements, fossil fuel subsidies which dampen renewable competitiveness, limited Feed-in Tariff (FiT) quotas and grid interconnection constraints remain structural bottlenecks. As a result, biogas development in

many mills remains compliance-driven rather than energy-optimised. The sector's future hinges on achieving full-scale methane capture across remaining mills, expanding biomethane upgrading for pipeline injection and repositioning AD infrastructure from wastewater treatment compliance toward a strategic low-carbon energy asset.

Beyond palm oil residues, Malaysia also generates approximately 17,000 tonnes of food waste daily, representing roughly 44.5% of total solid waste, indicating substantial untapped biogas potential^[8]. However, large-scale deployment of food waste-based AD systems is constrained primarily by economic and resourcing bottlenecks. Inefficient segregation at source, inconsistent feedstock aggregation and high capital and operating costs reduce bankability. Commercial viability depends on optimising plant scale relative to waste distribution logistics, securing long-term anchor supply agreements with major waste generators and enforcing effective segregation policies. Without coordination between municipal waste systems and energy planning, this resource will remain under-utilised.

In palm oil mills and municipal contexts alike, anaerobic digestion represents a technically proven solution. The engineering challenge now lies not in conversion science, but in infrastructure integration, feedstock system design and economic structuring that unlocks biomethane's full strategic value within Malaysia's energy transition.

Thermochemical Conversion & CHP: Scaling Solid Biomass Energy Systems

Malaysia's biomass energy development is structurally anchored in the oil palm sector, where solid residues (including EFB, PKS, mesocarp fibre, logging residues and wood waste) form the backbone of direct combustion-based power generation. Traditionally, biomass utilisation at mill level relies on boiler-steam turbine systems and CHP configurations, where residues are combusted to generate process steam and electricity. This configuration enhances self-sufficiency within agro-industrial operations and reduces reliance on external fuel sources.

At grid-connected scale, however, biomass power generation requires significant technical upgrades. Conversion from low-pressure process boilers to high-pressure, grid-synchronised systems substantially increase capital expenditure and operational complexity. Engineering challenges include high-pressure boiler design, steam cycle optimisation, grid compliance systems and advanced emissions control. Malaysia's limited local boiler design expertise and reliance on imported combustion technologies further elevate system costs and project risk.

Gasification provides an alternative thermochemical pathway. Operating between 700°C and 1,200°C under controlled oxygen conditions, gasification converts solid biomass into syngas composed primarily of carbon monoxide and hydrogen^[9]. Reactor types include fixed-bed, fluidised-bed and entrained-flow systems, with fluidised-bed configurations offering improved mixing and scalability but requiring more sophisticated control systems.

From an engineering perspective, both combustion and gasification systems are highly sensitive to feedstock quality. Moisture content, particle size uniformity, ash fusion behaviour and tar formation significantly influence performance^[9]. Malaysia's tropical climate contributes to high moisture variability, necessitating pre-drying processes which affect net system efficiency. In gasification systems, unmanaged tar formation can damage engines and turbines, requiring secondary cracking units or advanced gas cleaning systems.

Economic feasibility presents a parallel constraint. Biomass transport costs range between RM200 and RM500 per 10 tonnes, depending on distance, reducing viability for centralised plants^[9]. Approximately 40% of EFB, for instance, are already reused for mulching, composting or animal feed, intensifying feedstock competition^[10]. Refinery-scale biomass operations require roughly 2,000-5,000 tonnes per day to achieve economies of scale, levels which are logistically challenging without coordinated aggregation systems^[9]. Additionally, many palm oil mills are located more than 10km from grid interconnection points, increasing transmission infrastructure costs.

CHP systems remain the most practical and efficient configuration for biomass deployment. Biomass-based CHP significantly improves energy efficiency by simultaneously generating electricity and recovering usable heat. Electrical efficiencies in steam-based systems are typically lower than gas engine systems but overall thermal efficiencies can exceed 70% when process heat is fully utilised^[9]. At mill level, CHP supports sterilisation and processing operations while providing internal electricity supply. Upgrading these systems to export-capable, high-pressure configurations will enable surplus electricity sales to the grid, improving asset monetisation.

From an engineering standpoint, scaling thermochemical pathways will depend on four structural improvements:

1. Upgrading mill-level CHP systems to high-pressure, grid-export capable configurations.
2. Improving biomass densification through pelletisation or briquetting to reduce transport inefficiencies.
3. Adopting decentralised or on-site generation models to minimise logistics cost and associated CO₂ leakage.
4. Implementing policy instruments that close the cost gap between biomass power and subsidised fossil fuels.

When properly engineered, thermochemical systems, whether via direct combustion or gasification, can support CHP, synthetic fuel production and hydrogen generation pathways. However, achieving scale requires not only reactor optimisation but system-level integration across feedstock logistics, grid infrastructure and financial frameworks. The transition from mill-level self-sufficiency toward strategic grid-contributing biomass infrastructure will define the next phase of Malaysia's solid biomass energy development.

Biohydrogen: A Niche but Strategically Aligned Pathway in Malaysia's Hydrogen Transition

Within Malaysia's broader hydrogen ambition under the National Energy Transition Roadmap (NETR), biohydrogen represents a technically

viable but pre-commercial pathway that is structurally aligned with the country's agro-industrial base. Unlike green hydrogen, which depends on large-scale renewable electricity deployment, biohydrogen leverages Malaysia's abundant organic waste streams - particularly POME, biodiesel crude glycerol and fruit-processing residues, as low-cost carbon sources. Its strategic value lies not in competing at utility scale, but in embedding hydrogen production within existing agro-industrial systems.

Our biodiesel industry generates substantial volumes of crude glycerol, creating an opportunity for waste valorisation. Experimental studies have demonstrated that dark fermentative hydrogen production from crude glycerol is sensitive to redox potential control, with optimisation shifting microbial metabolism toward hydrogen-producing pathways^[11]. Additional work has shown that co-feeding crude glycerol with durian peel hydrolysate enables simultaneous production of biohydrogen and 1,3-propanediol (PDO), illustrating a multi-product biorefinery concept that strengthens overall process economics^[12].

As a case example, a prototype modular dark fermentation reactor has been constructed in Malaysia by the Centre of Excellence for Sustainable Technologies for Agricultural Advancement and a Zero-waste Economy (STARGAZE) at Xiamen University Malaysia to demonstrate decentralised deployment potential at biodiesel or agro-processing facilities (Figure 1). The system illustrates how compact hydrogen generation units can be integrated directly with existing waste streams, reducing feedstock logistics while enabling co-product recovery under a multi-product biorefinery configuration.

The integration of biohydrogen and PDO production has begun to attract institutional attention. During the National Innovation & Commercialisation Expo 2025 in Kuala Lumpur, the Minister of Science, Technology & Innovation visited a Malaysian research showcase featuring crude glycerol valorisation technologies (Figure 2). While still at a pilot scale, such engagement reflects growing policy awareness of circular

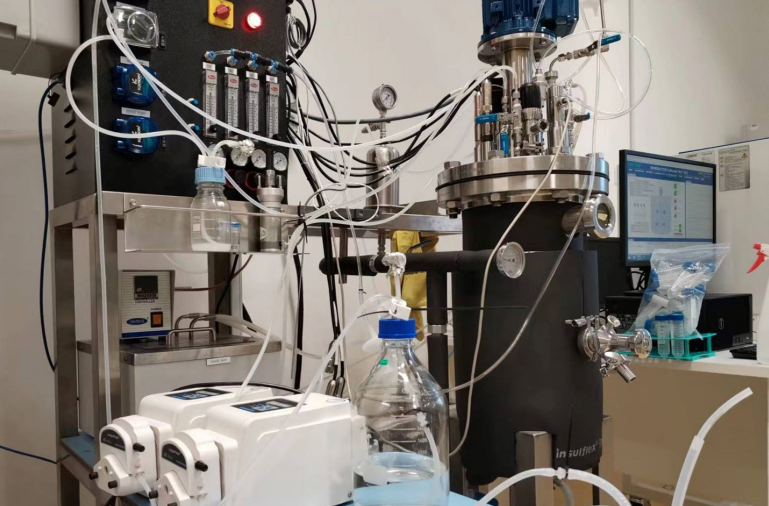


Figure 1: Modular dark fermentation biohydrogen reactor prototype developed in Malaysia.



Figure 2: MOSTI Minister visits STARGAZE Research Booth at the National Innovation & Commercialisation Expo 2025, World Trade Centre Kuala Lumpur (7 October 2025).

carbon utilisation pathways within the biodiesel and biochemical ecosystem, particularly as crude glycerol oversupply continues to weigh on biodiesel margins.

Complementing these findings, experimental work using POME has demonstrated the technical feasibility of staged hydrogen recovery upstream of conventional anaerobic digestion. Laboratory-scale reactor studies achieved stable hydrogen production under optimised retention times, with improved biomass retention through rapid sludge granulation. However, thermophilic operation required external heat input, resulting in negative net energy balance under standalone conditions^[13]. These results highlight a critical engineering insight: Biohydrogen systems must be integrated with existing mill heat streams to achieve viable energy efficiency at scale.

Strategically, biohydrogen is unlikely to dominate Malaysia's hydrogen supply in the near term, where blue and green hydrogen are expected to lead. However, it occupies a defensible niche within agro-industrial clusters where high-COD effluents, waste heat and concentrated feedstock streams already exist. When integrated with wastewater treatment systems, downstream anaerobic digestion for residual energy recovery and value-added biochemical production, biohydrogen can enhance carbon utilisation efficiency and reduce methane emissions.

Its future will depend less on isolated reactor optimisation and more on system-level engineering integration - heat recovery, co-product valorisation, modular scaling and alignment with industrial hydrogen demand. If executed cohesively, biohydrogen could evolve into a complementary pillar within Malaysia's decentralised and circular hydrogen ecosystem.

Engineering Integration & the Path Forward

Malaysia's bioenergy potential is structurally significant. With approximately 182.6 million tonnes of biomass generated annually - over 85% from palm oil residues - and national biomethane potential exceeding 500 MW from POME alone, the resource base is not the limiting factor. Current deployment momentum - 95 operational biogas plants, alongside existing and developing biomass facilities - demonstrates technical viability. Yet, scaling toward the NETR target of 1.4 GW bioenergy capacity by 2050 and contributing meaningfully to the 70% renewable installed capacity ambition will depend less on conversion science and more on system-level integration.

The engineering challenge now lies in architecture. Feedstock aggregation, moisture management, densification, high-pressure export-capable CHP upgrades, biomethane quality standardisation, biohydrogen integration and grid interconnection infrastructure must be coordinated within a unified energy framework. Transport inefficiencies, feedstock competition and remote mill locations continue to constrain economics, while fossil fuel subsidies and limited export quotas reduce competitiveness.

Without upgrading mill-level systems from compliance-driven wastewater or residue management into grid-synchronised, revenue-generating assets, bioenergy will remain under-scaled relative to its potential.

Future growth pathways are clear. Biomethane injection into the national gas network can directly decarbonise the gas sector if methane purity and interconnection standards are formalised. Hybrid renewable configurations pairing biomass or biogas CHP with solar PV can provide dispatchable firming capacity to stabilise intermittent generation.

Emerging biohydrogen platforms embedded within agro-industrial clusters can further extend biomass value chains into low-carbon fuel production. In the longer term, integration of carbon capture technologies could position bioenergy within negative-emissions pathways aligned with net-zero commitments.

Ultimately, engineering Malaysia's bioenergy transition requires moving beyond isolated plant optimisation toward integrated infrastructure design, linking feedstock logistics, upgrading technologies, grid systems, emissions controls, hydrogen pathways and financial structures into a scalable ecosystem. The next phase of the transition will not be defined by incremental gains in reactor efficiency, but by how effectively engineers integrate biomass conversion, renewable gas upgrading and hydrogen production into cohesive, economically viable energy systems. If executed holistically, bioenergy - across biomethane, CHP and emerging biohydrogen pathways - can evolve from a compliance-driven waste solution into a strategic pillar of Malaysia's low-carbon, dispatchable and resilient energy future. 🌱

Reference

1. Sustainable Energy Development Authority (SEDA) Malaysia, "Statistic time series – eFIT feed-in tariff (FiT) capacity (SEIP)," Sustainable Energy Information Portal (SEIP), SEDA Malaysia. Accessed: Feb. 24, 2026. [Online]. Available: <https://seip.seda.gov.my/data-statistics/capacity-generation/statistic-time-series-efit/fit-capacity>
2. Ministry of Economy Malaysia, "National energy transition roadmap (NETR): energising the nation, powering our future," Putrajaya, Aug. 2023. Accessed: Feb. 24, 2026. [Online]. Available: <https://ekonomi.gov.my/sites/default/files/2023-08/National%20Energy%20Transition%20Roadmap.pdf>
3. Ministry of Plantation and Commodities Malaysia, "National biomass action plan 2023–2030," Putrajaya, Dec. 2023. Accessed: Feb. 24, 2026. [Online]. Available: https://www.kpk.gov.my/kpk/images/mpi_biomass/27122023-National_Biomass_Action_Plan.pdf
4. M. K. Jameel *et al.*, "Biogas: production, properties, applications, economic and challenges: a review," *Results Chem.*, vol. 7, p. 101549, Jan. 2024, doi: 10.1016/j.rechem.2024.101549.
5. X. Lok, Y. J. Chan and D. C. Y. Foo, "Simulation and optimisation of full-scale palm oil mill effluent (POME) treatment plant with biogas production," *Journal of Water Process Engineering*, vol. 38, p. 101558, Dec. 2020, doi: 10.1016/j.jwpe.2020.101558.
6. M. A. Amin *et al.*, "Methane biogas production in Malaysia: challenge and future plan," *International Journal of Chemical Engineering*, vol. 2022, no. 1, Jan. 2022, doi: 10.1155/2022/2278211.
7. M. K. Jameel *et al.*, "Biogas: Production, properties, applications, economic and challenges: A review," *Results Chem.*, vol. 7, p. 101549, Jan. 2024, doi: 10.1016/j.rechem.2024.101549.
8. S. R. Sharvini and L. C. Stringer, "Challenges and solutions for food waste-based biogas in Malaysia," *Renewable and Sustainable Energy Reviews*, vol. 211, p. 115320, Apr. 2025, doi: 10.1016/j.rser.2024.115320.
9. N. A. Rashidi, Y. H. Chai and S. Yusup, "Biomass energy in Malaysia: current scenario, policies and implementation challenges," *Bioenergy Res.*, vol. 15, no. 3, pp. 1371–1386, Sep. 2022, doi: 10.1007/s12155-022-10392-7.
10. S. M. Ahmad, A. Ismail, N. Abdul Wahab, K. Mohamed Salleh, N. N. Kamil and N. Abdullah, "Comparative analysis of current biomass utilisation by palm oil mills in Peninsular Malaysia," *J. Sustain. Sci. Manag.*, vol. 19, no. 7, pp. 166–176, Jul. 2024, doi: 10.46754/jssm.2024.07.009.
11. X. Y. Sim *et al.*, "Unraveling the effect of redox potential on dark fermentative hydrogen production," *Renewable and Sustainable Energy Reviews*, vol. 187, p. 113755, Nov. 2023, doi: 10.1016/j.rser.2023.113755.
12. X. Y. Sim *et al.*, "Synergistic impact of co-substrate of biodiesel crude glycerol and durian peel hydrolysate for biohydrogen and 1,3-propanediol synthesis by *Clostridium butyricum*," *Int. J. Hydrogen Energy*, vol. 96, pp. 1119–1130, Dec. 2024, doi: 10.1016/j.ijhydene.2024.11.236.
13. S. S. Mahmod *et al.*, "Operation performance of up-flow anaerobic sludge blanket (UASB) bioreactor for biohydrogen production by self-granulated sludge using pre-treated palm oil mill effluent (POME) as carbon source," *Renew. Energy*, vol. 134, pp. 1262–1272, Apr. 2019, doi: 10.1016/j.renene.2018.09.062.

Intelligent Solution to Malaysia's Waste-to-Energy Incinerator Dilemma

by
Stella Kee Joo Bing
He Yu
Michelle Ng Xin Yi
Jocelyn Lim Jean Yi
Gabriella Ivana Sugianto
Tan Khang Wei*
Ban Zhen Hong*

*School of Energy & Chemical Engineering, Xiamen University Malaysia

As urban centres grow, so does the problem of managing waste. Currently, Malaysia generates an estimated 39,000 tonnes of solid waste daily or the equivalent of filling nearly 3,000 garbage trucks every day (MIDA, 2025). Despite 135 active landfills - most of which are non-sanitary, open dumpsites - many are projected to hit full capacity as early as 2041 (Pfordten, 2025). This over-reliance on landfilling leads to severe environmental degradation, including the release of high-potency methane and the generation of toxic leachate which threatens local groundwater systems.

The Ministry of Housing & Local Government has set out a roadmap for a clean energy future by developing 18 Waste-to-Energy (WtE) incineration plants across Peninsular Malaysia by 2050 (Bernama, 2025). At its heart lies the idea that non-recyclable waste can be converted into usable electricity or heat through thermo-chemical processes (Winanti et al., 2022).

In a high-efficiency WtE incinerator, waste is combusted at temperatures above 850°C to ensure complete decomposition and minimal pollution. The resulting heat generates high-pressure steam which drives turbines, potentially contributing 500-600kWh of electricity per ton of waste with energy recovery efficiency ranging from 30% to 92.75%. This process can reduce waste volume by 90% to 95%, significantly extending the lifespan of remaining sanitary landfills. In addition, the technology can reduce greenhouse gas emission reductions from 30% to 87% (Maphuhla & Oyedeki, 2025). However, the transition from traditional landfills to incineration faces resistance from public concerns over dioxins and furans, toxic by-products of incomplete combustion. How do we balance technical necessity with environmental safety?

Understanding Public Fears

The primary hurdle for WtE incineration projects is not just environmental considerations but also public apprehension about the impact on air quality (Chan, 2025; Achariam, 2023). The chemistry behind incineration can be complex as when temperatures drop or moisture levels rise, pollutants are more likely to form. The toxic compounds, including dioxins, are not an inherent part of the waste itself but are accidental by-products which can form during the thermal process.



In a high-functioning furnace, waste should ideally break down into carbon dioxide and water. However, the chemistry changes when temperatures are not strictly maintained. In tropical regions like Malaysia, municipal solid waste (MSW) often carries an average moisture content of about 55% (Kathirvale *et al.*, 2004). When this damp waste enters a furnace, it creates localised cold spot pockets where the temperature drops below the required threshold for clean combustion. In these cooler zones, carbon does not fully oxidise.

When temperatures fall into these zones, the furnace stops being a power generator and starts acting as a chemical reactor for pollutants. Solving this requires a fundamental paradigm shift, by giving the incinerator a “brain” to handle and dry the waste before it ever reaches the flames.

The proposed solution addresses this dilemma head-on by introducing an intelligent pre-treatment process which acts like a digital expert standing over the conveyor belt. Advanced thermal imaging and AI-driven logic enable it to identify the type of waste entering the facility in real-time, adjusting conveyor belt speed accordingly. By ensuring every batch is pre-treated to a uniform moisture level, cold spots can be eliminated, ensuring that the only thing released into the atmosphere is clean air.

Multi-Disciplinary Breakthrough

Managing waste in tropical climates like ours presents a unique challenge: The constant battle against humidity. For WtE plants, high moisture levels are a silent enemy, as higher water content in MSW reduces the average temperature and increases incomplete combustion, leading to inefficient energy recovery and increased pollution (Chen *et al.*, 2025). While traditional methods often rely on solar drying, the frequent rainfall and heavy air of a monsoon climate make this process slow and unreliable.

Traditional drying methods often fall short due to weather, so infrared (IR) sensing technology can identify hidden pockets of moisture which are invisible to human eyes, allowing AI-driven

adjustments on the fly. The system operates by merging the physical principles of chemical engineering with advanced digital intelligence. Using Artificial Intelligence and pre-trained data from Computational Fluid Dynamics (CFD) simulations, the system identifies the type of waste entering the facility and predicts its moisture levels. It then automatically calibrates the speed of the processing conveyor to ensure every batch is dried to the optimal level before it ever reaches the burner.

To achieve this precision without the need for massive, expensive hardware overhauls, the system utilises IR sensing to act as its “eyes”. These non-contact thermal cameras detect hidden pockets of moisture that are invisible to the naked eye, allowing the AI to make split-second adjustments to the conveyor belt speed. By combining these multi-disciplinary tools, including chemical engineering, AI logic, fluid simulations and thermal sensing, the system eliminates the long wait times of sun-drying and the risk of incomplete combustion. The result is a streamlined, cost-effective solution which turns a challenging environmental burden into a reliable, consistent source of renewable power.

‘Brain’ of Pre-treatment System

The system’s intelligence begins the moment waste arrives at the intake. Instead of processing every material the same way, the system uses IR to truly understand what it is working with. Imagine a digital expert standing over the conveyor belt, identifying the difference between food scraps and wood chips in a split second.

By using specialised thermal imaging and advanced neural networks, the system builds a detailed 3D moisture map that reveals with remarkable accuracy where water is hidden within the pile. Once the waste enters the torrefaction chamber, this data is put into immediate action. The system acts much like a careful chef adjusting heating timing to suit different ingredients. When it detects heavy, wet food waste, it automatically slows the conveyor belt down, giving the heat the necessary time to evaporate every stubborn drop of moisture. Conversely, when it senses drier materials like

wood, it speeds up the process to save energy and to prevent the waste from over-charring, thus avoiding the risk of explosion. This constant, real-time adjustment ensures that the final product is always uniform and ready for the next stage.

The ultimate goal is to ensure that everything leaving the chamber is now transformed into items that consistently holds less than 40% moisture. This precision does more than just improve efficiency; it guarantees a stable, high-temperature flame during incineration. By maintaining this steady heat, the system eliminates the cool pockets that usually lead to incomplete combustion, effectively preventing the release of harmful toxins like dioxins. It is a sophisticated dance of data and physics which turns unpredictable trash into a safe, reliable and clean source of energy.

Building Trust

For public confidence to be truly earned, transparency must be absolute. To ensure the facility remains a good neighbour, the innovation includes a smart safety net designed to act as a digital guardian for the surrounding environment. By simulating thousands of different wind patterns and weather conditions, the system identifies the most strategic locations for air quality sensors. This ensures every high-risk area is always under a watchful eye without the need for an excessive, costly number of devices.

By analysing gas concentrations and wind speeds, it can trace the source of a leak or even unauthorised open burning nearby down to its exact origin. This system allows operators to step in and stop problems before they escalate, providing peace of mind to the community and ensuring the plant operates safely.

The shift from traditional methods to this intelligent approach represents a massive leap in both environmental safety and industrial productivity. The move toward an AI-driven system replaces the uncertainty of the weather with a controlled, highly efficient process that benefits both the planet and the bottom line.

Solving the Incinerator Dilemma

By integrating digital intelligence with chemical engineering principles, waste can be transformed into a valuable resource rather than a burden. The intelligent system proposed here represents not just a technical fix but also a fundamental shift in urban waste management. It aligns perfectly with Malaysia's national visions, including the National Energy Transition Roadmap and the Circular Economy Blueprint.

By merging the grounded principles of chemical engineering with the precision of digital intelligence, we are no longer just looking at a distant possibility for a greener world. As Malaysia strives for carbon neutrality by 2050, the proposed solution offers both economic benefits and enhanced public trust. This is no longer about building bigger facilities or throwing more money at the problem but is focused on creating smarter ones that transform waste into clean energy with ease. 🌱

Reference

1. Achariam, N. (2023, August 29). Rawang residents oppose incinerator project. *Themalaysianinsight.com*; The Malaysian Insight.
2. Bernama. (2025). KPKT Targets 18 Waste-to-Energy Plants By 2050 To Boost Renewable Energy.
3. Chan, J. (2025, November 17). Batu Arang residents rally against proposed WTE plant, citing health, environmental concerns. *The Star*.
4. Chen, S., Xu, F., Chen, Y. and Yin, L. (2025). Numerical Simulation and Intelligent Prediction of Effects of Primary Air Proportion and Moisture Content on MSW Incineration. *Processes*. 13(5), 1479.
5. Maphuhla, N. G. and Oyediji, O. O. (2025). From Trash to Treasure: Systematic Evaluation of Potential and Efficiency of Waste-to-Energy Incineration for Electricity Generation. *Waste*, 3(4), 39–39.
6. MIDA. (2025). Turning Waste into Wealth: Malaysia's Circular Economy in Action. MIDA | Malaysian Investment Development Authority.
7. Pfordten, D. (2025, July 30). Landfills to hit full capacity by 2041. *The Star*.
8. Sivapalan Kathirvale, S., Yunus, M.N.M., Sopian, K. and Samsuddin, A.H. (2004). Energy potential from municipal solid waste in Malaysia. *Renewable Energy*. 29 (4), 559 – 567.
9. Winanti, W. S., Purwanta, W. and Wiharja. (2022). Utilization of municipal solid waste into electricity energy: A performance of PLTSA Bantargebang pilot project. *IOP Conference Series: Earth and Environmental Science*, 1034(1), 012003.

THE INGENIEUR

Where Engineers Excel

The Board of Engineers Malaysia (BEM), formed in 1972, is a statutory body constituted under the Registration of Engineers Act 1967. BEM falls within the ambit of responsibility of the Minister of Works. Its primary role is to register and regulate engineering professionals, engineering technologists and inspectors of works in order to safeguard the safety and interest of the public.

To-date there are more than 16,000 Professional Engineers, 140,000 Graduate Engineers and 9,000 Engineering Technologists registered with BEM.

Published quarterly by BEM, *The Ingenieur*, reaches out to the engineering community via a **16,800 printed** version as well an **e-format** for other readers in general.

Readership exceeds 100,000.



The content in our magazine, written mainly by the engineering community and technical professionals, provides first-hand and valuable knowledge to readers. There is a wealth of information on:

- Infrastructure design and development
- Professional practice
- Government policies and guidelines
- Legal issues
- Engineering personalities
- Management
- Continuous development of engineers

For advertising and subscription enquiries, please contact

Board of Engineers Malaysia

Tingkat 17 Ibu Pejabat JKR,
Jalan Sultan Salahuddin,
50580 Kuala Lumpur

Email : publication@bem.org.my

Tel : +603-2698 0590 / 603-2610 2090

Fax : +603-2692 5017

ADVERTISEMENT BOOKING FORM & RATE CARD**ADVERTISEMENT RATES**

Position	Per Insertion	Position	Per Insertion
Back Cover	RM7,000	Inside Back Cover	RM5,000
Inside Front Cover	RM5,600	Double Page Spread	RM6,600
Facing Inside Front (Page 1)	RM5,400	Facing Foreword/Message	RM5,000
Gatefold (Ad on Left/Right)	RM7,000	Facing Contents Page	RM5,000
Gatefold (Spread size)	RM11,000	ROP Full Page	RM4,000
		ROP Half Page	RM2,200

ADVERTISEMENT BOOKING FORM (Tick the appropriate boxes)**Issue**

Jan-March 2026 ☐	Jan-March 2027 ☐	Jan-March 2028 ☐
April-June 2026 ☐	April-June 2027 ☐	April-June 2028 ☐
July-Sept 2026 ☐	July-Sept 2027 ☐	July-Sept 2028 ☐
Oct-December 2026 ☐	Oct-December 2027 ☐	Oct-December 2028 ☐

Position

Back Cover ☐	Inside Back Cover ☐
Inside Front Cover ☐	Double Page Spread ☐
Facing Inside Front (Page 1) ☐	Facing Foreword/Message ☐
Gatefold (Ad on Left/Right) ☐	Facing Contents Page ☐
Gatefold (Spread size) ☐	ROP Full Page ☐
	ROP Half Page ☐

Magazine Specifications:

Page Size - 210mm x 280mm
Bleed Size - 218mm x 288mm
Text Area - 160mm x 230mm

PAYMENT

* Enclosed herewith our cheque no: _____ for RM_____ made payable to
Lembaga Jurutera Malaysia

** To invoice us. Payment will be made within 1 month from the date of invoice.

Name of Organisation : _____
Contact Person : _____
Designation : _____
Address : _____
Tel/HP No. : _____ Fax No : _____
Email : _____
Signature : _____

Send / Mail / Fax this form to: Communication & IT Department, Board of Engineers, Malaysia
Tingkat 17 Blok F, Ibu Pejabat JKR, Jalan Sultan Salahuddin, 50580 Kuala Lumpur
Tel: 03-26980590 Fax: 03-26925017 Email: publication@bem.org.my

Renewable Energy as Cornerstone of Energy Transition - The Way Forward for ASEAN Decarbonisation Towards 2030

by
Samniang Saenram

ASEAN's journey towards decarbonisation by 2030 is one of the most consequential engineering and development challenges of this decade. Rapid economic growth, rising energy demand and increasing climate risks require the region to fundamentally reshape its energy systems while preserving affordability, reliability and competitiveness. Renewable energy (RE) has emerged as the cornerstone of this transition. However, achieving scale requires more than technology deployment; it demands system-level planning, enabling policy, sustained investment and a technically competent engineering workforce.

Decarbonisation as an Engineering Imperative

For the past three decades, ASEAN has become one of the world's fastest-growing economic regions. This growth, while transformative, has been accompanied by increasing energy consumption and emissions intensity. Power generation, transportation and industrial activity remain heavily dependent on fossil fuels, exposing the region to climate risks, energy price volatility and future carbon-related trade barriers.

As ASEAN approaches the 2030 climate milestone, decarbonisation is no longer a peripheral environmental agenda. It has become a core engineering, infrastructure

and economic challenge. For engineers, this transition marks a shift from incremental optimisation of legacy systems toward the design, integration and governance of fundamentally new energy architectures.

RE lies at the heart of this transformation, but its successful deployment depends on how effectively engineers, policymakers and industry can work together to overcome structural constraints.

RE: Backbone of ASEAN Energy Transition

Renewable energy (particularly solar, hydropower, biomass and wind) offers ASEAN a viable and scalable pathway to decarbonise electricity generation while supporting economic growth. Technological advances and declining costs have made renewables increasingly competitive, in many cases cheaper than new fossil-based generation.

For ASEAN, RE serves multiple strategic objectives:

- Emissions reduction in the power sector, which remains the largest contributor to regional greenhouse gas emissions.
- Energy security, by reducing dependence on imported fossil fuels.
- Economic resilience, through localised generation and diversified energy supply.
- Industrial opportunity, including renewable manufacturing, services and system integration.



However, RE must be viewed not as isolated generation assets, but as part of an integrated energy system which includes grids, storage, demand response and digital control.

Need for Systems-Based Decarbonisation Approach

One defining lesson emerging from regional energy transition assessments is that sector-by-sector decarbonisation is insufficient. ASEAN's energy systems are deeply interconnected with transportation, industry, urban development and land use. For example:

- Large-scale solar deployment increases the need for grid flexibility and storage.
- Electrification of transport shifts emissions from tailpipes to power systems.
- Industrial decarbonisation raises demand for clean electricity and alternative fuels.

A systems-based approach recognises these interdependencies and enables optimisation across the entire value chain. For engineers, this requires moving beyond component-level design toward whole-system engineering, incorporating power electronics, control systems, data analytics and cross-sector coordination.

Key Challenges Confronting ASEAN's Decarbonisation Path

1. Grid Infrastructure and System Flexibility.

Most ASEAN power grids were designed around centralised, dispatchable fossil fuel plants.

Integrating high shares of variable renewable energy introduces challenges related to frequency control, voltage stability and balancing supply and demand.

Grid modernisation, including smart substations, advanced metering, distributed energy management systems and regional interconnections, is therefore essential. Without these upgrades, renewable penetration will remain constrained regardless of generation capacity.

2. Financing and Project Bankability. While global capital for green investments is abundant, its deployment in ASEAN remains uneven. High upfront costs, long payback periods and policy uncertainty continue to hinder renewable projects. Engineers play a critical role in improving project bankability through:

- Robust technical design.
- Accurate performance modelling.
- Risk-informed engineering solutions.
- Compliance with international standards.

Well-engineered projects reduce investor risk and accelerate financial closure.

3. Policy and Regulatory Alignment.

Inconsistent regulations, lengthy permitting processes and unclear grid access rules remain barriers across parts of ASEAN. Engineering institutions have a role to play in supporting evidence-based policymaking by providing technical input, standards development and independent expertise.

4. Human Capital and Skills Readiness.

The energy transition demands new competencies that extend beyond traditional engineering curricula. These include:

- Renewable system integration.
- Energy storage and power electronics.
- Digitalisation, AI and data-driven optimisation.
- Sustainability assessment and lifecycle analysis.

Without accelerated upskilling, the shortage of qualified engineers may become a limiting factor.

Preparing Engineers for Decarbonisation Journey

Engineers are the custodians of safety, reliability and public trust in the energy transition. To fulfill this responsibility, several shifts are required.

a. From Discipline-Centric to System-Oriented Practice. Future engineers must be capable of integrating electrical, mechanical, digital and environmental systems. This calls for interdisciplinary training and exposure to real-world system operation.

b. Digital Competency as a Core Skill. Smart grids, predictive maintenance and energy optimisation rely on digital tools. Engineers must be fluent in data analytics, modelling software and cyber-physical system design.

c. Ethics, Governance and Professional Accountability. Decarbonisation projects involve public funds, long-term infrastructure and societal impact. Professional engineers must uphold high ethical standards, ensure safety and provide independent technical judgement, roles that align closely with BEM's statutory mandate.

Malaysia's Position & Contribution within ASEAN

Malaysia occupies a strategic position in ASEAN's energy transition. With a relatively mature grid, strong engineering institutions and clearly articulated energy transition roadmaps, Malaysia is well placed to demonstrate how decarbonisation can be pursued pragmatically.

a. National Energy Transition Direction. Malaysia's energy policies emphasise:

- Gradual reduction of coal dependency.
- Expansion of solar and other renewables.
- Grid reinforcement and digitalisation.
- Industrial decarbonisation without compromising competitiveness.

This balanced approach reflects engineering realities and socioeconomic considerations.

b. Engineering Capacity and Institutional Strength. Malaysia's engineering ecosystem, supported by BEM, higher education

institutions and professional bodies, provides a strong foundation for skills development and professional governance.

Continuous professional development in RE, power systems and digital technologies will be critical to sustaining this advantage.

c. Regional Leadership Role. Malaysia can contribute to ASEAN decarbonisation by:

- Sharing best practices in grid management and renewable integration.
- Supporting regional standards harmonisation.
- Developing engineering talent aligned with ASEAN-wide needs.

Conclusion: Engineering Transition with Purpose

ASEAN's decarbonisation journey towards 2030 is fundamentally an engineering endeavour. RE provides the technological foundation, but success will depend on system integration, infrastructure readiness, financing credibility and human capital.

Engineers must rise to this challenge, not only as designers and implementers, but also as trusted professionals who safeguard public interest, advise policymakers and ensure that the energy transition is technically sound, economically viable and socially responsible.

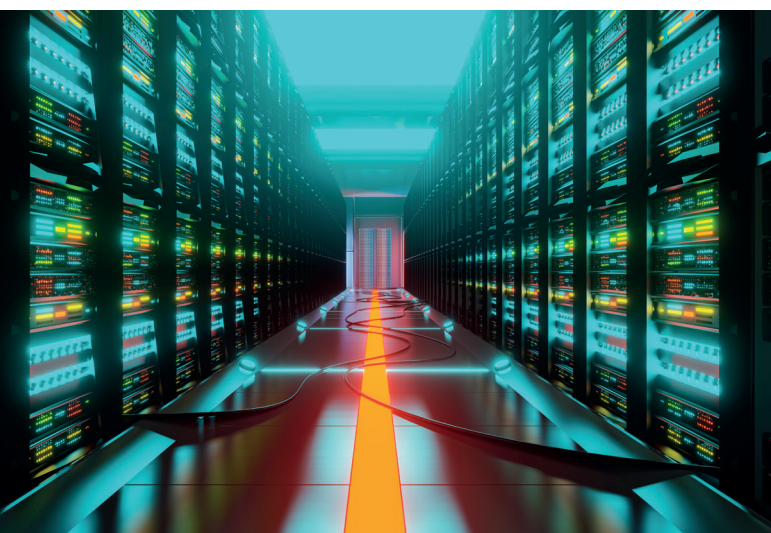
Malaysia, through strong institutions and engineering leadership, has the opportunity to contribute meaningfully to ASEAN's collective success. By aligning professional practice with sustainability goals, the engineering profession can help ensure that decarbonisation is not merely an aspiration, but a durable and well-engineered reality. 🌱

Reference

1. ASEAN Centre for Energy (ACE)
2. International Renewable Energy Agency (IRENA)
3. Asian Development Bank (ADB)
4. World Bank - Energy Sector

Energy the Currency of Digital Age: Rising Electricity Appetite of AI & Data Centres

by
Lee Soo Leng



Myth of a “weightless” digital economy: The rapid rise of artificial intelligence (AI), cloud computing and digital platforms is often portrayed as a transition toward a dematerialised or “weightless” economy. Data flows invisibly across borders, services are delivered instantaneously and value appears to be created through software and algorithms rather than factories, machines and physical infrastructure. This perception, while intuitive, is fundamentally misleading.

Keyu Jin, an economist and professor at the London School of Economics known for her work on global political economy, has succinctly captured the underlying reality by observing that “energy is the currency of the physical world”. Her statement provides a powerful lens through which we can understand the foundations of

the digital economy. While money measures value and facilitates exchange, energy is what ultimately enables physical work to be done.

In the digital age, energy has not diminished in importance; rather, it has become more central than ever. AI systems, data centres, telecommunications networks and cloud infrastructure are fundamentally energy-conversion systems, governed by engineering principles, thermodynamics and infrastructure constraints.

For engineers and regulators alike, recognising this reality is essential, because the future of digital transformation, national competitiveness and technological sovereignty will depend not only on software capability, but on how effectively societies design, supply, operate and regulate energy-intensive digital infrastructure.

Digital systems are physical systems

Despite their virtual appearance, digital systems are deeply physical. Servers are constructed from steel, silicon, copper and rare earth elements. Data centres occupy land, draw power from electrical grids, consume water for cooling and generate heat that must be dissipated continuously. Fibre-optic networks, mobile base stations and satellite systems all require stable and uninterrupted energy supply to function.

AI intensifies this physical reality. Unlike conventional IT workloads, AI training and inference demand massive parallel computation, often operating continuously at

high utilisation. Each computational operation consumes electricity and every joule of electrical energy ultimately degrades into heat. From an engineering perspective, AI is not “thinking” in an abstract sense; it is energy being transformed into probabilistic outputs.

These reframing challenges the popular narrative that digital growth can be decoupled from physical constraints. On the contrary, digital expansion is increasingly constrained by power availability, cooling capacity, grid reliability and infrastructure resilience.

Data centres as factories of digital economy

In the industrial age, factories converted energy into physical goods. In the digital age, data centres perform an analogous role, converting electrical energy into digital services such as search results, financial transactions, video streaming, cloud storage and AI-generated outputs.

Modern hyperscale data centres operate at a scale comparable to heavy industry. A single large facility may require between 100 and 500 megawatts of continuous power, equivalent to the electricity demand of a medium-sized city. Unlike many traditional industrial loads, data centre demand is continuous rather than cyclical, highly sensitive to power quality and outages and fundamentally intolerant of interruption.

This explains why data centre site selection is now driven primarily by energy considerations rather than labour cost or proximity to consumer markets. Access to reliable, affordable electricity and robust transmission infrastructure has become the decisive factor.

How World's Data Centres Follow the Flow of Power

Several countries illustrate how energy availability and infrastructure shape the geography of the digital economy.

- In the United States, hyperscale data centres have clustered in regions such as Northern Virginia, Texas and parts of the Midwest. Northern Virginia alone hosts the world's largest concentration of data centres, largely due to strong grid connectivity, abundant transmission capacity and access to reliable power. Texas, with its large generation base and competitive electricity market, has also attracted energy-intensive AI facilities, even as recent grid stress events have highlighted the importance of resilience and redundancy.
- China's approach explicitly recognises energy as a strategic foundation of digital infrastructure. Large data centres are increasingly located in inland provinces with abundant hydro, wind, or coal-based generation, while eastern coastal regions focus more on data consumption than data processing. This spatial separation reflects deliberate planning to balance digital growth with energy and grid constraints.
- In Nordic countries such as Norway, Sweden and Finland have positioned themselves as attractive data centre hubs by leveraging abundant low-carbon electricity, particularly hydropower. Cooler climates reduce cooling energy requirements, improving overall efficiency. Several global technology firms have established large facilities in these regions, drawn by energy reliability, sustainability credentials and stable regulatory environments.
- Singapore presents a contrasting case. As a major digital hub with limited land and energy resources, it faces challenges accommodating rapid data centre growth. Concerns over power demand, carbon emissions and grid capacity has led to a temporary moratorium on new data centre developments. This experience illustrates how energy constraints can directly limit digital expansion, regardless of technological ambition.

Collectively, the above examples demonstrate that the digital economy is not placeless. It is increasingly anchored to energy-rich, infrastructure-ready locations, much like traditional heavy industry.

Malaysia's Rapid Data Centre Growth: Energy & Water at Centre of Concern

Malaysia has emerged as one of South-East Asia's fastest-growing data centre destinations, driven by political stability, relatively competitive electricity tariffs, improving digital infrastructure and proximity to Singapore. The most concentrated growth has occurred in Johor, particularly in Iskandar Malaysia and the Johor Bahru-Sedenak corridor, where large tracts of land, grid connectivity and cross-border demand have attracted hyperscale developments. Significant data centre investments have also been recorded in the Klang Valley, especially in Cyberjaya, Sepang and parts of Selangor, building on Malaysia's earlier Multimedia Super Corridor legacy.

This rapid expansion has brought economic benefits, including foreign direct investment, construction activity and high-value digital services. However, it has also raised serious engineering and infrastructure concerns, particularly regarding electricity demand and water consumption.

From a power systems perspective, modern hyperscale data centres impose large, continuous electrical loads that differ markedly from traditional industrial demand. Individual facilities can require hundreds of megawatts of firm capacity, operating on a 24-hour basis with stringent reliability requirements. In Johor and parts of the Klang Valley, the cumulative impact of multiple data centre projects has prompted concerns over grid capacity, transmission reinforcement and long-term generation adequacy, especially during peak demand periods.

Water consumption presents a parallel challenge. Many data centres rely on water-based cooling systems, either directly or indirectly, to manage

the heat generated by high-density computing equipment. As facilities scale up, cooling water demand can become substantial, raising concerns about competition with domestic, agricultural and industrial users, particularly during dry periods. In regions already facing water stress or seasonal shortages, the sustainability of large-scale data centre cooling has become a critical planning issue.

These challenges have brought Malaysia's policy and regulatory framework into sharper focus. The government has signalled support for digital economy growth through initiatives such as MyDIGITAL, the National Investment Aspirations and incentives administered by agencies including MIDA. At the same time, authorities and utilities have increasingly emphasised the need for energy efficiency, responsible siting and sustainable resource use in approving new data centre developments.

For engineers, Malaysia's data centre boom reinforces Keyu Jin's insight that energy is the currency of the physical world. Digital growth ultimately settles in megawatts, kilowatt-hours and cubic metres of water. How effectively these resources are engineered, managed and regulated will determine whether Malaysia's digital infrastructure expansion is not only rapid, but also resilient and sustainable.

Thermodynamics: Hidden governor of AI growth

At the core of AI infrastructure lies a fundamental engineering constraint: Thermodynamics. Every unit of computation produces heat. As computing density increases, particularly with advanced GPUs and accelerators, the challenge of removing heat safely and efficiently becomes more severe.

Traditional air-cooling methods are approaching their practical limits. As a result, engineers are increasingly deploying liquid cooling, direct-to-chip cooling and immersion cooling systems. While these solutions improve heat transfer, they introduce new design, operational and safety considerations.

Cooling systems themselves consume substantial energy, meaning that energy is effectively spent twice: First to perform computation and again to remove its thermal by-product. This reinforces the reality that intelligence, in physical terms, carries a real and unavoidable energy cost. No degree of software optimisation can bypass the laws of thermodynamics.

Power Usage Effectiveness & language of energy

The centrality of energy considerations in data centre engineering is reflected in performance metrics. Power Usage Effectiveness (PUE) has become a standard indicator, measuring the ratio of total facility energy consumption to energy used by IT equipment.

While significant improvements in PUE have been achieved over the past decade, gains are increasingly incremental. As IT equipment becomes more efficient, auxiliary systems such as cooling, power conversion and distribution account for a growing share of total energy losses.

For engineers, this means that architectural design, mechanical and electrical system integration, control strategies and operations as well as maintenance practices are just as important as server efficiency in determining overall performance.

Grid Interaction & National Infrastructure Stress

Large-scale data centres impose unprecedented demands on national and regional power grids. Their continuous, high-load profiles require robust generation capacity, reinforced transmission networks and advanced protection and power-quality management.

In some regions, rapid data centre expansion has raised concerns about grid congestion, competition with residential and industrial users and the need for costly infrastructure upgrades. These developments raise important

policy questions regarding cost allocation and regulation of energy-intensive digital infrastructure.

From an engineering governance perspective, these issues directly affect planning approvals, connection standards, reliability criteria and long-term infrastructure investment decisions.

Reliability, Redundancy & Digital Resilience

In financial systems, liquidity and reserves protect against shocks. In digital infrastructure, energy redundancy serves a similar function.

Data centres are designed with multiple grid connections, uninterruptible power supply systems, battery energy storage and backup generators. These measures ensure continuity during grid disturbances but significantly increase capital and operational costs. They also reinforce a fundamental reality: Energy failure equals digital failure.

Unlike many traditional industries, even a brief power interruption can trigger immediate and widespread consequences, disrupting communications, financial transactions and essential services. Designing and maintaining this resilience is therefore a core professional responsibility for engineers.

AI efficiency as energy efficiency

Recent advances in AI increasingly mirror classical engineering trade-offs. Techniques such as model optimisation, reduced-precision computing and edge processing are not merely computational innovations but are also energy-efficiency measures.

By reducing the energy required per unit of useful output, these approaches effectively increase the “purchasing power” of energy. In Keyu Jin’s metaphor, they improve the exchange rate between energy input and economic value created. This convergence highlights the growing overlap between digital engineering and traditional disciplines such as electrical, mechanical and systems engineering.

Implications for practising engineers

For practising engineers, recognising energy as the currency of the digital age has several important implications. Engineering decisions made today lock in energy consumption patterns for decades. Choices in system design, equipment selection and standards compliance directly shape long-term operational performance.

Operations and maintenance take on heightened importance, as efficient operation, predictive maintenance and continuous optimisation are essential to controlling energy costs and ensuring reliability. At the same time, interdisciplinary competence becomes increasingly valuable, as digital infrastructure demands close collaboration across engineering domains.

Regulatory & Professional Considerations

From a regulatory perspective, codes, standards and approval processes effectively act as energy policy instruments. Decisions on efficiency requirements, redundancy levels, environmental performance and reporting transparency shape the trajectory of digital infrastructure development.

Engineers should be equipped to address these challenges ethically and competently. As digital infrastructure becomes a core national asset, professional accountability in energy stewardship becomes a matter of public interest.

Conclusion: Energy Settles All Digital Transactions

The digital economy may appear intangible, but it rests on a physical foundation that cannot be ignored. AI systems and data centres convert electricity into intelligence, coordination and economic value. In this sense, energy truly functions as the currency that settles all digital transactions.



For engineers, this perspective restores clarity. The future of AI and digital infrastructure will not be determined by algorithms alone, but by how effectively societies design, supply, operate and regulate the energy systems that sustain them. In the digital age, engineering remains what it has always been: The disciplined management of energy in service of society. 🏢

“ Artificial intelligence does not escape physical limits; it converts electrical energy into intelligence-making energy the true currency of the digital age. ”

Reference

1. International Renewable Energy Agency (IRENA)
2. World Bank Group
3. International Energy Agency (IEA)
4. Keyu Jin, London School of Economics

Ultra-High Voltage Transmission: The Backbone of Long-Distance Power Delivery

by
Casey Loo Kam Choong

As the world moves toward decarbonisation and rapid electrification, the location of energy resources increasingly differs from where electricity is consumed. Renewable energy zones, such as large hydropower plants, desert solar farms and offshore wind arrays, are often situated hundreds or even thousands of kilometres from urban and industrial centres. This spatial mismatch has made long-distance, high-capacity electricity transmission a strategic engineering priority.

Ultra-High Voltage (UHV) transmission, defined as alternating current (AC) systems $\geq 1,000$ kV and direct current (DC) systems $\geq \pm 800$ kV, has emerged as a transformative solution. UHV enables efficient bulk power delivery over thousands of kilometres, minimising losses and optimising land use, while integrating large-scale renewable energy into national grids. In this article, we examine the advantages of UHV, engineering elements, international case studies and relevance to Malaysia and the ASEAN region.

Understanding Ultra-High Voltage Transmission

Transmission of electricity at UHV levels extends beyond conventional high-voltage (HV) and extra-high-voltage (EHV) systems, which typically operate between 220 kV and 500 kV. While effective for regional networks, these voltages become inefficient over very long distances and for high-capacity power transfer.

- UHVAC ($\geq 1,000$ kV): Suitable for meshed grids requiring synchronous interconnection across regions. Ideal for transmitting large power blocks between multiple generation and load centres.

- UHVDC (± 800 kV to $\pm 1,100$ kV): Optimised for point-to-point transfer over long distances, asynchronous interconnections and scenarios demanding precise controllability of power flows.

The choice between UHVAC and UHVDC depends on grid topology, distance, power volume and system stability considerations. UHVDC is particularly advantageous for distances exceeding 1,000 km, where losses and stability issues in AC systems become significant.

Advantages of UHV Transmission

a. Exceptional Power Transfer Capacity:

A single UHVDC link can transmit between 8 and 12 GW, equivalent to the output of several large thermal or hydroelectric power stations. This capability reduces the number of required transmission corridors, optimising capital expenditure and land utilisation. For UHVAC, higher voltage levels allow for the interconnection of multiple generation sources across regional and national grids.

b. Reduced Transmission Losses: Transmission losses are proportional to the square of the current (I^2R). By increasing voltage, UHV reduces the current required to transmit the same power, which can cut line losses by 30-50% compared with lower-voltage alternatives over long distances. This is particularly crucial for renewable energy zones located far from load centres, where conventional transmission would otherwise be economically and technically inefficient.

c. Optimised Land Use & Environmental Impact: UHV transmission consolidates energy flows into fewer lines, reducing the total

right-of-way footprint. Though UHV towers are taller (often 80-100 metres), fewer corridors are required, which translates to:

- Lower cumulative land acquisition and deforestation.
- Reduced disruption to communities and ecosystems.
- Improved sustainability per unit of power delivered.

d. Enabler of Renewable Energy Integration:

UHV facilitates the delivery of renewable energy from remote generation zones to urban and industrial load centres. By enabling bulk transfer of hydro, solar, wind and offshore energy, UHV supports decarbonisation and energy security initiatives while allowing nations to exploit their renewable resources optimally.

Engineering Elements of UHV Systems

Designing UHV transmission requires a multi-disciplinary engineering approach, integrating civil, electrical, mechanical and digital systems expertise.

a. Transmission Lines & Structural Design:

UHV transmission towers are significantly taller than conventional towers to maintain clearance and mitigate corona discharge.

Key design elements include:

- Height and span. 80-100 metres or more, depending on terrain.
- Multi-bundle conductors. 6-8 sub-conductors per phase to reduce corona effects.
- Structural resilience. Designed to withstand wind, ice, temperature variations and seismic activity.
- Right-of-way planning. Minimising environmental and social impacts while ensuring safety.

b. Insulation & Corona Control: The extreme voltages require long insulator strings, using porcelain or composite materials, combined with corona rings and grading devices to control electric stress. These measures reduce audible noise, radio interference and ozone generation.

c. Substations & Converter Stations

- UHVAC substations: Feature expansive layouts, robust busbar systems and advanced switchgear to handle extreme voltages and currents.
- UHVDC converter stations: Incorporate high-power transformers, thyristor or IGBT valves, harmonic filters and reactive power compensation. Redundancy and no-single-point-of-failure design principles ensure high reliability.

d. Protection, Control & Digitalisation: UHV systems require sophisticated monitoring and control.

- Wide-area protection schemes using Phasor Measurement Units (PMUs).
- Real-time monitoring of conductor temperature, sag and weather conditions.
- Digital control platforms for predictive maintenance and stability management.

e. Grid Stability & Power Quality: UHVDC links allow precise regulation of power flows, improving grid stability by damping oscillations and isolating disturbances. These capabilities are especially valuable for integrating intermittent renewable energy.

Challenges in UHV Deployment

Despite the advantages, UHV deployment comes with engineering and operational challenges.

- High capital costs for lines, towers and substations.
- Construction complexity over mountains, rivers, deserts and dense urban zones.
- Electromagnetic and environmental concerns, including EM field exposure and public acceptance.
- Grid integration, requiring careful coordination with existing networks and market structures.

Effective project planning, rigorous standards and multi-disciplinary collaboration are essential for successful implementation.

International Case Studies

a. China: Global Benchmark

China has developed the world's most extensive UHV network to connect western energy-rich regions with eastern load centres:

- **Changji--Guquan $\pm 1,100$ kV UHVDC**
 - o Length: ~3,300 km
 - o Capacity: 12 GW
 - o Significance: World's highest-voltage DC project, demonstrating extreme engineering integration.
- **UHVAC 1,000 kV backbone** enables nationwide synchronous interconnection and integration of large-scale renewable energy.

b. India & Brazil: Long-Distance Integration

- **India:** ± 800 kV HVDC links (e.g., Raigarh-Pugalur, Biswanath-Agra) enhance grid resilience, manage regional power flow and integrate renewable resources.
- **Brazil:** HVDC corridors transmit Amazon hydroelectric power over 2,000 km to coastal load centres, reducing dependence on fossil fuels.

These cases show that UHV is not just a technological upgrade but that it is also strategic national infrastructure, supporting energy security and economic development.

Relevance to Malaysia & ASEAN

While Malaysia has not yet deployed UHV transmission, regional trends indicate growing relevance.

- Renewable energy expansion. Offshore wind, large solar farms and hydro projects are increasingly located far from demand centres.
- ASEAN Power Grid. Future cross-border interconnections may require UHV or near-UHV technology to transmit bulk power efficiently.
- Data centre demand. High-capacity data centres in Johor, Selangor and Cyberjaya will benefit from robust high-voltage transmission infrastructure.

Opportunities for Malaysian engineers include:

- High-voltage system design and consultancy.
- Mechanical and civil engineering for towers, foundations and substations.
- Grid digitalisation, monitoring and predictive maintenance.
- Renewable energy integration and power system planning.

Conclusion

Ultra-High Voltage transmission is a cornerstone of modern power engineering. By enabling efficient, reliable electricity transfer across thousands of kilometres, UHV supports national energy security, economic development and the global energy transition. For engineers, UHV exemplifies systems-level thinking, where electrical, civil, mechanical and digital disciplines converge to deliver infrastructure of national and regional importance.

In Malaysia and the ASEAN region, UHV presents an opportunity to:

- Optimise renewable energy integration.
- Enhance grid stability and interconnection.
- Build world-class engineering expertise and workforce.
- Support decarbonisation and sustainable development goals.

As demand for electricity continues to rise and renewable energy scales, UHV will remain an essential technology for the grids of the future, combining engineering innovation with strategic national development. 🏗️

Reference

1. Our China Story. Overview of China's UHV projects, highlighting long-distance transmission capability, power capacity and infrastructure scale.
2. AllElectroHub. Technical review of UHV core technologies, transmission efficiency, loss characteristics and engineering design considerations.
3. Energy Reports. Research article on the impact of flexible UHV transmission on grid stability, renewable energy integration and economic dispatch.
4. Energy Economics/ScienceDirect. Analysis of UHV transmission's effect on carbon emissions, efficiency improvements and environmental benefits.

Electrical Safety Standards for Rooftop PV & Battery Energy Storage Systems in ASEAN

by
Mary Foo Mee Sim

The rapid deployment of rooftop photovoltaic (PV) systems and Battery Energy Storage Systems (BESS) in ASEAN countries marks a decisive shift toward decentralised and low-carbon energy systems. Driven by national renewable energy targets, falling technology costs and increasing corporate sustainability commitments, distributed solar installations are now a common feature on residential, commercial and industrial rooftops throughout South-East Asia.

However, the acceleration of rooftop PV and battery deployment introduces a parallel responsibility: Ensuring robust electrical safety governance. Unlike conventional building electrical systems, PV and BESS installations involve high-voltage direct current (DC) circuits, bidirectional power flow, power electronics and electrochemical energy storage.

Without proper design, installation and maintenance controls, these systems present risks such as electric shock, arc faults, equipment damage, fire and thermal runaway.

For engineers and regulators in ASEAN, the challenge lies in not merely promoting renewable energy adoption, but in ensuring deployment is technically sound, professionally supervised and aligned with internationally recognised safety standards.

Electrical Risk Landscape of Rooftop PV & BESS

High-Voltage DC Hazards. Rooftop PV arrays commonly operate at DC voltages ranging from 600 V to 1,500 V. Unlike alternating current (AC), DC does not naturally pass through a zero-crossing point, making DC arcs more persistent and difficult to extinguish. Live conductors remain energised whenever sunlight is present, even if a building's main AC supply is disconnected. This creates ongoing hazards for installers, maintenance personnel and emergency responders.

DC Arc Faults & Fire Risks. Loose connections, damaged cables, or degraded insulation may lead to DC arc faults. Temperatures in DC arcs can exceed 3,000°C, igniting surrounding materials. Globally, rooftop PV-related fires have often been traced to poor workmanship, incompatible connectors, or inadequate protection devices.



Battery Thermal Runaway. Lithium-ion batteries, widely adopted for BESS applications, store significant amounts of chemical energy in compact enclosures. Under abnormal conditions such as overcharging, internal short circuits, or overheating, batteries may enter thermal runaway - a self-propagating reaction that releases heat and flammable gases. Without adequate containment, ventilation and monitoring systems, such events may escalate rapidly.

System Integration Complexity. Modern rooftop installations increasingly combine PV arrays, hybrid inverters and battery storage systems. Bidirectional power flows, anti-islanding protection and grid synchronisation requirements add layers of engineering complexity. Protection coordination must address both DC and AC faults, as well as battery-specific hazards.

These risks underscore the importance of structured electrical safety standards.

International Standards as Foundation. Most ASEAN countries reference or adopt International Electrotechnical Commission (IEC) standards as the technical backbone of PV and BESS regulation. Key standards include:

- **IEC 60364-7-712** - Requirements for solar PV power supply systems.
- **IEC 61730** - PV module safety qualification.
- **IEC 62109** - Safety of power converters for use in PV systems.
- **IEC 62933 series** - Safety and performance of electrical energy storage systems.
- **IEC 62305** - Lightning protection.

In addition, UL standards such as UL 9540 and UL 1973 are often referenced for battery system testing and fire propagation assessment, particularly for projects influenced by international financiers or insurers.

The adoption of these standards provides a harmonised technical baseline. However, national implementation and enforcement vary across ASEAN.

National Approaches: Singapore, Malaysia & Thailand

a. Singapore: Structured & Integrated Regulatory Oversight. Singapore maintains one of the most comprehensive electrical safety regimes in the region. The Energy Market Authority (EMA) regulates electrical installations, supported by the Singapore Civil Defence Force (SCDF) for fire safety compliance.

The national code, SS 638 (Code of Practice for Electrical Installations), aligns closely with IEC 60364 requirements. Rooftop PV installations must be supervised by a Licensed Electrical Worker (LEW) and strict compliance is required before grid connection approval.

Singapore's BESS regulations integrate electrical, fire and building codes. Requirements may include:

- Fire-rated enclosures.
- Mechanical ventilation.
- Gas detection systems.
- Emergency shut-off mechanisms.
- Separation distances from occupied spaces.

This integrated model reflects a systems-based approach to safety.

b. Malaysia: Statutory Framework with Professional Accountability.

Malaysia's regulatory regime operates under the Electricity Supply Act 1990 and Electricity Regulations 1994, overseen by the Energy Commission (Suruhanjaya Tenaga). Grid interconnection requirements are governed by Tenaga Nasional Berhad (TNB), while professional accountability rests with the Board of Engineers Malaysia (BEM). Rooftop PV systems must comply with:

- MS IEC 60364-7-712.
- Anti-islanding protection requirements.
- Overcurrent and earth fault protection.
- Proper DC and AC isolation devices.
- Lightning protection where applicable.

Installation works must be undertaken by Registered Electrical Contractors (REC) and supervised by competent persons.

Malaysia's tropical environment necessitates particular attention to surge protection, UV-resistant cabling, corrosion protection and effective earthing systems. For BESS installations, compliance with IEC 62933 and battery management system (BMS) integration is increasingly expected, although detailed residential-level BESS fire codes are still in the process of being developed. Fire safety oversight involves the Fire & Rescue Department (BOMBA), particularly for commercial installations.

c. Thailand. Rapid Deployment with Progressive Standard Enhancement.

Thailand's solar expansion has been substantial, particularly in commercial and industrial sectors. Regulatory oversight is provided by the Energy Regulatory Commission (ERC), along with the Provincial Electricity Authority (PEA) and Metropolitan Electricity Authority (MEA).

Thai Industrial Standards (TIS), largely aligned with IEC standards, govern PV installations. Grid-connected systems must include anti-islanding protection and certified inverters.

Increasing emphasis is placed on:

- Proper grounding and bonding.
- Surge protection due to frequent lightning events.
- Pre-connection inspection and approval.

Thailand is expanding utility-scale BESS installations and progressively incorporating safety measures such as thermal management systems and fire suppression requirements.

Core Electrical Safety Principles Across ASEAN

Despite variations in regulatory maturity, several consistent principles are emerging regionally:

1. Competent Installation and Supervision

Electrical safety is directly linked to professional competency. All reviewed jurisdictions require certified installers or licensed electrical workers.

Engineering design and sign-off remain critical in preventing improper conductor sizing, inadequate protection coordination or non-compliant installations.

2. Effective Isolation & Disconnect Mechanisms

Clear and accessible AC and DC isolators are essential. Emergency responders must be able to de-energise systems quickly. Labelling, signage and circuit identification are not merely administrative details but safety necessities.

3. Surge & Lightning Protection

ASEAN's equatorial climate exposes installations to frequent lightning strikes. Proper bonding, surge protective devices (SPDs) and compliance with IEC 62305 are indispensable.

4. Arc Fault Detection

Arc Fault Circuit Interrupters (AFCIs) are increasingly recognised as critical in rooftop PV installations, particularly for residential systems where early fault detection can prevent fire escalation.

5. Battery Management Systems & Thermal Protection

For BESS installations, intelligent BMS units are central to safety. These monitor cell voltage, temperature and current flow, triggering automatic shutdown when abnormal conditions arise. Adequate ventilation and physical separation further mitigate risk.

Gaps & Emerging Challenges

While progress is evident, ASEAN faces several challenges:

- Uneven enforcement across member states.
- Limited dedicated BESS fire codes for residential installations.
- Inconsistent installer certification frameworks.
- Rapid technology evolution outpacing regulatory updates.



Additionally, as hybrid inverters and smart energy management systems become more common, cybersecurity considerations intersect with electrical safety, adding another dimension to system resilience.

Case for ASEAN Harmonisation

The ASEAN Centre for Energy (ACE) has begun mapping electrical safety regulations across member states, identifying opportunities for regional cooperation. A harmonised ASEAN guideline for rooftop PV and BESS safety will provide:

- Standardised installer competency benchmarks.
- Shared best practices on battery fire mitigation.
- Common technical reference frameworks.
- Improved cross-border knowledge exchange.

Such harmonisation would not replace national regulations but strengthen them through coordinated alignment.

Role of Engineers

Professional engineers bear a central responsibility in safeguarding public safety during the energy transition. Beyond

compliance, engineers must exercise due diligence in:

- Protection coordination studies.
- Thermal risk assessment for battery installations.
- Structural load analysis for rooftop systems.
- Inspection and testing protocols prior to commissioning.

Electrical safety must remain paramount over commercial expediency.

Conclusion

Rooftop PV and BESS installations are transforming ASEAN's energy landscape. Yet, the sustainability of this transformation depends fundamentally on electrical safety integrity. International standards provide the technical foundation, but effective implementation requires competent professionals, regulatory vigilance and continuous capacity building.

Singapore demonstrates structured integration of electrical and fire safety governance. Malaysia combines statutory control with professional oversight. Thailand exemplifies rapid deployment accompanied by strengthening regulatory measures.

As ASEAN advances toward a resilient, decentralised energy future, harmonised safety frameworks and strong engineering leadership will ensure that renewable energy expansion remains not only green but safe, reliable and sustainable. 🌱

Reference

1. International Electrotechnical Commission (IEC). IEC 60364-7-712: Low-Voltage Electrical Installations – Requirements for Special Installations or Locations - Solar Photovoltaic (PV) Power Supply Systems. Geneva: IEC.
2. Energy Regulatory Commission (ERC), Thailand. Regulations for Grid-Connected Solar PV Systems and Interconnection Standards. Bangkok.
3. ASEAN Centre for Energy (ACE). Mapping the Current State of Electrical Safety Regulations in ASEAN: Preliminary Assessment of Electrical Safety Standards and Practices for Solar PV and Battery Energy Storage Systems. Jakarta: ACE.

Dealing with Spent Batteries: Green Industrial Recycling at Crossroads of the Green Economy & E-Waste Management

by
Lim Tau Wee

The global transition toward electrification and digitalisation has gathered extraordinary momentum over the past decade. Electric vehicles are becoming mainstream, renewable energy (RE) systems increasingly rely on battery storage and consumer electronics have become indispensable tools of modern life.

Batteries, particularly lithium-ion batteries, now sit at the core of economic growth, decarbonisation strategies and technological progress. However, while batteries are widely recognised as enablers of the green economy, much less attention has been devoted to the consequences of their end-of-life phase. As deployment accelerates, the volume of spent batteries is rising sharply, presenting an urgent environmental, industrial and engineering challenge that cannot be ignored.

The success of the green transition depends not only on how batteries are produced and used, but also on how they are managed once they reach the end of their service life. Without effective recycling and recovery systems, the rapid expansion of battery usage risks creating a parallel crisis of hazardous waste, undermining the very sustainability goals that electrification seeks to achieve.

Battery usage is expanding across multiple sectors simultaneously. Electric vehicles, ranging from passenger cars and buses to two-wheelers and



delivery fleets, represent one of the fastest-growing sources of large-format batteries. At the same time, micromobility devices such as electric scooters and bicycles rely heavily on compact battery packs. Consumer electronics, including smartphones, laptops, tablets and wearables, continue to proliferate at scale, each containing one or more rechargeable batteries.

Stationary energy storage systems supporting renewable power integration are also adding to the total stock of batteries in circulation. Each of these applications has a finite operational lifespan, after which batteries must be replaced.

As batteries age, degrade, or fail, they become part of an expanding stream of electronic waste. Unlike conventional waste, spent batteries pose unique hazards. They contain flammable electrolytes, toxic metals and residual electrical energy that can lead to fires, chemical leaks and environmental contamination if improperly handled. Landfills and informal recycling operations are particularly vulnerable to battery-related incidents, including fires which are difficult to extinguish and pollution that can persist for decades.

From an environmental perspective, improper disposal of batteries threatens soil, groundwater and air quality. From an economic perspective, it represents a loss of valuable materials that are increasingly scarce and geopolitically sensitive. Modern batteries depend on lithium, cobalt, nickel, manganese, copper and graphite, all of which require energy-intensive extraction processes and carry significant environmental and social costs. Recycling these materials is therefore not merely a waste treatment exercise, but a strategic necessity for resource security and sustainable industrial development.

The concept of battery end-of-life is more nuanced than simple disposal. In many cases, batteries removed from service, particularly from electric vehicles, still retain a significant proportion of their original capacity. These batteries may no longer meet the performance requirements of mobility applications, but they remain suitable for less demanding uses such as stationary energy storage, backup power systems, or rural electrification projects. This concept of second-life deployment extends the useful life of batteries, reduces the immediate volume of waste and improves the overall efficiency of material use across the battery lifecycle.

Eventually, however, all batteries reach a point where reuse is no longer viable and recycling becomes essential. Industrial battery recycling is a complex process that requires careful engineering, strict safety controls and advanced technologies. The diversity of battery chemistries, formats and designs complicates recycling efforts, as different materials and structures require different treatment methods. Nevertheless, several industrial approaches have emerged and continue to evolve.

In the past, high-temperature smelting processes, commonly referred to as pyrometallurgical recycling, was used to recover metals such as cobalt, nickel and copper from spent batteries. While these methods were robust and capable of handling mixed battery streams, they were energy-intensive and often resulted in the loss of lighter elements such as lithium and aluminium. Chemical-based hydrometallurgical processes, which use controlled leaching and precipitation techniques, offer higher recovery rates for a broader range of materials and typically operate at lower temperatures. However, they require careful management of chemicals and wastewater to avoid secondary environmental impacts. More recently, direct recycling approaches have emerged, aiming to preserve battery materials in forms which can be reused with minimal reprocessing. Although promising, these technologies remain at an early stage of commercialisation and face scalability challenges.

Beyond electric vehicles, smaller consumer batteries present an equally significant challenge. Individually, these batteries contain relatively small quantities of material, but collectively they account for a vast volume of waste. Their widespread distribution, lack of standardisation and frequent improper disposal make them a major contributor to battery-related incidents in waste collection and processing facilities. Addressing this segment requires effective collection systems, public awareness and design improvements that facilitate safe disassembly and recycling.

The rapid growth of the green economy has created a fundamental tension between technological advancement and waste management capacity. While policies and investments have focused heavily on promoting electrification and renewable energy, waste management systems have often lagged behind. In many regions, regulatory frameworks, collection infrastructure and recycling capacity have not kept pace with the scale and speed of battery deployment. This disconnect risks shifting environmental burdens from greenhouse gas emissions to waste pollution and resource depletion.

Balancing green economic growth with responsible waste management requires a more integrated approach. Battery design must increasingly account for end-of-life considerations, including ease of disassembly, material transparency and recyclability. Manufacturers and producers play a crucial role through extended producer responsibility mechanisms, which assign responsibility for collection and recycling to those who place batteries on the market. At the same time, informal recycling activities, which are prevalent in many parts of the world, must be addressed through formalisation, improved safety standards and environmental controls.

Engineers occupy a central position in this transition toward a circular battery economy. Process engineers are needed to design recycling systems that maximise material recovery while minimising energy use and emissions. Safety engineers must address the unique hazards associated with spent batteries, developing protocols for discharging, storage, transport and fire suppression.

Automation and digitalisation offer opportunities to improve efficiency and safety through robotic dismantling, intelligent sorting and real-time monitoring. Life-cycle assessment and sustainability analysis, increasingly integral to engineering practice, provide critical insights into the true environmental impacts of different recycling pathways.

Despite growing awareness, significant challenges remain. Regulatory fragmentation across jurisdictions complicates cross-border battery flows and investment decisions. High capital costs limit the deployment of advanced recycling facilities, particularly in developing economies. The lack of standardisation in battery design and insufficient data on battery composition and state of health further constrain recycling efficiency. Addressing these challenges requires coordinated action among policymakers, industry players, engineers and research institutions.

Looking ahead, the future of battery systems must be circular by design. Recycling capacity must expand in parallel with battery deployment, not as an afterthought. Transparency in battery composition and life-cycle data should become standard practice, enabling more efficient recovery and reuse. Engineering education and professional development must incorporate circular economy principles, equipping engineers with the skills needed to design sustainable systems from cradle to grave.

In conclusion, batteries are indispensable to the global transition toward a low-carbon and digitally enabled economy. However, their long-term sustainability depends on how effectively society manages their end-of-life phase. Green industrial recycling offers a pathway to transform battery waste into valuable resources, reduce environmental risks and strengthen economic resilience. Engineers, guided by professional responsibility and technical innovation, have a critical role to play in closing the loop. By addressing the tail end of batteries with the same urgency and ingenuity applied to their deployment, the green economy can move closer to becoming truly sustainable, resilient and circular. 

Reference

1. International Energy Agency (IEA)
2. United Nations Environment Programme (UNEP)
3. International Renewable Energy Agency (IRENA)
4. World Bank Group

Extending UN Decade of Sustainable Energy to 2030: Engineering the Path Towards SDG 7 in ASEAN & Beyond

by
Vindy Teoh Sin Yin



In December 2024, the United Nations General Assembly adopted a resolution to extend the global initiative known as the United Nations Decade of Sustainable Energy for All through 2030. This decision was far more than an administrative extension. It was a clear acknowledgement that the world remained off-track in achieving Sustainable Development Goal 7 (SDG 7: To ensure affordable, reliable, sustainable and modern energy for all) and that intensified, coordinated action was urgently required over the remaining years of the 2030 Agenda.

Energy is not merely one sector among many. It is the backbone of modern civilisation, enabling economic productivity, healthcare delivery, education systems, digital connectivity, industrialisation and climate resilience. The extension of the Decade therefore signals

a renewed political and technical focus on energy as a strategic enabler of sustainable development, placing engineers at the very centre of global and regional transformation.

Why Extension is Necessary

The original UN Decade of Sustainable Energy for All (2014-2024) succeeded in raising awareness, mobilising partnerships and accelerating renewable energy deployment. However, progress across its three core pillars (universal energy access, renewable energy expansion and energy efficiency improvement) had been uneven.

While global access to electricity had improved, hundreds of millions of people still lacked reliable power, particularly in rural and remote areas. Even more concerning was the slow progress on clean cooking, where billions continued to rely on polluting fuels which damaged health and the environment. At the same time, global energy demand continued to rise, driven by population growth, urbanisation, electrification and digitalisation.

The UN resolution extending the Decade through 2030 recognises that technical, financial and institutional barriers remain unresolved and that without renewed momentum, SDG 7 risks becoming one of the goals most severely missed. Aligning the Decade with the SDG timeline ensures that energy remains high on national and regional policy agendas during this critical final stretch.

Engineering at the Core of SDG 7

SDG 7 is often discussed in terms of policy commitments and financing targets, but at its foundation, it is an engineering challenge. Delivering affordable, reliable, sustainable and modern energy requires systems which are technically sound, resilient, safe and scalable. Engineers are responsible for:

- Designing and deploying renewable energy systems such as solar, wind, hydro, geothermal and bioenergy.
- Planning and upgrading power transmission and distribution networks, including smart grids and microgrids.
- Improving energy efficiency across buildings, transport, industry and agriculture.
- Integrating energy storage, digital control systems and demand-side management.
- Ensuring system reliability, safety and cybersecurity amid increasing decentralisation and electrification.

The extension of the Decade reinforces the reality that achieving SDG 7 will not be possible through policy declarations alone. It requires competent engineers, strong institutions and rigorous professional standards to translate ambition into functioning infrastructure.

ASEAN Energy Landscape: Progress & Constraints

The ASEAN region occupies a strategically important position in the global energy transition. With a combined population exceeding 680 million, rapid economic growth and rising energy demand, ASEAN's performance will significantly influence global SDG 7 outcomes.

ASEAN has made notable progress.

- Most ASEAN countries have achieved near-universal electricity access, particularly in urban and peri-urban areas.
- Renewable energy capacity, especially solar photovoltaics and hydropower, has expanded steadily over the past decade.
- Regional cooperation platforms, such as the ASEAN Power Grid, have been established to promote cross-border electricity trade and system resilience.

However, challenges persist.

- Energy systems in many ASEAN countries remain fossil-fuel-dependent, particularly on coal and natural gas.
- Grid infrastructure in rural, island and mountainous areas remains weak or fragmented.
- Renewable energy integration faces technical issues related to intermittency, grid stability and storage.
- Energy efficiency improvements have not kept pace with economic growth, resulting in rising absolute energy consumption.

The UN's extension of the Decade provides ASEAN with a renewed framework to accelerate reforms, modernise infrastructure and close remaining gaps in access and sustainability.

Engineers' Role in ASEAN Energy Transition

In ASEAN countries, engineers are not merely implementers of imported technologies. They are system integrators, adapting solutions to diverse geographic, climatic and socio-economic contexts, from dense megacities to remote islands and rural communities.

Key engineering roles include:

1. Distributed and Decentralised Energy Systems.

ASEAN's geography makes decentralised solutions such as solar mini-grids, hybrid systems and energy-storage-backed microgrids, essential. Engineers design systems which balance affordability, reliability and maintainability for local communities.

2. Grid Modernisation and Regional Interconnection.

The success of the ASEAN Power Grid depends on engineers skilled in high-voltage transmission, grid protection, power electronics and system harmonisation across national borders.

3. Energy Efficiency in Industry and Buildings.

Engineers play a central role in reducing energy intensity through efficient motors, process optimisation, green building design and digital energy management systems.

4. Integrating Digital Technologies.

Smart meters, AI-based forecasting, predictive maintenance and cybersecurity are increasingly critical to modern energy systems. Engineers bridge traditional power engineering with data and control disciplines.

5. Ensuring Safety, Standards and Ethics.

Rapid energy deployment must not compromise public safety, environmental protection, or system reliability. Professional engineers uphold standards, codes and ethical accountability, especially vital during accelerated transitions.

Financing, Policy & Capacity Building

The UN resolution emphasises that international cooperation and financing are indispensable, particularly for developing regions. However, financing alone does not deliver results without technical readiness.

ASEAN countries face a dual challenge:

- Mobilising capital for renewable energy and grid upgrades.
- Building sufficient engineering capacity, regulatory competence and institutional governance to manage complex energy systems.

This highlights the importance of:

- Strengthening engineering education and continuous professional development.
- Recognising professional engineers as strategic contributors to national energy planning.
- Encouraging collaboration between governments, industry, academia and professional bodies.

Engineering institutions in ASEAN can play a pivotal role by aligning professional standards with sustainability goals and supporting engineers to lead innovation responsibly.

Beyond 2030: Building Foundations for Next Era

While the extension of the Decade runs through 2030, its implications extend far beyond. Infrastructure built today will operate for decades. Decisions made during this period will determine whether ASEAN's energy systems remain resilient, inclusive and climate-aligned well into the mid-century.

The UN resolution should therefore be viewed not as a final push, but as a bridge between short-term targets and long-term transformation. Engineers, as custodians of infrastructure and technology, carry a long-term responsibility that transcends political cycles.

Conclusion: Demand for Engineering Leadership

The extension of the UN Decade of Sustainable Energy for All through 2030 is a recognition that the global energy transition is unfinished - and that time is limited. Achieving SDG 7 will require more than ambition as it will require engineering excellence, systems thinking and professional accountability.

For ASEAN, the coming years represent both a challenge and an opportunity: To meet rising energy demand while leapfrogging towards cleaner, smarter and more inclusive systems. Engineers will be central to this journey, not only as problem solvers, but also as leaders shaping the region's sustainable future.

In the end, sustainable energy is not only about megawatts and emissions. It is about enabling human development, strengthening resilience and ensuring that progress is built on sound technical foundations. The extended Decade is a call to action and, for engineers, it is a call to lead. 🏗️

Reference

1. United Nations General Assembly. Resolution on extending the promotion of the United Nations Decade of Sustainable Energy for All beyond 2024 and through 2030. New York: United Nations, December 2024.
2. ASEAN Centre for Energy (ACE). ASEAN Energy Outlook; ASEAN Power Grid studies, regional energy transition strategies.

Just & Inclusive Energy Transition in APAEC 2026-2030 - Powering progress

by
Ng Mary



The Association of South-East Asian Nations (ASEAN) stands at critical crossroads. As one of the world's fastest-growing economic regions, its energy demand is projected to double by 2050.

Historically, this thirst for power was quenched by coal and gas - the twin engines of the region's industrial miracle. However, the climate crisis and global shift toward sustainability have rendered the old model obsolete.

The ASEAN Plan of Action for Energy Cooperation (APAEC) Phase 2026-2030 marks a departure from traditional utility planning. By embedding the Just & Inclusive Energy Transition (JIET) concept, ASEAN has signalled

that the move to renewables is no longer just an environmental imperative but that it is also a social contract. Here, we will delve into the mechanics of JIET, the scenarios that define its necessity and the localised strategies required to ensure that as the region powers up, it does not leave the people behind.

Defining JIET: More Than Just "Going Green"

A Just Transition is often misunderstood as merely replacing a coal plant with a solar farm. In the ASEAN context, JIET is a multidimensional framework that balances decarbonisation, energy security and social equity.

While decarbonisation focuses on carbon molecules, JIET focuses on human lives. It recognises that the energy transition is disruptive. For a worker in a coal mine in East Kalimantan or a thermal power plant in Vietnam, Net Zero can sound like a threat to their family's survival. JIET addresses this transition anxiety by integrating social considerations into the very blueprint of energy policy. It moves from a least-cost engineering approach to a maximum-benefit social approach.

Workforce Scenario: From Black Diamonds to Green Grids

One of the most pressing challenges under APAEC 2026-2030 is the fate of the fossil fuel workforce.

Scenario: Transition of a Coal Town.

Imagine a community in South Sumatra, Indonesia, where 70% of the local economy relies on coal mining. Under a standard transition, the closure of mines leads to a rust belt syndrome: Rising unemployment, migration of youth to cities and the collapse of local businesses.

The JIET Implementation: Instead of an abrupt exit, JIET mandates a Long-term Regional Economic Diversification Plan.

- **Early Intervention.** Five years before a mine closes, the government and private sector establish Green Vocational Hubs.
- **Skill Transferability.** A coal plant technician's knowledge of high-voltage systems and mechanical maintenance is repurposed for the offshore wind sector or geothermal plant operations.
- **Social Protection.** Transition funds provide bridge wages for older workers nearing retirement while offering entrepreneurial grants for younger workers to start eco-tourism or sustainable agriculture ventures on reclaimed mining land.

Energy Access & the Last Mile Challenge

South-East Asia's geography - comprising thousands of islands and rugged mountainous terrain - makes centralised grid expansion expensive and slow. Millions still rely on expensive, polluting diesel generators or have no electricity at all.

The Implementation: Decentralised Renewable Energy (DRE) JIET prioritises Community-Owned Micro-Grids. In remote parts of the Philippines or Myanmar, the transition isn't about shutting down coal; it's about leapfrogging it.

Scenario: A remote fishing village receives a solar-plus-storage micro-grid.

Inclusive Factor. Inclusivity here means the village doesn't just receive the hardware but that the villagers are trained to maintain it. Local women are trained as Solar Mamas (technicians) which provides them with an income stream and ensures the community isn't dependent on distant urban technicians for repair work. This fosters Energy Sovereignty.

Affordability: The Silent Barrier

As ASEAN shifts to renewables, the Green Premium (initial high cost of new technology) risks being passed down to the consumer. For a low-income family in Bangkok or Manila, a 10% increase in electricity tariffs can mean choosing between light and food.

Implementation: Targeted Subsidies and Digitalisation under APAEC 2026-2030, JIET promotes Socially Conscious Pricing.

- **Smart Subsidies.** Instead of blanket subsidies which benefit the wealthy (who use more power), AI-driven data is used to provide targeted rebates to low-income households.
- **Energy Efficiency as Equity.** Governments provide free or subsidised Energy Audits and LED retrofitting for low-income housing, reducing the total volume of energy needed and thereby lowering bills regardless of the per-kWh price.

Gender & Inclusion (GEDSI)

Energy policy has traditionally been a male-dominated field, but energy usage is deeply gendered. In many ASEAN rural households, women are the primary managers of energy for cooking, heating and small-scale home industries.

Scenario: The Clean Cooking Revolution. Switching from wood or charcoal to electric induction stoves or biogas isn't just a carbon play; it's a health and gender play. JIET implementation involves:

- **Health Outcomes:** Reduces indoor air pollution, which disproportionately affects women and children.
- **Time Poverty:** Reduces time spent gathering fuel, allowing women more time for education or income-generating activities.

Regional Mechanism: ASEAN Power Grid (APG)

The APG is the hardware of the transition, a massive undertaking to link the region's power systems. JIET provides the software. When a dam is built in Laos to export hydropower to Singapore, JIET ensures that local communities displaced by the dam are not just compensated monetarily but are made stakeholders in the long-term revenue of the project.

Overcoming Implementation Hurdles

Expanding JIET from a 100-page policy document to 600 million lives requires overcoming three major barriers:

1. The Financing Gap. Green finance often seeks bankable large-scale projects. JIET requires a shift toward Blended Finance, where philanthropic or public funds de-risk smaller, inclusive community projects, making them attractive to private investors.

2. Data Gaps. To be inclusive, one must know who is being excluded. Many ASEAN nations lack Energy Poverty Maps. APAEC 2026-2030 calls for a regional database to track social metrics -not just CO₂ reductions, but Livelihood Improvement Indices.

3. Policy Harmonisation. A Just Transition in Singapore (a high-income service economy) looks very different from one in Cambodia (a developing agricultural economy). ASEAN's challenge is to maintain a unified JIET standard while allowing for National Flexibility.

Conclusion: A Resilient, Unified ASEAN

JIET is not an optional add-on to energy policy; it is the foundation upon which the future of South-East Asia will be built. If the transition is perceived as an elite-driven agenda that raises costs and destroys jobs, it will face a populist backlash which could derail climate goals for decades.

By embedding JIET into APAEC 2026-2030, ASEAN is choosing a different path. It is a path where the Green Silk Road is paved with new opportunities for the marginalised, where the air in Jakarta and Hanoi becomes breathable again and where a worker in a closing coal mine is seen as not a relic of the past, but as a pioneer of a sustainable future.

The transition will be difficult, but by focusing on people-centred planning, ASEAN ensures that the light at the end of the tunnel is bright, clean and most importantly, available to all. 🌱

Reference

1. International Energy Agency (IEA): Southeast Asia Indicators Handbook for Just and Inclusive Transitions (2025).
2. ASEAN Centre for Energy (ACE): A Guide to a Just and Inclusive Energy Transition in ASEAN (2025).

Role of Carbon Data Open Protocol in Modern Carbon Markets: Engineering the Future of Carbon Integrity

by
Yeow Yu Chuan



As Malaysia intensifies its efforts to achieve net-zero emissions by 2050, the engineering fraternity finds itself at the forefront of a dual challenge: Advancing technical innovation while ensuring the integrity of carbon accounting.

Traditionally, engineers have focused on Scopes 1, 2 and 3 emissions - metrics that quantify a firm's environmental footprint. However, a significant gap has persisted in measuring the positive impact of engineering solutions - emissions which are avoided because a cleaner technology has replaced a more carbon-intensive one.

This "missing link" is known as Scope 4 (Avoided Emissions). While conceptually sound, the concept has, historically, been plagued by inconsistent

methodologies and greenwashing concerns. Enter the Carbon Data Open Protocol (CDOP). Launched in late 2025 as a multi-stakeholder voluntary framework, CDOP aims to provide the standardised, open-source data schema necessary to bring transparency to Scope 4 reporting and the voluntary carbon markets (VCM). For Malaysian engineers, CDOP represents more than just a reporting tool; it is a technical standard that validates the climate-positive value of modern engineering design.

Understanding Scope 4: The Engineer's Value Proposition

While Scopes 1-3 measure the carbon we emit, Scope 4 measures the carbon we prevent. For instance, if a Malaysian engineering firm designs

a high-efficiency district cooling system that replaces traditional individual air-conditioning units, the resulting reduction in regional energy demand constitutes “avoided emissions”.

The following are common scenarios for Scope 4 in engineering.

- **Infrastructure:** Developing low-carbon cement which reduces the embodied carbon of a bridge compared to industry-standard materials.
- **Energy:** Implementing AI-driven grid optimisation which allows for higher penetration of intermittent solar power, displacing coal-fired baseload.
- **Transport:** Designing EV charging networks which facilitate the transition away from internal combustion engines.

Despite its potential, Scope 4 has been difficult to quantify because it relies on counterfactual baselines, comparisons against what would have happened if the technology weren’t implemented. Without a standard like CDOP, these baselines are often arbitrary, leading to market scepticism.

CDOP Framework: Standardising Transparency

The Carbon Data Open Protocol (CDOP) addresses the data fragmentation which has hindered the maturity of the carbon market. Developed by a coalition including S&P Global, Sylvera and RMI, CDOP Version 1.0 (2025/2026) provides a harmonised schema across five foundational categories: Location, project details, approach, disclosures and issuances.

1. Open-Source Data Model

For engineers, the most significant aspect of CDOP is its interoperability. Historically, a project developer in Malaysia might have to submit data in five different formats to satisfy various registries and rating agencies. CDOP eliminates this technical overhead by providing a single, open-source baseline. This allows for:

- **Automated Due Diligence.** Enabling investors to use AI tools to scan project data for additionality (proof that the carbon reduction wouldn’t have happened without the project).
- **Simplified Reporting:** Reducing the administrative burden on engineering firms, allowing them to focus on project execution rather than data re-entry.

2. Bringing Integrity to Carbon Credits

The voluntary carbon market has recently faced a crisis of confidence. CDOP seeks to restore this by ensuring that every carbon credit is backed by transparent, verifiable data. By standardising how carbon crediting projects are described (regardless of geography), CDOP ensures that a solar project in Kedah is measured with the same rigour as a reforestation project in Brazil.

Engineering Implementation: Step-by-Step Scenario

To understand how CDOP functions in a real-world engineering context, consider the following implementation scenario for a Smart Industrial Park project in Penang:

Step A: Baseline Establishment (CDOP Approach).

Under CDOP, the engineers must first define a Standardised Baseline. Instead of choosing an arbitrary comparison, the protocol provides data on the average regional grid intensity. The engineers calculate that their integrated microgrid will save 50,000 tonnes of \$CO_2e\$ per year compared to the grid average.

Step B: Data Ingestion and Verification

The project sensors feed real-time energy data into a CDOP-compliant dashboard. Because the data follows the CDOP schema, it is automatically legible to third-party rating agencies. This transparency reduces the risk premium for investors, making the project easier to fund.



Step C: Scope 4 Disclosure

The firm reports these 50,000 tonnes as Scope 4 Avoided Emissions. Crucially, because they followed CDOP protocols, they do not “net” these against their own Scope 1-3 emissions (which would be greenwashing). Instead, they report them as a “comparative climate impact”, showcasing their competitive advantage as a green solution provider.

Challenges & the Road Ahead for Malaysia

While CDOP offers a path forward, several hurdles remain for the Malaysian engineering sector.

- **Green Premium vs. Accuracy.** High-fidelity data collection (IoT sensors, satellite monitoring) can be expensive. However, as CDOP standardises the market, the cost of these technologies is expected to fall.
- **Regulatory Alignment.** The authority will need to decide how voluntary protocols like CDOP interact with Malaysia’s emerging domestic carbon market and carbon tax frameworks.
- **Technical Literacy.** Engineers must move beyond traditional thermodynamics and civil mechanics to become proficient in Carbon Accounting and Life-Cycle Assessment (LCA).

Conclusion: The New Metric of Engineering Excellence

The launch of the Carbon Data Open Protocol (CDOP) represents a pivotal moment in the transition to a low-carbon economy. For too long, the positive impact of engineering innovation was lost in a sea of inconsistent data and vague claims. By standardising Scope 4 and carbon credit reporting, CDOP provides engineers with the language they need to prove their value to a world increasingly concerned with climate integrity.

As we move toward 2030, the hallmark of a “great” engineering project will no longer be just its structural integrity or its cost-efficiency. It will be Data Integrity. By adopting the CDOP protocol, Malaysian engineers can lead the way in building a transparent, high-integrity carbon market which truly rewards those who engineer a better, cleaner world. 🌱

Reference

1. Carbon Data Open Protocol (CDOP) Coalition. (2025). CDOP Version 1.0 Data Schema and Adoption Guidance
2. Greenhouse Gas Protocol (GHGP). (2025). Revised Guidance on Comparative Emissions (Scope 4).
3. Sylvera. (2025). Data Standardisation is Here: How CDOP Benefits Carbon Market Participants.

Grid Code Strengthening Roadmap for ASEAN in the Era of Data Centres: Securing the digital future ultimately begins with securing the grid

by
Teresa Ong Siew Har

Feature

As South-East Asia is entering a defining phase of development. Across the region, digital services are expanding rapidly - from online banking and e-commerce to artificial intelligence (AI), cloud computing and smart manufacturing. Behind all these services lies a critical physical backbone: Data centres.

At the same time, ASEAN is advancing its long-standing vision of a regionally interconnected electricity network known as the ASEAN Power Grid (APG), coordinated under ASEAN. It aims to link national grids, enable cross-border electricity trading and strengthen regional energy security.

These two developments - digital expansion and power grid integration - are converging. And at the centre of this convergence lies an important but often overlooked subject: Grid codes.

Growing Impact of Data Centres on Electricity Systems

Data centres are not ordinary commercial buildings. A large hyperscale facility can consume between 100 and 300 megawatts of electricity - comparable to the demand of a small city. Moreover, data centres operate 24/7, with extremely low tolerance for power interruptions.



Even a short voltage dip or frequency fluctuation can disrupt operations. For financial institutions, cloud services or government systems, such disruptions can have serious economic consequences.

As ASEAN countries attract digital investment, electricity demand patterns are changing. Power systems which were originally designed for conventional industrial loads must now serve highly sensitive, high-density digital infrastructure. This new reality requires stronger technical rules to ensure stability and reliability.

Grid Codes

Grid codes are the technical rules which govern how electricity systems operate. They specify:

- Acceptable voltage and frequency limits.
- How power plants must respond during disturbances.
- Requirements for connecting to the transmission network.
- Protection and safety standards.

In simple terms, grid codes are the “operating manual” for the power system.

Historically, grid codes were designed around conventional power plants such as coal, gas or hydro stations. Today, however, the system is evolving. Renewable energy is expanding. Batteries are being installed. Cross-border interconnections are increasing under the APG and large data centres are emerging as major electricity users. Without updated and harmonised grid codes, the system may struggle to cope with these changes.

Maintaining Frequency Stability in Changing Grid

Electricity systems in ASEAN operate at a frequency of 50 Hz. Frequency must remain stable as otherwise, equipment can malfunction or disconnect automatically.

Traditionally, large spinning generators helped stabilise frequency. But renewable energy sources such as solar and wind do not naturally provide the same stabilising effect. As renewable penetration increases, the system can become more sensitive to sudden imbalances. If a large generator trips or a major load disconnects, frequency may change rapidly. In a regionally interconnected grid, such disturbances can spread across borders. Stronger grid codes should therefore require:

- Faster response from renewable plants and battery systems.
- Clear standards for frequency ride-through capability.
- Coordinated frequency control parameters across ASEAN countries.

Such measures help ensure that the APG enhances resilience rather than increasing vulnerability.

Ensuring Voltage Stability & Power Quality

Voltage stability is equally important. Data centres use advanced electronic equipment, including uninterruptible power supplies (UPS) and power converters. These can introduce electrical distortions known as harmonics. If harmonics are not properly managed, they may:

- Overheat transformers.
- Interfere with protection systems.
- Reduce equipment lifespan.

Grid codes should therefore include:

- Clear limits on voltage distortion.
- Mandatory harmonic studies for large connections.
- Continuous power quality monitoring.
- Proper filtering requirements.

International standards from bodies such as the International Electrotechnical Commission provide useful reference frameworks that ASEAN countries can adopt or adapt.

Special Provisions for Large Digital Loads - Regional Harmonisation

Traditionally, grid codes focused mainly on generators. However, in today’s digital economy, very large electricity consumers also influence system stability. Data centres, because of their size and sensitivity, should be subject to clear connection requirements. These may include:

- The ability to remain connected during short disturbances.
- Participation in demand response programmes.
- Coordination of backup generation systems.
- Compliance with cybersecurity and communication standards.

Advanced power systems, such as those operated by California ISO, already incorporate mechanisms for large loads to contribute to grid stability. ASEAN can progressively introduce similar practices suited to regional conditions.



Because the APG connects multiple countries, inconsistent technical standards can create operational risks. For example, if one country allows wider frequency deviations than its neighbour, or if protection systems are not aligned, disturbances may propagate across borders. A harmonised framework should therefore establish the following:

- Common baseline frequency and voltage tolerances.
- Coordinated protection philosophies.
- Shared emergency response procedures.
- Regular joint system studies and simulation exercises.

Such coordination strengthens trust and reliability within the regional network.

Role of Engineers

Engineers play a crucial role in this transition. They study how the power system behaves under stress, design protection systems, assess power quality impacts and draft practical technical standards. Their expertise ensures that policy ambitions are translated into safe, workable technical rules.

By conducting stability studies, reviewing connection applications and implementing monitoring systems, engineers help maintain the delicate balance between innovation and

reliability. In the era of digital transformation, their work becomes even more vital in safeguarding both electricity supply and economic stability.

The Way Forward

Strengthening grid codes across ASEAN will require phased implementation. Initial steps should include regional technical studies, establishment of harmonisation taskforces and publication of updated guidelines which address renewable energy and large digital loads.

Subsequent phases may involve deploying advanced monitoring technologies, enhancing cybersecurity standards and conducting coordinated cross-border stress tests. Over time, these measures will support smoother electricity trading, higher renewable energy penetration and increased investor confidence.

Conclusion

The digital economy runs on electricity. As South-East Asia expands its data centre footprint and advances the APG, the importance of robust and harmonised grid codes cannot be overstated.

Stronger grid rules will help prevent blackouts, support renewable integration and ensure stable power for critical digital infrastructure. In doing so, ASEAN will position itself as not only a growing digital hub but also as a region with reliable, resilient and forward-looking energy systems. 🌱

Reference

1. Association of Southeast Asian Nations (ASEAN). ASEAN Power Grid initiative framework and regional energy cooperation strategy.
2. International Electrotechnical Commission (IEC). Standards on grid interconnection, power quality and communication protocols (IEC 61850 series).
3. National Grid ESO (UK). Frequency response and grid code reform in low-inertia systems.
4. California ISO (USA). Flexible ramping products and load participation mechanisms in modern grids.

Do You Know?

Engineering Energy Transition

by
Pang Soo Mooi

Spark of a New Era: The Birth of Public Electricity - IEEE Global History Network.

The modern world was effectively “switched on” in 1882 with the commissioning of the Pearl Street Station in New York City. Conceived by Thomas Edison, this landmark facility served as the world’s first central power station designed for public electricity distribution.

Operating on a 110-volt Direct Current (DC) system, it initially powered a modest network of 59 customers using roughly 400 incandescent lamps. While revolutionary, Edison’s DC system faced a significant hurdle: It could only transmit power over short distances due to massive energy loss.

As Edison lit up Manhattan, a parallel revolution was unfolding in Europe. Pioneers such as Werner von Siemens and Sebastian Zilla de Ferranti began championing Alternating Current (AC). Unlike DC, AC allowed electricity to be stepped up to high voltages, enabling efficient long-distance transmission from remote power plants to growing urban centres.



This transition from localised mechanical power to a distributed electrical grid, fundamentally reshaped society. It gave rise to the modern engineering profession and specialised regulatory bodies to manage the inherent risks of high-voltage systems. Beyond technicalities, it birthed a new social landscape. Night illumination extended the human day, while mechanised industry decoupled production from the constraints of daylight and manual labour.

The Earth is a Giant Battery: UNESCO & International Geothermal Association (IGA)

We often think of energy as something we must actively generate through combustion or harvesting, but we are actually living on top of a massive, self-sustaining heat engine. The centre of the Earth is a realm of extreme physics, reaching temperatures of roughly 5,200°C, a heat intensity nearly identical to the surface of the Sun. This immense thermal reservoir makes our planet less of a cold rock and more of a colossal, “charged battery”.

A fascinating engineering reality is that this heat is not merely a leftover from the planet’s violent birth. Approximately 50% of the Earth’s internal heat is being continuously generated by a “natural nuclear reactor” deep within.



This occurs through the radioactive decay of isotopes such as potassium-40, uranium-238 and thorium-232, found in the crust and mantle. This decay releases a constant stream of subatomic energy, ensuring the Earth's core remains molten and active.

From an engineering and geological perspective, this heat flux is so powerful that it drives the movement of tectonic plates, the formation of mountain ranges and volcanic activity. Humans are essentially riding on a slow-motion explosion of thermal energy. By tapping into this “battery” through geothermal engineering, we can harvest steam and hot water to drive turbines, providing a baseload renewable energy source that, unlike solar or wind, operates 24 hours a day, regardless of weather conditions.

Cow Dung: Traditional & Modern Energy Source

Cow dung has been a source of fuel for centuries in agrarian societies. Traditionally dried into patties, it served as a dependable cooking fuel long before electricity or gas reached rural villages. The benefits were straightforward:

Dung was abundant, cost-free and accessible, especially in cattle-rearing communities across South Asia and Africa. However, direct burning produced smoke and particulate matter, which led to health and environmental concerns.

Modern engineering transformed this age-old practice with anaerobic digesters that convert cow dung into biogas, a methane-rich fuel. Farms and rural homes across India and beyond now use these digesters to generate clean fuel for cooking, heating and even electricity generation. The leftover effluent, known as slurry, serves as organic fertiliser, enhancing soil health. As an energy resource, cow dung embodies the principle of circular economy: Converting waste into usable energy while providing environmental and social benefits.

History of Power in Malaysia: From Tin Mines to a National Grid

The story of electricity in Malaysia did not begin with streetlights, but with tin mining. In 1894, the first recorded use of electricity in Malaya took place at a mine in Rawang, operated by Loke Yew and Thamboosamy Pillay. They installed a small generator to power their mines and the surrounding town, making Rawang the first town in the country to enjoy electric light.

The real turning point for public infrastructure came in 1900, with the commissioning of the Sempam Hydroelectric Power Station in Pahang. This was a monumental engineering feat at the time and was built to supply power to the Raub Australian Gold Mine. By 1905, the first urban power station, the Ulu Langat Hydroelectric Station, began supplying electricity to Kuala Lumpur, eventually leading to the formation of the Central Electricity Board (CEB) in 1949.

This rapid expansion from isolated private generators to a nationwide National Grid necessitated a high standard of professional governance. Today, what started as a few lightbulbs in a Rawang mine had evolved into a sophisticated energy landscape, powering a modern industrial nation and setting the stage for the transition to renewable energy.

Rise of Piezoelectric Energy: JR East

Piezoelectric tiles are innovative flooring systems which generate electricity from mechanical pressure such as footsteps or vehicle movement, using the piezoelectric effect -the ability of certain materials (like PZT or PVDF) to produce electric charge when stressed. These tiles are designed with embedded piezoelectric elements beneath durable surfaces, converting human motion into usable power for low-energy applications such as LED lighting, digital displays or sensors.

A notable example is the Tokyo Shibuya Station, where piezoelectric floor mats have been installed to harvest energy from thousands of daily commuters. The electricity produced is used to power nearby information displays and lighting, showcasing a practical form of energy harvesting in high-footfall environments.

The technology offers advantages in sustainability and smart city infrastructure by capturing otherwise wasted kinetic energy. However, current limitations include low energy output per tile, high installation costs and durability concerns under continuous stress.

Ongoing research focuses on lead-free ceramics, optimised bending designs and IoT integration to improve performance. With future advancements and cost reductions, piezoelectric tiles can become integral to green building projects, complementing solar or other renewable systems to create smarter, energy-efficient urban environments.



History of Electrical Inspectors: Safeguarding the Innovation - Institution of Engineering & Technology (IET)

In the late 19th century, the War of Currents between Thomas Edison's DC and Nikola Tesla's AC systems brought electricity to the public at an explosive pace. However, this rapid adoption was chaotic; there were no standardised colours for wires, grounding was non-existent and insulation often consisted of flammable cloth or paper. By the early 1880s, high-profile electrical fires - including 65 fires caused by electric lighting in a single year in New York City - forced a realisation: Electricity was a wild force which required professional oversight.

Electric inspector first emerged from, not the government but from insurance companies. In 1881, fire underwriters in New York began hiring experts to inspect Edison's installations to protect their financial interests. This led to the publication of the first set of rules for electric wiring in 1882 by the Institution of Electrical Engineers (IEE) in the UK and the National Board of Fire Underwriters in the US.

As the profession formalised, organisations such as the International Association of Electrical Inspectors (IAEI), founded in 1928, were established to unify these rules. These inspectors became the Authority Having Jurisdiction (AHJ) and were tasked with a critical mission: To review blueprints, to investigate electrical accidents and to certify that an installation was safe for human occupancy.

World's First Hydroelectric Power Plants

The origin of hydroelectric power extends far back into history, but its transition into electricity generation began in earnest in the late 19th century. One of the earliest hydroelectric plants was installed at the Fox River in Appleton, Wisconsin, in 1882. Flowing water turned turbines which powered electrical generators, bringing reliable power to nearby homes and businesses - often before larger thermal stations were built.



Countries with abundant mountain rivers such as Norway, Switzerland and later Italy and Canada, soon adopted hydroelectric systems, recognising their ability to provide clean, renewable energy long before the era of fossil fuel concerns. Hydroelectric power rapidly became the backbone of industrial and urban electrification in many regions, valued for its renewability, low operating cost and relative environmental cleanliness compared to coal or oil.

Over time, hydroelectric power evolved from small local plants to massive dams such as the Hoover Dam in the US and the Aswan High Dam in Egypt. Today's systems include pumped-storage schemes which balance grid variability, making hydroelectric power both a historical pioneer and a modern energy stabiliser.

Jatropha as biofuel: The Plant That Promised a Revolution

Jatropha curcas emerged on the global stage as a potential biofuel crop capable of growing on marginal lands unsuitable for food cultivation. Its seeds contain an oil which can be refined into biodiesel, making it attractive for rural energy initiatives and efforts to reduce fossil fuel dependence. Governments and private ventures in Asia, Africa and Latin America invested in large *Jatropha* plantations in the early 2000s, viewing the crop as an alternative fuel source that was environmentally friendly.

However, commercial results varied widely. *Jatropha* often required more water and soil nutrients than expected, yields were inconsistent and economic viability proved elusive at scale. Nonetheless, the plant sparked valuable research into drought-tolerant crops and hybrid strains, pushing scientists to explore agricultural energy solutions beyond conventional feedstocks like palm or sugarcane.

Today, *Jatropha* is more commonly seen in community-level projects and research settings rather than large commercial biofuel operations. Its story serves as a cautionary yet inspiring chapter in renewable energy development - showing both the potential of unconventional biomass and the complexities of translating agricultural promise into sustainable energy output.



Ingenious Bottle Lamp on the Roof: Daylight in a Plastic Bottle

In the early 2000s, communities in the Philippines and parts of rural Asia rediscovered a remarkably simple but powerful idea: Using a plastic bottle filled with clear water and bleach to illuminate homes. By inserting the bottle through a roof sheet, half above and half below the ceiling, sunlight refracts through the water and diffuses into the room below. This creates the power equivalent of a 40-60 watt lightbulb but without using electricity.



Known as the Litre of Light movement, the system proved transformative for low-income households with limited access to power. The engineering behind it is rooted in basic optics: Water refracts incoming sunlight in all directions, while the plastic casing acts like a prism. The result is bright, evenly distributed illumination.

Its success inspired a wave of energy-saving innovations in the developing world. While it cannot replace electric lighting at night, its daytime contribution reduces electricity use, cuts costs and improves quality of life.

Stratosphere Airborne Wind Energy System (SAWES): Power from High-Altitude Winds - Global Times

As the world seeks cleaner and more reliable renewable energy sources, the Stratosphere Airborne Wind Energy System (SAWES) offers a bold new approach to wind power generation. SAWES captures stronger and steadier winds found at high altitudes - typically between 1,500m and 2,000m above ground.

Unlike conventional wind turbines mounted on tall steel towers, SAWES uses a helium-filled airborne platform resembling a large airship. The buoyant structure lifts multiple turbine generators into high-altitude wind streams, where wind speeds are significantly higher and more consistent than near the surface.

Electricity is generated as onboard turbines rotate in the strong stratospheric winds. The power produced is transmitted to the ground through a tether cable, which also anchors and stabilises the airborne system. This dual-purpose tether carries electrical conductors as well as structural reinforcement.

Two notable prototypes include the S1500 (around 1 MW capacity) and the larger S2000, which aims for multi-megawatt generation. Early tests have demonstrated promising performance, suggesting that airborne wind systems may complement traditional onshore and offshore wind farms.

If successfully commercialised, SAWES technology can reduce the need for heavy foundations, enable deployment in remote areas and expand the renewable energy landscape by literally tapping into a higher level of the wind resource.

Solar Energy in its Earliest Form - Mirrors & Sunlight

Long before modern solar panels captured headlines, ancient civilisations recognised the sun's potential as a source of useful energy. Greek and Roman engineers used polished bronze mirrors to concentrate sunlight, achieving heating and even fire starting for ceremonial purposes. These practices demonstrated an intuitive understanding of optics and solar concentration long before photovoltaic (PV) technology existed.

Today's concentrated solar power (CSP) plants are built on that principle, using mirrors or lenses to focus sunlight onto receivers which collect heat. That thermal energy then drives



steam turbines to generate electricity much like a conventional power station, but with zero carbon emissions. Modern CSP systems can also incorporate thermal storage, allowing power generation even after sunset.

This deep history underscores human's long fascination with capturing sunlight. From simple polished mirrors to complex CSP arrays and PV farms, the fundamental idea remains consistent: The sun provides an abundant, renewable source of energy which, with appropriate engineering, can power homes, industries and entire cities.

Why Asean's coal promises keep colliding with reality - Eco Business

South-East Asian countries have struggled to keep their promises to reduce coal use in their energy mix. High-level commitments must be translated into enforceable roadmaps and private demand unlocked to accelerate clean energy investments.

The year 2024 marked a record high in coal use with an interesting pattern of 1% increase in global coal demand, 1% increase in global coal power capacity and 1% increase in energy-related CO₂ emissions. Despite years of climate summits and international commitments, these statistics strongly remind us how the world still relies on coal.

Asia, including South-East Asia, holds the heart of coal's resilience. Coal currently powers 37% of Asean's total energy generation. A recent report from the Asean Centre for Energy shows that among the most coal-dependent economies - Indonesia (67%), the Philippines (63%), Vietnam (49%) and Malaysia (43%) - a clear pattern has emerged over recent years: The coal transition is underway, but the path forward remains complex and uneven.

Asean's coal transition will be judged, not by new pledges but by whether governments can break free from the cycle of policy ambiguity, economic dependence and financial inertia. Asean must turn its fastest-growing sectors such as data centres, smelters and industrial parks into engines of clean energy demand rather than drivers of new coal. Coal plants will remain in pipeline operation because sunk costs, long-term contracts and cheap financing keep them viable. Therefore, the economics of coal also need to be fundamentally reshaped through smarter financing. 



Melbourne Kokoda Memorial Walk: Engineering, Memory & Spirit of Kokoda Trail

by
Chin Siew Yin

Tucked into the lush foothills of the Dandenong Ranges National Park in Victoria, Australia, the Melbourne Kokoda Memorial Walk, popularly known as the 1,000 Steps, stands as a living tribute to the courage, resilience and mateship of the Australian soldiers who fought along the original Kokoda Trail in 1942.

Far more than a fitness destination, the walk is a thoughtfully designed landscape which invites modern visitors to reflect on the challenges of the Papua New Guinea campaign, even as they ascend a forested slope that echoes the terrain of one of Australia's defining battles in the Second World War.

I was amazed by the historical origin, design and engineering, the memorial plaques link to the Kokoda campaign and how the trail structure mimics the experience of the Papua New Guinea landscape, albeit on a much smaller scale. It also considers that the site fosters appreciation of endurance and remembrance, for the public in general and engineers in particular, which value the intersection of public infrastructure, heritage and symbolism.

Historical Origins: From Tree Fern Trunks to Concrete Steps

Long before the Melbourne Kokoda Memorial Walk became a commemorative destination, the area was part of a working forest and popular walking ground for outdoor enthusiasts. In the early 1900s, the original pathway up the steep hill was made using local tree fern trunks, laid



*Entrance to Dandenong Melbourne
Kokoda Track Memorial Walk.*

to form rustic steps for bushwalkers navigating the rugged terrain. These early steps were rough, uneven and deeply rooted in the natural materials of the forest, just as the original Kokoda Trail was carved in the mountainous jungles of Papua New Guinea.



Left: Beginning of the trail. Right: Dandenong range.

It wasn't until the post-war period, around 1950, that the pathway began to take on a more permanent and formal structure. Concrete blocks replaced the tree fern logs, creating durable steps capable of sustaining heavy foot traffic and the growing number of bushwalkers. Over time, the site became known affectionately as the 1,000 Steps, a name that captured both its physical challenge and its symbolic representation of the long and arduous Kokoda Track, which stretched hundreds of kilometres through rugged hill country.

In the early 21st century, local community groups and veteran organisations championed the installation of memorial plaques along the trail, each dedicated to units and individuals of the Australian Military Forces who served during the Kokoda campaign from 23 July to 13 November 1942, a period marked by strategic defensive battles, immense fatigue and steadfast determination. These plaques transformed the site from a recreational walk into a memorial and educational landscape, where every step invites reflection on sacrifice and service.

Engineering the Climb: Design and Symbolism

For engineers and planners, the Melbourne Kokoda Memorial Walk is a compelling case study in landscape design, trail engineering

and heritage interpretation. The original steps, fashioned from tree fern trunks, represented a practical response to a steep gradient in a forest environment. Tree ferns were abundant, relatively easy to position and they provided natural traction for walkers.

With the introduction of concrete blocks in the mid-20th century, the pathway gained durability and consistency, allowing more people to access the steep hillside safely. Concrete allowed engineers to create uniform risers and treads which could withstand erosion, roots and heavy usage, while still harmonising with the forest setting. Drainage channels were integrated to manage stormwater, prevent washing out of steps and protect the slope from excessive degradation.

Today's trail blends functionality with commemoration. Carefully placed retaining structures, erosion-resistant surfaces and well-designed seats ensure the safety and comfort of walkers. Yet each pull-out, each resting bench and each viewpoint is also a moment of pause, a chance to consider the significance of what is being remembered.

While the original Kokoda Trail in Papua New Guinea covers approximately 96kms of varied terrain - from coastal plains to mountain passes rising over 2,000m - the Melbourne Kokoda Memorial Walk presents a condensed symbolic ascent.

The climb to the top of the 1,000 Steps is only about 1.2-1.5km but its steep gradient and consistent rise in elevation evoke the sense of uphill struggles familiar to those who study or reflect on the Kokoda campaign.

Each section of the walk has been intentionally designed so that as one climbs, the experience shifts in tone and focus - just as the original Kokoda Track had taken soldiers from relative flatlands into dense jungle and steep ravines. Engineers and landscape architects used the natural features of the Dandenong Ranges - including rock outcrops, tree cover and varying slopes - to vary the walking experience.

Lower sections are wide and open, reminiscent of the early convenience of coastal tracks. Mid-sections tighten and steepen beneath dense ferns, conjuring the jungle-like conditions of Imita Ridge while upper sections level out slightly near seating and plaques, offering space for reflection akin to the rest points troops would have sought along the PNG track.

Plaques & Storytelling: Linking Melbourne to Kokoda

One of the most powerful elements of the walk is the set of memorial plaques placed at intervals along the way. Each plaque bears the name of a unit or significant figure from the Kokoda campaign, accompanied by concise interpretive text explaining their role. As walkers ascend, the chronological and thematic placement of plaques create a loose narrative experience, moving from initial engagements and turning points to eventual withdrawal and regrouping.

This design approach is vital. It transforms the trail from a physically demanding climb into a story landscape where participants are continually reminded of the historical context. In doing so, the trail becomes a learning space, a place where discipline, sacrifice and perseverance can be appreciated not only through words, but through embodied movement.

For example, lower plaques focus on the first defensive and delaying actions, when Australian infantry units faced advancing Japanese forces.

Mid-trail plaques highlight key battles around villages and ridges, especially where terrain played a decisive role. Higher plaques near the summit speak more of the endurance and strategic withdrawal which eventually contributed to turning the tide of the campaign.

Engineers and planners will appreciate how the placement of these plaques considers sightlines, rest points and walking fatigue. By aligning remembrances with physical moments of challenge - after steep steps, at scenic overlooks or before difficult sections - the design subtly ties the walkers' physical experience to the emotional and historical weight of the story being told.



Plaque depicting the topography of the Kokoda Trail with a brief description of the trail (23 July–13 Nov 1942)



Plaque with the inscription, 'The concrete structure work for the Kokoda Plaques Walk was performed by the soldiers of the 39 Electrical & Mechanical Squadron Corps of Engineers, Royal Australian Army Reserve on the 17th of January 1998 and is in memory of a past generation of Australian soldiers who served their country in war.'



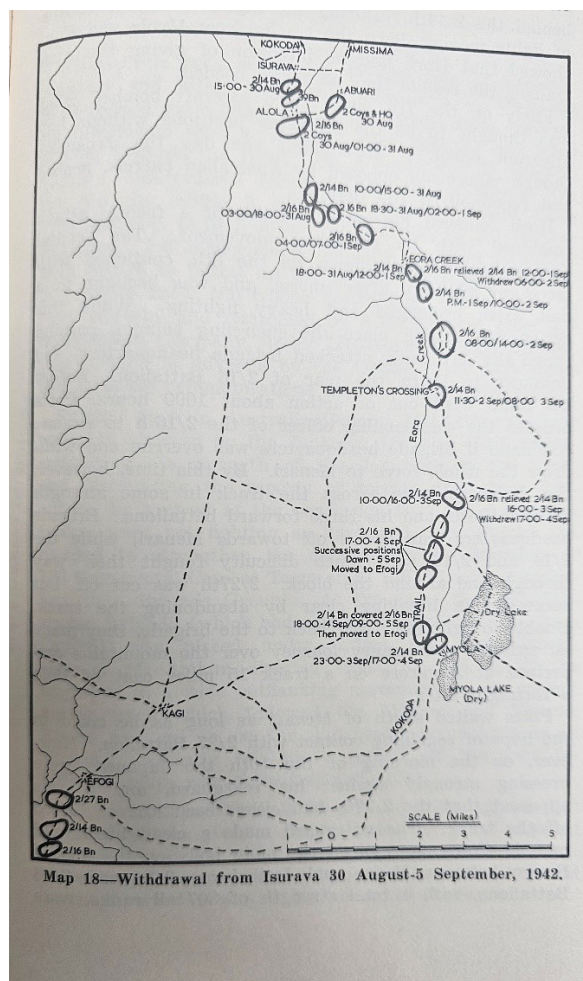
Plaque denoting the Ower's corner as the start of the actual Kokoda Trail. It was from here that Australian soldiers caught their first glimpse of the daunting Ower Stanley mountain range. The Japanese army advanced across these mountains and halted only when it reached Ioribaiwa Ridge, 9km away.



Another mid-way plaque describing Templeton's Crossing, named after an Australian officer killed at Oivi on 26 July 1942. On 3 September 1942, the Japanese captured Templeton's Crossing while in close pursuit of the Australians. From here the Australians fell back steadily. Nearby they abandoned the air dropping zone at Myola and only found a secure defensive position at Bridge Hill just south of Efoi.

Kokoda Campaign: Endurance, Terrain & Local Support

The Kokoda campaign of 1942 remains one of the most studied and commemorated episodes of Australian military history. At its core was the battle to defend Port Moresby, a strategic town on the southern coast of Papua New Guinea, after Japanese forces attempted to capture it, threatening the Allied control of the South Pacific.



Map of the actual Kokoda Trail.

Because the Japanese landed on the island's northern coast and moved south along the Kokoda Track toward Port Moresby, Australian forces had no option of attacking directly from the south. Instead, they were forced to advance from the opposite end of enemy before they could reach the town. The island's rugged mountain spine, lack of roads and Japanese naval and air dominance made any large-scale flanking or seaborne counter-attack impractical, forcing the campaign into a gruelling overland struggle through the Owen Stanley Range.

The campaign took place from July to November 1942, with intense combat occurring in extremely challenging conditions such as steep, muddy slopes, dense tropical vegetation, unpredictable weather and minimal infrastructure.

Australian soldiers, many of whom had limited jungle experience and were often young recruits, found themselves fighting in an environment for which few training manuals could fully prepare them. Marching up narrow ridges, crossing swollen rivers and navigating thick vines and mud became the daily reality. Engineering units, improvised porters and local Papuan carriers played crucial roles in moving supplies and stabilising tracks under fire and in poor conditions.

It is here that the Melbourne Kokoda Memorial Walk finds deep resonance. While the physical distance and overall terrain differ vastly from PNG's mountain ridges, the notion of steady, effortful gain and the mix of challenge and companionship, echoes the historical experience. Each of the 1,000 Steps symbolises a fragment of what the Kokoda soldiers and support personnel faced - if on a fractionally smaller scale - and invites reflection on what endurance, determination and mutual support look like in both war and peace.

In Papua New Guinea, local villagers and carriers (often called Fuzzy Wuzzy Angels) offered indispensable support. They guided troops along narrow paths, carried wounded soldiers and provided food and encouragement even when resources

were scarce. Their contribution is now widely recognised as a crucial part of the campaign's human story, a reminder that conflict environments are shaped by the courage and care of many, not just combatants.

On the Melbourne walk, this broader human dimension is echoed in the communal culture of the trail. Walkers often assist one another, offering encouragement, sharing water and helping less experienced climbers. This way, the site becomes not simply a place of individual fitness, but a living memorial to shared effort and mutual aid, a principle deeply rooted in the Kokoda legacy.



Members of the 2/1st, 2/2nd and 2/3rd Australian Infantry Battalions, comprising the 16th Australian Infantry Brigade, moving along the Kokoda Trail across the Owen Stanley Ranges.



Local villager assisting a wounded Australian soldier from the war zone.



Local villagers carrying a wounded Australian soldier on a stretcher across the river.



A monument and plaques showing the fallen soldiers who died along the Kokoda Trail.

Reflections for Engineers and Planners

The Melbourne Kokoda Memorial Walk offers rich material for reflection. It bridges technical design, public space utility and heritage interpretation in a way that honours history while serving contemporary community needs. Key lessons include:

- **Blending Structure with Landscape.** Using local materials (initially tree fern trunks) and durable modern materials (concrete blocks) demonstrates how infrastructure can respectfully integrate with natural environments.
- **Narrative Through Design.** The arrangement of plaques and resting points highlights how storytelling can be embedded in the built environment, so that physical movement resonates with historical meaning.
- **Accessibility and Durability.** Thoughtful engineering ensures safety and longevity in a public trail, accommodating diverse users while preserving natural features and managing erosion.
- **Commemoration as Engagement.** Heritage sites can be designed not only for remembrance but also for active participation, allowing visitors to engage physically and mentally with history.

Conclusion

The Melbourne Kokoda Memorial Walk is more than just a steep climb of steps through a Victorian forest. It is a living tribute to the endurance and spirit of Australians who had served on the Kokoda Trail as well as a remarkable fusion of engineering, landscape and memory. For engineers, planners and heritage professionals, it offers a model of how physical infrastructure can do more than connect points on a map: It can connect people with history, challenge with reflection and landscape with legacy.

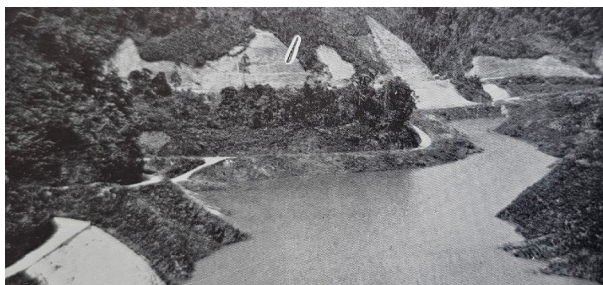
Climbing 1,000 Steps today is a reminder of not only physical resilience, but also of the deeper human values which bind us across time: Courage, camaraderie and respect for those who walked hard paths before us. 🇦🇺

Reference

1. Parks Victoria. (n.d.). Dandenong Ranges National Park: Kokoda Track Memorial Walk (1000 Steps). Victoria State Government.
2. Victorian Heritage Database. (2014). Kokoda Track Memorial Walk, Dandenong Ranges National Park. Heritage Council Victoria.
3. The Mt. Dandenong & District Historical Society: This local group was instrumental in installing the 14 memorial plaques along the trail that depict the history of the campaign.
4. Mount Dandenong & District Historical Society.
5. From Tree Ferns to Concrete: A History of the 1000 Steps as source for the early 1900s engineering transitions.

Ringlet to Habu, Cameron Highlands Road Construction, 1962

by
Cheo Hong Keyong



The newly completed Ringlet - Habu Cameron Highlands road improvement in 1962.



The new completed Sungai Bertam Bridge, Cameron Highlands in 1962.

Access to the Cameron Highlands plateau was progressively improved from the 1920s and 1930s as tea and vegetable plantations expanded and the area became a tourist destination. By the post-war period, the Public Works Department (PWD, now JKR) was carrying out systematic upgrades to the Tapah-Ringlet-Tanah Rata corridor and to feeder links into plantation settlements such as Habu to support agriculture, tourism and emerging hydro-electric and water-supply works in the area.

PWD undertook road improvement works in Cameron Highlands in the early 1960s. These included alignment improvements, earthworks on steep slopes, drainage and retaining works to reduce landslide risk and the construction of short to medium-span bridges to replace older timber or masonry crossings. Contemporary JKR/engineering bulletins and later JKR district publications record major slope-stability and road-upgrade activity from the early 1960s.

The early 1960s was the period when prestressed concrete bridge technology became established in Malaysia for economical, durable short- and medium-span bridges. Standard precast and prestressed beams were adopted in Malaysia in the 1950s/60s and became a routine choice for highway bridges in the 1960s/70s. Naturally, PWD's bridge works on new and upgraded hill-access routes (including the Ringlet to Habu link) used prestressed beam solutions where site constraints and span lengths were favourable.

The two prestressed-concrete bridges were as part of the Ringlet-Habu improvements carried out by PWD in the early-1960s. These bridges replaced earlier, less durable crossings and were designed as simply-supported prestressed beam spans appropriate to short mountain streams and valley crossings typical of the plateau approaches. The choice of prestressing reduced on-site casting, shortened construction time in difficult terrain and delivered the durability needed for a sub-tropical, high-rainfall environment.

The Ringlet-Habu alignment traverses steep, weathered slopes with intensive rainfall and shallow soils. Since the 1960s, the area had been a known landslide hotspot, so slope-stability monitoring and repeated remedial works had been necessary for decades.

Publicly available web sources provide good context (JKR bulletins, engineering presentations and contemporary newspaper references) but do not routinely publish original 1962 contract documents, as-built drawings or PWD site reports online. Those interested in primary archival material (as-built drawings, specifications, contractor names, tender documents and inspection reports) may consult: PWD Annual Report, 1962. 

Reference

1. Annual Report of PUBLIC WORKS DEPARTMENT for 1962.

KYODO PIPE STANDARD GALVANISED STEEL CONDUIT



BS 31 CLASS B (SCREWED) / MANUFACTURER'S STANDARD

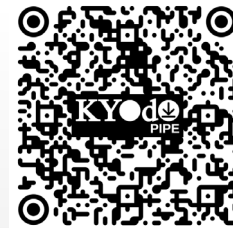
NOMINAL SIZE	OUTSIDE DIAMETER				WALL THICKNESS				CALCULATED WEIGHT WITH COUPLER			NUMBERS OF THREADS	LENGTH OF THREADS			
	MINIMUM		MAXIMUM		MINIMUM		MAXIMUM						MINIMUM		MAXIMUM	
in	mm	in	mm	in	mm	in	mm	in	kg/m	kg/ft	lb/ft	PER INCH	mm	in	mm	in
¾	18.76	0.7387	19.05	0.7500	1.52	0.060	1.63	0.064	0.713	0.217	0.479	16	12.70	0.5000	14.29	0.5625
1	25.11	0.9887	25.40	1.0000	1.52	0.060	1.63	0.064	0.972	0.296	0.653	16	15.88	0.6259	17.46	0.6875
1¼	31.46	1.2387	31.75	1.2500	1.52	0.060	1.63	0.064	1.240	0.376	0.830	16	17.46	0.6875	19.05	0.7500
1½	37.80	1.4880	38.10	1.5000	1.73	0.068	1.83	0.072	1.680	0.511	1.130	14	19.05	0.7500	20.64	0.8125
2	50.50	1.9880	50.80	2.0000	1.93	0.076	2.03	0.080	2.510	0.765	1.690	14	22.23	0.8750	23.81	0.9375

MS 275 / BS 4568 CLASS 3 (SCREWED) / MANUFACTURER'S STANDARD

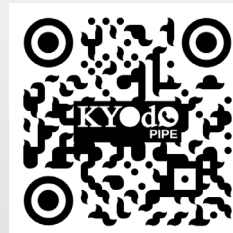
NOMINAL SIZE	OUTSIDE DIAMETER		WALL THICKNESS	CALCULATED WEIGHT WITH COUPLER		PITCH	LENGTH OF THREADS	
	MINIMUM	MAXIMUM		MINIMUM	MAXIMUM		MINIMUM	MAXIMUM
mm	mm	mm	mm	kg/m	kg/m	mm	mm	mm
20	19.7	20.0	1.6 ± 0.15	0.643	0.783	1.5	13	15
25	24.6	25.0	1.6 ± 0.15	0.811	0.995	1.5	16	18
32	31.6	32.0	1.6 ± 0.15	1.069	1.301	1.5	18	20

MS IEC 61386-1 / MS 61386-21 CONDUIT SYSTEM FOR CABLE MANAGEMENT

NOMINAL SIZE	OUTSIDE DIAMETER		INSIDE DIAMETER	EXTERNAL THREAD LENGTHS
	MINIMUM	MAXIMUM	MINIMUM	MINIMUM
mm	mm	mm	mm	mm
20	19.7	20.0	1.6 ± 0.15	13
25	24.6	25.0	1.6 ± 0.15	16
32	31.6	32.0	1.6 ± 0.15	18



Download Brochure



Contact Sales



KYODO
PIPE

KYODO PIPE SDN BHD
Plot 322 Jalan PKNK 3/2,
Kaw. Perusahaan Sungai Petani,
08000 Sungai Petani, Kedah.

www.kyodopipe.com.my
sales@kyodopipe.com
604.444.5178 (General Line)
6012.314.9968 (Sales)

Empowering a Net Zero 2050 Future Together.

We are dedicated to driving a responsible energy transition and leading the pathway to a sustainable future.

Let us shape a world where clean energy defines tomorrow, sustainable cities thrive, green mobility becomes the norm, and digitalisation serves as the catalyst for transformation.

Together, let us ignite a change and empower a better, brighter future.

NET ZERO 2050



Scan to read our
ESG stories



**TENAGA
NASIONAL**

Better. Brighter.