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## SMART GRID MANAGEMENT:

# The Backbone of Future-Proof Energy Efficiency

By Ts. Visnu Varatan, MEng, REM T1& T2

**As the global energy landscape evolves, nations are racing to transition from traditional energy systems to more resilient, sustainable, and intelligent grids. With increasing concerns over climate change, rising energy demand, and the growing integration of renewable energy sources, there is a pressing need to modernise existing electrical infrastructure. Smart grid management emerges as a critical solution to address these challenges, particularly in the context of future-proofing energy efficiency.**

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## /chief editor's note

This edition discusses a crucial topic in electricity generation, distribution, and consumption. The growing share of renewable energy in power generation is encouraging news for reducing carbon emissions. While renewable energy is often seen as "free fuel", managing it is not always straightforward. Its inherent variability and the mismatch between supply and demand present challenges to existing grid infrastructure.

At the same time, the growing enthusiasm for electric mobility is adding new stress to the grid. For example, electric vehicle charging stations can create localised spikes in electricity demand. This raises an important question: Is our current grid ready to handle such changes?

Smart grids offer a promising solution to this evolving energy landscape. By integrating the Internet of Things and Artificial Intelligence, smart grids can analyse real-time data and even propose optimised usage schedules for consumers. However, the success of smart grid systems does not rely on technology alone, consumer cooperation is equally essential.

We have a role to play in this energy transition. By educating those around us about the importance of collective action and responsible energy use, the transition period will be more comfortable.

'Selamat Hari Kebangsaan dan Hari Malaysia 2025'

*Assoc. Prof. Dr. Mohamad Asmidzam Ahamat*

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### Understanding Smart Grid Management

A smart grid refers to an electricity network that utilises digital technology to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end users. Smart grid management incorporates a wide range of technologies, including Internet of Things (IoT) devices, advanced sensors, automation systems, and real-time data analytics. These components work together to enable two-way communication between utilities and consumers, allowing for greater visibility, control, and optimisation of the entire energy system.

Unlike conventional grids, which rely on centralised control and unidirectional energy flow, smart grids operate with distributed intelligence and adaptive capabilities. Smart grid management ensures that the system can detect and respond to changes in electricity demand, generation variability, equipment failures, and other operational conditions—thereby reducing energy losses and improving overall efficiency.

### Future-Proofing Through Smart Grids

One of the most compelling advantages of smart grid management is its ability to future-proof energy systems. As the energy sector becomes increasingly decentralised with the integration of renewable energy sources such as solar, wind, and biomass, traditional grids face significant limitations in accommodating fluctuating power flows. Smart grids, however, are designed to handle this variability with greater flexibility and resilience.

Smart grid technologies facilitate the seamless integration of distributed energy resources (DERs), including residential solar panels, battery storage systems, and electric vehicle (EV) charging stations. By enabling dynamic load balancing and real-time adjustments, smart grid management helps to prevent grid overloads and maintain power quality.

Moreover, with the adoption of predictive analytics and artificial intelligence (AI), smart grids can anticipate demand patterns and proactively optimise energy distribution. This capability is especially critical in

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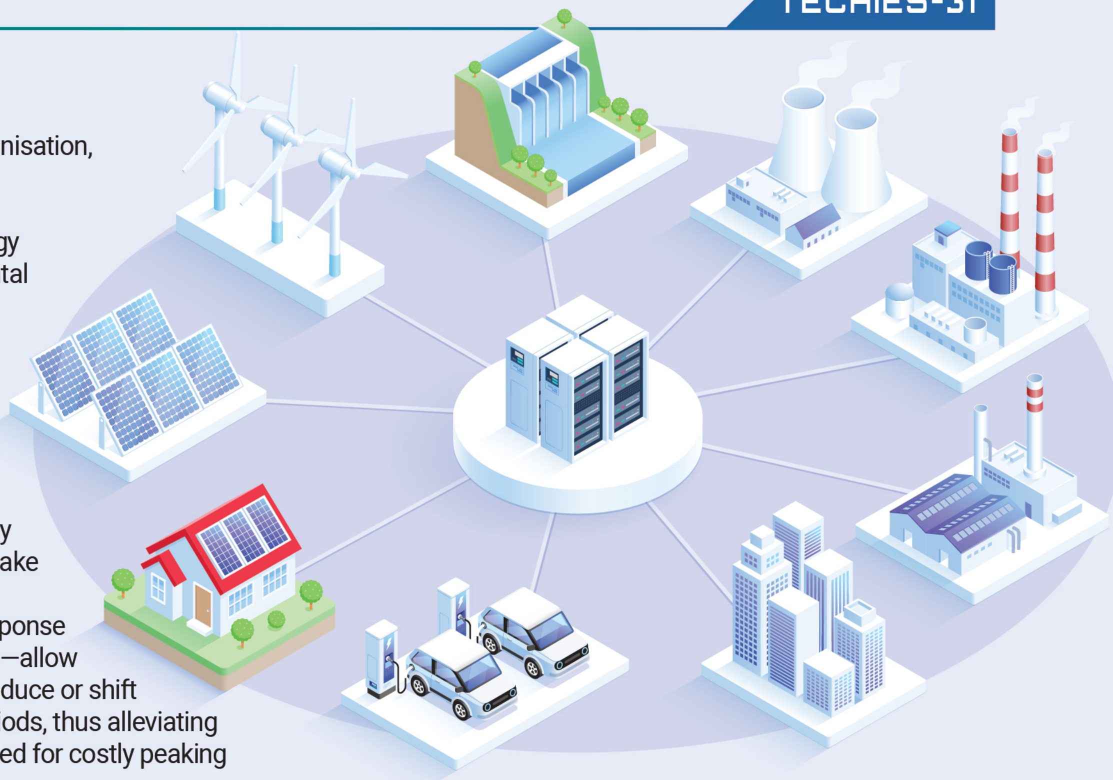


the face of climate uncertainties, urbanisation, and evolving consumer behavior. Future-proofing through smart grid management ensures long-term energy security, grid stability, and environmental sustainability.

## Enhancing Energy Efficiency

Energy efficiency lies at the core of smart grid management. Through Advanced Metering Infrastructure (AMI), consumers gain access to detailed information about their energy consumption, empowering them to make informed decisions and adopt energy-saving behaviors. Demand response programmes—enabled by smart grids—allow utilities to incentivise consumers to reduce or shift their electricity usage during peak periods, thus alleviating stress on the grid and reducing the need for costly peaking power plants.

Additionally, smart grids improve operational efficiency by minimising transmission and distribution losses. Automation systems can swiftly detect faults, reroute power, and restore services without human intervention, resulting in reduced downtime and enhanced reliability. Utilities can also perform remote diagnostics and schedule maintenance more effectively, thereby optimising asset utilisation and extending the lifespan of infrastructure components.

## Challenges and Considerations

Despite the numerous benefits, the transition to smart grid management is not without challenges. High initial capital investment, cybersecurity risks, interoperability issues, and the need for skilled professionals are some of the key barriers to implementation. Ensuring data privacy and protecting the grid from cyber threats is paramount, especially as more devices become interconnected.

Furthermore, regulatory frameworks and standardisation play a crucial role in enabling the smooth deployment of smart grid technologies. Policymakers must establish clear guidelines and incentivise innovation while fostering collaboration between stakeholders, including utility providers, technology developers, and consumers.

## Malaysia's Progress and Opportunities

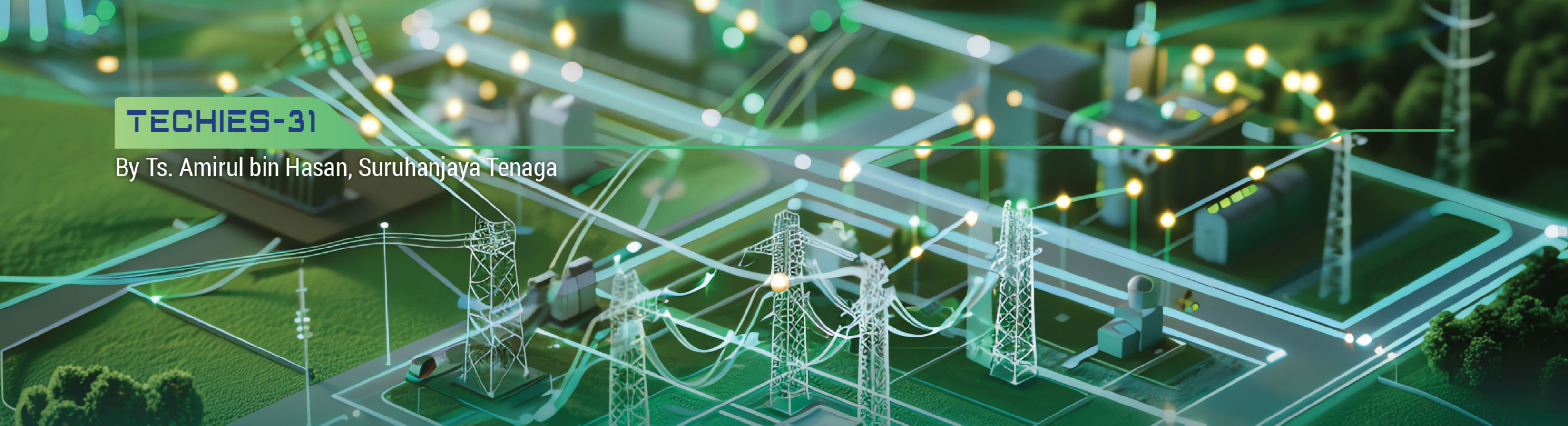
In Malaysia, the journey towards smart grid adoption is steadily gaining momentum. Tenaga Nasional Berhad (TNB) has initiated the rollout of smart meters in Melaka and the Klang Valley, aiming to enhance transparency and encourage energy-conscious behavior among consumers. Government-led initiatives such as the National Energy Transition Roadmap (NETR) and the Renewable Energy Transition Roadmap (RETR) underscore the country's commitment to a greener and more efficient energy future.

Smart grid management also presents new opportunities for local energy managers, engineers, and IoT specialists to contribute to the development of next-generation energy systems. By aligning with the programmes under the Sustainable Energy Development Authority (SEDA) and the Energy Commission, professionals can actively participate in energy audits, system optimisation, and the integration of renewable energy solutions.

## Conclusion

Smart grid management represents a transformative approach to achieving energy efficiency, resilience, and sustainability. By leveraging advanced technologies, real-time data, and consumer engagement, smart grids pave the way for a more intelligent and adaptive energy infrastructure. As Malaysia and other nations embrace this paradigm shift, it is imperative to invest in capacity building, regulatory support, and technological innovation. Future-proofing energy efficiency through smart grid management is not just a necessity—it is the foundation for a sustainable and secure energy future.

By Ts. Amirul bin Hasan, Suruhanjaya Tenaga



# Powering a Greener Tomorrow: Smart Grid Management and Carbon Footprint Reduction in Malaysia

Malaysia is committed to achieving net-zero emissions by 2050. With a burgeoning economy and a growing population, the demand for reliable and sustainable energy is escalating. Central to addressing this challenge and significantly reducing the nation's carbon footprint is the strategic implementation of Smart Grid Management, incorporating cutting-edge technologies such as Battery Energy Storage Systems (BESS).

The traditional electricity grid, often characterised by its unidirectional power flow and centralised generation, is ill-equipped to handle the complexities of a decarbonised future. The intermittent nature of renewable energy sources such as solar and wind, while crucial for emission reduction, poses significant challenges to grid stability and reliability. This is where the concept of a "smart grid" emerges as a transformative solution, offering a dynamic, resilient, and intelligent electricity network capable of integrating diverse energy sources, optimising consumption, and empowering consumers.

## The Malaysian Context: A Drive Towards Decarbonisation

Malaysia's commitment to climate action is evident in its Nationally Determined Contribution (NDC) under the Paris Agreement, aiming for a 45% reduction in economy-wide carbon intensity by 2030 compared to 2005 levels. This ambition is further reinforced by the National Energy Transition Roadmap (NETR) and the National Energy Policy 2022-2040, which lay out a comprehensive strategy for a cleaner energy mix and enhanced demand-side management. Tenaga Nasional Berhad (TNB), the nation's primary utility provider, is at the forefront of this transformation, spearheading grid modernisation initiatives across Peninsular Malaysia.

Key pillars of Malaysia's decarbonisation efforts within the energy sector include:

- **Renewable Energy Integration:** Accelerating the adoption of solar, hydro, biomass, and biogas into the national grid. TNB is actively upgrading its systems to accommodate two-way energy flow, enabling consumers with rooftop solar to feed excess electricity back into the grid through schemes like Net Energy Metering (NEM). Large-scale solar farms and community-based renewable energy aggregation mechanisms are also being developed.
- **Energy Efficiency:** Promoting efficient energy usage through initiatives like the widespread deployment of smart meters. TNB aims to install over 10.3 million smart meters across Peninsular Malaysia by 2030, providing consumers with real-time energy consumption data and empowering them to make informed choices.
- **Grid Modernisation and Digitalisation:** Investing in advanced digital tools, automation, and sensors to enhance grid reliability, optimise energy flows, and reduce outage durations. The Distribution Automation (DA) Project, for instance, has already upgraded tens of thousands of distribution substations, improving fault detection and response time.

## The Indispensable Role of Smart Grid Management

Smart Grid Management is the overarching framework that enables these decarbonisation technologies to operate efficiently and effectively. It involves the integration of information and communication technologies (ICT) into the electricity grid, facilitating real-time monitoring, control, and optimisation of energy generation, transmission, and distribution.

The core components and benefits of smart grid management in the context of carbon footprint reduction include:

- **Enhanced Grid Stability and Reliability:** By leveraging real-time data and automated controls, smart grids can quickly detect and respond to fluctuations in renewable energy supply and demand. This minimises disruptions and ensures a stable power supply, even with a high penetration of intermittent renewables.
- **Optimal Integration of Distributed Energy Resources (DERs):** Smart grids are designed to seamlessly integrate various DERs, including rooftop solar, small-scale wind turbines, and community energy systems. This decentralised approach reduces reliance on large, centralised fossil fuel power plants.
- **Demand Response Management:** Smart grids enable dynamic pricing and demand response programs, encouraging consumers to shift their energy consumption to off-peak hours or reduce usage during peak demand. This helps flatten the load curve, reducing the need for peaker plants (often fossil-fuel based) and minimising grid strain.
- **Improved Energy Efficiency:** Real-time data from

smart meters and sensors allows for precise identification of energy losses and inefficiencies within the grid, leading to targeted improvements and overall energy savings.

- **Predictive Maintenance:** Advanced analytics and machine learning applied to smart grid data can predict equipment failures, allowing for proactive maintenance and preventing costly outages that might otherwise necessitate reliance on less efficient backup systems.

### Battery Energy Storage Systems (BESS): A Game-Changer for Carbon Reduction

Within the landscape of smart grid technologies, Battery Energy Storage Systems (BESS) stand out as a particularly impactful solution for carbon footprint reduction. BESS addresses the fundamental challenge of intermittency associated with renewable energy sources.
Here's how BESS contributes to a low-carbon energy future in Malaysia:

- **Storing Excess Renewable Energy:** During periods of high renewable energy generation (e.g. sunny afternoons for solar), BESS can store the surplus electricity that would otherwise be curtailed or wasted. This stored energy can then be discharged during times of high demand or low renewable output (e.g. evenings), effectively "time-shifting" clean energy. This maximises the utilisation of renewable energy and reduces the need to fire up fossil fuel plants to meet demand.
- **Grid Stabilisation and Ancillary Services:** BESS can provide crucial ancillary services to the grid, such as frequency regulation, voltage support, and black start capabilities. By rapidly injecting or absorbing power, BESS helps maintain grid stability, allowing for higher penetration of variable renewables without compromising reliability.
- **Peak Shaving and Load Leveling:** BESS can be charged during off-peak hours when electricity prices are lower and demand is minimal, and then discharged during peak demand periods. This "peak shaving" reduces the strain on the grid, defers the need for costly grid upgrades, and minimises the dispatch of less efficient, carbon-intensive generation units.
- **Supporting Microgrids:** BESS is a vital component of microgrids, which are localised energy systems that can operate independently or be connected to the main grid. Microgrids, often powered by renewables, enhance energy resilience and can reduce reliance on the centralised grid, further decentralising power generation and lowering overall emissions.
- **Facilitating Electric Vehicle (EV) Integration:** As Malaysia expands its EV infrastructure, BESS can play a role in managing charging demands, especially during peak hours, and can even facilitate vehicle-to-grid (V2G) technology, where EVs act as mobile energy storage units, further supporting grid stability and renewable integration.

Malaysia is already seeing tangible progress in BESS deployment. The recent grid connection of the Sejingkat 60 MW Energy Storage Station in Sarawak, Malaysia's first large-scale electrochemical energy storage project, marks a significant milestone. This project, employing lithium iron phosphate ($LiFePO_4$) battery technology, demonstrates the nation's commitment to leveraging BESS for optimising energy distribution and enhancing grid reliability. Furthermore, the Malaysia Renewable Energy Roadmap (MyRER) explicitly outlines the prioritisation of cost-effective energy storage solutions, including battery storage, as a central pillar of its post-2025 strategy.

### Challenges and the Path Forward

While the benefits of smart grid management and BESS are clear, Malaysia faces certain challenges in their widespread adoption. These include:

- **High Initial Investment Costs:** The capital expenditure for smart grid infrastructure and large-scale BESS can be substantial.
- **Regulatory Frameworks:** Evolving existing regulatory frameworks and grid codes to fully accommodate the dynamic nature of smart grids and BESS.
- **Interoperability and Standardisation:** Ensuring seamless communication and interoperability between different smart grid technologies and systems from various vendors.
- **Cybersecurity Concerns:** Protecting the digitalised grid from potential cyber threats is paramount to maintaining reliability and data integrity.
- **Public Awareness and Acceptance:** Educating consumers about the benefits of smart meters and demand response programs is crucial for successful implementation.

To overcome these challenges, Malaysia must continue to:

- **Develop Supportive Policies and Incentives:** Provide clear policy signals and financial incentives to encourage private sector investment in smart grid technologies and BESS.
- **Foster Research and Development:** Invest in local R&D to drive innovation in smart grid solutions and battery technologies, potentially reducing costs and tailoring solutions to Malaysia's specific needs.
- **Strengthen Human Capital:** Develop a skilled workforce capable of designing, deploying, and maintaining advanced smart grid systems.
- **Promote Public-Private Partnerships:** Encourage collaboration between government agencies, utility companies, technology providers, and academic institutions to accelerate smart grid deployment.

### Conclusion

Malaysia's journey towards a sustainable, low-carbon future is intricately linked to the successful implementation of Smart Grid Management and carbon footprint reduction technologies. Battery Energy Storage Systems, with their ability to enhance renewable energy integration, stabilise the grid, and optimise energy usage, are proving to be a cornerstone of this transformation. By strategically addressing the challenges and continuing to invest in innovative solutions, Malaysia will achieve its ambitious net-zero targets and also emerge as a regional leader in smart and sustainable energy management, paving the way for a cleaner, greener, and more resilient tomorrow.

# Building Malaysia's Smart Energy Future: A Conversation on Innovation, Collaboration, and Impact

*an interview with*

**Assoc. Prof. Ts. Dr. Norzanah Rosmin**
Director of the Centre of Electrical Energy Systems (CEES), UTM's Institute of Future Energy

**Could you share a brief overview of your background and professional journey?**
I'm Norzanah, an Associate Professor at the Faculty of Electrical Engineering, Universiti Teknologi Malaysia, Johor Bahru. Currently, I am the Director of Centre of Electrical Energy Systems (CEES). In 2015, I obtained my PhD in Renewable Energy from Loughborough University, United Kingdom.

I began my career at UTM as a tutor in 1999. Today, my leadership roles focus on connecting education, research, industry, and community. At the CEES, I lead collaborative initiatives that enhance grid reliability, improve energy management, increase energy efficiency, conduct energy audits, and implement sustainable technologies. These efforts also support talent development and foster research partnerships with government agencies and industry, in Malaysia and overseas.

I am passionate about translating research into real-world impact and contributing to Malaysia's energy transition through standards-driven, ethical, and future-ready engineering practices.

**What inspired you to focus your career on energy systems and smart grid technology? Was there a particular moment or experience that sparked your interest in this field?**
My journey into energy systems and smart grid technology has been shaped by both academic curiosity and a deep desire to create real-world impact. Early in my career at UTM, I was introduced to solar energy research. During that time, solar PV technology was still very new in Malaysia. The price for a solar PV panel was prohibitively expensive.

What truly inspired me was observing how my former Master's supervisor actively collaborated on solar research projects. This exposure encouraged me to explore other forms of renewable energy. In addition to ocean energy, I found wind energy particularly fascinating, especially considering

EV Charging Station with BESS at Faculty of Electrical Engineering, UTM

Malaysia's relatively low average wind speeds. I often asked myself: How can we design wind turbines that are both effective and commercially viable under Malaysia's unique conditions?

This curiosity led me to pursue a PhD in Renewable Energy at Loughborough University in the UK. During my time there, I had the opportunity to engage with industry players, including a local business owner near the university who powered both his home and factory using renewable sources to reduce reliance on the grid.

The lectures on renewable energy integration, which were part of my PhD programme, broadened my perspective on how different energy resources can complement one another to create more reliable and resilient systems. I also gained hands-on experience through visits to wind farms, practical work with solar technologies at the CREST laboratories, and served as a trainer to raise awareness about renewable energy in local schools and colleges.

These experiences demonstrated the transformative role that technology can play in building a resilient, low-carbon future, and they inspired me to focus my career on developing innovative and scalable solutions for sustainable energy management.

I would say that a defining moment came during my PhD, when I realised how intelligent control systems and renewable energy integration could significantly enhance the reliability of the power system. That was when my passion for smart grids truly took off. I became driven to explore how Malaysia could adapt and benefit from the insights and experiences I gained during my studies abroad.

When I returned to Malaysia, the Centre of Electrical Energy Systems (CEES) had just been established at UTM. Joining CEES made both research and teaching even more meaningful, as we were developing the field of smart grids and renewable integration from the ground up. It has been deeply fulfiling to see this work evolve from concept to implementation and contribute to Malaysia's energy transition.

**Can you share an example of how smart grid innovations are improving people's lives in Malaysia?**

Smart grid innovations are already making a real difference in Malaysia. For example, with TNB's smart meters, households can monitor their electricity usage in real time, empowering them to reduce their bills and make more informed energy choices.

In a broader context, a smart grid with automation and sensors enables quicker fault detection, reduces the occurrences and duration of blackouts, and enhances overall reliability. Smart grids are also essential for integrating renewable energy sources, such as rooftop solar, and preparing the grid for the rise of electric vehicles. These technologies ensure grid stability as more renewable energy sources are added.

Importantly, the government has committed RM43 billion toward grid modernisation initiatives, including battery energy storage and AI-powered systems, the key investments that will strengthen Malaysia's energy security and resilience.

Altogether, these innovations translate into lower costs for consumers, a cleaner environment for communities, and a stronger, future-ready energy grid for the nation.

**In your opinion, what is the biggest misunderstanding the public has about renewable energy or smart energy systems?**

One of the biggest misunderstandings the public has about renewable energy is the belief that renewables alone, like solar or wind, are perfectly reliable and serve as a replacement for conventional power plants. In reality, renewable energy sources are variable and intermittent. Without smart energy systems such as battery storage, demand and response management, and grid automation, renewable energy cannot guarantee a stable and continuous electricity supply.

Another common misconception is that smart energy systems are simply about digital meters. In reality, they incorporate advanced forecasting, automated controls, and the integration of distributed energy resources, the key elements that are essential for


**101 kWh BESS at P19A Building.**

balancing supply and demand in real time. Similarly, some believe that smart meters automatically lead to higher electricity bills. Smart meters only provide accurate and transparent readings; if a bill increases, it reflects actual consumption rather than additional charges. With Malaysia's new tariff structure, smart meters play a crucial role in enabling Time-of-Use pricing, allowing consumers to save money by shifting electricity use to off-peak hours. The key is awareness; if people understand how to utilise the data from smart meters, they can manage their consumption more effectively and potentially reduce costs. Bridging the gap between perception and reality is crucial. Renewable energy and smart grids are not one-step solutions. However, with the right technology, careful planning, and community awareness, they can become the backbone of Malaysia's sustainable energy future.

### Can you share how collaborative efforts between academia, industry, and government are contributing to advancing energy solutions in Malaysia?

Collaboration between academia, industry, and government is the backbone of advancing energy solutions in Malaysia. Universities like UTM play a central role in bridging research and real-world applications. For instance, UTM partnered with Huawei Malaysia and NanoMalaysia Berhad to develop solar EV charging systems integrated with battery storage. In collaboration with Enpro Energy, we deployed a 101 kWh Battery Energy Storage System at the Faculty of Electrical Engineering to help reduce peak demand charges.
Additionally, the Centre of Electrical Energy Systems (CEES) conducts energy audits across industrial and commercial buildings, identifying inefficiencies in motors, lighting, and HVAC systems. These audits have helped companies lower their operational costs, reduce carbon emissions, meet compliance standards, and create demand for advanced energy management solutions.

On the government side, UTM collaborates with agencies such as the Public Works Department (JKR) to pilot off-grid solar LED street lighting systems with up to one week of energy autonomy. The collaboration also includes studying the impact of photovoltaic (PV) arrays on power quality, including a notable project at the Malaysian Parliament Building. UTM experts serve as technical advisors to key agencies such as the Energy Commission, the Sustainable Energy Development Authority (SEDA), and TNB Integrated Learning Solution (TNB ILSAS), helping ensure that the policies outlined in the National Energy Transition Roadmap are grounded in sound technical expertise.


**UTM Wind Turbine Laboratory UTM.**

Equally important, UTM works with government agencies and communities to ensure that innovation benefits society at large. For instance, in collaboration with Suruhanjaya Tenaga (ST) and the Department of Agriculture, UTM introduced solar PV integrated with IoT-based control systems for hydroponic vegetable farming. This has enabled local communities to adopt sustainable agriculture, boost productivity, and even generate new income streams from selling produce. Another impactful initiative from the Faculty of Electrical Engineering, UTM, is the development of inverter technology for night market traders in Skudai and Johor Bahru. This solution allows traders to operate independently of the grid, reducing their reliance on diesel generators and reducing operational costs, while promoting cleaner and more sustainable business practices.

International collaboration is also vital. UTM partners with companies like Gold Electronics, TD Energy, and Eve Energy in China to advance smart battery algorithms for grid resilience. At the same time, local companies such as Tectra and Chint Global support these efforts, helping to fast-track BESS deployment in Malaysia.

**"In Malaysia, three key trends are shaping the future of energy. The first trend is the rapid advancement of energy storage and smart grid technologies. With advanced technologies such as battery energy storage systems, intelligent microgrid controls, and AI-driven forecasting, we can integrate a higher share of renewable energy without compromising grid reliability.**

Altogether, these collaborations create a strong ecosystem where academia generates knowledge, industry implements solutions, and government establishes policies. Together, they accelerate Malaysia's transition towards a cleaner, smarter, and more resilient energy future.

**Smart-Eco PV Boat at Mersing Johor.**

### As a researcher and innovator in this field, what excites you most about the future of energy?

The most exciting aspect is how emerging technologies, supportive policies, and changes in societal values are converging to drive the transition toward a cleaner, more intelligent, and resilient energy ecosystem.

In Malaysia, three key trends are shaping the future of energy. The first trend is the rapid advancement of energy storage and smart grid technologies. With advanced technologies such as battery energy storage systems, intelligent microgrid controls, and AI-driven forecasting, we can integrate a higher share of renewable energy without compromising grid reliability. Additionally, real-time optimisation and dynamic pricing models will promote more sustainable and cost-effective energy management.

The second trend is the rise of decentralised and community-based solutions. Rooftop solar for homes and schools, hydroponic farming powered by solar and integrated with IoT, and inverter technologies for night market traders show that energy is no longer just a utility; it is becoming an enabler for better livelihoods, higher productivity, and new business models.
The third trend is the growth of green mobility and the hydrogen economy. In the coming decade, we will see electric vehicles, green hydrogen, and digital energy platforms moving from pilot projects to mainstream technologies, and creating new industries and job opportunities for Malaysia's young talent.

At UTM, we are not only witnessing these changes. We are actively exploring how to translate research prototypes into real-world technologies that empower communities, reduce emissions, and support Malaysia's National Energy Transition Roadmap. These are the motivation that drives my passion for working in this interesting field.

By Ts. Dr. Noramalina binti Abdullah, USM Engineering Campus, Pulau Pinang

# Bridging Predictive Maintenance in Smart Factories with Smart Grid Management

The rapid advancement of digital technologies under Industry 4.0 and Energy 4.0 paradigms has catalysed innovation across multiple sectors, especially in manufacturing and energy systems. An industry-based project titled Predictive Maintenance and Intelligent Sensors in Smart Factory (PREMIS-F) demonstrates the practical integration of IoT, machine learning, and digital twin technologies to create a smarter, more efficient factory ecosystem. Interestingly, many of these innovations are not only confined to factory settings but are highly transferable to the domain of Smart Grid Management.

## An Overview of PREMIS-F

The PREMIS-F system is a fully integrated, non-intrusive monitoring and predictive maintenance framework tailored for industrial machines. By leveraging sensors such as vibration sensors, smoke detectors, encoders, and temperature or humidity sensors, the system continuously tracks the health of motors and actuators.

Using WISE-IoTSuite for real-time dashboards and the ECU-1251 edge gateway for communication and preprocessing, data is visualised and analysed using cloud-based platforms. A machine learning model, trained on over 1000 data entries, accurately predicts motor failure conditions with over 98% accuracy. Figure 1 shows the overall monitoring system of PREMIS-F. The system also includes a Digital Twin created via SaaS Composer, visually syncing real-time physical equipment status with 3D dashboard models. Alerts are pushed via email and web notifications, enabling proactive response to anomalies and promoting reliability and safety.

The technological foundation laid out in PREMIS-F for predictive maintenance and smart sensing in industrial factories has substantial potential for adaptation within the realm of Smart Grid Management. Just as the system is used to monitor motors and actuators for operational efficiency, a similar architecture can be employed to manage critical components within the electric power grid, such as transformers, circuit breakers, capacitors, switchgear, and other substation assets.

In a smart grid, these components form the backbone of electricity transmission and distribution. Failures in any of these nodes can lead to outages, equipment damage, or cascading effects across the network. Therefore, real-time monitoring and fault prediction become essential. The sensor-rich and non-intrusive approach of PREMIS-F allows for continuous tracking of temperature, vibration, electrical noise, and mechanical behaviour. These parameters are equally relevant for substation components such as transformers and circuit breakers. For example, vibration and acoustic sensors can detect early signs of arcing or loose fittings inside switchgear, while temperature sensors can detect overheating in transformer windings or busbars.

The machine learning model used in PREMIS-F, which was trained to predict motor degradation based on parameters like temperature, RPM, humidity, and vibration, can be extended to forecast transformer overload conditions, insulation degradation, contact resistance anomalies, or harmonic distortions in grid equipment. By training such models with historical data from SCADA systems and phasor measurement units (PMUs), it becomes feasible to preemptively identify grid nodes that are at risk of imminent failure. In particular, the fuzzy logic layer used in PREMIS-F to classify operational states as “Good” or “Not Good” is especially valuable in smart grid contexts where thresholds for failure can overlap due to environmental noise, load variance, or weather-induced stress on equipment.

Another direct parallel is the use of Digital Twin technology. In the PREMIS-F project, a virtual 3D model of the conveyor system is linked to live sensor data, allowing operators to visualise and validate system performance in real time. This concept can be extended to

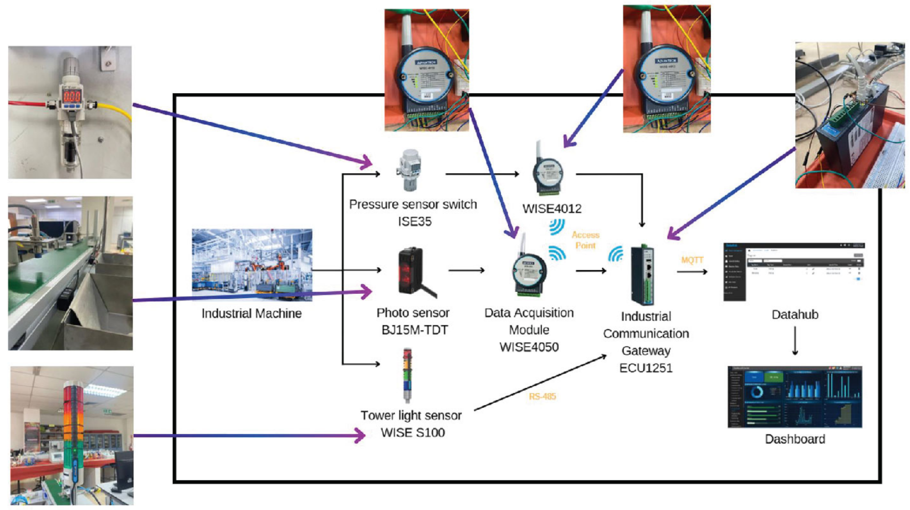



Figure 1. Monitoring system of PREMIS-F

smart grids by creating Digital Twins of substations or feeder circuits. These twins allow operators to simulate grid energy flows under varying load conditions, test the impact of renewable energy injections, or observe the dynamic behavior of microgrid elements. Moreover, when integrated with weather and load forecasting data, Digital Twins can help utility companies proactively reconfigure grid topology during peak demand periods or storm events, minimising outages and improving grid resilience.

In terms of communication, PREMIS-F relies on lightweight and robust protocols such as MQTT, Modbus, and RS-485. These are well-suited for distributed IoT deployments and are already compatible with many smart grid edge devices. However, smart grids often demand additional interoperability and cybersecurity features, which are supported by protocols like IEC 61850 for substation automation, DNP3 for remote telemetry, and CoAP for low-power field devices. The architecture of PREMIS-F, with its modularity and gateway integration via ECU-1251, makes it inherently flexible and compatible with these protocols, requiring only modest adjustments.

The dashboarding system provided by WISE-IoTSuite in PREMIS-F also finds a natural counterpart in grid control centers, which often employ Energy Management Systems (EMS), Distribution Management Systems (DMS), or SCADA platforms. These systems benefit greatly from enhancements like machine learning-driven fault alerts, Digital Twin overlays, and anomaly visualisations. Integrating real-time insights with control actions (e.g., load shedding, remote switch control) creates a closed-loop system that embodies the vision of an autonomous and self-healing grid.

Finally, the broader implications of PREMIS-F's architecture on grid sustainability and reliability are noteworthy. By optimising asset utilisation and predicting failures before they escalate, utilities can reduce

| Feature/Function | PREMIS-F | Smart Grid Management |
| --- | --- | --- |
| Real-time Monitoring | Sensors for motors, actuators | Grid nodes, transformers |
| Predictive Analytics | ML model for motor condition | ML for asset health, load forecasting |
| Digital Twin | Convey system replica | Substation/grid simulation |
| Communication Protocols | MQTT, Modbus, RS-485 | MQTT, IEC 61850, DNP3 |
| Dashboard + Alerts | WISE-IoT Suite, Email alerts | SCADA+Grid Control Center |
| Impact | Factory efficiency, uptime | Grid Stability, reliability |

**Table 1: Comparative overview of PREMIS-F functions with Smart Grid applications.**

> **By adapting its principles to the energy sector, we can accelerate the transition to a more reliable, resilient, and responsive power grid aligned with global energy sustainability goals. Table 1 shows the comparative overview of PREMIS-F functions.**

unnecessary maintenance dispatches, extend the life of costly infrastructure, and minimise unplanned outages. This contributes directly to reduced transmission and distribution losses, more efficient use of resources, and lower operational expenditure. Moreover, these enhancements enable grids to better accommodate distributed renewable energy sources (such as solar or wind) whose variability places extra stress on aging infrastructure.

In summary, PREMIS-F is more than a factory-centric solution. It represents a modular, scalable, and intelligent framework that can be tailored for the future of smart grid management. By adapting its principles to the energy sector, we can accelerate the transition to a more reliable, resilient, and responsive power grid aligned with global energy sustainability goals. Table 1 shows the comparative overview of PREMIS-F functions.

## Conclusions

The PREMIS-F project is a remarkable achievement in predictive maintenance and smart factory operations. Its core technologies in smart sensing, AI-based condition monitoring, real-time dashboards, and digital twinning align closely with the requirements of modern Smart Grid Management systems. By adapting PREMIS-F into the smart grid domain, we unlock new capabilities to enhance asset reliability, reduce outage risk, and support resilient energy delivery. In a world moving toward digital transformation in energy, systems like PREMIS-F could serve as scalable building blocks for tomorrow's smart and sustainable power infrastructure.

While the transferability of PREMIS-F technology to smart grid environments is high, a few adjustments are necessary. Grid components may operate in harsher outdoor conditions than factory floors. Smart grids span large geographic areas, so additional communication security and redundancy layers are required. Compliance with grid-specific standards like IEC 61850, NERC CIP, or IEEE 1547 must also be ensured. Nonetheless, with minor upgrades, the system offers a promising foundation for localised smart grid pilot implementations.

# MBOT COMPUTING EDUCATION SYMPOSIUM 2025: BRIDGING ACCREDITATION AND COMPUTING EDUCATION FOR GLOBAL EXCELLENCE

The Malaysia Board of Technologists (MBOT) successfully hosted the Computing Education Symposium 2025 at The Everly Hotel, Putrajaya. The objective of this symposium is to advance Malaysia's computing education by aligning it with global accreditation standards and integrating emerging technologies. The event brought together technologists, academics, industry leaders, and policymakers. The symposium reaffirmed Malaysia's commitment to internationalising accreditation through frameworks such as the Seoul Accord, ensuring that its computing education ecosystem remains globally competitive, industry-relevant, and future-ready.


In her welcoming remarks, the President of MBOT, Professor Emeritus Datuk Ts. Ir. Dr. Siti Hamisah binti Tapsir, shared the latest organisational developments and asserted MBOT's commitment to elevating computing education in Malaysia to be on par with global standards.

Then, the Director of Infrastructure Technology at Johor Corporation, Datuk Ts. Mahadhir bin Aziz, emphasised the evolving needs of the industry, highlighting the importance of infrastructure development, digital transformation, and talent cultivation.

The forum, featuring Professor Datuk Ts. Dr. Massila Kamalrudin, Professor Ir. Yuen Pak Leung, Dato' Ts. Dr. Haji Amirudin Abdul Wahab, and Mr. Koay Tze Siang, explored best practices in accreditation, deepened industry–academia collaboration, addressed cybersecurity readiness, and examined innovations in digital learning.


The highlight of the day was the keynote address by Professor Ir. Yuen Pak Leung. As Chairman of the Seoul Accord, he emphasised the importance of aligning Malaysia's computing curricula with global benchmarks to boost graduate mobility, enhance international recognition, and ensure the competitiveness of Malaysian graduates in the global job market. The Seoul Accord is an international agreement among organisations responsible for accrediting academic programmes in computing and information technology at the professional level.

MBOT extends its warmest appreciation to Professor Ir. Yuen Pak Leung for his special visit to Malaysia and sharing his invaluable insights that will inspire and shape the future of computing education in the country.


**/mbot registration**

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| 61,820 | Graduate Technologists |
| 13,553 | Qualified Technicians |
| 26,023 | Professional Technologists |
| 3,674 | Certified Technicians |
| 105,070 | Total MBOT Registrants (As of August 2025) |

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