

The Official Bulletin of the Faculty of Engineering Research Office, Universiti Malaya

ENGINITIUM

Harnessing
Man-made Wind

Power in the
Pipeline: The
Super Butterfly
Effect

Power
Beneath the
Wheels

Energy Secret
Behind Solar Panels

Turning Pest
Fish into Fuel

Energy Hiding in Plain Sight

...in the Least Expected Places

Volume 08 | June 2026

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Foreword

Energy Hiding in Plain Sight

When we think about energy, we often picture power plants, solar farms, wind turbines, or national grids. Yet, this issue of Enginitium invites us to look closer at the energy already around us, often hidden in places we rarely notice.

With the theme “Energy Hiding in Plain Sight,” this volume highlights how engineering can turn overlooked sources into meaningful possibilities. From exhaust air and pipeline flow, to heat behind photovoltaic panels, pressure beneath vehicle wheels, and biomass from pest fish, the featured articles remind us that useful energy can come from unexpected places. These ideas may not power entire cities, but they can support cleaner systems, smarter infrastructure, renewable fuel pathways, and more sustainable technologies.

At the heart of this issue is a simple message: innovation begins with noticing. It begins when engineers ask how ordinary surroundings, waste streams, and underused resources can be transformed into something valuable. This spirit is reflected in the work of our Faculty of Engineering researchers, whose ideas continue to advance sustainability, energy recovery, and applied engineering solutions.



This volume also features The Researcher’s Story, introducing newly joined lecturers who bring fresh ideas and new energy to our Faculty community.

As Deputy Dean of Student Affairs, I hope this issue speaks especially to our students. Just as this volume explores energy hidden in unexpected places, I believe every student carries their own hidden potential, waiting to be discovered through curiosity, perseverance, and the willingness to try something new. The journey of an engineer is not only about finding answers, but also about asking better questions. I hope these stories inspire you to see possibilities where others see obstacles, to stay curious, and to never stop asking yourself: “What else is possible?”



We hope this issue brings readers a moment of surprise and inspiration, while reflecting the imagination, commitment, and purpose that continue to shape engineering research and education at Universiti Malaysia.

*Small energy may not power cities,
...but it can spark ideas, inspire people, and open new possibilities.*

Welcome to Enginitium Volume 8.

Dr. Suhana Koting
Deputy Dean (Student Affairs)
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Revolutionizing Industrial Energy Recovery with the Cross-Axis Wind Turbine (CAWT)

As Malaysia accelerates its transition toward a sustainable energy future, I have witnessed firsthand the mounting pressures on our energy-intensive industrial sectors. Facilities such as hyperscale data centres, semiconductor fabrication plants, and power generation stations consume massive amounts of electricity – and in doing so, continuously reject vast volumes of heat into the atmosphere through industrial cooling towers. This relentless, high-velocity exhaust represents an enormous untapped renewable energy resource, entirely independent of volatile weather patterns. Until now, it has gone to waste.

Traditional wind energy solutions have long been deemed unviable in Malaysia, where ambient wind speeds typically average below 3 metres per second. When I first explored the possibility of retrofitting conventional Horizontal-Axis Wind Turbines (HAWTs) or standard Vertical-Axis Wind Turbines (VAWTs) directly above cooling towers, I quickly understood why earlier attempts had their challenges: these designs induce significant back-pressure, forcing cooling fans to work harder, compromising primary cooling operations, and ultimately negating any energy savings. There had to be a better way.



Artist's impression of the Cross-Axis Wind Turbine (CAWT) integrated into a data center cooling system.

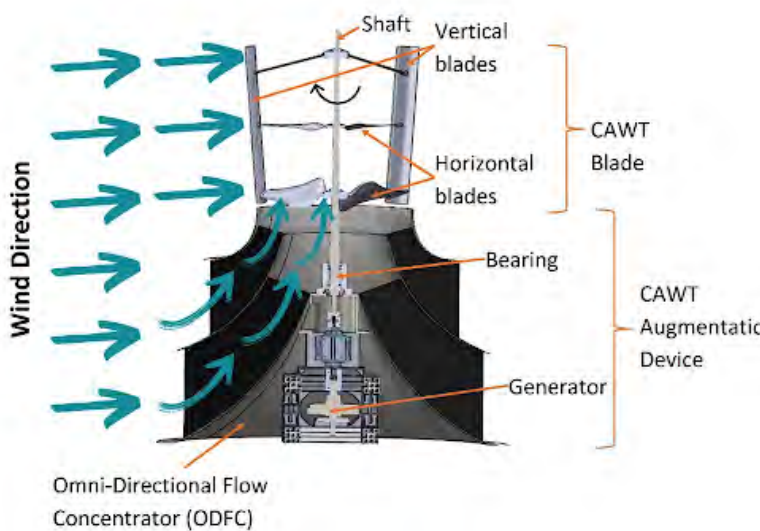
Closing the Technical Gap

A critical technical gap was identified: existing technologies were not designed to safely harvest energy from industrial exhaust fans without disrupting the airflow and cooling performance of the host system. Instead of working against the exhaust stream, the research team explored a more practical question: how can this airflow be harvested by working with its natural direction and behavior? This question led the team at Universiti Malaya's Department of Mechanical Engineering and the UM Centre for Energy Sciences through years of rigorous computational fluid dynamics (CFD) modeling and aerodynamic research. The goal was to develop an accredited, retrofit-compatible energy recovery system capable of capturing industrial exhaust fan energy while preserving the vital cooling processes that industries depend on. The outcome is the Retrofit Cross-Axis Wind Turbine, or CAWT, a technology that represents a significant step forward in industrial energy recovery.

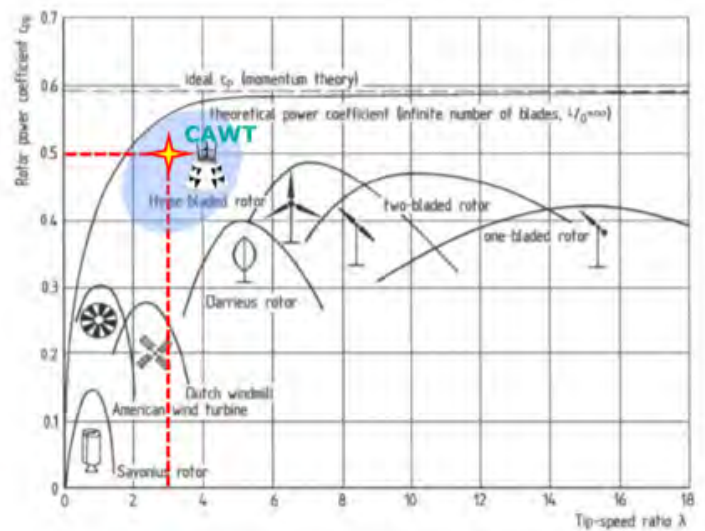
Engineering the Dual-Source Advantage

What sets the CAWT apart is its dual-source design. Unlike traditional turbines, which are typically limited to a single plane of airflow, the CAWT's patented dual-axis aerodynamic geometry is engineered to harness two wind sources simultaneously: the high-velocity vertical exhaust released from the cooling tower and the natural horizontal ambient wind passing over the facility.

Through specialized mounting structures developed and refined using extensive CFD modeling, the system is designed to recover energy efficiently while maintaining the baseline performance of the host cooling tower. In practice, the CAWT functions as a retrofit-compatible, plug-and-play energy recovery mechanism, capturing useful energy from existing airflow without disrupting the facility's primary cooling operations.



Working concept and components of CAWT with ODFC.



Comparison with other available technologies.

Economic and Environmental Impact

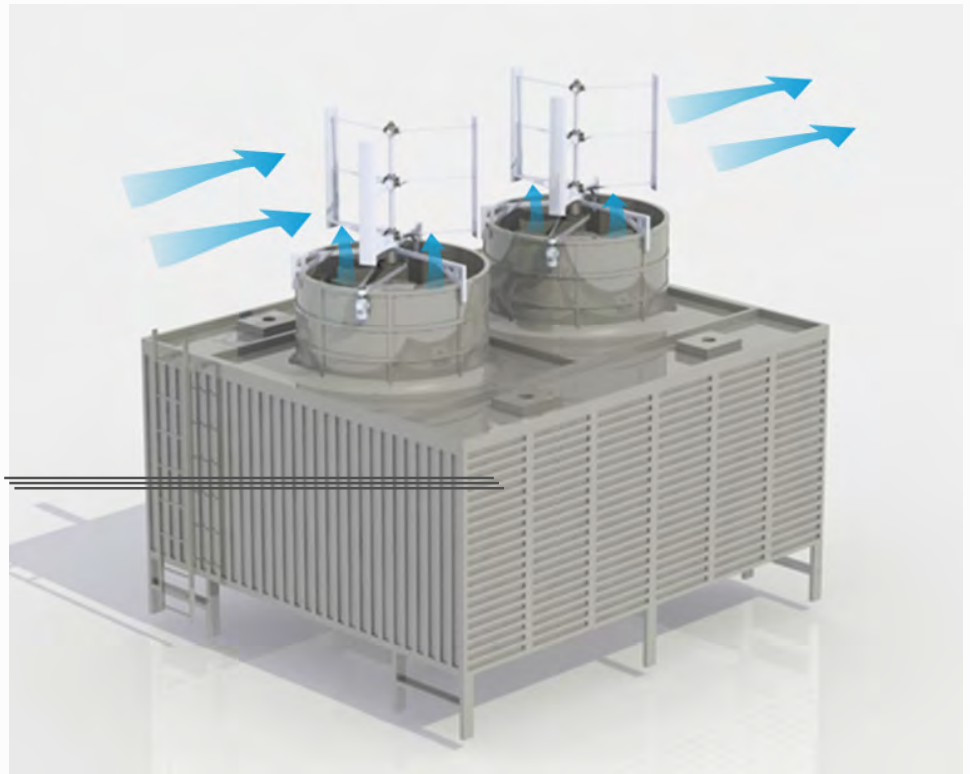
The implications of this technology are both timely and significant. With the implementation of Malaysia's Energy Efficiency and Conservation Act (EECA) 2024, energy-intensive facilities are increasingly expected to optimise their energy consumption. The CAWT offers a practical pathway to support this transition by recovering energy from airflow that would otherwise be wasted.

Operational projections indicate that the system could achieve a capacity factor of 75%, exceeding many conventional renewable installations. A fully integrated facility may recover up to 15% of its cooling energy waste, equivalent to approximately 3,400 MWh of recovered energy per year and an annual reduction of 1,980 tonnes of CO₂ emissions. From an economic perspective, the technology is targeting a return on investment within 3.5 years, while helping facilities reduce dependence on the national grid and improve resilience against energy cost fluctuations.

Path to Commercialization

While aerodynamic viability and component performance have been validated through laboratory and wind tunnel testing, the journey from lab to market requires strategic scaling. The technology is currently at Technology Readiness Level 4, and further funding support and industry collaboration are being sought to advance it toward Technology Readiness Level 8. The next phase will focus on field validation under real industrial conditions. With the proposed support, the team aims to deploy a Minimum Viable Product, a 3 kW CAWT unit, and subject it to more than 4,000 hours of performance testing. Collaboration with independent third-party certification bodies, such as TÜV NORD, will also help establish local test protocols and strengthen the commercialization pathway.

Artist's impression of retrofitted CAWT on a cooling tower.



Beyond its technical achievement, the Cross-Axis Wind Turbine represents a potential catalyst for Malaysia's industrial sustainability agenda. By transforming an invisible waste stream into a continuous power source, the project reflects Universiti Malaya's commitment to research that supports industry, advances decarbonisation, and contributes to a more sustainable nation.

The broader goal is not only academic achievement, but also to support a high-value green economy workforce and position Malaysia as a leader in industrial decarbonisation technologies.

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Piezoelectric Vibration Energy Harvester (PVEH)

Driven by the rise of Industry 4.0, the demand for self-powered Internet of Things (IoT) devices in smart sensing and condition monitoring is skyrocketing. Since frequently replacing batteries in remote sensors is impractical, researchers are turning to a more sustainable alternative: Harvesting wasted ambient vibration energy from everyday environments, such as operating machinery and moving vehicles.

For converting ambient vibration into electricity, piezoelectric vibration energy harvesters (PVEHs) are preferred over electromagnetic and electrostatic mechanisms due to their higher energy storage density for micro-scale applications and ease of system integration. However, their power generation

is primarily constrained by three factors: (i) Mechanical loss, (ii) Mechanical-electrical transduction loss, and (iii) Electrical loss.

Minimizing mechanical loss is the most critical step, as it is the first stage in converting the vibration energy from the operating environment into a suitable input force for the PVEH. A delicate balance must be struck: Excessive input force risks structural failure, while insufficient force yields inadequate power output. At the Faculty of Engineering, Universiti Malaya, our research team explores how structural design and optimization can enable minimizing the mechanical loss for enhancing the output power. This requires the design consideration of the frequency matching, PVEH location, force amplification factor, etc.

Vibration-Based Energy Harvesting from Machinery

For vibrating machinery like motors and air conditioners, strategic PVEH placement and frequency matching are critical. Our research team developed a cantilever PVEH system (Figure 1) capable of capturing energy from high displacement / acceleration region of a vibrating host structure, where the traditional PVEH patch configuration fails. The proposed PVEH system is able to generate up to 6.0 Vac from microvibration (43.8 μm rms). Moreover, a location selection scheme utilizing Experimental Modal Analysis (EMA) or Operating Deflection Shape (ODS) is introduced for selecting the optimal PVEH location mounted on the vibrating machinery (i.e., host structure). The dynamic effect of the vibrating host structure on the harvester performance is important for practical implementation, as placing the PVEH at a structural node can reduce harvested voltage by 70%.

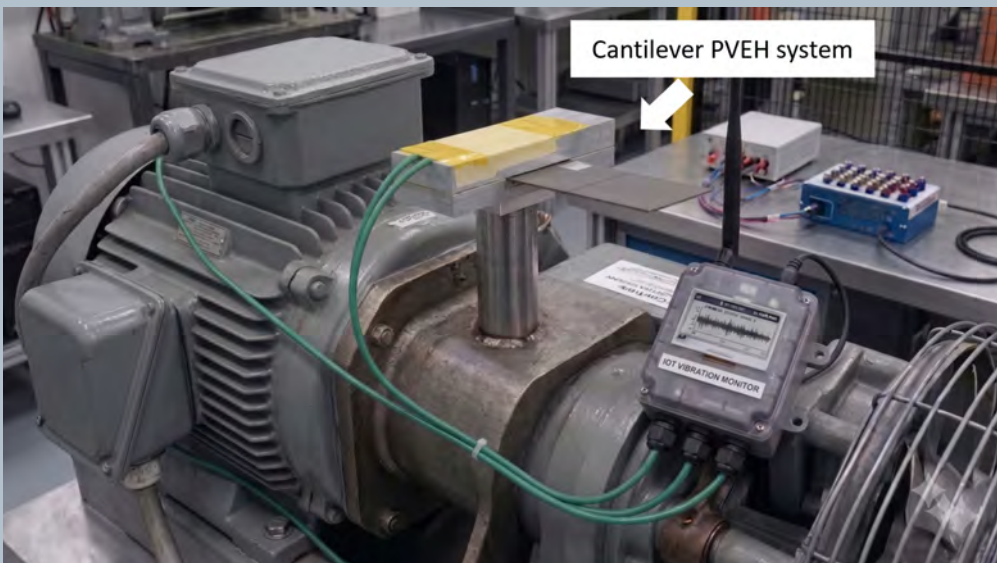


Figure 1: Artist's impression of a cantilever PVEH integrated into rotational machinery to power an IoT vibration sensor (Generated by Google Gemini, 2026).

Potential Application

Roadways are rich in vibration energy, but the crushing weight of a moving vehicle will destroy a standard piezoelectric harvester. Traditional Cymbal PVEH tried to solve this by converting the downward road excitation into lateral pulling (tensile) forces, using a “flextensional” mechanical amplifier frame to absorb the excessive stress. However, piezoelectric materials (e.g., PZT) can break easily under tension. Motivated by the fact that PZT’s compressive yield strength being around 10 times higher than its tensile yield strength. Our research team has developed a Hull PVEH (Figure 2) that takes a massive downward excitation force and converts it into a lateral compressive force directly on the PZT plate safely at a higher loading capacity. By optimizing the design geometry, the Hull PVEH achieves force amplification factors of 8.01 - 11.49 (from 10 - 1000 N), while maintaining a safety factor of 2. Most importantly, Hull PVEH generates 6.8 times more voltage than the conventional Cymbal PVEH under the same impacts via experimental verification (Figure 3).

The era of the self-powered Internet of Things (IoT) device is rapidly approaching. In the near future, the power generated by PVEH will be more than enough to sustainably run remote wireless sensor networks without ever needing a battery replacement. Energy truly is hiding in plain sight. It is in every step we take and every mile we drive. The next time you go for a run or drive to work, remember: You aren't just moving; You are generating power.

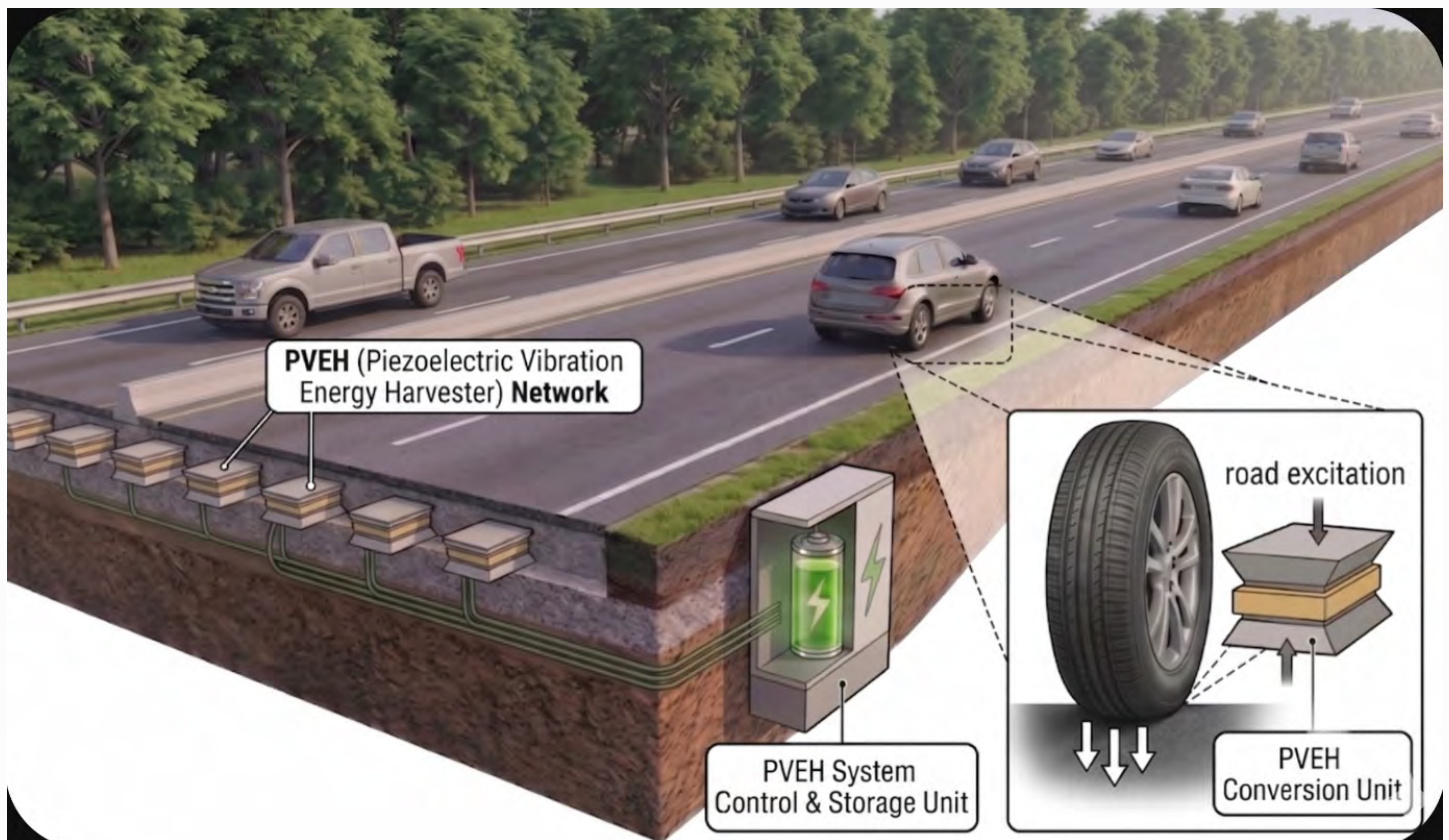


Figure 2: Artist's impression of the Hull PEH embedded in a roadway, acting as a sustainable power supply for a smart traffic monitoring system (Generated by Google Gemini, 2026).

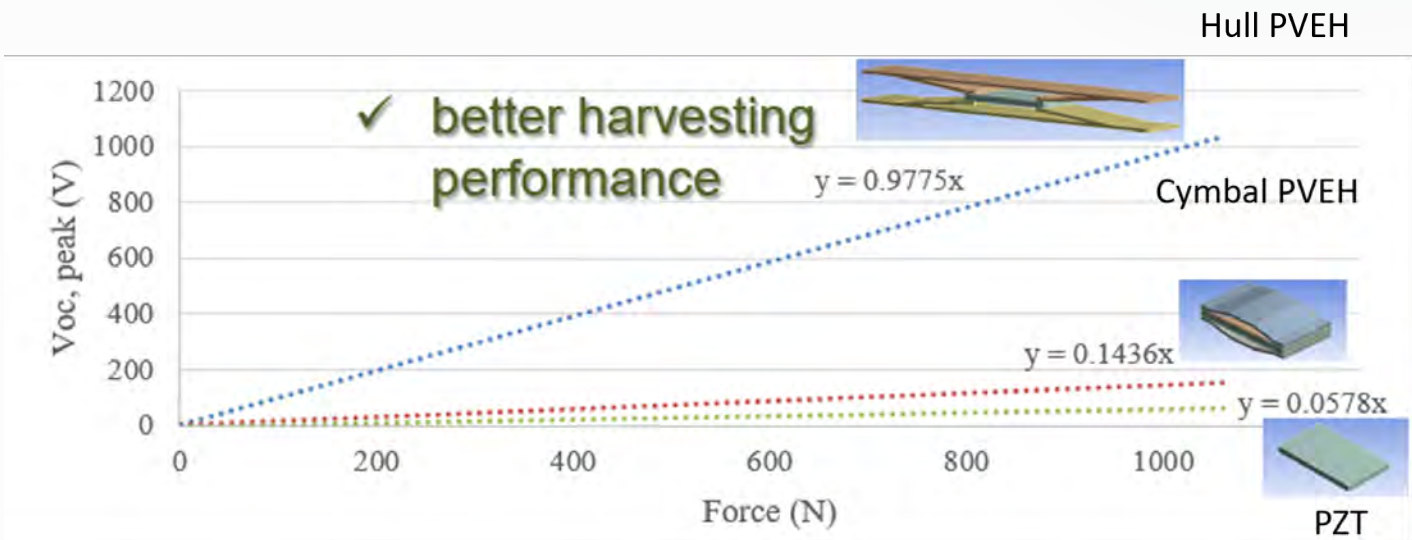


Figure 3: The comparison of the voltage output of Hull-type PVEH versus conventional Cymbal-type PVEH and standalone PZT (Edited from Long et al. (2023)).

Related Awards, Patent, and Publication:

Gold Prize, HULL PEH: A Novel Compressive Amplifier Structure for Piezoelectric Energy Harvesting, International Expo of Innovation Product and System Design (In-ViDE) 2021

Patent Filling (Registration No: PI 2023001213). Long, S. X., Khoo, S. Y., Ong, Z. C., Soong, M. F. A Mechanical Amplifier Structure for Piezoelectric Energy Harvesting.

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From River Pest to Renewable Fuel: Finding Energy in Ikan Bandaraya

Some sources of energy announce themselves loudly. Sunlight floods our rooftops. Wind turns turbine blades. Rivers push against dams. But some forms of energy hide quietly in places we rarely consider — in waste, in unwanted biomass, and even in an invasive fish swimming through local waterways.

One such example is *Hypostomus plecostomus*, better known in Malaysia as Ikan Bandaraya. Many people recognise it as the “janitor fish” once kept in aquariums to clean algae. Over time, however, this hardy species has escaped into natural river systems and become a growing ecological concern. With its armoured body, strong survival ability and limited natural predators, Ikan Bandaraya can reproduce rapidly, compete with native species, disturb aquatic habitats and contribute to riverbank damage through its burrowing behaviour.

To most people, this fish is a nuisance. It is not commonly eaten, partly because of its hard body structure and public concern over contamination in urban waterways. Removal efforts may help control the population, but they can be costly and do not always create useful value from the collected biomass. This raises an interesting engineering question: what if this unwanted fish is not only a problem, but also an overlooked resource?

That question became the starting point for a Final Year Project at the Department of Mechanical Engineering, Universiti Malaya. The work explored the possibility of converting Ikan Bandaraya into biodiesel through microwave-assisted processing. At first glance, the idea sounds unusual: producing fuel from an invasive fish. Yet this is exactly where the theme “Energy Hiding in Plain Sight” becomes meaningful. The energy is not hidden in the water itself, but in the biological lipids stored within the fish biomass.



Collection of invasive Ikan Bandaraya (*Hypostomus plecostomus*) from a local waterway as a non-edible biomass source for biodiesel production.

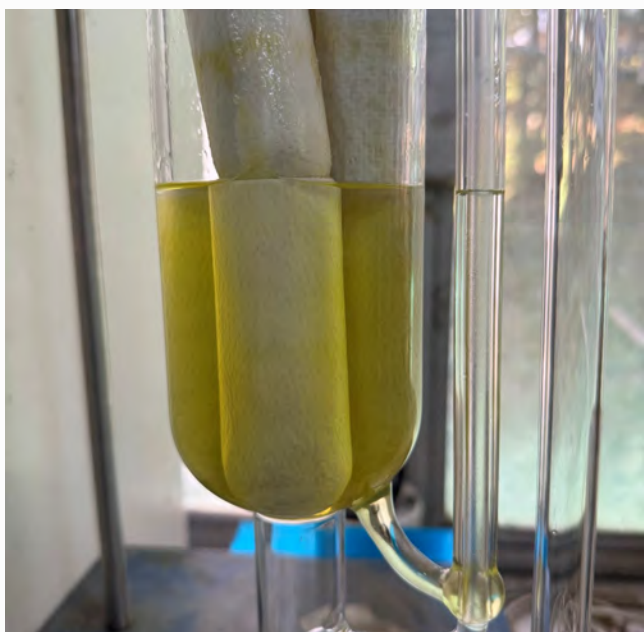
Turning Pest Fish into Fuel

Biodiesel is commonly produced from oils and fats through a chemical process known as transesterification. Commercial biodiesel often relies on edible oils such as palm, soybean or rapeseed oil. While these feedstocks are well established, they raise long-standing concerns about cost, land use and the “food versus fuel” debate. Ikan Bandaraya offers a different pathway. It is non-edible, locally available, and does not require agricultural land or cultivation. In other words, it is a feedstock that already exists as an ecological burden.

Synthesis and Optimization



Prepared Ikan Bandaraya biomass following cutting and sample preparation, prior to drying, grinding, and lipid extraction.



Soxhlet extraction of lipids from Ikan Bandaraya biomass prior to the transesterification process for biodiesel production.

The research began by collecting and preparing the fish biomass for oil extraction. The biomass was dried, ground and processed using Soxhlet extraction with n-hexane to recover crude fish oil. This step is important because the oil becomes the raw material for biodiesel synthesis. However, fish-derived oil presents a challenge: it can contain high levels of free fatty acids, or FFA. If FFA is too high, the biodiesel reaction may produce soap instead of fuel, causing poor separation and lower yield.

In this study, the extracted crude oil had an initial FFA content of 8.69%, which was too high for direct alkaline transesterification. To solve this, the oil underwent a two-stage microwave-assisted acid esterification pre-treatment. This reduced the FFA content to 1.94%, bringing it below the level required for the next stage of conversion. This is a key engineering step: before the hidden energy in the fish oil can be used, the chemistry must first be made suitable for efficient reaction.

The main conversion process used Microwave-Assisted Transesterification, or MAT. Instead of relying only on conventional heating, MAT uses microwave energy to heat polar molecules rapidly and more uniformly. In simple terms, the microwave helps the reacting mixture heat from within, allowing the conversion process to proceed faster. This is especially useful for low-value or waste-based feedstocks, where the process must be efficient to remain practical.

The study optimized two main parameters: the methanol-to-oil ratio and the KOH catalyst concentration. Using the One-Factor-At-A-Time method, the best result was achieved at a 6:1 methanol-to-oil ratio, 1.25 wt.% KOH catalyst, 80 W microwave power and 10 minutes reaction time. Under these conditions, the process achieved a maximum FAME conversion of 96.70%. This is an encouraging result because it shows that an invasive fish oil can be converted into biodiesel rapidly under controlled laboratory conditions.

The produced biodiesel was then tested for important fuel properties. Its heating energy content was 39.029 MJ/kg, which is close to palm oil biodiesel reported in the comparison. This suggests that the fuel has promising energy potential. It also achieved a Class 1 copper strip corrosion rating, indicating that it is non-corrosive under the test conditions and therefore safer for metallic fuel system components. The GC-MS analysis further confirmed the conversion of fish oil into methyl esters, with a fatty acid profile rich in polyunsaturated components.

However, the research also showed that the fuel is not yet ready to be used directly as neat biodiesel without further improvement. The measured kinematic viscosity and density were higher than the limits set by strict fuel standards. This likely reflects the need for better downstream purification, improved phase separation, or blending with commercial diesel or biodiesel at lower ratios such as B10 or B20. In practical engineering, this is not a failure; it is a useful finding. It tells researchers exactly where the next stage of development should focus.

The broader significance of this work lies in its dual benefit. On one side, it proposes a way to create renewable fuel from a non-food biological resource. On the other, it gives value to an invasive species that

damages local freshwater ecosystems. Instead of seeing Ikan Bandaraya only as waste, the research reframes it as a possible contributor to a circular bioeconomy.

This is the quiet power of engineering: to notice what others overlook, and to design a pathway that turns a problem into something useful. Ikan Bandaraya will not replace major energy systems overnight. But that is not the only measure of impact. Small and unexpected energy sources can still matter when they reduce waste, support sustainability and inspire new ways of thinking about local resources.

Energy is not always found in obvious places. Sometimes, it is swimming unnoticed in our rivers, waiting for engineers to ask a better question.



Laboratory recovery of biodiesel using rotary evaporation following transesterification of Ikan Bandaraya lipid.



Final biodiesel product derived from Ikan Bandaraya lipid, held by the student researcher involved in the study.

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Harvesting the Heat: The Hidden Energy Secret Behind Solar Panels

As climate change alters weather patterns and disrupts traditional agriculture, indoor farming has emerged as a vital shield for global food security. By transitioning crops into vertical setups or urban warehouses, farmers gain a dependable, year-round harvest insulated from the whims of nature. However, this modern agricultural shield comes with a massive catch: it requires a staggering amount of energy. To replicate nature, indoor farms rely heavily on a constant draw of electricity to power artificial lighting, climate control, and automated irrigation.

If this electricity is pulled directly from a fossil-fuel-dominated grid, the very system meant to save us from climate disruptions ends up contributing to them. While solar photovoltaic (PV) panels offer an obvious renewable escape path, they possess a counterintuitive vulnerability that engineering researchers set out to exploit. The secret lies in a form of energy hiding in plain sight on the very surface designed to capture light: waste heat.

We naturally associate solar panels with the blazing sun, but solar panels actually dislike excessive heat. As ambient temperatures rise and solar rays bake the silicon cells, a standard photovoltaic panel grows less efficient, losing a fraction of its power potential for every degree it warms up. In a hot and humid tropical climate like Malaysia's, an outdoor panel sitting in the afternoon sun can easily soar to temperatures of up to 55°C.

This thermal buildup represents a significant penalty to electricity generation, forcing a standard mono-silicon panel's performance to degrade sharply. But where traditional setups simply accept this thermal degradation as an unavoidable operational loss, Dr. Nursyahirah and team saw an overlooked bounty of raw energy. The scorching backplane of the solar module is an unmapped reservoir of thermal energy just waiting to be harvested.



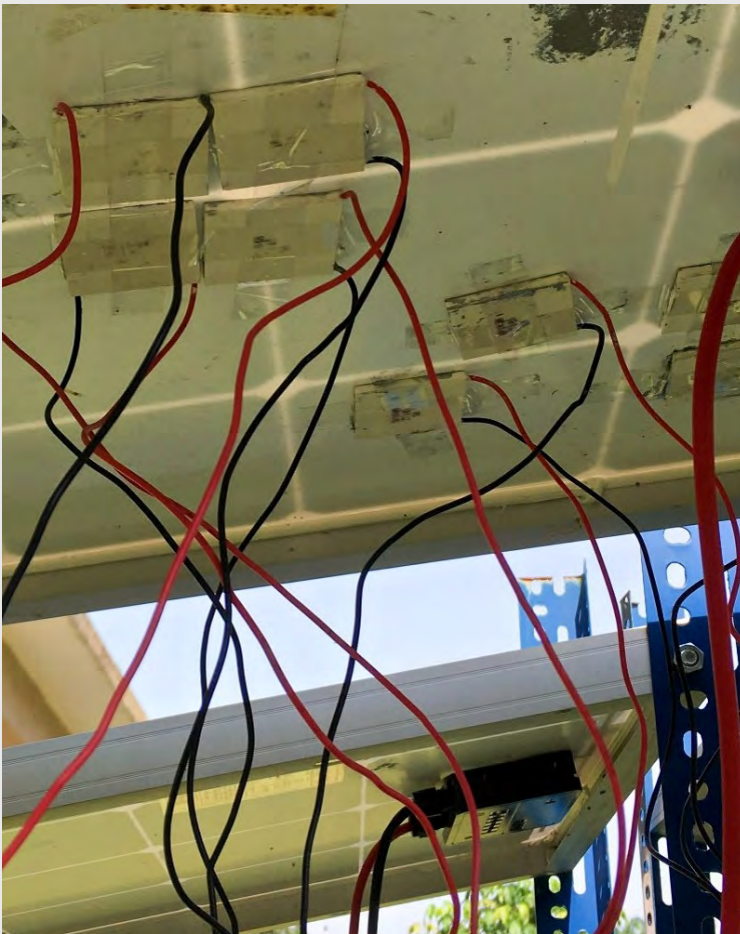
The outdoor experimental setup featuring the stationary photovoltaic frames designed to maximize tropical solar harvesting.

Energy Secret Behind Solar Panels

What if we could use the very heat that degrades a solar panel to generate more electricity? This is the core concept behind the unconcentrated Photovoltaic-Thermoelectric Generator (PV-TEG) hybrid system. To turn this unexpected idea into a physical reality, the research team introduced a solid-state device known as a Thermoelectric Generator (TEG). TEGs have no moving parts, making them incredibly durable and easy to integrate silently behind existing machinery. They operate on a deceptively simple thermodynamic principle: if you can create a temperature difference across the two sides of the TEG module, it will directly convert that heat flow into an electrical current.

By adhering twelve bismuth telluride TEG modules directly to the back of standard 100 W solar panels with a layer of thermal paste to maximize heat transfer, the team created a thermal trap. The sun-baked panel serves as the continuous "hot side," while the ambient air acts as the "cold side". Suddenly, the waste heat isn't a design flaw anymore—it's an active fuel source.

To prove the viability of this low-power harvesting concept, the researchers built a functional outdoor prototype stationed on campus in Kuala Lumpur. Over a rigorous three-month field experiment spanning December to March, the system was subjected to real-world fluctuating tropical weather.



The underbelly of the hybrid system, showing twelve tightly spaced thermoelectric generator modules nestled against the back of the PV panel.

The team closely monitored how the changing weather conditions affected power production. They quickly discovered that the TEG circuit architecture plays a critical role in managing this hidden energy. By experimenting with three distinct wiring configurations, the team discovered that an all-series arrangement provides the most stable, light-independent power production during nighttime hours, whereas a series-parallel hybrid combination maximizes peak current flow during daytime temperature spikes.

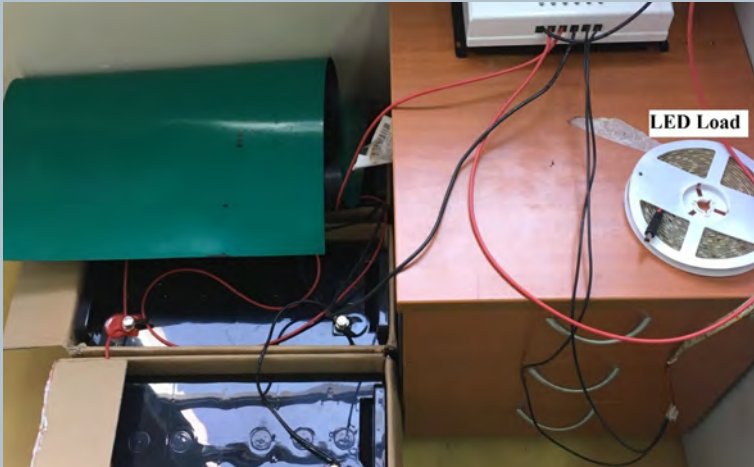
During the peak heat of February and March, the temperature difference between the sun-blitzed panel and the surrounding air reached up to 18°C to 20°C. This thermal gradient allowed the tiny TEG modules to steadily produce bonus electricity purely from what would have been discarded waste.

From a macro perspective, a few milliwatts may seem insignificant compared to the hundred-watt output of a massive commercial solar array. However, in the rapidly expanding landscape of smart agriculture and infrastructure, these small packets of hidden energy are precisely what matter most.

Power generation beyond daylight

While the primary photovoltaic array successfully managed the heavy lifting of running the farm's indoor LED lights for 18 hours a day and maintaining a water irrigation pump, the mini-grid proved completely self-sustaining. The true brilliance of the TEG layer lies in its independence from light itself.

Because the TEG modules depend strictly on a temperature differential rather than direct solar irradiance, they successfully demonstrated the ability to produce electricity long after the sun went down. In December's cooler monsoon climate, the TEGs generated continuous night-time power from 19:30 h until 07:30 h the following morning by utilizing the residual heat radiating away from the structure into the cool night air.



The indoor monitoring station tracking real-time load distribution and battery state-of-charge.

This uninterrupted, light-independent stream of tiny energy is perfectly suited to support low-power smart agricultural systems, including wireless sensor networks, smart indicators and data logging infrastructure. By proving that an independent indoor farm can completely thrive on localized renewable architectures, this research sets a clear pathway toward carbon-neutral food production. The project elegantly illustrates that useful energy doesn't always have to come from massive power plants or loud machinery. Sometimes, the key to building a smarter, more resilient infrastructure is simply looking closely at the surfaces around us, finding the heat hiding in plain sight, and engineering a way to capture it.

Image Credits & Acknowledgments

All data and experimental figures featured in this article are adapted from the originally published open-access research paper: Shatar, N. M., Rahman, M. A. A., Muhtazaruddin, M. N., Salim, S. A. Z. S., Singh, B., Muhammad-Sukki, F., Bani, N. A., Saudi, A. S. M., & Ardila-Rey, J. A. (2019). Performance Evaluation of Unconcentrated Photovoltaic-Thermoelectric Generator Hybrid System under Tropical Climate. *Sustainability*, 11(22), 6192; <https://doi.org/10.3390/su11226192>. Used under the Creative Commons Attribution (CC BY 4.0) License.

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Super Butterfly In-Pipe Hydropower System: Unlocking the Hidden Energy in Water Distribution Networks

Every day, enormous amounts of energy are unintentionally wasted within pressurised water distribution systems. Water utilities around the world invest significant amounts of electricity to pump treated water through extensive pipeline networks to ensure a reliable water supply. However, due to differences in elevation, fluctuating demand, and hydraulic design requirements, many sections of these networks operate with excess pressure. To protect pipelines and maintain stable operating conditions, this excess pressure is commonly dissipated through pressure reducing valves (PRVs), where valuable hydraulic energy is simply converted into heat and turbulence before being released into the environment.

Unlike solar and wind energy, this source of renewable energy is largely invisible. It already exists within the water infrastructure that serves millions of people every day, yet it remains untapped because water distribution systems have traditionally been designed solely for water delivery rather than energy recovery. As countries strive to improve energy efficiency and achieve carbon neutrality, recovering this hidden hydraulic energy presents an opportunity to transform existing water infrastructure into a new source of clean and sustainable electricity without constructing new dams, reservoirs, or large-scale hydropower facilities.

Super Butterfly In-Pipe Hydropower System

The idea behind the Super Butterfly In-Pipe Hydropower System is surprisingly simple: instead of wasting excess pressure, why not convert it into electricity? Rather than treating excess pressure as a problem that needs to be eliminated, Super Butterfly views it as a valuable renewable energy resource. The technology enables existing water pipelines to generate electricity while continuing to perform their primary function of delivering clean water. No additional water abstraction is required, no rivers need to be diverted, and no changes to customer water supply are necessary.

This approach challenges the conventional perception that hydropower can only be generated using large rivers, waterfalls, or dams. In reality, pressurised water pipelines already contain significant hydraulic energy that has never been systematically utilised. By unlocking this hidden energy source, Super Butterfly introduces an entirely new category of distributed renewable energy that can be deployed within existing water distribution infrastructure.

What makes the technology particularly attractive is that it converts an unavoidable energy loss into a valuable asset. Instead of allowing pressure to be wasted through conventional pressure reducing devices, the same energy can be recovered and converted into useful electrical power. This creates a unique opportunity for water utilities to become not only water providers but also renewable energy producers.

The Engineering Solution



Figure 1: The Super Butterfly In-Pipe Hydropower System.

The Super Butterfly In-Pipe Hydropower System is specifically engineered to recover excess hydraulic pressure without compromising the normal operation of the water distribution network.

The system consists of a specially designed impulse turbine installed within existing pressurised pipelines at locations where excess pressure is available. Water jets are directed onto the turbine runner, converting hydraulic energy into rotational mechanical energy. The turbine shaft is then connected to an electrical generator that converts the mechanical rotation into electricity, as shown in Figure 1.

Unlike conventional hydropower systems that rely on large water flows and significant elevation differences, the Super Butterfly turbine is designed to operate efficiently under the relatively low flow rates and moderate pressure heads commonly found within municipal water distribution systems.

An important design principle of the technology is that it absorbs only the excess hydraulic pressure that would otherwise be dissipated. The required downstream pressure and flow conditions are maintained to ensure uninterrupted water supply and system reliability. In other words, electricity is generated without negatively affecting the hydraulic performance of the existing pipeline network. This allows Super Butterfly to function as an energy recovery system rather than an additional hydraulic load, making it highly suitable for integration into existing water infrastructure.

The Possible Applications

The electricity generated by the Super Butterfly system can be utilized immediately within the same facility, reducing operational energy consumption and improving overall system efficiency. Potential applications include powering water pumping stations, water treatment plants, booster stations, SCADA and telemetry systems, pressure monitoring equipment, lighting systems, security facilities, and other auxiliary electrical loads associated with water utility operations. By offsetting part of the electricity consumed by these facilities, water operators can reduce operational expenditure while lowering greenhouse gas emissions.

Beyond municipal water distribution systems, the technology also offers significant potential in industrial water networks, irrigation systems, district cooling networks, desalination plants, and large commercial facilities where pressurized water pipelines continuously dissipate excess pressure.

The technology also supports emerging Energy-as-a-Service (EaaS) business models, allowing renewable electricity to be generated from existing infrastructure without requiring customers to make substantial capital investments. This creates opportunities for collaboration between technology providers, energy service companies, and infrastructure operators to accelerate renewable energy deployment.

The Progress So Far

The Super Butterfly technology has progressed well beyond the conceptual stage and is now entering the early phase of commercial deployment. The technology has been successfully developed through extensive research conducted at the Universiti Malaya, leading to the establishment of Xcess Pressure Sdn. Bhd., a Universiti Malaya spin-off company responsible for commercializing the innovation.

To validate the technology under real operating conditions, an operational pilot project has been implemented within an actual water distribution network in Brinchang, Cameron Highlands, as shown in Figure 2. The pilot project has successfully demonstrated the feasibility of recovering excess hydraulic pressure and converting it into electricity while maintaining stable water supply operations. More importantly, the pilot has generated valuable engineering data that supports system optimization, generator matching, performance validation, and future commercial-scale deployment.

The innovation is further strengthened through multiple patent filings covering the turbine design and associated energy recovery system. In recognition of its commercial potential and technological innovation, Xcess Pressure Sdn. Bhd. was selected as one of the participating companies under PETRONAS FutureTech 2.0, providing additional opportunities for technology development, industry engagement, and strategic partnerships.

Current activities focus on optimizing turbine-generator integration, validating larger-capacity installations, expanding pilot deployments, and collaborating with industry partners to accelerate commercial implementation across Malaysia and internationally.



Figure 2: Operational pilot installation of the Super Butterfly In-Pipe Hydropower System at Brinchang, Cameron Highlands.

The Bigger Impact

The significance of the Super Butterfly technology extends beyond electricity generation. It demonstrates a new way of thinking about infrastructure by transforming existing water distribution systems into distributed renewable energy assets.

Rather than investing in entirely new energy infrastructure, utilities can improve the efficiency of assets that already exist. Every pressure reducing station within a water network represents a potential opportunity for renewable energy recovery. When deployed across multiple locations, these small energy recovery systems collectively contribute to meaningful reductions in electricity consumption, operational costs, and carbon emissions.

The technology also complements national initiatives promoting renewable energy, energy efficiency, and sustainable infrastructure development. It supports Malaysia's transition towards a low-carbon economy while strengthening the resilience of critical public infrastructure.

Looking ahead, Super Butterfly has the potential to diversify renewable energy portfolios by introducing the water utility sector as a new source of clean energy generation. It also creates opportunities for innovative business models such as Energy-as-a-Service (EaaS), enabling infrastructure owners to adopt renewable energy solutions with minimal upfront investment.

Ultimately, the Super Butterfly In-Pipe Hydropower System demonstrates that the future of renewable energy is not only about building new power plants—it is also about recognising and recovering the hidden energy that already exists within the infrastructure we use every day. By transforming wasted hydraulic pressure into valuable clean electricity, the technology contributes to a smarter, greener, and more sustainable future for both the water and energy sectors.

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Turning Signals into Safeguards: Dr. Kayser's Mission to Protect Future Infrastructure

Modern cities run on an illusion of permanence that fundamentally relies on a highly complex, fragile system of high-voltage power grids and telecommunication networks. For Dr. S. M. Kayser Azam, a newly appointed Lecturer at Universiti Malaya's Department of Electrical Engineering, the invisible vulnerabilities within these systems are not just abstract academic concepts, they are the frontline of his research.

Dr. Kayser's research approach was forged not in a laboratory, but in the real engineering field. Before pursuing his postgraduate studies, he worked as a telecommunications Power Engineer at Huawei Technologies in Bangladesh. Tasked with deploying critical infrastructure and confirming zero-downtime operations for telecommunication service providers, he routinely confronted the stark realities of systemic failure. He learned early on that when a network goes down, it doesn't just cause a technical glitch; it halts the pulse of a modern city. This hands-on, high-stakes environment taught in him a philosophy that continues to drive his academic career today: theoretical engineering must ultimately solve real-world problems to benefit people.

Today, Dr. Kayser operates at the nexus of telecommunication and energy systems. At the core of his work is the application of antenna sensors and chipless radio-frequency identification (RFID) tags to monitor the structural and operational health of critical infrastructure. Currently, as a Principal Investigator of a Universiti Malaya Research Excellence Grant, he is developing smart, battery-free multi-functional sensors capable of detecting early-stage electrical faults and thermal anomalies in metro rail power substations. By identifying micro-failures before they trigger catastrophic grid collapse, his work provides a crucial safety net for urban transport networks.

With over 42 scientific publications, many featured in top-tier Q1 and Q2 IEEE transactions and journals, his technical authority is increasingly recognized. His research has not only earned him multiple Best Paper Awards at IEEE international flagship conferences but has also made him a sought-after invited speaker, frequently called upon by organizations like the IEEE to share his expertise with the global engineering community.



Since officially joining the faculty in March 2025, he has quickly established himself as a dynamic and empathetic educator. He is recognized the faculty's Outstanding Teaching and Learning Delivery recognition, a testament to his ability to translate dense engineering concepts into accessible, engaging knowledge. His skill in technical communication was previously highlighted when he secured first place in Universiti Malaya's Three-Minute Thesis (3MT) competition at the Faculty level.

As a supervisor to a growing cohort of postgraduate researchers, Dr. Kayser views human capital as the ultimate critical infrastructure. He actively nurtures his students to see beyond textual equations, encouraging them to design solutions that directly contribute to societal resilience. Whether he is preparing students for elite industrial placements at multinational tech firms or directing laboratory research, his goal is to cultivate a new generation of engineers who are as pragmatic as they are innovative.



The cities of tomorrow will require systems that are intelligent, self-diagnosing, and fiercely resilient. Through his relentless pursuit of advanced sensing technologies and his dedication to shaping the engineers who will deploy them, Dr. S. M. Kayser Azam is ensuring that when the future faces its greatest tests, we will not be caught in the dark.



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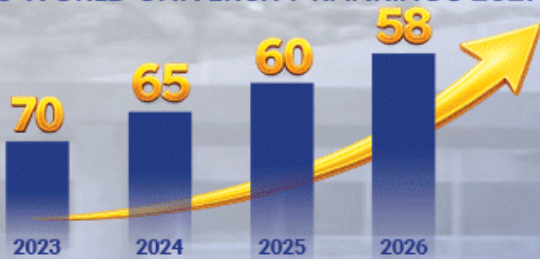


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KEYNOTE SPEAKER

Professor Kamal Youcef-Toumi

Professor of Mechanical Engineering
Massachusetts Institute of Technology (MIT)
USA

Research Interests

- High-Speed Atomic Force Microscopy
- Instrumentation and controls as related to robotics, smart-grids, and manufacturing automation.
- System Modelling and Design Methodologies
- Control Theory and Computational Intelligence



KEYNOTE SPEAKER

Professor Shaligram Pokharel

Professor and Coordinator of Industrial and Systems Engineering Department
Qatar University of Mechanical and Industrial Engineering Department
Qatar

Research Interests

- Engineering management of complex systems.
- Logistics and supply chain, including humanitarian logistics.
- Reverse logistics and circular, low-carbon supply chains.
- Energy planning, modeling, and sustainable operations



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