# MALAYSIA ENTERPRISE CAMPUS NETWORK POLICY GUIDE 2025

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APAC IPv6 COUNCIL

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## FOREWORD

Malaysia's higher education sector is entering a decisive new phase, where world-class digital infrastructure is no longer a luxury but a prerequisite for competitive teaching, research, and innovation. With this context, the **Malaysia Enterprise Campus Network Policy Guide** is both timely and necessary, providing a **structured roadmap to modernize campus connectivity** and **align universities with the nation's broader digital transformation agenda**.

This guide recognises that universities are not only centres of learning, but also engines of innovation, talent development, and industry collaboration. By setting out a clear framework for 10 Gigabit Ethernet backbones, Wi-Fi 7, and Time-Sensitive Networking, it addresses longstanding gaps in capacity, reliability, and consistency across Malaysian campuses. It also provides practical pathways to upgrade legacy environments so that even geographically remote or resource-constrained institutions can participate fully in the digital economy.

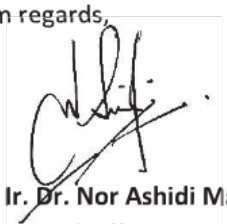
Importantly, the policy framework is firmly anchored in national priorities such as MyDIGITAL, JENDELA, Industry4WRD, the National Energy Transition Roadmap, and the 5G Malaysia initiative. This alignment ensures that investments in campus networks are not made in isolation, but contribute directly to broader goals in digital inclusion, industry competitiveness, and sustainable growth. The emphasis on Green ICT, energy-efficient designs, and carbon monitoring further reinforces Malaysia's commitment to a low-carbon, climate-resilient future.

From the perspective of a public university, **the guide offers a compelling vision of what a future-ready campus should be**. **High-capacity, secure, and intelligent networks** will enable **data-intensive research collaborations, immersive hybrid teaching models, and seamless connectivity** for students, staff, and partners. The focus on human capital development and upskilling will also empower campus ICT teams to design, operate, and secure these advanced environments with confidence.

Equally significant is the guide's attention to governance and shared responsibility. It promotes a coherent ecosystem approach rather than fragmented, one-off projects. The proposed monitoring and evaluation mechanisms, including real-time dashboards and annual reporting, will help ensure that **progress is measurable, transparent, and responsive to emerging technologies**.

This policy guide **deserves strong support from the higher education community**. It provides the **technical, institutional, and strategic foundations needed to transform our campuses into intelligent, secure, and sustainable digital ecosystems** that can stand alongside leading research and education networks globally. With committed implementation and sustained collaboration, it will help position Malaysia's universities as true digital hubs at the heart of a vibrant, innovation-driven national economy.

Warm regards,



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## Executive Summary

Malaysia's higher education system is at a defining moment in its digital transformation. Universities today are more than academic institutions they are innovation ecosystems that nurture research, develop talent, and connect industries. To sustain Malaysia's growth as a digital nation, our universities must be equipped with **world-class digital infrastructure** that enables high-speed connectivity, reliable access, and advanced research capabilities.

To support this shift, Malaysia must develop **large-scale, high-performance campus networks** that connect students, researchers, and industries under a unified digital framework.

The **Enterprise Campus Network (ECN) Policy Guide** proposes a national framework to standardize the design and evolution of university networks across Malaysia. Its goal is to ensure every institution has access to **consistent, scalable, and secure digital connectivity**. Many campuses still rely on legacy systems that limit bandwidth and performance. The ECN framework will address these gaps by promoting high-speed connectivity and best practices for network design and management.

This policy focuses on three core technologies driving next-generation campus networks: **10 Gigabit Ethernet (10GE)** for ultra-fast backbone connectivity, **Wi-Fi 7** for seamless wireless access, and **Time-Sensitive Networking (TSN)** for real-time, precision-based data transmission. Together, these technologies will create intelligent, high-capacity campus environments capable of supporting research, cloud applications, and data-driven learning.

Aligned with national priorities such as **MyDIGITAL**, **JENDELA**, **Industry4WRD**, and the **National Energy Transition Roadmap (NETR)**, this initiative strengthens Malaysia's digital infrastructure and supports sustainable, inclusive innovation. It promotes universities as key enablers of digital economy growth and aligns campus modernization efforts with national broadband and smart education strategies.

Implementation will proceed in structured phases to ensure large-scale deployment and long-term sustainability. From 2025 to 2027, pilot projects in leading universities such as **UM**, **UTM**, and **USM** will establish technical standards and benchmark performance. Between 2027 and 2030, the framework will expand to all public and major private universities, incorporating network management, cybersecurity, and green ICT principles. By 2035, all institutions will be

integrated into a unified **National Higher Education Network Grid**, enabling large-scale collaboration and shared innovation across Malaysia's academic ecosystem.

Strong collaboration between **government agencies, universities, and industry partners** will be essential. Public–private partnerships will accelerate deployment and facilitate technology transfer, while national training and certification programs will build local expertise in advanced network management, cybersecurity, and sustainable ICT operations.

Sustainability and security are central to the policy. All deployments will follow **Green ICT principles**, emphasize energy-efficient hardware and low-carbon practices, while adhering to the **National Cyber Security Policy** and **Personal Data Protection Act (PDPA)** to ensure data safety and network integrity.

Through this initiative, Malaysia will create a **nationwide, intelligent, and sustainable education network** that enhances research collaboration, supports digital learning, and drives innovation. By standardizing and upgrading university networks, Malaysia will strengthen its position as a **regional leader in connected, future-ready higher education**, paving the way for inclusive digital growth and national competitiveness.

# 1. Introduction

## 1.1 Background and Rationale

Malaysian universities are moving beyond traditional education models and embracing new digital ecosystems that enable advanced research, global collaboration, and technology-driven learning. The COVID-19 pandemic further accelerated this digital shift, revealing the importance of reliable and high-performance network infrastructure to ensure continuity in learning and operations.

While Malaysia has made considerable progress in expanding internet access and digital services, the **network infrastructure within higher education institutions remains uneven**. Many universities continue to rely on legacy systems with limited bandwidth, fragmented network management, and outdated wireless technologies. This constrains their ability to support emerging technologies such as artificial intelligence (AI), cloud computing, data analytics, and immersive learning platforms all of which demand seamless, high-speed connectivity.

To address these challenges, there is a pressing need for a **unified national framework** that defines standards and best practices for campus network construction and evolution. This **Enterprise Campus Network (ECN) Policy Guide** has been developed to fulfil this need. It proposes standardized guidelines for the design, deployment, and management of large-scale campus networks across Malaysia's universities and research institutions.

## 1.2 Higher Education in Malaysia's Digital Economy

Higher education institutions play a pivotal role in Malaysia's transition towards a **knowledge-based and digitally-empowered economy**. Universities are not only centres of learning but also catalysts for research, innovation, and the development of human capital. In an increasingly interconnected world, the ability to integrate digital technologies into education and research determines a nation's competitiveness and resilience.

By adopting high-speed, intelligent, and secure networks, universities can enable new forms of digital collaboration between academia, industry, and government. Such infrastructure allows for large-scale research data sharing, cloud-based learning platforms, and the implementation of smart campus systems that optimize energy, resources, and student experiences.

Furthermore, as Malaysia fully embraces Industry 4.0, the **skills and capabilities of the future workforce** must align with emerging technological trends. Universities are the primary drivers of this talent pipeline, preparing graduates in areas such as data science, cybersecurity, and network engineering. Reliable and high-performance network environments are essential to support laboratories, research simulations, and real-time digital training platforms.

An upgraded enterprise campus network will thus strengthen Malaysia's innovation ecosystem by:

- Enabling high-capacity research and development (R&D) collaboration among universities.
- Supporting e-learning and hybrid education through stable, low-latency connectivity.
- Enhancing partnerships with industry through shared digital infrastructure.
- Promoting inclusive access to high-quality education across regions.

In this context, the ECN Policy Guide serves as a **strategic enabler** of Malaysia's digital economy, ensuring that the country's universities are not only users of technology but also contributors to technological innovation and economic growth.

## 1.3 Alignment with National Digital Initiatives

The proposed Enterprise Campus Network Policy is fully aligned with Malaysia's national digital transformation agenda. It complements and strengthens several key policy frameworks and initiatives that collectively shape the nation's journey toward a high-income digital economy.

The **MyDIGITAL Blueprint** outlines Malaysia's vision to become a digitally driven, high-income nation by 2030. By improving campus connectivity and digital infrastructure, the ECN Policy directly supports MyDIGITAL's objectives under the "Digital Infrastructure" and "Digital Government" pillars. The establishment of high-speed, large-scale campus networks enables universities to contribute to digital innovation, research, and capacity building, aligning with national goals.

The **JENDELA (National Digital Network Plan)** aims to expand and enhance nationwide connectivity, focusing on both urban and rural areas. The ECN Policy complements this initiative by extending the focus from consumer broadband to **institutional and enterprise-grade networks** in higher education. Universities can become demonstration sites and innovation hubs for high-speed networking technologies that feed into the broader JENDELA ecosystem.

Malaysia's **Industry 4.0 (Industry4WRD) Policy** emphasizes smart manufacturing, automation, and data-driven innovation. A modern enterprise campus network serves as the backbone for R&D collaboration between universities and industries in these domains. With TSN and 10GE capabilities, universities will be equipped to host testbeds for advanced technologies, simulation environments, and digital twin applications that accelerate industrial transformation.

Finally, the **5G Malaysia Initiative** reinforces the importance of high-speed, low-latency communication infrastructure to support new digital services and applications. The deployment of **Wi-Fi 7 and 10GE campus networks** aligns closely with 5G objectives, creating a complementary environment where universities can test, validate, and innovate around 5G-enabled applications such as smart campuses, connected laboratories, and AI-based research systems.

By aligning with these key national programs, the Enterprise Campus Network Policy Guide ensures that Malaysia's higher education sector is fully integrated into the national digital transformation agenda.

# 2. Policy Objectives

## 2.1 Strategic Goals

The **Malaysia Enterprise Campus Network Policy Framework** seeks to position Malaysian universities as **core digital hubs** within the national knowledge economy, aligning connectivity infrastructure with MyDIGITAL, JENDELA, Industry4WRD, and 5G Malaysia initiatives.

The key strategic goals include:

### 2.1.1 Establishing a Unified Network Standard:

Develop national guidelines and specifications for campus network design encompassing 10 Gigabit Ethernet (10GE), Wi-Fi 7, and Time-Sensitive Networking (TSN) to ensure uniformity, interoperability, and cost efficiency across public and private universities.

### 2.1.2 Enhancing Network Capacity and Quality:

Upgrade legacy networks to meet international benchmarks for performance, latency, and reliability. The policy targets large-scale deployment of **10GE backbone networks** and **Wi-Fi 7 access infrastructure**, capable of supporting research-grade data transfer, smart classrooms, IoT systems, and AI-assisted management.

### 2.1.3 Promoting Digital Inclusion and Regional Balance:

Bridge the digital divide between metropolitan and rural institutions, particularly in East Malaysia, through government co-funding, shared backbone infrastructure, and public–private partnerships (PPP).

### 2.1.4 Strengthening Cybersecurity and Data Sovereignty:

Implement a unified cybersecurity framework that integrates compliance with **Cybersecurity Malaysia** and **MCMC** standards, including zero-trust architectures, encrypted network management, and local data hosting for university networks.

#### 2.1.5 Supporting Sustainable and Green ICT Practices:

Integrate energy-efficient network hardware, intelligent power management, and carbon monitoring systems to reduce the environmental footprint of large-scale campus network operations, contributing to Malaysia's **Net Zero 2050** commitments.

#### 2.1.6 Building National Research and Education Network (NREN) Foundations:

Lay the groundwork for a future **National Higher Education Network Grid (NHENG)** that connects all universities, research centres, and technology parks into a unified, high-capacity backbone for collaboration and data sharing.

## 2.2 Target Beneficiaries

This policy framework is designed to benefit multiple tiers of stakeholders across Malaysia's higher education and research ecosystem:

#### 2.2.1 Public Universities:

Malaysia's public universities will serve as the first phase of deployment, receiving high-speed 10GE connectivity and Wi-Fi 7 infrastructure upgrades. Over **13,000–14,000 access points** [2] have already been installed nationwide under Phase 2 of the national Wi-Fi enhancement initiative, with **32,000 APs planned** in total.

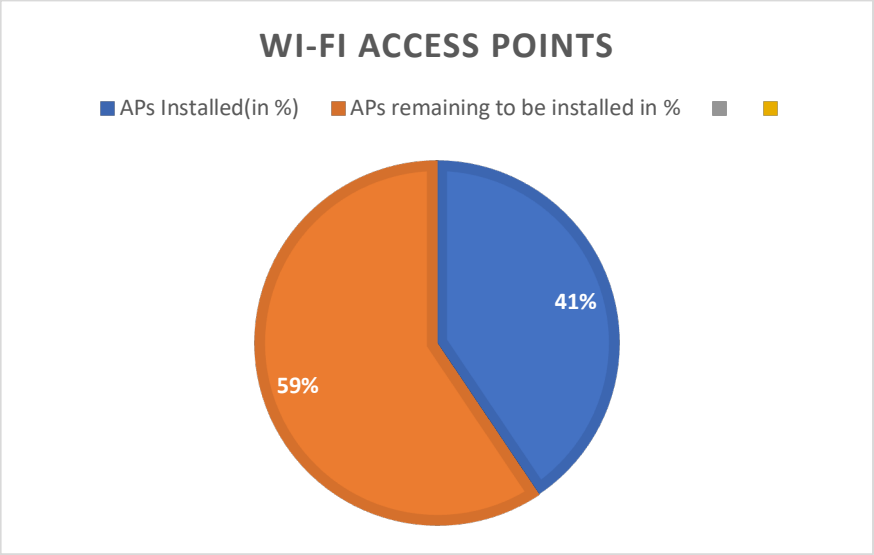


Figure 2-1: Wi-Fi Access Point (AP) Rollout Progress (Planned Target: 32,000 APs by 2027)

### 2.2.2 Private Universities and Colleges:

Private higher learning institutions, which cater to over **40% of total tertiary enrolment**[1], will benefit through policy incentives and standardized technical guidelines, ensuring interoperability with public university networks and shared research frameworks.

### 2.2.3 Research Institutes and Innovation Hubs:

Dedicated connectivity for national R&D centres such as MIMOS, MRANTI, and sectoral research clusters (e.g., health, energy, and agriculture) will enable high-speed data exchange, remote instrumentation, and distributed computing.

### 2.2.4 Enterprises and Industry Partners:

Through university-industry collaboration models, enterprises can leverage high-performance campus networks for joint research, testbeds, and workforce development. The policy promotes **enterprise campus network integration** to strengthen industry-academia linkages and pilot Industry 4.0 technologies.

#### 2.2.5 Students and Academic Communities:

With **over 1.2 million tertiary students** in Malaysia, this policy ensures equitable digital access, enabling seamless online learning, digital content creation, and collaboration regardless of geographical location or institutional capacity.

## 2.3 Expected Outcomes

By implementing this policy framework, Malaysia's higher education ecosystem will undergo a structured digital evolution, yielding the following measurable outcomes:

#### 2.3.1 High-Speed, Scalable Connectivity:

All public and major private universities will achieve **campus-wide 10GE backbone networks and Wi-Fi 7 access** by 2030, ensuring speeds up to 10 Gbps for academic and research applications. Although not required in most cases, administrative applications and workflows will also benefit from this spillover.

#### 2.3.2 Unified National Higher Education Network Grid:

By 2035, universities, research institutions, and innovation centres will be interconnected through a secure **National Higher Education Network Grid (NHENG)**, facilitating large-scale data sharing and collaborative research.

#### 2.3.3 Standardized Campus Network Architecture:

A nationally adopted technical standard will guide infrastructure planning, procurement, and lifecycle management, improve network reliability, and reduce operational costs across institutions.

#### 2.3.4 Cybersecurity Maturity Enhancement:

100% of participating institutions will implement advanced cybersecurity protocols including next-generation firewalls, AI-based threat detection, and zero-trust identity management aligned with **Cybersecurity Malaysia** guidelines.

### 2.3.5 Green ICT Adoption:

Implementation of energy-efficient equipment and intelligent power management is expected to reduce network energy consumption, supporting national climate targets.

### 2.3.6 Improved Digital Learning and Research Capabilities:

Enhanced connectivity will enable universities to adopt AI-driven learning systems, AR/VR-enabled teaching platforms, and distributed cloud research environments, significantly improving academic performance and research outputs.

# 3. Current State of Campus Networks in Malaysia

## 3.1 Overview of Existing University Campus Infrastructure

Malaysia has made clear recent investments to improve campus connectivity, driven by national priorities to modernize education and research infrastructure. The Malaysian Research & Education Network (MYREN) provides a dedicated R&E backbone that links public universities, private universities, polytechnics and several teaching hospitals, forming the foundation for high-speed academic traffic and inter-campus collaboration[40].

At the campus level, the government has funded large Wi-Fi rollout programs: MCMC and other agencies have committed significant budgets to improve wireless access at public universities, with reported national allocations exceeding **RM 600 million** to upgrade Wi-Fi in public higher education institutions[3]. To date, over **13,000 Wi-Fi access points** have been installed across public university campuses as part of the current nationwide programme (out of a planned ~32,000 access points)[2]. Earlier phase work also documented **3,149 APs** deployed across three universities under Phase 1, illustrating the phased rollout approach[4].

| University | Date of Data Reported | Approx. APs Installed | Coverage Status | Features/ Upgrades |
|---|---|---|---|---|
| **Universiti Tun Hussein Onn Malaysia (UTHM)**[42] | 11 August 2025 | ~1,200 APs | 100% main campus coverage | Completed in 50 days; first large-scale full Wi-Fi campus rollout |
| **Universiti Malaya (UM)**[43] | 8 February 2025 | ~1,500 APs | 85% coverage (Wi-Fi 7 pilot in select areas) | Dual-band 6 GHz Wi-Fi 7 pilot zones |
| **Universiti Teknologi Malaysia (UTM) Bintulu** | | ~1,100 APs | 80% coverage | Fiber-to-AP deployment in research blocks |
| **Universiti Putra Malaysia (UPM)**[44] | 5 March 2025 | ~800 APs | 70% coverage | Upgraded core switches to 10GE |
| **Private Universities (Taylor's, MMU, INTI, etc.)** | | 3,000+ combined | 90–100% coverage | Privately funded Wi-Fi 6E/7 implementations |

| | | | | |
|---|---|---|---|---|
| **Total (Estimated National)** | | **13,000+ APs** | Average ~80% national coverage | Full completion target: 32,000 APs by 2027 |

Table 3-1: Phased Rollout Plan to Improve Wireless Access at Universities

National Internet demand has also surged, demonstrating the pressure on institutional networks: the Malaysia Internet Exchange (MyIX) reported a peak traffic of **2.1 Tbps** in 2023 nearly four times the traffic seen during the early 2020 lockdown reflecting the rapid growth in data consumption that campus networks must accommodate[5].

These investments and backbone services indicate strong policy intent and growing capability, yet the current infrastructure landscape is mixed: while some flagship universities have modernized significant portions of their wireless and backbone networks (including rapid full-campus Wi-Fi rollouts at certain institutions), many campuses still operate with legacy wiring, mixed access speeds (1G/10G), and piecemeal management systems.

**Universiti Putra Malaysia Bintulu Campus (UPMKB)** achieved a milestone by implementing a **Coarse Wavelength Division Multiplexing (CWDM)** backbone through a **Fiber-to-the-Room (FTTR)** model, providing **2.5 Gbps per endpoint**; first among Malaysian public universities[6].

Additionally, **Universiti Sultan Zainal Abidin (UniSZA)** partnered with **TM ONE** in 2025 to establish a **Smart Campus infrastructure**, integrating IoT-based lighting, cloud security, and a hybrid academic data centre. While a number of Malaysia's research universities have deployed 10 Gbps broadband and are architected for high-capacity connectivity, a broader survey of campus network readiness indicates that many Malaysian higher education institutions still require enhancement of their logical network architectures to support smart campus initiatives and next-generation demands such as 10GE backbones and Wi-Fi 7.

## 3.2 Challenges and Gaps in Current Deployments

Despite visible progress, several structural challenges must be addressed to realize a nationwide, high-quality ECN ecosystem:

**3.2.1 Inconsistent Backbone Standards:** A significant share of campuses still operates mixed-speed backbones (1G / 10G / occasional 40G links) without a national minimum baseline. This variance complicates inter-campus collaboration and the efficient use of MYREN for high-performance research workloads.

**3.2.2 Incomplete Wi-Fi Modernization:** Although thousands of APs are deployed, coverage quality and AP density vary substantially across campuses and student housing. National rollout targets (≈approximately 32,000 APs) demonstrate scale but not uniform; campuses remain in mid-transition and will require coordinated trunk upgrades to avoid wireless bottlenecks.

**3.2.3 Limited Deterministic Networking Experience:** Time-Sensitive Networking (TSN) is essential for robotic labs, industrial testbeds, and precision research setups; however, TSN adoption and operational experience in Malaysian campuses are still developing.

**3.2.4 Operational & Skills Gaps:** Many campus IT teams lack experience with multi-gigabit campus design, Wi-Fi 7 planning, SDN/automation, and streaming telemetry skills that are essential to manage modern large-scale networks efficiently.

**3.2.5 Regional Digital Divide:** Urban flagship universities (e.g., UM, UTM, USM) have benefited from early investments and pilot projects, while some rural and East Malaysian institutions lag in both backbone capacity and wireless density.

**3.2.6 Rising Traffic and Security Needs:** The surge in national internet traffic (MyIX ~2.6 Tbps) is accompanied by increased cybersecurity exposure; campus networks must scale throughput and upgrade security posture.

A key issue is the **fragmented procurement and management** of ICT infrastructure as each university operates independently, resulting in **non-standard configurations**, inconsistent **security postures**, and **redundant costs**.

These gaps underscore the need for a national ECN policy that sets a minimum backbone standard (recommended baseline: 10GE), prescribes staged Wi-Fi 7 adoption in high-density zones, builds TSN pilot programs, and funds capability building across campuses.

## 3.3 International Benchmarking

Regional and global Research & Education networks (R&E) provide instructive models for Malaysia as it scales campus networks. Three practical dimensions emerge from international benchmarking: (1) Backbone capacity and upgrade rhythm, (2) Wireless and campus fabric design, (3) Federated services and operational models for identity, security and peering.

First, elite campuses in **Singapore** and other leading Asian economies operate multi-10Gbps/40Gbps campus fabrics with substantial aggregation and international peering capacity. For example, the National University of Singapore (NUS) operates a multi-site campus fabric combining thousands of 10Gbps and 40Gbps ports with an 80Gbps uplink architecture to support ~200,000 wireless clients and heavy research traffic a practical model for dense, multi-node campuses[7].

**South Korea's** national research networks demonstrate the value of a high-capacity national backbone and regional Points of Presence(PoP) architecture. Korea's research backbone (KOREN / KREONET family) interconnects major cities with links from 10Gbps up to multiple Tbps aggregate capacity (published descriptions cite backbone capacities up to 1.2 Tbps and national DWDM/100G+ planning), enabling distributed HPC, testbeds and industry collaborations across universities and research centers[8].

**Europe's** GÉANT and the constellation of national NRENs illustrate a federated, service-oriented approach: GÉANT interconnects around 44 European NRENs with multiple 100Gbps circuits and offers shared services (high-capacity backbone, federated identity, eduroam, eduGAIN, cloud onramps). The GÉANT model demonstrates how centralized services and pan-regional peering minimize duplicate investment at the campus level, while facilitating large-scale scientific collaboration[9].

Operational services that simplify mobility and collaboration at scale are essential: **eduroam,** the global federated roaming service for education, reached a record **8.4 billion authentications in 2024**, underscoring how federated Wi-Fi access has become the default expectation for mobile researchers and students. Malaysia's ECN approach should embed eduroam and similar federated services to streamline authentication, roaming and campus-to-campus collaboration[10].

Connectivity in Asia is already moving toward 100G+ transnational links and multi-100G national rings that benefit campuses willing to peer. These higher-capacity international rings reduce latency and increase throughput for cross-border research collaborations and should inform Malaysia's NHENG planning[11].

| Benchmark Indicator | International Exemplar / Case | Current Global Practice (2024–2025) | Recommended Malaysian Target (2030) | Rationale / Reference |
|---|---|---|---|---|
| **Campus Backbone Capacity** | NUS (Singapore) / KREONET (Korea) | 10–40 Gbps campus distribution; 100 Gbps national backbone links | **10 Gbps as baseline**, scalable to 40/100 Gbps in research-intensive universities | Enables large-scale scientific data exchange and AI-driven research workloads; |
| **Wi-Fi Generation Standard** | NUS / NTU / European NRENs | Wi-Fi 6/6E under transition to Wi-Fi 7 pilots (2024) | **Nationwide Wi-Fi 7 adoption** in all public universities by 2030 | Supports deterministic latency, higher concurrency, and IoT integration for smart campus environments |
| **Time-Sensitive Networking (TSN) Integration** | KOREN Testbeds / GÉANT R&E pilots | Early deployments for industrial automation and | **Pilot TSN use cases** in engineering and research labs (2025– | Ensures interoperability with Industry 4.0 systems and smart |

| | | | | |
|---|---|---|---|---|
| | | precision networking | 2027), expansion nationwide (by 2030) | manufacturing curriculam |
| **Federated Identity & Wi-Fi Roaming (eduroam / eduGAIN)** | Europe (GÉANT) / Asia-Pacific (eduroam Federation) | 8.4 billion global authentications (2024) | **100% campus adoption of eduroam** and eduGAIN federation by 2028 | Simplifies roaming, enhances academic mobility, reduces network management overhead; |
| **Network Operations & Security Model** | GÉANT / SingAREN / KOREN | Centralized Network Operation Centers with shared cybersecurity services | **National Higher Education Network Operations Center (NHENOC)** by 2030 | Enhances resilience, cost-efficiency, and unified security compliance |
| **Green ICT & Energy Efficiency** | European GreenNREN Initiative | 25–30% energy efficiency gains through network virtualization & power optimization | **20% energy efficiency improvement** through virtualization & renewable power by 2030 | Aligns with Malaysia's sustainability targets (MyDIGITAL Green Tech Strategy) |
| **Backbone Peering & International Connectivity** | Asia-Pacific R&E 100 G+ Links (APAN, AARNet, SingAREN) | 100 Gbps+ cross-border peering links operational (since 2020) | **Malaysia to join 100 Gbps+ regional peering ring by 2028** | Improves regional collaboration and access to international research facilities; |
| **Digital Inclusion / End-User Access Density** | Singapore, Japan, EU Universities | ≥ 2.5 networked devices per student | **Target: 2.5 devices per student (wired + wireless)** | Ensures ubiquitous connectivity for hybrid learning and remote labs |
| **Data Management & Cloud Integration** | Europe (GÉANT Cloud Framework) / US (Internet2) | Federated cloud onramps integrated into R&E networks | **National Research Cloud Onramp** by 2032 | Supports AI, HPC, and open science workloads securely within the NHENG backbone |

Table 3-2: Practical Takeaways for Malaysia (International Benchmarks & Targets)

## 4. Policy Recommendations

### 4.1 Formulation of a National Enterprise Campus Network (ECN) Policy Guide

Malaysia's higher education sector requires a unified **National Enterprise Campus Network (ECN) Policy Guide** to standardize large-scale network design, management, and evolution across universities and research institutions. This guide should be developed under a joint task force led by the **Ministry of Higher Education (MOHE)**, the **Malaysian Communications and Multimedia Commission (MCMC)**, and the **Ministry of Communications and Digital**, in alignment with national frameworks such as **MyDIGITAL Blueprint (Government of Malaysia, 2021)**, **JENDELA Phase 2 (MCMC, 2023)**, and **Industry4WRD (MITI, 2018)**.

Key components will include:

#### 4.1.1 Tiered Campus Classification:

- *Tier 1:* Research-intensive universities and innovation hubs (e.g., UM, USM, UTM, UKM).
- *Tier 2:* Comprehensive public and private universities.
- *Tier 3:* Technical and community colleges, satellite campuses.

  Each tier will have minimum network performance benchmarks and scalability goals for 10GE backbone and Wi-Fi 7 coverage.

#### 4.1.2 Compliance and Reporting Framework:

Institutions will be required to submit a **Campus Network Modernization Plan** to MOHE by 2026, detailing existing infrastructure, gaps, and upgrade roadmaps.

#### 4.1.3 Policy Synchronization:

The ECN Policy Guide will align with JENDELA's target of achieving 100% 4G coverage and 5G readiness, integrating higher education campuses as high-bandwidth "digital anchor zones" to support both academic and commercial connectivity.

#### 4.1.4 Dynamic Updates:

The guide will be versioned every two years to incorporate new technology standards (e.g., Wi-Fi 8, 400GE, quantum-safe encryption), ensuring Malaysia remains regionally competitive.

## 4.2 Establishment of Technical Standards

The ECN Policy will define technical and architectural standards that support large scale, future-ready, and secure digital campus environments. These standards will be aligned with international frameworks such as **IEEE 802.11be**, **ISO/IEC 27001**, and **ITU-T G.8013 (Y.1731)** for service performance monitoring.

### 4.2.1 10 Gigabit Ethernet (10GE) Backbone

The backbone architecture will serve as the digital nervous system of the campus ecosystem.

- **Core Design**:
  Each Tier 1 and Tier 2 university must adopt dual-redundant 10GE fiber rings, supporting scalability to 40/100 GE. These cores will integrate with the **MyREN** national research network backbone, ensuring low-latency (≤ 3 ms) inter-campus connectivity and seamless cross-border collaboration with Trans-Eurasia Information Network (TEIN) and other networks.
- **Resilience and Redundancy**:
  The core should include dual-homing to separate optical paths and diverse peering through two separate Internet Service Providers, guaranteeing 99.99% uptime.
- **Energy-Efficient Design**:
  Implementation should follow IEEE 802.3az Energy-Efficient Ethernet standards to reduce operational carbon footprint, supporting Malaysia's **Green Technology Master Plan 2030**.

### 4.2.2 Wi-Fi 7 Access Standards

The Wi-Fi 7 (IEEE 802.11be) rollout across Malaysian universities represents a major leap in wireless learning and digital campus transformation.

- **Spectrum Utilization**:
  The **6 GHz band allocation by MCMC (2024)** allows Malaysian universities to deploy Wi-Fi 7 access points capable of delivering up to 30 Gbps peak throughput per AP[12].

- **Design Guidelines**:

  Wi-Fi 7 zones should prioritize lecture halls, laboratories, and co-working spaces.

  Deployment models will adopt AI-powered Radio Frequency optimization for dynamic load balancing and predictive fault management.

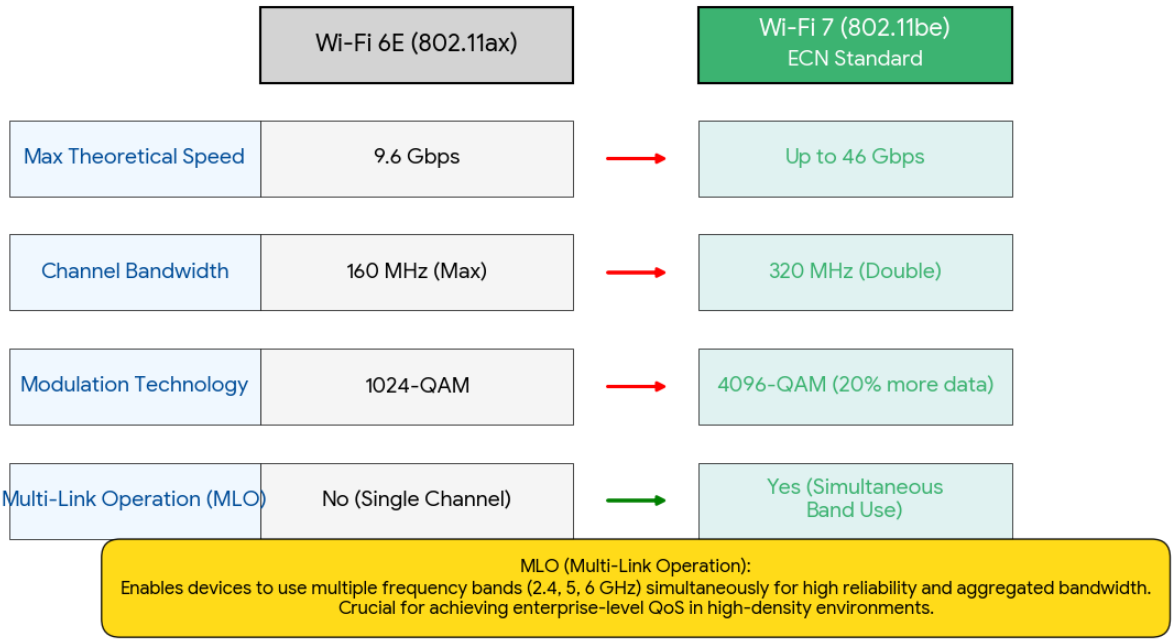


Figure 4-1: Wi-Fi 7 vs Wi-Fi 6E: Key Technical Advancements

- **Integration with Smart Systems**:

  Wi-Fi 7 networks will form the communication layer for IoT-based campus management, covering smart lighting, environmental monitoring, and occupancy analytics, in alignment with **Smart Campus Blueprints** by Universities in Malaysia[13].

### 4.2.3 Time-Sensitive Networking (TSN) for Research and Industry Collaboration

Malaysia will pioneer **Time-Sensitive Networking (TSN)** deployments in higher education to support ultra-low latency applications in engineering, robotics, and Industry 4.0.

- **Pilot Testbeds**:
  - **MIMOS**: Establish a TSN interoperability testbed for smart manufacturing protocols (IEEE 802.1Qbv, Qbu, and 802.1AS).
  - **MRANTI Park**: Enable TSN use cases in 5G test corridors for AR/VR, connected vehicles, and industrial automation[14].
- **Academic Collaboration**:

  UM, USM, and UTM will host integrated research labs connected to the MyREN backbone, sharing real-time data streams for experimental simulation and remote robotics testing.
- **Commercialization Objective**:

  TSN testbeds will link to regional technology parks, creating a "Malaysia TSN Corridor" under MOSTI for commercial use cases and industrial certification programs by 2032.

## 4.3 Human Capital Development and Certification Programs

The success of the ECN policy depends heavily on skilled human capital. Malaysia must cultivate a new generation of network engineers capable of managing high performance and time-sensitive infrastructures.

### 4.3.1 Certification Program:

In partnership with **APAC IPv6 Council, IPv6 Forum Malaysia**, **Huawei ICT Academy**, **Cisco NetAcad**, and **Malaysia Digital Economy Corporation – Penang Digital Transformation Initiative(MDEC PDTI)**, Malaysia will introduce the **Campus Network Engineer Certification,** focusing on Wi-Fi 7, IPv6, 10GE, and TSN competencies.

- **Capacity Targets**:
  - By 2030, produce **at least 500 Certified Campus Network Engineers**.
  - Integrate certification programs into local universities (UM, UTHM, UNIMAS, UTM, and others).

- **Research and Innovation Mobility**:

  Launch an annual **Campus Network Innovation Challenge** at **MRANTI Park**[15] to promote academic industry collaboration.

- **Sustainability Integration**:

  ECN deployments will also train personnel in **Green ICT frameworks**, supporting Malaysia's carbon neutrality goal by 2050.

## 5. Governance and Oversight

The success of Malaysia's National Enterprise Campus Network (ECN) Policy depends on strong, multi-stakeholder governance that ensures cross-ministerial alignment, transparent execution, and measurable outcomes. A central ECN Governance Council, chaired by the

**Ministry of Higher Education (MOHE)** and supported by **MOSTI**, **MCMC**, and **JDN** will oversee the policy's implementation, supported by academic and industry advisory panels. This governance model mirrors the collaborative structures used in Malaysia's MyDIGITAL Blueprint governance framework and the JENDELA National Steering Committee, ensuring policy continuity and accountability.

## 5.1 Lead Ministries and Agencies (MOHE, MOSTI, MCMC, JDN)

Each ministry and agency will play a defined leadership role in implementing and regulating the ECN framework.

### 5.1.1 Ministry of Higher Education (MOHE)

- Serves as **policy owner and lead coordinator** for the ECN framework.
- To align ECN goals with Malaysia's broader digital transformation agenda, MOHE will integrate them into the ongoing **Higher Education Development Plan (2026–2035)**[41] and align implementation with the national **Malaysia Digital Economy Blueprint (MyDIGITAL)** and the **National Digital Education Policy**. These frameworks collectively guide infrastructure modernization, talent development, and digital strategy across the education ecosystem.
- Will issue **Annual Campus Digital Infrastructure Reports** to Parliament, similar to existing MOHE reporting under the **Higher Education Blueprint (2015–2025)** [16].
- Coordinates with universities and the Malaysian Research and Education Network (**MyREN**) for backbone integration and cross-campus collaboration.

### 5.1.2 Ministry of Science, Technology and Innovation (MOSTI)

- Oversees **R&D and technology standardization**, particularly for Time-Sensitive Networking (TSN), AI network management, and smart campus innovation.

- Through **MIMOS Berhad** and **MRANTI**, MOSTI will lead the **TSN testbed certification** and innovation commercialization ecosystem.
- MOSTI will also publish a **TSN and Smart Network Readiness Index**, benchmarking Malaysia's academic and industrial connectivity levels against regional peers.

#### 5.1.3 Malaysian Communications and Multimedia Commission (MCMC)

- Regulates network quality and wireless spectrum usage under the **Communications and Multimedia Act 1998**.
- Will allocate and manage **6 GHz Wi-Fi 7 spectrum** for universities in coordination with **DNB's 5G deployment framework**.
- MCMC will also enforce the **National Broadband Quality of Experience (QoE)** requirements, with KPIs tied to campus-level network uptime and service latency.

#### 5.1.4 National Digital Department (*Jabatan Digital Negara*) (JDN)

- Ensures alignment with the **Public Sector Digitalisation Strategic Plan (PSDSP)** and the **Malaysian Government Cloud Framework (MyGovCloud)**.
- JDN will audit data security, interoperability, and digital identity integration under **MyDigital ID** standards.
- Responsible for integrating the ECN monitoring dashboard into **MyGDX (Government Data Exchange)** for real-time oversight and reporting.

## 5.2 University & Industry Partnerships

Strong collaboration between academia, government, and industry is fundamental for ECN sustainability and innovation. Malaysia's ECN framework emphasizes shared ownership and cross-sector cooperation through structured partnerships.

#### 5.2.1 University Consortiums

- Flagship institutions like **Universiti Malaya (UM)**, **Universiti Teknologi Malaysia (UTM)**, and **Universiti Sains Malaysia (USM)** will lead working groups on IPv6 adoption, Wi-Fi 7 design, and campus network energy efficiency.

#### 5.2.2 Industry Partnerships

- Strategic collaborations with **Telekom Malaysia (TM One)**, **TIME dotCom**, **Huawei Malaysia**, and **Cisco Systems** will accelerate deployment through co-funded pilot programs and knowledge transfer.
- TM One's **Smart Campus Solutions** will serve as an operational model for multi-campus cloud integration and AI-driven analytics.
- Huawei Malaysia will contribute through the **Huawei ICT Academy Program**, providing Wi-Fi 7 and TSN training to over 1,000 local engineers by 2030.
- Public-private collaboration will be formalized via **Memoranda of Understanding (MoUs)** and **Public-Private Research and Development (PPRD)** agreements, supported by **MOSTI's Collaborative Research in Engineering, Science and Technology (CREST)** platform.

## 5.3 Monitoring and Compliance Mechanisms

To ensure long-term accountability and measurable impact, a **multi-tiered monitoring and compliance framework** will be implemented under MOHE and MCMC supervision.

#### 5.3.1 ECN Performance Dashboard

- A centralized **National ECN Dashboard** will be hosted on **MyGovCloud (*Rangkaian Awan Sektor Awam*)**.
- It will track KPIs such as:
    - Campus network uptime (%)
    - Wi-Fi 7 coverage ratios
    - IPv6 utilization
    - TSN latency performance
    - Carbon footprint of ICT infrastructure

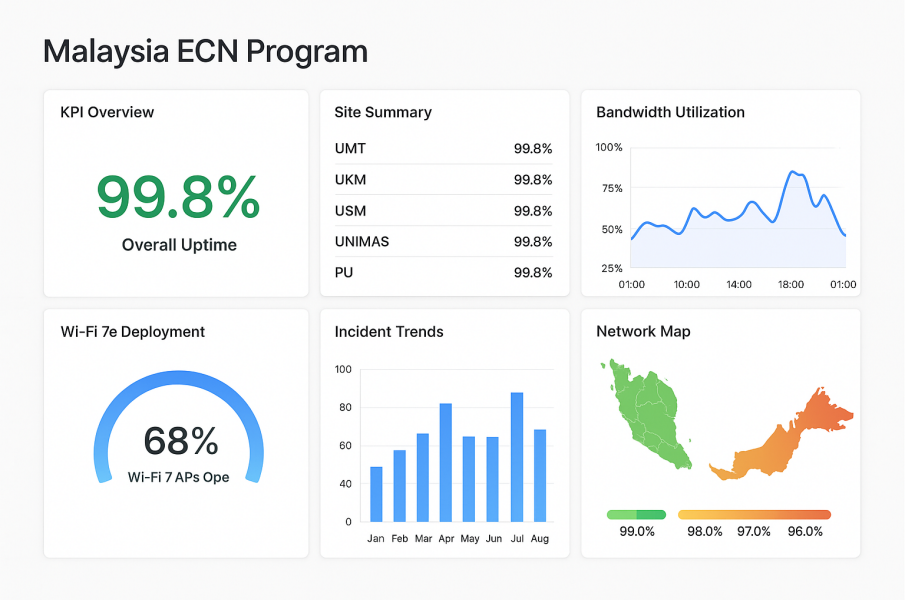


Figure 5-1. Sample Malaysia ECN Monitoring Dashboard

- Data will be collected through APIs integrated with campus network controllers and verified by MCMC and MyREN.

### 5.3.2 Annual Audit and Benchmarking

- Annual audits will be conducted jointly by MOHE and JDN using an **ECN Compliance Index**, rated across five parameters: infrastructure readiness, performance, security, sustainability, and interoperability.

- Results will be publicly published in the **ECN Annual Report**, aligning with Malaysia's open data policy under **data.gov.my**[17].

### 5.3.3 Regulatory Enforcement

- Non-compliance penalties or performance gaps may result in withholding of federal network grants or delayed accreditation under the **Malaysian Qualifications Agency (MQA)**[18].
- Conversely, high-performing universities will qualify for **Green ICT Excellence Awards**, backed by **Malaysia Green Technology and Climate Change Corporation (MGTC)** and **Malaysia Digital Economy Corporation** (**MDEC**).

### 5.3.4 Stakeholder Engagement and Review

- A **biannual ECN Steering Council** meeting will review implementation status and revise standards as technology evolves.
- Stakeholders include ministry representatives, university CIOs, internet service providers, and industry experts.
- Progress summaries will be shared during **Malaysia Digital Xcelleration (MDX) Summit hosted by MDEC** and **Digital Economy Week**, ensuring national visibility and public accountability.

## 6. Case Studies of Implementation in Malaysia

### 6.1 University of Malaya (UM) - Pilot Deployment of Wi-Fi 7 & 10GE-ready Backbone

**Project snapshot (pilot):** UM partnered with TP-Link and campus ICT teams to deploy an **AI-driven Wi-Fi 7 pilot** at the Faculty of Computer Science & Information Technology as a first public-university Wi-Fi 7 rollout in Malaysia. The pilot demonstrates multi-gigabit wireless connectivity, AI-assisted RF optimisation, and an operational model for rolling Wi-Fi 7 across a large urban campus[19].

**Technical design & features**

- Wi-Fi 7 APs supporting Multi-Link Operation (MLO) and 320 MHz channels; AI controller for channel planning, interference mitigation, and automated troubleshooting.
- Localized 10GE-capable aggregation switches in faculty buildings to ensure AP uplinks do not become the bottleneck; designed as modular, hot-swappable leaf-spine pods to allow future 40/100GE upgrades[20].
- Integration with campus identity (SAML/RADIUS) and eduroam for secure roaming.

**KPIs & Targets (pilot)**

- Per-AP throughput target: sustained multi-Gbps aggregate across AP cluster.
- End-user experience: <50 ms median latency for web/lecture streaming; 95% of lecture halls maintain >300 Mbps per concurrent class session.
- Operational: automated fault detection mean time to detect (MTTD) < 5 minutes; mean time to repair (MTTR) < 60 minutes via AI alarm triage.

**Outcomes & impact**

- Validates Wi-Fi 7 performance in dense academic environments; establishes AI-driven Operations and Maintenance (O&M) playbook for scale rollout[21].

**Challenges encountered**

- Need to balance 6 GHz spectrum planning with neighbouring municipal deployments (requires close MCMC coordination)[19].
- Backhaul planning: some older faculty buildings required fibre uplift to support 10GE AP aggregation.

**Lessons learned & policy implications**

- AI-assisted Wi-Fi operations materially reduce O&M load and improve SLA compliance that includes AI-O&M as recommended capability in ECN technical standards.
- Recommended to design backbones with spare fibre and modular switch chassis to enable non-disruptive upgrades to 40/100GE as research needs grow.

## 6.2 Universiti Teknologi Malaysia (UTM) - Wi-Fi 7 / Smart Classrooms for Hybrid Learning

**Project snapshot:** UTM has run smart-classroom pilots in collaboration with Cisco (and other vendors) to modernise teaching spaces with secure collaboration tools, high-quality AV streaming, and managed wireless infrastructure; a practical template for Wi-Fi 7 and integrated classroom ecosystems[22].

**Technical design & features**

- Smart classroom stack includes: multi-camera lecture capture, classroom AV switching, local edge compute for real-time captioning and remote collaboration, and managed Wi-Fi with guaranteed QoS for synchronous learning.

Figure 6-1: UTM Smart Classroom: Piloting Wifi 7 for Hybrid Learning

- Emphasis on secure access (role-based network segmentation) and multicast video delivery optimised by campus distribution switches to reduce bandwidth waste.

**KPIs & Targets**

- Lecture capture and multi-site broadcasting with <100 ms end-to-end latency for interactive sessions.
- Classroom connectivity SLA: 99.9% up-time during teaching hours; capacity for ≥100 simultaneous HD lecture streams per smart-classroom cluster.

**Outcomes & impact**

- Improved learning experience and measured uplift in student engagement for blended/hybrid courses. Smart classroom infrastructure also doubles as research infrastructure for AV/edge computing projects.

**Challenges encountered**

- Integration of legacy AV systems and faculty adoption (training required).

- Need for robust QoS policies and traffic policing to preserve research bandwidth.

**Lessons learned & policy implications**

- Smart classroom standards should be specified in ECN (AP density, edge compute requirements, multicast policies).
- Combine classroom rollout with instructor upskilling plans to maximize ROI. This should also be included into the KPIs within pilot sites.

| Pilot Site | Scope & Focus | KPIs (by 2027) |
|---|---|---|
| **Universiti Malaya (UM)** | Wi-Fi 7 deployment across 10 faculties; 10GE redundant backbone; AI network monitoring integrated with MRANTI 5G lab. | 95% Wi-Fi 7 coverage; <2 ms latency; IPv6-only network by 2027. |
| **UPM Bintulu (UPMKB)** | Hybrid 10GE + DWDM link; smart agriculture IoT lab with TSN synchronization. | 100% IPv6 compliance; 2.5 Gbps endpoint; <0.8 PUE. |
| **MRANTI Park** | National TSN testbed; Wi-Fi 7 and 5G edge integration for industrial automation R&D. | TSN latency ≤1 ms; 10 enterprise partners onboarded. |
| **MIMOS Lab** | TSN & 10GE applied research facility; real-time industrial data replication. | 5 TSN use cases; 20 joint projects; 2 international patents filed. |

Table 6-1: KPIs for Pilot sites

## 6.3 Universiti Sains Malaysia (USM) - High-Capacity Research & Education (R&E) Links & Time-Sensitive Networking (TSN) Readiness for Industrial Collaboration

**Project snapshot:** USM has recently advanced international R&E connectivity via partnerships (e.g., ARENA-PAC) to secure **100 Gbps** R&E links enabling global research collaboration; a prerequisite for TSN and data-intensive science workflows[23].

**Technical design & features & TSN roadmap**

- International high-capacity link (ARENA-PAC / 100 Gbps) provides the global on-ramp to low-latency research partners in Japan and Singapore that is essential for distributed High-Performance Computing (HPC) and real-time data streaming.
- TSN readiness plan (recommended): implement IEEE 802.1AS for time synchronization across lab floor switches; 802.1Qbv for scheduled traffic in designated industrial labs; isolate TSN islands and interconnect via MyREN for wider experiments[24].

**KPIs & Targets**

- End-to-end TSN test cases: deterministic latency ≤1 ms over local TSN corridors; packet delivery ratio ≥99.999% for scheduled traffic.
- Research throughput: sustain multi-TB/day transfers over ARENA-PAC peering for genomics, climate, and physics datasets.

**Outcomes & impact**

- Enables USM to host multinational experiments requiring real-time coordination (e.g., remote instrument control, distributed simulation). Partnership with ARENA-PAC significantly increases USM's attractiveness for international research consortia.

**Challenges encountered / anticipated**

- TSN at campus scale requires careful segmentation to avoid interference with regular best-effort traffic.
- Device ecosystem: many research instruments may need gateway adapters or firmware upgrades to be TSN-compatible.

**Lessons learned & policy implications**

- National TSN testbeds and shared toolkits (timing profiles, open reference designs) accelerate campus adoption and must be published as ECN blueprints.

- Secure high-capacity international peering first (e.g., 100 Gbps ARENA-PAC) before large-scale TSN experiments to avoid bottlenecks.

## 6.4 Lessons Learned from International Case Studies (applied to Malaysia)

Drawing on international R&E/NREN and campus examples (NUS, KREONET, GÉANT, Internet2), Malaysia's pilot experience points to several scalable lessons:

### 6.4.1 Start with high-quality national R&E peering

- International leaders (GÉANT, KREONET, SingAREN) demonstrate the value of early investment in 100G+ regional rings to enable global science collaboration. Malaysia's MyREN and ARENA-PAC links are strategic assets to leverage; hence must ensure that these are integrated into ECN routing and testing frameworks[25].

### 6.4.2 Use modular, upgradeable backbone and campus designs

- Singapore (NUSnet) and Korean KREONET use modular leaf-spine fabrics and dense DWDM fibre approaches enabling non-disruptive upgrades to higher line rates. ECN designs should mandate spare fibre pairs and modular optics[26].

### 6.4.3 Federated services (eduroam / eduGAIN) accelerate mobility & identity

- eduroam/eduGAIN models used across Europe and U.S. simplify cross-institution access. Malaysia should embed eduroam and eduGAIN onboarding in ECN requirements[27].

### 6.4.4 National testbeds & industry parks shorten commercialization paths

- MRANTI Park and MIMOS as 5G/TSN testbeds reflect international practice (testbeds in Japan and EU) as they provide practical commercialization routes for industry and research labs. Funding and fast-track procurement must be prioritised for these sites[28].

### 6.4.5 Human capital & operational models are the real constraint

- International NRENs emphasize central NOC operations, shared security services, and recurring training. Malaysia's certification programs and regional NOCs should be planned and established early to avoid O&M bottlenecks[25].

### 6.4.6 TSN & 5G convergence requires careful staged pilots

- International TSN pilots (Europe, Japan) show convergence with private 5G is feasible but requires co-design of timing and scheduling across domains. Malaysia's MRANTI/MIMOS pilots are well-placed to validate these architectures[29].

# 7. Anticipated Outcomes

## 7.1 Enhanced Research and Innovation

The deployment of high-capacity 10GE and Time-Sensitive Networking (TSN) across Malaysian universities is expected to **revolutionize research collaboration**, enabling real-time data exchange, distributed simulation, and AI model training between universities and research agencies. Under the ECN framework, universities connected through the **National Higher Education Network Grid (NHENG)** can achieve data transfer speeds comparable to **SingaREN (Singapore)** and **SINET6 (Japan)**, fostering multi-institutional projects in climate modeling, genomics, and advanced materials.

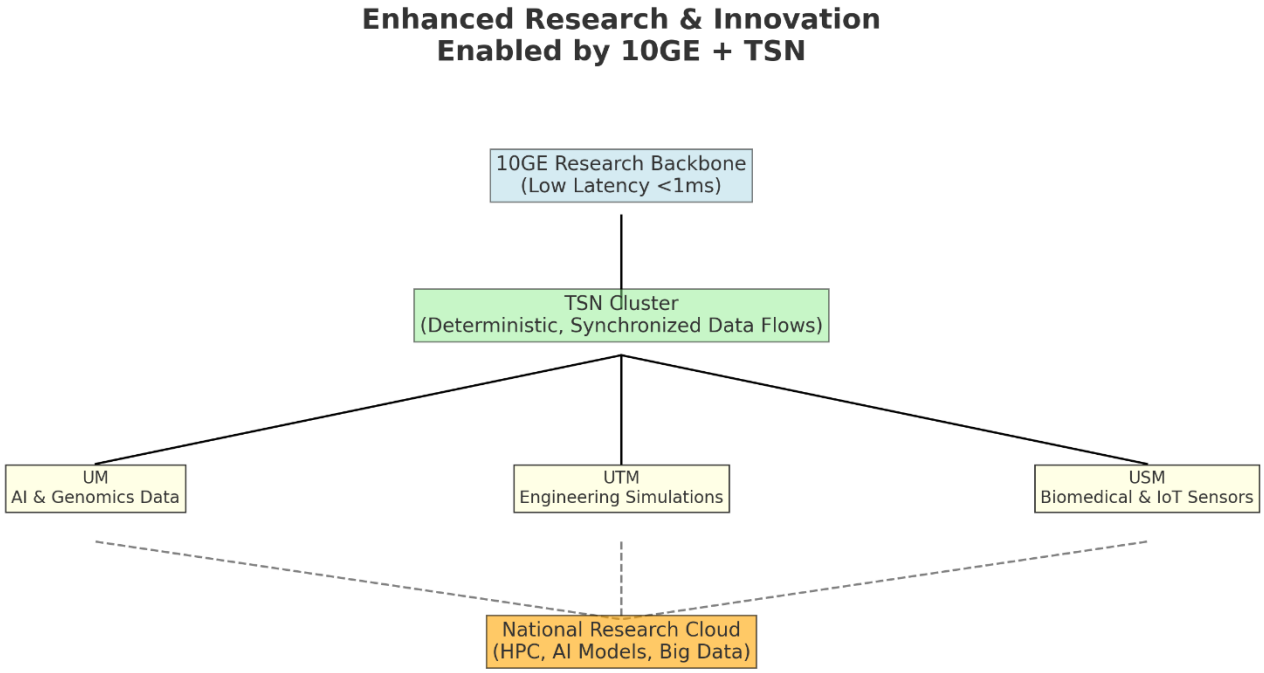


Figure 7-1: Research and Innovation enabled by 10GE & TSN

The enhanced research backbone also supports integration with **MIMOS' AI Sandbox** and **MRANTI's 5G Testbed**, allowing joint development of real-time systems and smart manufacturing prototypes.

## 7.2 Improved Teaching and Learning Environments

The ECN rollout supports Malaysia's transition towards **immersive and data-driven education**, where **Wi-Fi 7-enabled smart classrooms** facilitate seamless augmented reality (AR), virtual labs, and hybrid learning.

Similarly, **Universiti Sains Malaysia (USM)** has introduced **real-time monitoring for engineering and biomedical labs** using TSN-enabled IoT networks, enabling precision control for research instruments. The **Ministry of Education's Digital Learning Transformation Plan 2025** projects that by 2030, majority **of public universities** will transition to hybrid teaching models leveraging 10GE backbones and AI-driven learning analytics[39].

These outcomes also contribute to **reduced digital inequality** across regions by connecting rural campuses such as **UPM Bintulu and UniSZA Terengganu**. The ECN policy can help ensure equitable access to high-quality digital learning infrastructure.

## 7.3 Strengthened Global Competitiveness of Malaysian Universities

Upgrading to unified ECN infrastructure positions Malaysian universities to meet **international accreditation and digital excellence benchmarks**, improving their standings in **global university rankings**. According to **Times Higher Education (THE) 2025**, digital infrastructure and industry collaboration are now key indicators in Asia-Pacific university rankings[30].

By implementing 10GE, Wi-Fi 7, and TSN standards, Malaysia's top universities (UM, UTM, USM, UKM) can better participate in global research consortia such as **Internet2's International Partnerships Program**, enabling direct peering with leading R&E networks.

Moreover, the ECN policy supports **international student recruitment;** the **Education Malaysia Global Services (EMGS)** estimates that improved digital learning infrastructure could raise international enrolments by **15% by 2030**, contributing RM1.5 billion annually to the economy[31].

## 7.4 Contribution to Digital Economy and Industry 4.0 Goals

The ECN initiative directly advances Malaysia's **MyDIGITAL Blueprint** and **National Industry 4WRD Policy**, aligning higher education infrastructure with national economic transformation priorities. By integrating **high-speed campus networks**, universities will become the testing grounds for **AI, robotics, and 5G-driven manufacturing**, accelerating the diffusion of innovation into industry.

The synergy between **MOSTI's R&D cluster**, **MIMOS innovation platforms**, and **university data networks** will create a sustainable **academic–industrial innovation pipeline**.

In addition, integrating **green ICT standards** such as energy-efficient networking and data centre optimization aligns with Malaysia's **Low Carbon Nation Aspiration 2040**, targeting a **30% reduction in ICT-related carbon emissions** by 2035[32].

# 8. Implementation Considerations

## 8.1 Regulatory and Policy Alignment

To deploy 10GE, Wi-Fi 7 and TSN nationwide, Malaysia must align the ECN Program with existing legal/regulatory frameworks and remove administrative bottlenecks. Key actions and references:

### 8.1.1 Personal data & privacy compliance (PDPA)

- All campus identity, learning-management, and research systems that process personal data must document lawful basis, retention schedules, cross-border transfer safeguards and consent handling in line with the **Personal Data Protection Act (PDPA) 2010**(Act 709). Use university Data Protection Officers to register data processing activities and Data Protection Impact Assessments for high-risk services (e.g., biometrics, student tracking).

### 8.1.2 Cybersecurity certification & guidance

- Adopt Cybersecurity Malaysia's guidelines (best-practice principles, MySEAL & relevant certifications) for campus Secure Operations (SOC/NOC) and secure procurement. Use MyCERT platform for national incident coordination and vulnerability reporting[33].

### 8.1.3 Spectrum & wireless regulation

- Coordinate campus Wi-Fi 7 6 GHz usage with MCMC licensing and test-licence pathways; ensure campus deployments observe national co-existence rules and power/indoor/outdoor limits. Engage MCMC early to reserve testbed bandwidth and private 5G trial licences[34].

### 8.1.4 Cloud & government data alignment

- Where campuses connect to government services or hold public research grants, adopt JDN's MyGovCloud interoperability and hosting rules. Integrate ECN logging and audit exports to MyGovCloud or an approved private Cloud Service Provider where required[34].

#### 8.1.5 Procurement & contracting conformity

- Standardize RFP templates and SLA language to include PDPA, ISO/IEC 27001 obligations, supply-chain security clauses, end-of-life and spare-parts obligations, and energy-efficiency requirements[35].

#### 8.1.6 Standards & interoperability

- Mandate compliance with ISO/IEC 27001 (information security management) for campus NOCs/SOCs and IEEE/ITU specifications for network/time sync (IEEE 802.1AS, IEEE 802.1Qbv) and Wi-Fi 7 (IEEE 802.11be). Ensure MyREN peering and eduroam onboarding are planned in procurement documentation[36].

## 8.2 Cybersecurity Standards and Data Protection

Campus networks must be operated to a high security baseline not only to protect student/faculty data, but to secure national research assets and industry collaborations. The following are prescriptive controls and processes.

#### 8.2.1 Core security controls (must-have)

- **Information Security Management System (ISMS):** Each university NOC/SOC must adopt an ISMS certified to **ISO/IEC 27001:2022**, covering risk assessment, control selection, and continuous improvement.
- **Zero-Trust Network Architecture (ZTNA):** Implement micro-segmentation for research clusters, VLAN/VRF isolation for student vs research traffic, and identity-based policy enforcement (SAML / eduroam) for staff and guests. Reference ITU guidelines on network slicing and service separation where applicable[37].
- **Encryption & Key Management:** Enforce TLS 1.3 for application traffic, MACsec or IPsec for campus trunk links where required, and FIPS-compliant key management for critical research datasets.

- **Endpoint & IoT Security:** Secure IoT endpoints through device onboarding (certificate-based) and per-device profiling; isolate legacy lab devices in DMZs with gateway proxies.
- **Identity & Access Management (IAM):** Centralized IAM with Multi-Factor Authentication (MFA) for administrative access and role-based controls for researcher/data access. Integrate with eduroam and federated identity services where possible.

### 8.2.2 Operational security processes

- **Security Operations Centre (SOC):** Each Regional NOC must include SOC capabilities (24/7) with SIEM ingesting NetFlow/sFlow/packet telemetry, endpoint telemetry, and vulnerability scan results. Use shared SOC playbooks across campuses for incident triage.
- **Vulnerability Management & Patch Cadence:** Standardize vulnerability scanning cycles (weekly automated scans, quarterly penetration tests) and define patch SLAs (critical: 7 days; high: 30 days).
- **Supply-chain security:** RFPs must require vendor SBOMs (software bill of materials), signed secure development practices, and timely patch disclosures.
- **Incident Response & Reporting:** Formalize incident escalation to MyCERT (Cybersecurity Malaysia) and to the ECN Dashboard; include legal counsel and communications in playbooks.

### 8.2.3 Data protection (PDPA & research data)

- **Data classification & handling policies:** Classify data (public / internal / restricted / highly restricted) and apply controls (encryption at rest/in transit, retention periods). High-value research data may require on-premise hosting or approved MyGovCloud cloud service providers.
- **Cross-border transfer controls:** For international research collaboration, use controller/processor agreements and approved transfer mechanisms; maintain records for PDPA audits.

#### 8.2.4 Certification and assurance

- Encourage ISO/IEC 27001 certification for Tier-1 NOCs, and Cybersecurity Malaysia's **MySEAL** scheme for product assurance where applicable. Use independent third-party red-team exercises for high-risk research zones.

## 8.3 Monitoring and Evaluation (M&E) performance dashboard & governance

A robust M&E program is essential. Below is a production-ready **Performance Monitoring Dashboard** specification (metrics, thresholds, data sources, visualization recommendations, roles and cadence). This can be implemented on MyGovCloud or a joint MOHE-MyREN analytics platform.

#### 8.3.1 Dashboard objectives

- Provide near-real-time visibility of network health, security posture, sustainability metrics and compliance across all campuses.
- Support operational decision making (NOC escalations), strategic monitoring (MOHE / MCMC KPIs), and public transparency (annual reports).

#### 8.3.2 Core metrics & thresholds (recommended)

Separate dashboards/tabs for Network Health, Security, Service Experience, Sustainability, and Compliance.

##### 8.3.2.1 Network Health (real-time & 5-min, 1-hour aggregates)

- Core backbone throughput (aggregate Gbps per campus): Alert if >85% sustained utilization on 10GE links[38].
- Link availability (percentage uptime): Target ≥ 99.95%; alert on drop below 99.9% over 24h.
- Packet loss & jitter (intra-campus): Target packet loss <0.1%; jitter <5 ms for research VLANs.

- Per-AP utilization & contention (Wi-Fi 7): Flag APs with >75% channel utilization for >15 minutes.

#### 8.3.2.2 Service Experience (user-facing KPIs)

- Median web/streaming latency (ms) per building target <50 ms for lecture zones.
- Percentage of lecture sessions with successful HD streaming target ≥ 95%.
- User authentication success rate (eduroam) target ≥ 99.5%. **Data sources:** synthetic tests (iperf3, HTTP probes), LMS logs, RADIUS logs.

#### 8.3.2.3 Security & Compliance

- Number of detected incidents (per severity) per month: Set target of having zero critical incidents requiring MyCERT escalation.
- Mean time to detect (MTTD) and mean time to respond (MTTR) for incidents: MTTD < 15 min, MTTR < 2 hours for critical incidents.
- Patch compliance rate (hosts with latest critical patches): target ≥ 98% within SLA window.
  **Data sources:** SIEM, vulnerability scanners, patch management systems.

#### 8.3.2.4 TSN & Research QoS

- TSN scheduled traffic delivery ratio (%): target ≥ 99.999% for scheduled flows.
- End-to-end latency for TSN corridors: target ≤ 1 ms where specified. **Data sources:** TSN agent telemetry, PTP (precision time protocol) logs, IEEE 802.1AS counters.

#### 8.3.2.5 Sustainability (Green ICT)

- Power Usage Effectiveness (PUE) (data centre) and energy per Mbps target PUE < 1.6 for campus data centres.

- Percentage of network equipment with EPEAT / energy-efficiency certification.
  **Data sources:** DCIM, smart meters, vendor energy reports.

#### 8.3.2.6 Compliance & Audit

- PDPA compliance items fulfilled vs outstanding (%).
- ISO 27001 control maturity score (quarterly).
  **Data sources:** internal audit trackers, certification bodies.

### 8.3.3 Dashboard visualizations & UX

- **Top row (global indicators):** Coloured KPI tiles for backbone health, security incidents (last 24 h), Wi-Fi health score, PUE.
- **Time series charts:** backbone utilization, incidents over time, authentication success rates.
- **Map view:** campus sites with colour status (green/amber/red). Click-through to site details.
- **Drill-downs:** per-AP heatmaps, per-link flow charts (NetFlow sankey), SIEM event explorer.
- **Export & API:** automated CSV and PDF reporting; role-based API access for MOHE, MCMC and other stakeholders.

### 8.3.4 Data collection & quality

- **Telemetry pipes:** Use secure, authenticated agents to send telemetry (gNMI, NETCONF, sFlow) to central collectors. Use TLS + mutual auth.
- **Sampling & retention:** Raw telemetry for 30 days; aggregated summaries for 5 years to support trend and KPI reporting.
- **Data assurance:** Automated validation (schema checks), timestamp sync via NTP/PTP; missing data alerts.

### 8.3.5 Governance, roles & cadence

- **Operational (NOC):** 24/7 monitoring, triage, and First Response. Regional NOCs handle Level-1/2; MOHE central team handles Level-3 policy decisions.
- **Security (SOC):** 24/7 SOC integrated with NOC; incidents escalate to MyCERT for critical national impact.
- **Assurance & Audit:** Quarterly compliance reviews (MOHE + JDN + independent auditor) and annual public ECN Report (KPIs + financials).
- **Policy Review:** Biannual ECN Steering Council reviews using dashboard analytics; update SLA thresholds and procurement clauses accordingly.

## 9. Conclusion

The formulation of Malaysia's Enterprise Campus Network (ECN) Policy represents a decisive step toward strengthening the nation's higher education digital infrastructure and its alignment with Malaysia's MyDIGITAL Blueprint, JENDELA initiative, and Industry 4.0 roadmap. Over the next decade, this framework seeks to unify university and research networks into a high-capacity, intelligent, and sustainable national grid that will underpin academic excellence, industrial collaboration, and innovation-led growth.

The policy's phased implementation beginning with flagship pilots at Universiti Malaya (UM), Universiti Teknologi Malaysia (UTM), Universiti Sains Malaysia (USM), and national R&D anchors such as MRANTI Park and MIMOS provides a structured, scalable foundation for digital modernization across Malaysia's academic and industrial ecosystem. Through the deployment of **10 Gigabit Ethernet (10GE)** backbones, **Wi-Fi 7** access technologies, and **Time-Sensitive Networking (TSN)** for precision data and research synchronization, universities will be empowered to deliver high-performance connectivity comparable to leading international research networks such as **GÉANT (Europe)** and **Internet2 (United States)**.

Moreover, the ECN Policy establishes robust governance and oversight under **MOHE**, **MOSTI**, **MCMC**, and **JDN**, supported by a clear monitoring framework and real-time telemetry dashboard. This ensures that each phase of deployment from pilot to national expansion is measurable, transparent, and adaptable to emerging technologies. The integration of **cybersecurity standards**, **data protection mechanisms**, and **ISO 27001-aligned compliance protocols** further strengthens trust and resilience within the national academic network ecosystem.

From a socio-economic perspective, the anticipated outcomes of this initiative extend far beyond connectivity. Enhanced research productivity, immersive digital learning environments, and sustainable data-driven collaboration will reinforce Malaysia's global competitiveness in science, technology, and innovation. The policy's focus on **green ICT**, **energy efficiency**, and **renewable integration** also ensures that digital

progress aligns with the nation's sustainability commitments under the **Malaysia Low Carbon Blueprint 2040**.

Ultimately, the ECN Policy embodies a shared vision where every Malaysian university, research institute, and enterprise operates within an integrated, high-speed, secure digital fabric that nurtures creativity, supports Industry 4.0 adoption, and accelerates the digital economy. The next decade will be defined by how effectively these networks enable real-time collaboration, cross-border research, and data-driven innovation. Through strong public–private partnerships, strategic investment, and continuous capacity-building, Malaysia is well positioned to emerge as a **regional leader in high-performance campus networking and digital transformation.**

# 10. Annexes

## 10.1 Contribution of ECN to Digital Economy and Industry 4.0 Goals

| Outcome Area | 2025 Baseline | 2030 Target | 2035 Target | Indicators / KPIs |
|---|---|---|---|---|
| **Enhanced Research & Innovation** | Fragmented university networks with ≤1 Gbps connectivity; limited R&D data sharing | 80% of public universities interconnected via 10GE; active TSN-enabled research trials | Full National Higher Education Network Grid (NHENG) operational linking >30 institutions | -50% increase in joint publications<br>-25% increase in international patents<br>-10GE/TSN network readiness index ≥0.8 |
| **Improved Teaching & Learning** | Limited AR/VR-enabled classrooms (<10% of total); average Wi-Fi latency >35 ms | 70% of classrooms connected via Wi-Fi 7; latency <10 ms | 100% digital campus coverage; all universities hybrid-ready | -40% increase in student engagement<br>-30% reduction in digital access disparity<br>- 95% Wi-Fi 7 coverage |
| **Global Competitiveness of Universities** | Average global rank: 500–800; limited R&E network participation | Top 3 Malaysian universities in global top 300; member of APAN/Internet2 collaboration | At least 5 universities ranked top 250 globally | -QS/THE ranking improvement<br>- 60% latency reduction for global collaboration<br>- 15% increase in international enrolment |
| **Digital Economy & Industry 4.0 Integration** | University–industry collaboration limited to pilot IoT/AI projects | 50% of universities integrated with Industry 4.0 testbeds | Full integration of academia–industry R&D network nationwide | -RM30B GDP contribution by 2035<br>- 10,000 skilled digital graduates per year<br>- 30% reduction in ICT carbon footprint |

Table 10-1: Contribution of ECN to Digital Economy

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