COET International Conference 2024

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Engineering Education and Sustainable Development

By

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Er. Professor LOCK Kai Sang

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- Professor, Singapore Institute of Technology & Head, Energy Efficiency Technology Centre
- Emeritus President, Institution of Engineers, Singapore
- Past Chairman, Engineering Accreditation Board, Singapore
- Past Board Member, Professional Engineers Board, Singapore
- Past Chairman, Singapore Standards Council
- Chairman, Accreditation Committee for Energy Services Companies
- Co-Chair, Singapore Certified Energy Manager Steering Committee
- Co-Laureate of the 2021 WFEO Medal for Excellence in Engineering Education

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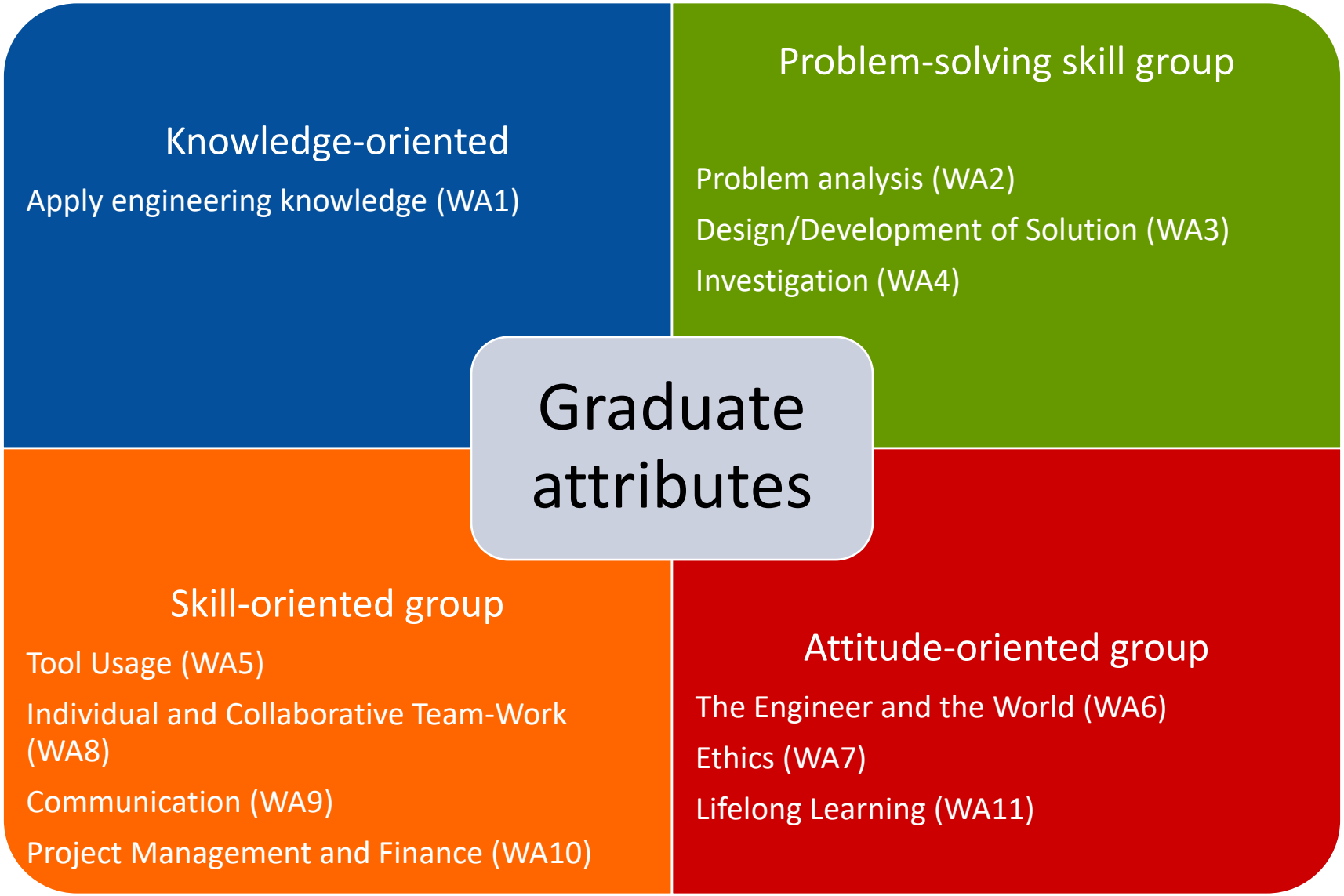
Engineering Education - the Context

- Engineering education for future engineers
- A world of volatility, uncertainty, complexity and ambiguity
- Roles of engineers in industry/economy of the future
- Changing global economy leveraged on technology and sustainable development
- Common destiny – climate change & sustainability
- Rapid disruptive technological innovations, short shelf life of specialized knowledge
- Global interconnectedness, technology decoupling and restrictions
- Interdisciplinary collaboration
- Diversity, inclusiveness and grounded to the community

Engineering Education

- Engineering education is intended to develop competent, innovative, and socially responsible engineers who possess the knowledge, skills and ethical grounding necessary to address the complex challenges of the contemporary world.
- Engineering education prepares students to apply engineering principles to design, analyze and improve systems, products and processes in a way that advances technology and benefits society.



Washington Accord

Globally aware, locally contextualized

- Students have a greater degree of control and input over their education and be able to pursue their passions
- About skills competencies and what people need for the 21st century
- Look at continuous transformation of competencies
- Digital and data literacy increasing important
- It is collaboration, critical thinking, communication skills - anticipating and responding to the changes we see today
- Being globally aware but having a local context towards the kind of outcomes that different states or countries would like to have

Changing landscape of engineering education

- Interdisciplinary focus
- Hands-on and project-based learning
- Incorporation of emerging technologies
- Soft-skills development
- Ethics and sustainability
- Engineer in the world – global perspective
- Diversity and inclusion
- Online and blended learning
- Adaptive learning

Pedagogical transformation

- Active learning
- Problem-based learning
- Flipped classrooms
- Adaptive learning
- Collaborative learning
- Competency-based
- Lifelong learning
- Stackable micro-credentials
- Student-centered approach

Role of technology in education

- Access to information
- Engagement and interactivity
- Personalized learning
- Online courses and distance learning
- Virtual labs and simulations
- Collaboration and communication
- Online assessment and instant feedback
- Multimedia and visualization
- Education management system
- Innovative teaching-learning tools

Technology impacts on engineering education

- Enhanced visualization and 3D modelling
- Real-world simulations and experiments
- Interactive learning
- Blended learning
- Personalized learning
- Online courses – MOOCs
- Collaborative tools
- Remote learning
- Practical skills development
- Assessment and feedback

Technology enhanced learning

- Technology-Enhanced Learning (TEL) is a broad field that encompasses the use of technology to improve and enhance the teaching and learning process
  - Online and blended learning
  - Digital content
  - Learning management systems (LMS)
  - Synchronous and asynchronous learning
  - Adaptive personalization
  - Collaborative learning
  - Assessment and feedback
  - Accessibility and inclusivity
  - Analytics and data-driven insights
  - Resource sharing – global reach

Immersive Learning

Students engaged in a highly engaging and interactive learning environment using immersive technologies.

Immersive technology creates a sense of presence – active learning by doing and hence more effective.

Immersive learning goes beyond traditional classroom teaching by leveraging technologies to enhance experiential learning like

- Virtual reality (VR)
- Augmented reality (AR), and
- Mixed reality (MR)

Pedagogy design to impart competencies

The pedagogy for imparting competencies should include:

1. **Active learning**: Students should be engaged in activities that require them to apply knowledge to solve problems, make decisions, and achieve goals. This includes hands-on activities, case studies, simulations, and group projects.
2. **Collaborative learning**: Collaboration is an essential part of engineering practice. Therefore, students should be encouraged to work in teams to solve problems and deliver solutions. This can be achieved through group projects, peer-to-peer learning, and teamwork exercises.
3. **Contextual learning**: Learning should be contextualized to real-world problems and challenges. This can be achieved through project-based learning, case studies, and simulations.
4. **Feedback and reflection**: Students should receive timely and constructive feedback on their work, and encouraged to reflect on their learning experiences to identify areas for improvement.
5. **Experiential learning**: Students should be provided with opportunities to gain real-world experience through internships, co-op programs, and other experiential learning opportunities.

Engineering education should be designed to impart competencies that enable graduates to apply their knowledge to solve real-world problems effectively. This requires a pedagogy that emphasizes active learning, collaborative learning, contextual learning, feedback and reflection, and experiential learning.

Innovative Learning & Applied Research

- Applied research plays a crucial role in informing and improving applied learning by bridging the gap between theory and practice, enhancing the relevance of educational programs, and fostering a culture of innovation in academia
  - Relevance and practicality
  - Innovation
  - Problem-based learning
  - Curriculum development
  - Student engagement
  - Collaboration with industry
  - Hands-on experience
  - Interdisciplinary learning
  - Industry-focused capstone projects

Sustainability requirements

in GAPC2021

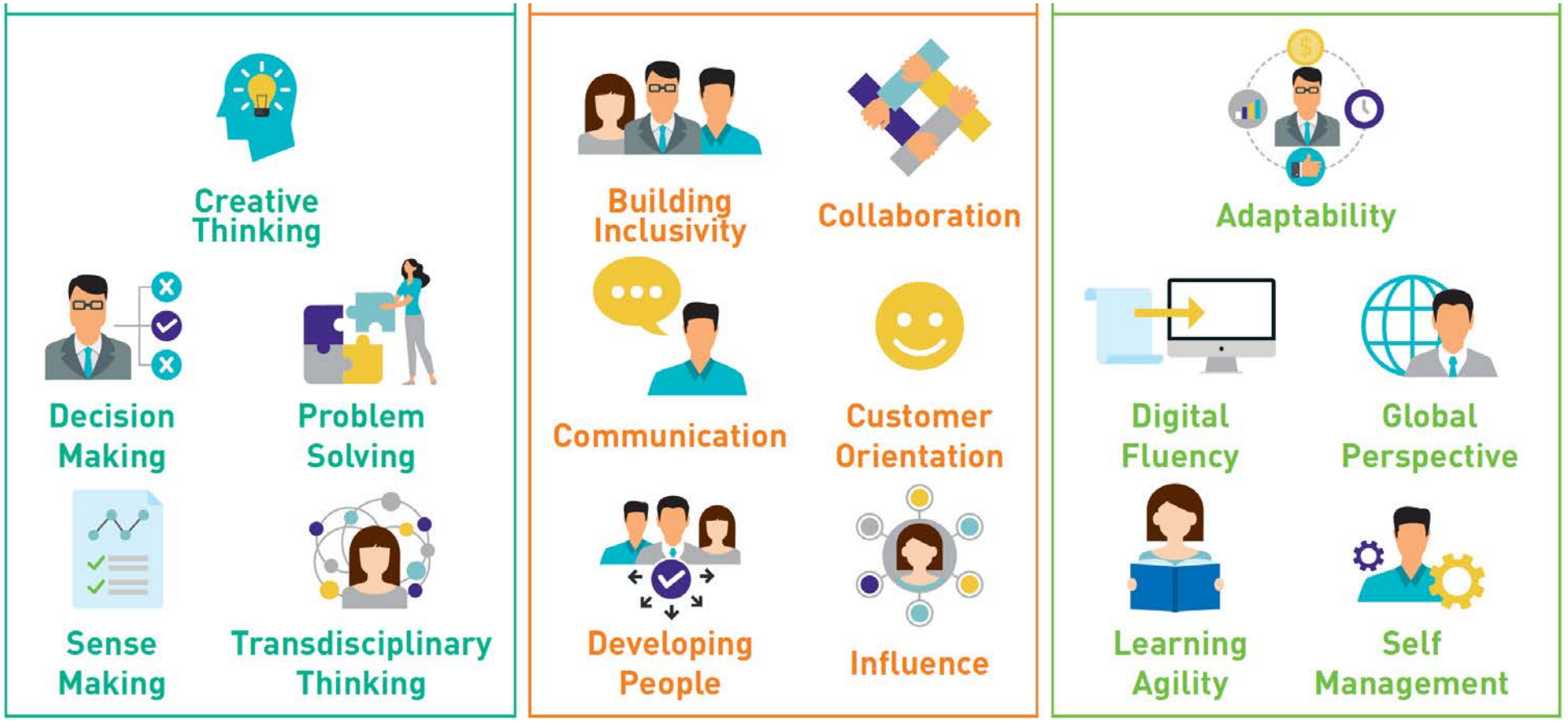
A CLASSIFICATION BASED ON KEY-WORDS OF CHANGE (contributed by Prof Arif Bulent Ozguler – Deputy Chair, WA)

DIGITIZATION/ AUTOMATION	WA1: Apply knowledge of ... computing and engineering fundamentals	WA8: Function effectively ... in ... remote and distributed settings	WA11: ... adaptability to new and emerging technologies	WK2: Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science	
DIVERSITY/ INCLUSION	WA7: ... commit to professional ethics and norms ... Demonstrate an understanding of the need for diversity and inclusion	WA9: Communicate effectively and inclusively	WA8: Function effectively ... as a member or leader in diverse and inclusive teams	WK9: Ethical attitude, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes	
CREATIVITY	WA2: Identify, formulate, research literature	WA4: Investigate ... problems using research methods including research-based knowledge	WA3: Design creative solutions	WA5: Create ... techniques, resources, ... and IT tools	WA11: ... ability for ... critical thinking
BROADER VIEW	WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences	WK8: ... awareness of the power of critical thinking, creative approaches to evaluate emerging issues.			
CONTINUOUS DEVELOPMENT	WA11: Recognize the need for, and have the preparation and ability-for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change	EC11: Undertake CPD activities to maintain and extend competences and enhance the ability to adapt to emerging technologies and the ever-changing nature of work			
SUSTAINABILITY	WA3: Design ... solutions ... with appropriate consideration for public health and safety, whole-life cost, net zero carbon as well as resource, cultural, societal, and environmental considerations	WA4: Investigate ... with holistic considerations for sustainable development	WA6: ...evaluate sustainable development impacts ...	WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area	WK7: Knowledge of the role of engineering in society and identified issues in engineering practice ... such as the professional responsibility of an engineer to public safety and sustainable development*

Future Economy & Critical Core Skills

Singapore's Experience

Singapore's Skills-Future Development
Clusters of Critical Skills



Critical Core Skills

Thinking Critically

1. Creative thinking
2. Decision making
3. Problem solving (5)
4. Sense making
5. Transdisciplinary thinking

Interacting with Others

6. Building inclusivity
7. Collaboration (4)
8. Communication (1)
9. Influence
10. Developing people (2)
11. Customer orientation

Staying Relevant

12. Adaptability
13. Digital fluency (3)
14. Global perspective
15. Learning agility
16. Self management

Integration of Sustainable Development Goals (SDGs) in Engineering Education

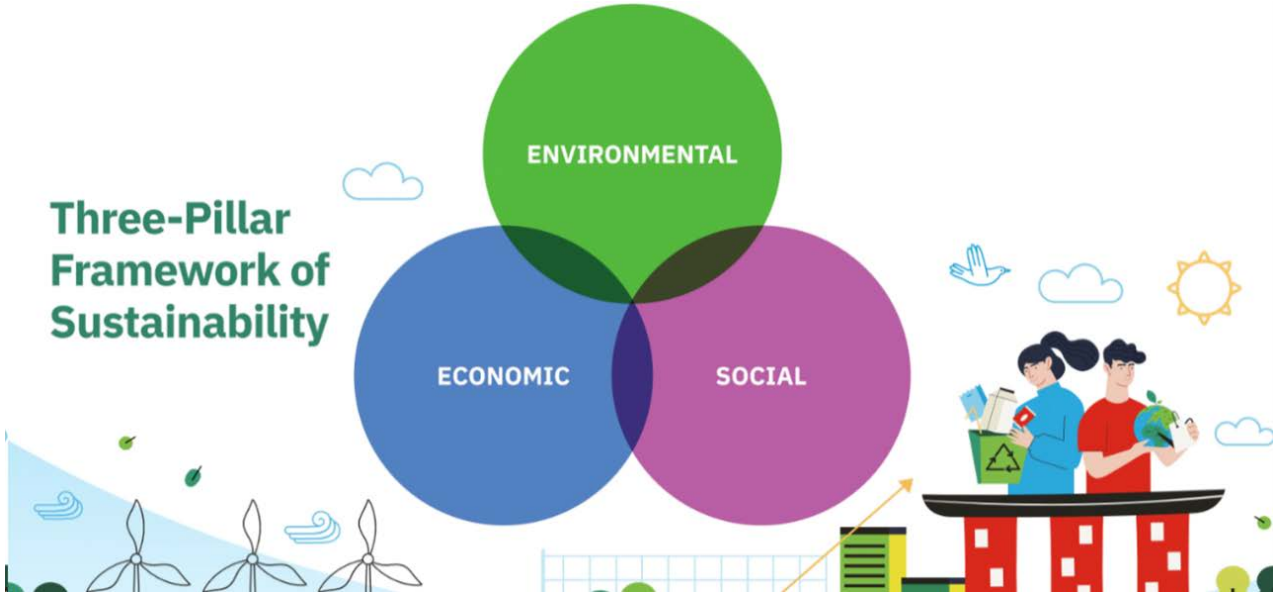
Sharing Singapore's Experience

Engineering education & sustainable development

- Engineering education and sustainable development are increasingly interlinked as the world faces significant environmental, social, and economic challenges.
- Integrating sustainability into engineering curricula is essential to prepare engineers to address these challenges effectively.

SUSTAINABLE DEVELOPMENT GOALS

Sustainable development is a comprehensive approach to growth and progress that meets the needs of the present without compromising the ability of future generations to meet their own needs.



Integrate three core dimensions: economic growth, social inclusion, and environmental protection, ensuring that development is balanced and beneficial for all sectors of society.

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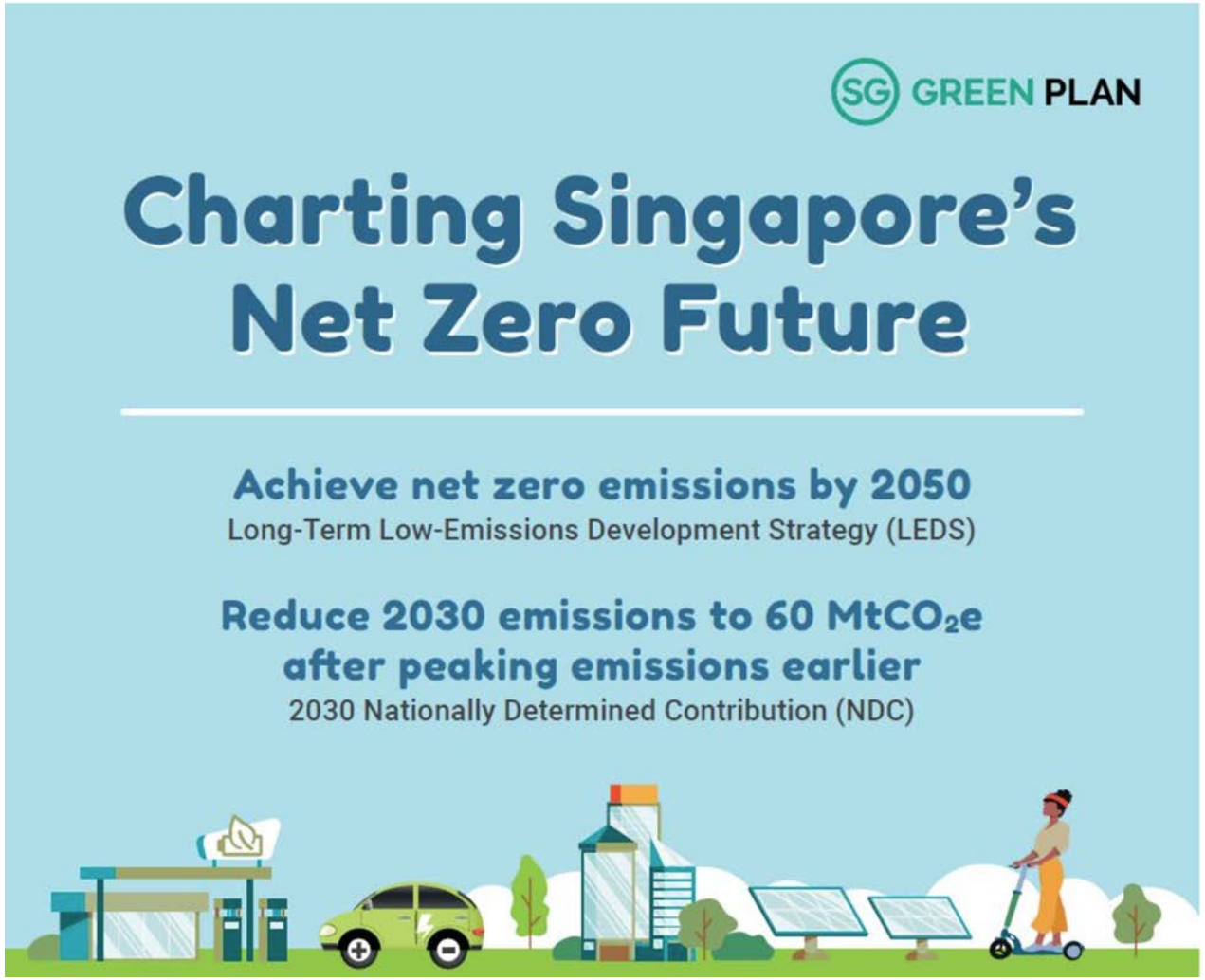
SUSTAINABLE DEVELOPMENT GOALS

Challenge statements can fall under one or more of the 17 UN SDGs

Singapore's Commitment & Plan



National Perspectives

City in nature

- Transforming Singapore into a City in Nature

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Green Economy

- Seek green growth to create new jobs
- Transform our industries and harness sustainability as a competitive advantage
- Transform existing sectors and help them decarbonize
- Help our businesses seize opportunities in the green economy

In support of SDGs:

Resilient future

- Shoring up our coastal and flood defences
- Strengthen food security
- Keep Singapore cool

In support of SDGs:

Sustainable living

- Circular economy
- Eco stewardship programme
- Green commutes

In support of SDGs:

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Energy reset

- Green energy
- Green transport
- Green buildings

In support of SDGs:

Green Skills for the Green Economy

Green Skills for the Green Economy

- Many existing jobs will require green skills as companies across sectors adopt more environmentally sustainable practices and develop sustainability targets for compliance and reporting. For instance, as more buildings and transport systems go green, skills such as **Green Facilities Management** are seeing demand growth of more than 2,000%.

- Environmental, sustainability, and compliance-related green skills are the most transferable across sectors and job roles, and are 'no regrets' moves for citizens to upskill in. **Environmental Sustainability Management** is required by more than 400 job roles while **Environment and Social Governance** by close to 300 job roles, spanning across many sectors.

- Within the Sustainable Finance domain, skills such as **Carbon Markets and Decarbonisation Strategies Management** and **Sustainable Investment Management** are seeing demand growth of more than 1,500%. Other emerging areas such as urban farming, food technologies, and novel food development are also seeing high demand for related skills as Singapore aims to produce 30% of our nutritional needs by 2030.

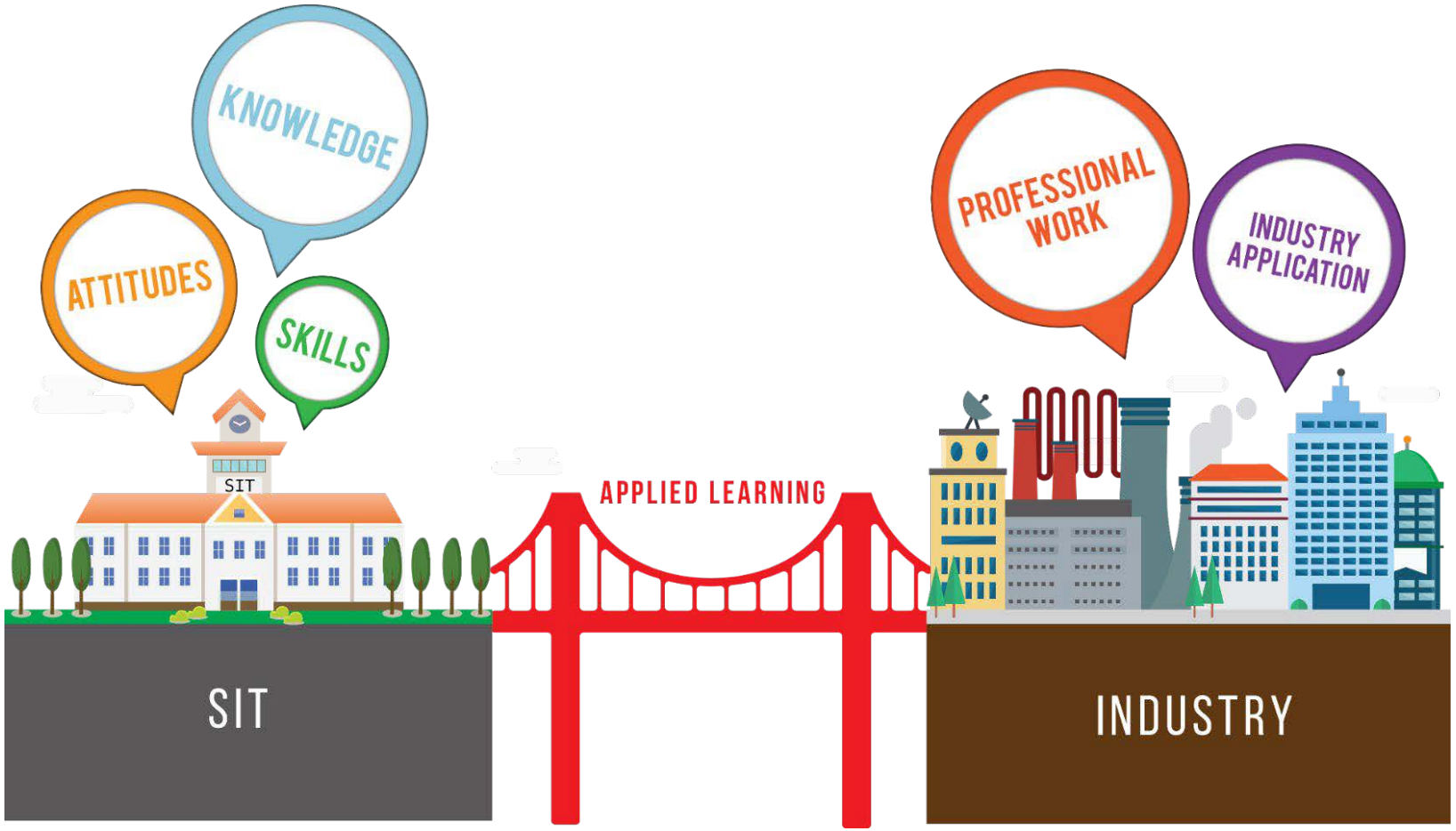
Green Ecosystem – Singapore Example

- People is key – a whole-of-nation movement to advance Singapore's national agenda on sustainable development
- Green programs to involve all stakeholders – energy efficiency national partnership
- Performance standards – minimum energy performance standards
- Laws and legislations on energy efficiency – energy conservation act, carbon tax
- Recognition and awards – EENP, Green Mark
- Financial incentives – energy efficiency fund
- Competent energy professionals – SCEM, EEO Assessor, EEUP
- Green professional networks – Chartered energy engineers, ESCO

Sustainability Education in SIT

Sustainability Education Committee

- **Bridging academic knowledge and skills with real-world applications in industry**
- **Integrating classroom with industry – effective scaffold to learning**



Effective Learning through:

Strong partnerships with industry in education and applied research

Integrated work-study program

Applied learning pedagogies

AL “bridge” to community - Punggol in 2024

Recap: Sustainability Education Via Learner's Perspective

SUSTAINABILITY EDUCATION ROAD MAP FOR SITIZENS

LEVEL 0: GENERAL AWARENESS FOR PUBLIC

LEVEL 1: BASELINE EDUCATION - MICROMODULE

Compulsory for all students. provides fundamental knowledge for learners to better transit into deeper, discipline-specific, and multi-disciplinary sustainability subjects and projects

LEVEL 2: SUSTAINABILITY IN CURRICULUM

Sharpen and enhance sustainability content in SIT and joint undergraduate programmes

LEVEL 3: OPPORTUNITY TO DEEPEN THROUGH MINOR

Student will read discipline-specific modules, embedded with sustainability content, read sustainability core modules which cover a variety of topics, such as life cycle assessment, sustainability report, green financing

LEARNING LOOPS

Applications of sustainability concepts and addressing problem statement from 17 UN SDGs through opportunities such as Communication Studies, Integrated Work Study Programme, Social Innovation Project and Capstone etc.

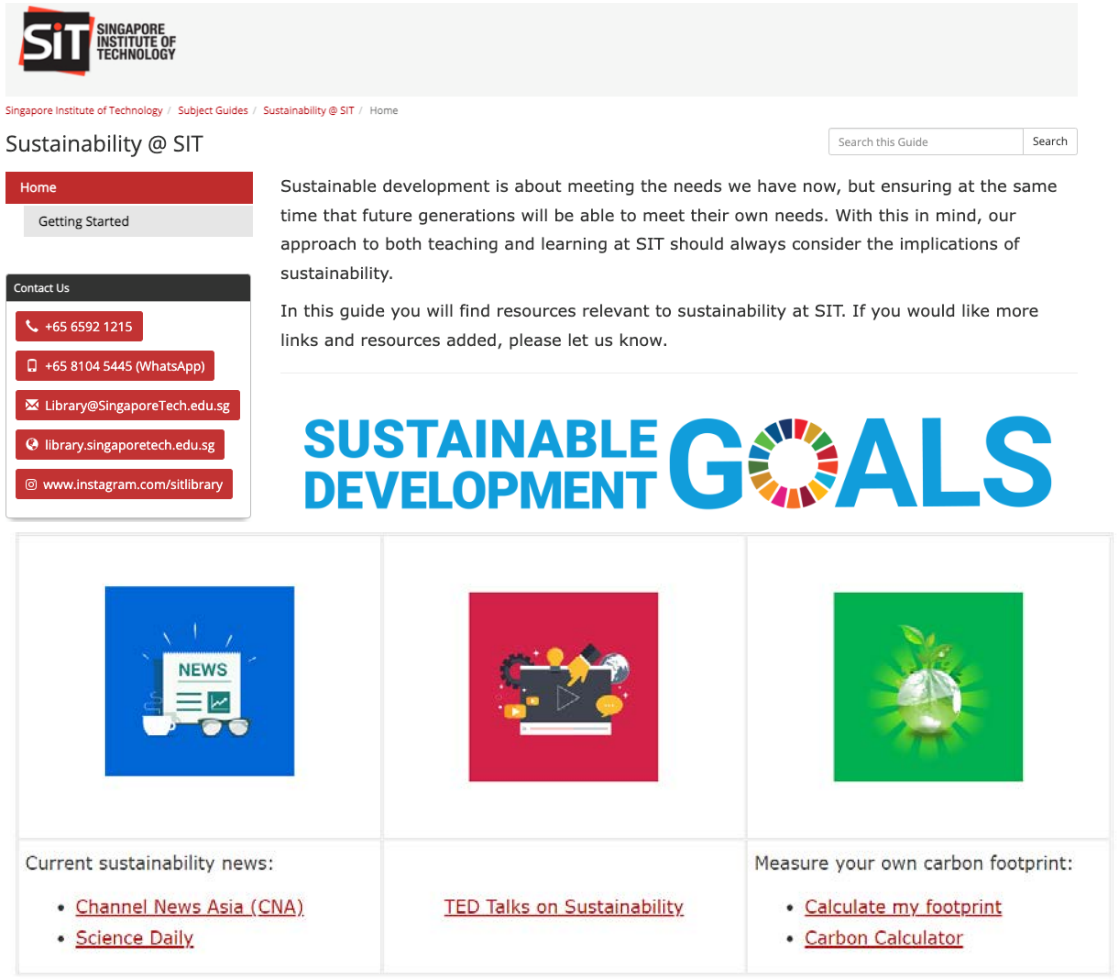
LEVEL4:EMPOWERING PROFESSIONALS

Supercharge sustainability knowledge through CET courses & workshops, with stackable pathways to certificates and degrees

Level X: Student participation in Sustainability-related activities are encouraged throughout their stint in SIT

Level 1 – Incorporate baseline sustainability education for SIT and joint degree UG students (Started for AY22/23):

- Embedded sustainability element in university-wide modules such as:
  - Sustainability 101 Micro-module – Introduction to Sustainability,
  - UCS1001 Critical Thinking & Communication,
  - USI2001 Social Innovation Project
- Made available library resources to support sustainability education



Level 1 – Incorporate baseline sustainability education for SIT and joint degree UG students (Started for AY22/23):

Sustainability 101 Micro-module:

- Two hours of e-learning
- Launched on 29 Aug 2022
- Compulsory starting from AY22 Cohort
- Four topics:
  1. Why is sustainable development important?
  2. What is sustainable development?
  3. What are the key challenges in Singapore?
  4. How can individuals, organisations and Singapore contribute to sustainable development?

Supports the learning of sustainability–related modules (e.g., SIP) & projects (e.g., capstones)

Level 2 – Sharpen and enhance sustainability content in SIT and joint undergraduate programmes:

- Working with all Programmes to make recommendations to incorporate sustainability elements (Contents, Module Descriptions, Module Learning Outcomes, Programme Education Objectives)

- Reference frameworks: ESG, MOE/SSG's Green Skills and United Nations General Assembly's Sustainable Development Goals, etc.

Level 3 – Opportunity to Deepen Through Minor

Minor in Environmental Sustainability (Launched in AY23/24)

18 credits
3 Environmental Sustainability (ES) modules (ES Microcredential)

+

12 credits
2 Discipline-specific modules embedded with ES content

+

SUSTAINABILITY ACTIVITIES
Min. 3 No of Participations with total accumulated 10 hours in seminars / talks / activities with ES theme

=

30 credits + Participations
Minor in Environmental Sustainability

ES Measurement
- Environmental Sciences
- Environmental Economics
- Life Cycle Assessment
- Sustainability Reporting

+

ES Management
- Sustainability Business Model
- Green Financing
- Sustainability Strategies and Climate Change Mitigation/ Adaptation
- Sustainable Development Policy

+

ES Project
- Applications of ES Measurement and Management

NOTE:

- *Pre-requisite: MMCENG1001 Introduction to Sustainability micro-mod*
- *ES Management module to be offered after ES Measurement module whenever curriculum structure allows. Otherwise, to offer this module in the same trimester with ES Measurement module*

To enable SIT graduates of various disciplines to contribute towards environmental sustainability targets of organizations, industry, and nation.

Level 3 – Opportunity to Deepen Through Minor

Sci. Dpl. Glenn S. Banaguas, renowned scientist, diplomat, and one of the of the leading experts on environment, climate change, and disaster risks in Asia, sharing his experience on Sustainability with students reading the Minor in Environmental Sustainability

- Appreciation to IAC for giving input on the Minor in Environmental Sustainability (MES) during the first IAC Meeting.
- Offering of Minor in Environmental Sustainability (MES) in AY2023
  - In AY2023, students from Electrical Power Engineering & Engineering Systems programmes are eligible to sign up for MES. They will start Environmental Sustainability modules in their year 2 (i.e., AY2024).
  - From AY2024, students from the Mechanical Engineering and Digital Supply Chain will be eligible to sign up for the Minor.
  - Key feedback from students: Appreciated the sharing from industry and case studies – *Invitation to IAC members to contribute on this if available*
- At the overall programme level, learning loop created with application/reflection via the Integrated Work Study Programme, Social Innovation Project and Capstone

Level 3 – Opportunity to Deepen Through Minor

- Students apply their learning by using real-life examples of companies listed on the SGX.
- In their group report and presentation, they make comparison of key environmental indicators, discuss carbon accounting, LCA and sustainability reporting, and analyze the improvement strategies to reach their carbon reduction emission goals

Level 3 – Opportunity to Deepen Through Minor

SHEIN

ZALORA

KEY ENVIRONMENTAL INDICATORS

KEY FACTORS	SHEIN	ZALORA
Carbon Footprint	SHEIN's 2022 production spike led to a **52% emissions rise**, over **99% 9.17 million tonnes CO2e are scope 3 activities.** Efforts to reduce carbon footprint - Usage of **Renewable Energy for Operations** - Source for **environmentally friendly products** - **decarbonising** their **supply chain**	ZALORA emitted **211,886 tons of CO2, manufacturing** taking up **62%** Efforts to reduce carbon footprint - **Reduction** in **Electricity Consumption** - **Replacing packaging material** to one that has **lower environmental impacts** - **increase recycling rates**
Fair Labour Practices	Efforts to ensure fair labour practices - Human Rights Policy: **SHEIN's Human Rights Responsibilities** - Ensure fair wages, working hours etc - SHEIN **audits suppliers** (SHEIN's **Code of Conduct**) to ensure **fair labour standards**	Efforts to ensure fair labour practices - Code Of Conduct and Ethical Trade Manual social **audits** to **evaluate working environments** - **training sessions** to proper ethical trade, wage, and working hour management.
Ensuring Sustainable Consumption and Production Patterns	GHG emissions **increased** by **112,486 CO2** in **2022** Efforts to increase sustainable consumption and production patterns - **material traceability** - **educate suppliers** to cater new production models - set plans for **circular economy** for SHEIN's products	Efforts to increase sustainable consumption and production patterns - **switch fabrics** with **lower environmental impacts** to ensure sustainable consumption - promote **conscious shopping** and **circular fashion** to consumers - **minimise** use of **plastic** for packaging

SDE3001 Environmental Sustainability Measurement:

- Students compare Shein and Zalora and shared the disastrous impact of fast fashion on the environment and in terms of unfair labor practice.

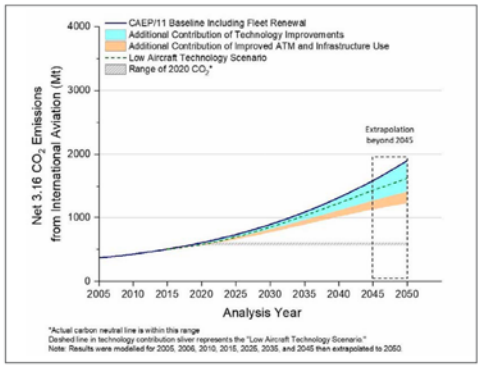


Fig 3: Global aviation CO_2 emissions through 2050 (Fleming et al., n.d.)

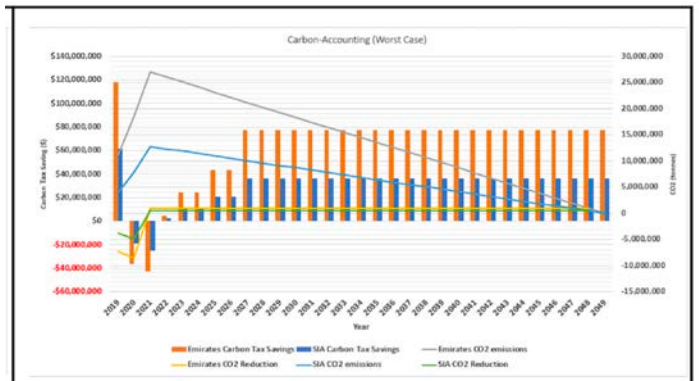


Fig. 12: Worst case scenario for carbon tax

- Students compare Singapore and Emirates Airlines CO_2 footprints and the insufficient commitments they intend to take. They model the cost of operations as the value of carbon credits increases over time, underlying the urgency to transform the sector.

Level X – Facilitate student activities as a learning platform

- Support and promote student participation in sustainable related events and student life activities
  - For example: supporting the upcoming AECOM City Hack, student participation in international competition – “Make the Case” – East Asia

Overarching theme

FastTrack CityHack SG leverages digital tools to deliver ESG-oriented solutions, addressing complex and interrelated challenges and crafting solutions with universal value for **Singapore's stakeholders** and **scalable to other cities globally**.

AECOM Pillars

- **RESILIENCE** — People, Environment, Economy
- **CARBON-ZERO** — Mobility, Energy, Waste
- **DIGITAL ECOSYSTEM** — Interconnected systems, Black swam event readiness

Singapore Green Plan

SG GREEN PLAN

Key targets: City Nature; Sustainable living; Energy reset; Green economy; Resilient future

The purpose

Culture

Talent development
To **identify and grow talents**, offering them support, visibility and a platform to grow.

Approach

Identify opportunities
To develop innovative solutions for complex challenges in Singapore that can be scalable to other cities in the region and globally - **scaling success**.

Event type

When
November 25-27

Where
AECOM SG Office

How
In-person weekend, 70-80 participants

What
- Competition-style event
- Mentorship
- Money prizes

Outcomes

Bespoke challenges for SG
Bespoke innovative solutions for Singapore

Global promotion
Leverage AECOM & partners' network for a global outreach

Draft media kit information [tbc]

Level X – Student Participation in Sustainability Activities

- Sustainability Education Committee (SEC) played an advisory role to students keen to set up Digital Sustainability Club – now officially recognized by Office of SITizen Experience

- Working with partners to curate or organize Sustainability related events

[Register Now!] Seminar on Getting to Zero: Achieving Climate Success and the Role of the University | 26 Jan 2024

Date: 26 January 2024 **Time:** 3.15 pm to 4.30 pm
Location: SIT@Dover, 10 Dover Drive, S138683

The seminar by **MIT Professor John E. Fernández,** *Director of the MIT Environmental Solutions Initiative (ESI),* focuses on strategies for achieving net zero emissions by mid-century, spotlighting MIT and ESI's efforts to confront climate challenges across various areas.

Registration closes on **24 January 2024**. Due to the limited availability of seats for this event, we encourage you to **register early to secure your participation.**

Register Now!

Learning Outcomes

- Recognise urgent climate concerns: trajectory of greenhouse emissions and emerging tipping points
- Gain awareness of positive developments: decarbonised energy production and low carbon technologies
- Understand the challenges but necessary goal of reducing emissions rapidly and deploying carbon capture globally and maintaining net-zero greenhouse emission by mid century
- Gain insights into MIT and ESI's roles in addressing sustainability issues

Speaker

Professor John E. Fernández

Professor and Director
Environmental Solutions Initiative (ESI)
Massachusetts Institute of Technology (MIT)

John E. Fernández is the Director of ESI and a Professor in the Department of Architecture at MIT. He has initiated work at MIT and with colleagues across the globe in addressing some of the most important environmental challenges today. He founded and directs the MIT Urban Metabolism Group, which is focused on sustainable and biodiverse futures for cities around the world. He is also a published author in scientific/design journals and is a practicing architect, focusing on low-energy and net-zero-carbon buildings globally. He serves on the World Economic Forum's Global Commission on BiodiverCities by 2030, holds a leadership position at OceanVisions, and is on the US Advisory Panel of EarthPercent.

Energy Efficiency Technology Centre @ SIT

To promote and develop energy efficiency capability and new technologies in the local energy efficiency ecosystem for industrial sectors

Build Capability for SMEs

- Offer low-cost high quality energy assessments to SMEs
- Help SMEs to achieve energy savings
- Advise grants available for SMEs

Upskill Energy Professionals

- Offer Energy Efficiency Upskilling Programme Upskill industry professionals in industrial energy efficiency
- Training deep dives into industrial systems for e.g. Compressed Air Systems, Pump Systems and Electrical Power Systems
- 3-day theory + 2-day practical course
- Fulfill part of requirements to be in-house EEOA (Energy Efficiency Opportunities Assessor)

Training of Talent Pipeline

- Attach SIT students to industry through Integrated Work Study Programme (IWSP) to work on energy assessment/ energy efficiency projects
- Opportunity to continue projects to capstone / MEng Tech projects

Hands-on real world experience

Integrated Work Study Programme – Students work at EETC from 6 to 12 months will acquire competencies through actual industrial energy audits.

Conclusion

- Sustainable development is a global challenge that requires collective action and collaboration across sectors and regions.
- Organic Integration of Sustainable Development Goals (SDGs) in Engineering Education can be facilitated through immersion in
  - National commitments to global climate change/ net-zero targes & UN SDGs
  - National ecosystem for green economy
  - National education framework (incorporation of critical core skills)
  - University's requirements for critical core skills
  - Engineering school's requirements for interdisciplinary sustainability education
  - Disciplinary in-depth sustainability requirements
- Engineering education has to reshape curriculum and practice to develop green skills which encompass the knowledge, abilities, and competencies required to operate in a green economy, and to deliver UN SDGs.

Thank you

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