PLEA 2017 EDINBURGH
Design to Thrive

Campus Wide Energy Intensity Reduction through Performance Evaluation at Building Level – an Example of Singapore

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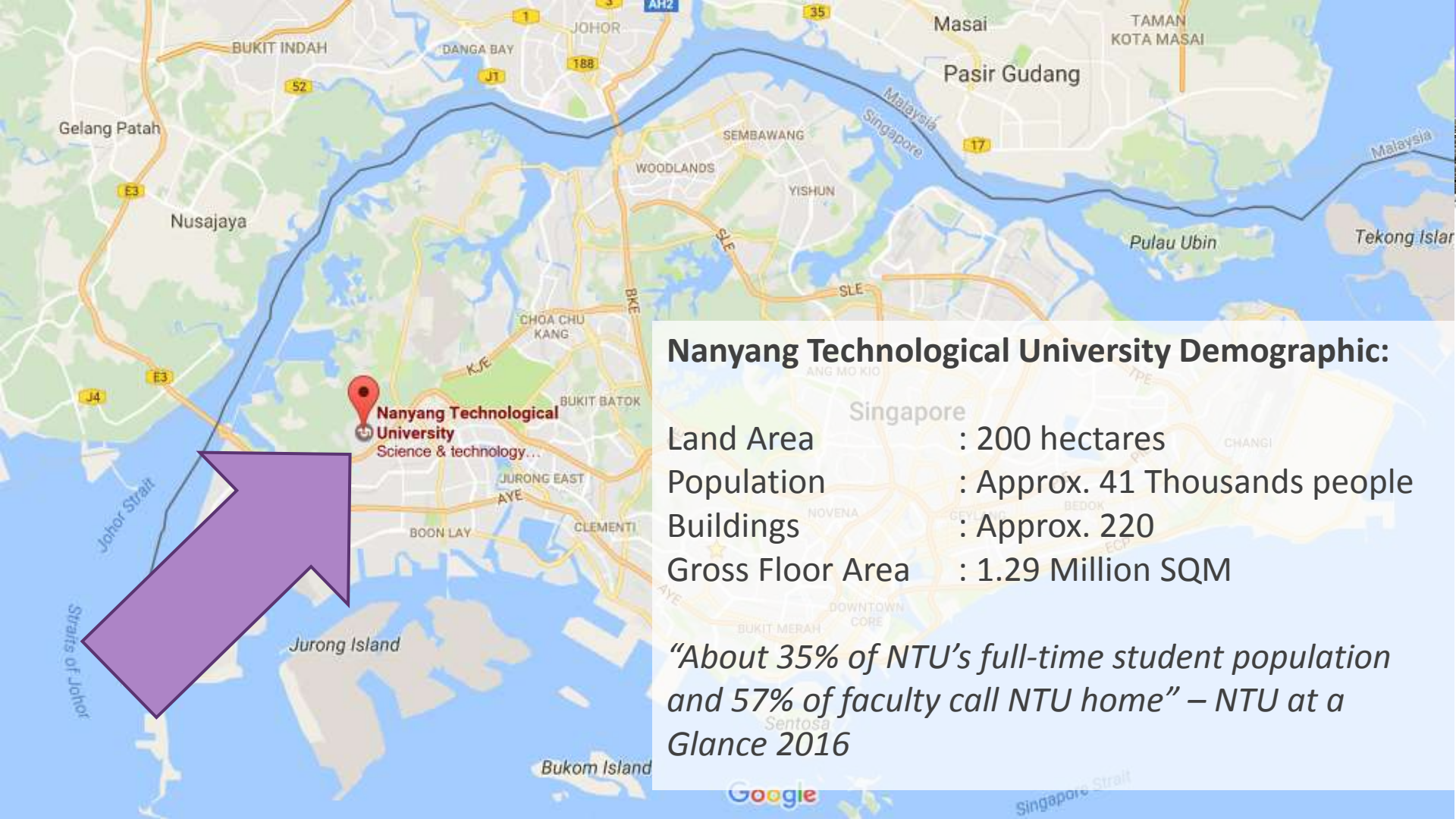
EcoCampus - 35% Living Laboratory

Singapore Demographic:

Land Area	: 719.7 KM2
Population	: 5.535 million (2015)
GDP per population	: 52,888.74 USD (2015)

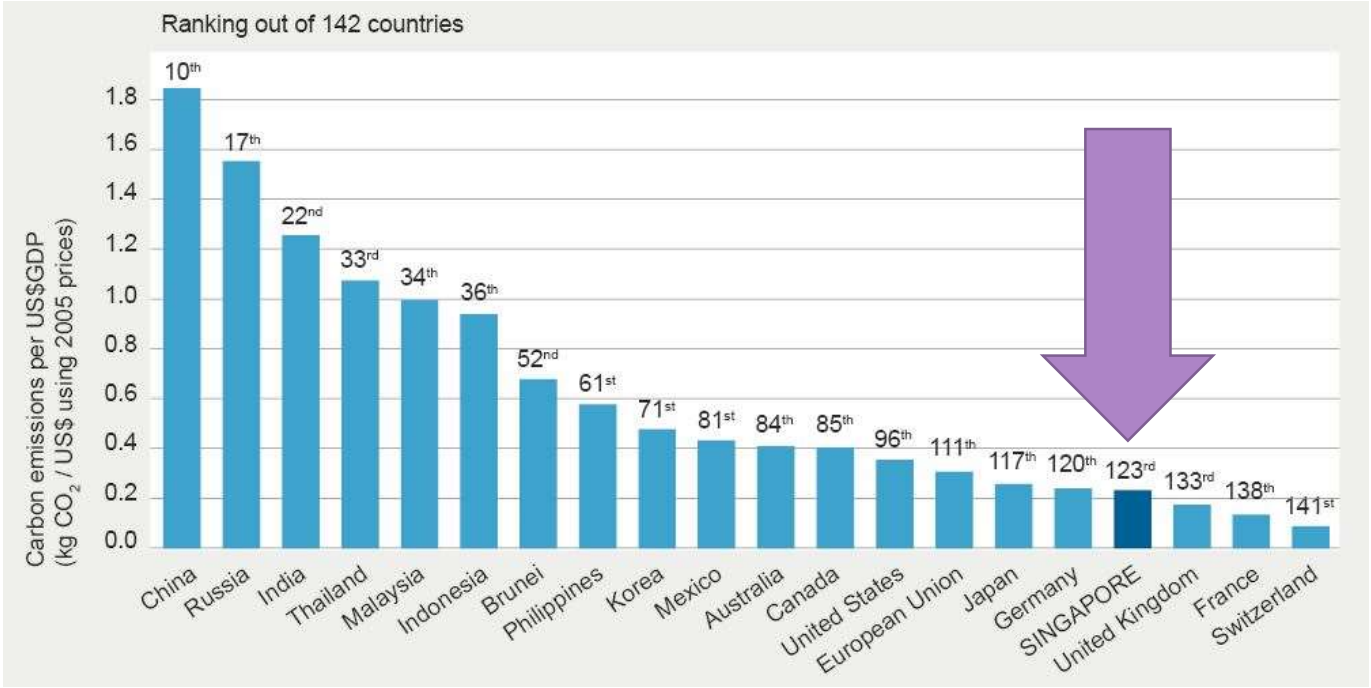


Nanyang Technological University Demographic:

Land Area	: 200 hectares
Population	: Approx. 41 Thousands people
Buildings	: Approx. 220
Gross Floor Area	: 1.29 Million SQM

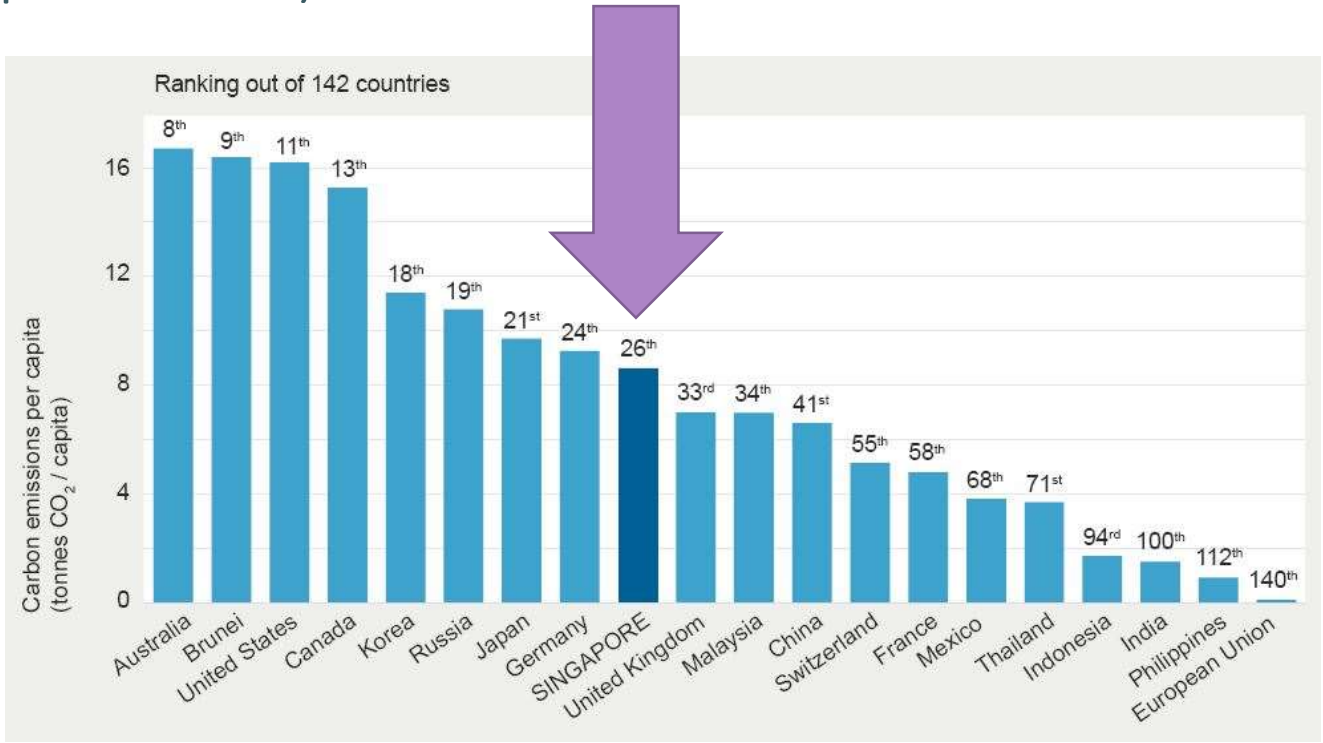
"About 35% of NTU's full-time student population and 57% of faculty call NTU home" – NTU at a Glance 2016

Singapore Carbon Intensity
(Emission per $GDP)



Ref: https://www.nccs.gov.sg/climate-change-and-singapore/national-circumstances/singapores-emissions-profile

Singapore Carbon Intensity
(Per Capita Emissions)



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NCCS NATIONAL CLIMATE CHANGE SECRETARIAT | STRATEGY GROUP PRIME MINISTER'S OFFICE

5.3% Savings

Chilled-water system retrofit

Retrofit existing chiller plants to achieve higher energy efficiency.

28 large public sector building owners have adopted the Guaranteed Energy Savings Performance (GESP) contracting model to improve their chiller plants. The GESP contract is a turnkey contract where an Energy Services Company (ESCO) will carry out an Investment Grade energy audit, implement the energy conservation measures, and guarantee the chiller plant efficiency and annual energy savings.

3.8% Savings

Lighting replacement

Replace existing fluorescent tubes and bulbs with more energy efficient ones.

3.0% Savings

Air-conditioners replacement

Replace aging unitary systems with more energy efficient models such as those certified with 3-tick rating and above under NEA's MELS.

2.0% Savings

Optimise equipment operation

Optimise mechanical ventilation fans, Air Handling Units (AHUs), and data centre operations. Practise energy conservation habits, such as raising the indoor temperature setting and switching off computers and lights when not in use.

1.1% Savings

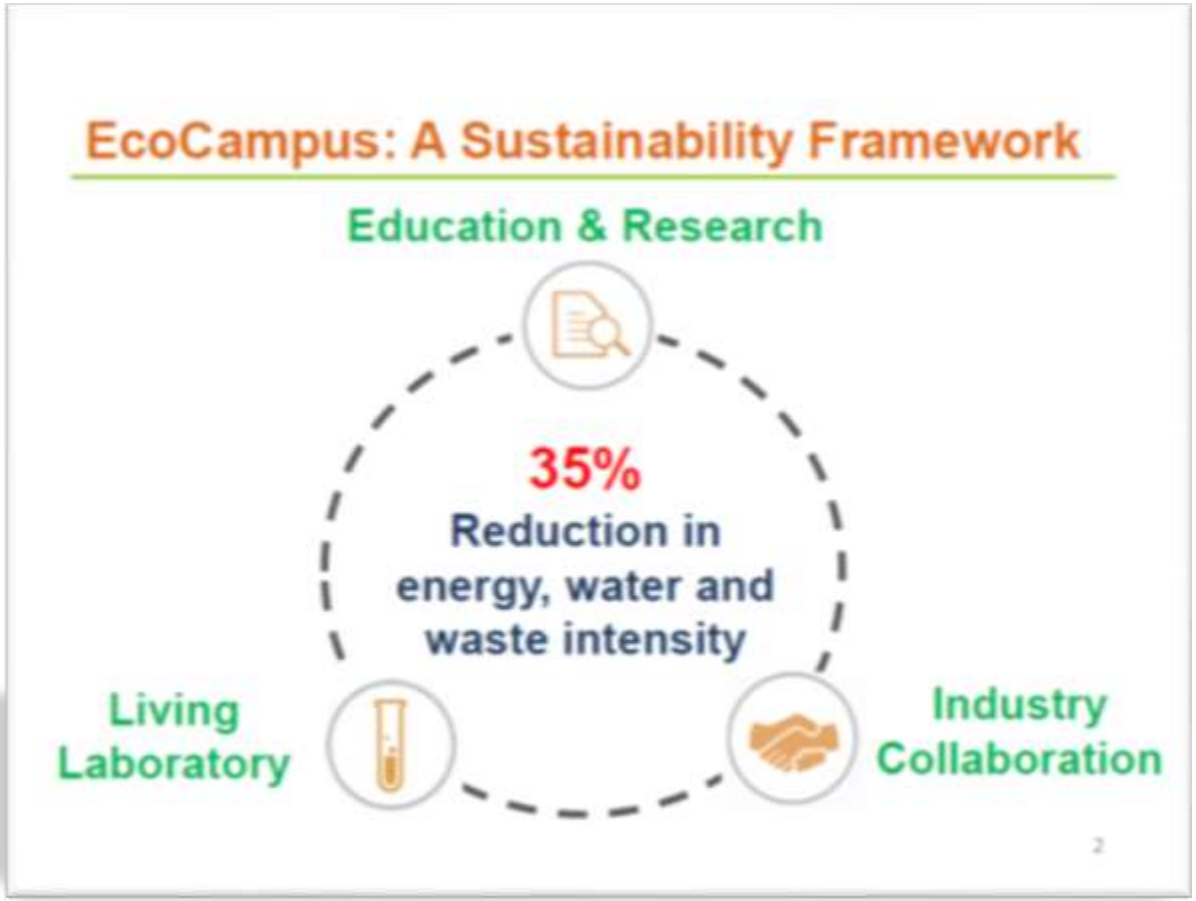
Others

Other measures include upgrades of equipment such as lifts, escalators, and other appliances.

Singapore will do our part...

The Inter-Ministerial Committee on Climate Change (IMCCC) will study how Singapore can stabilise our long-term emissions. Its work will build on Singapore's past and ongoing efforts in sustainable development. The clean and green living environment we enjoy today is the result of the high priority we have placed on protecting the environment over the years. For instance, we generate about 80% of our electricity from natural gas—the cleanest form of fossil fuel.

Efforts to reduce our long-term emissions will be challenging. Our small size limits our ability to draw on alternative energy such as solar, wind or nuclear. Nonetheless, we will enhance energy efficiency efforts and develop low carbon technologies to overcome current constraints.

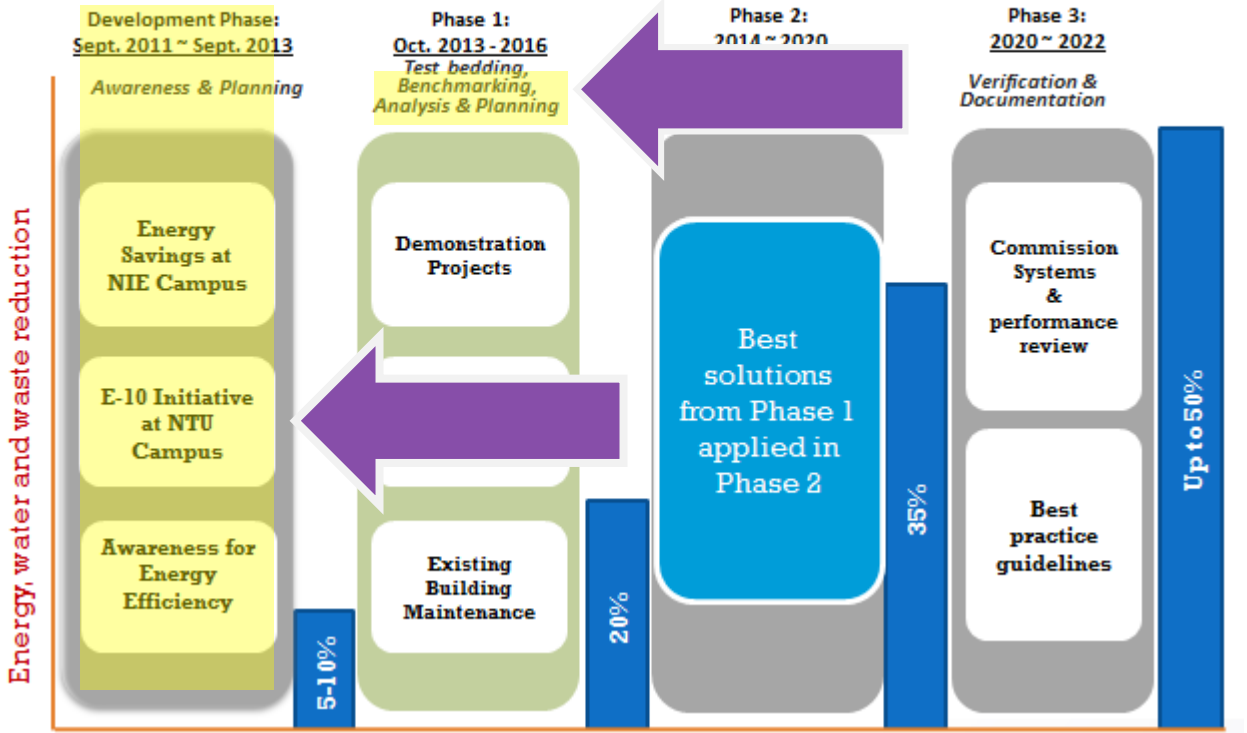


EcoCampus

- 35%

Living Laboratory

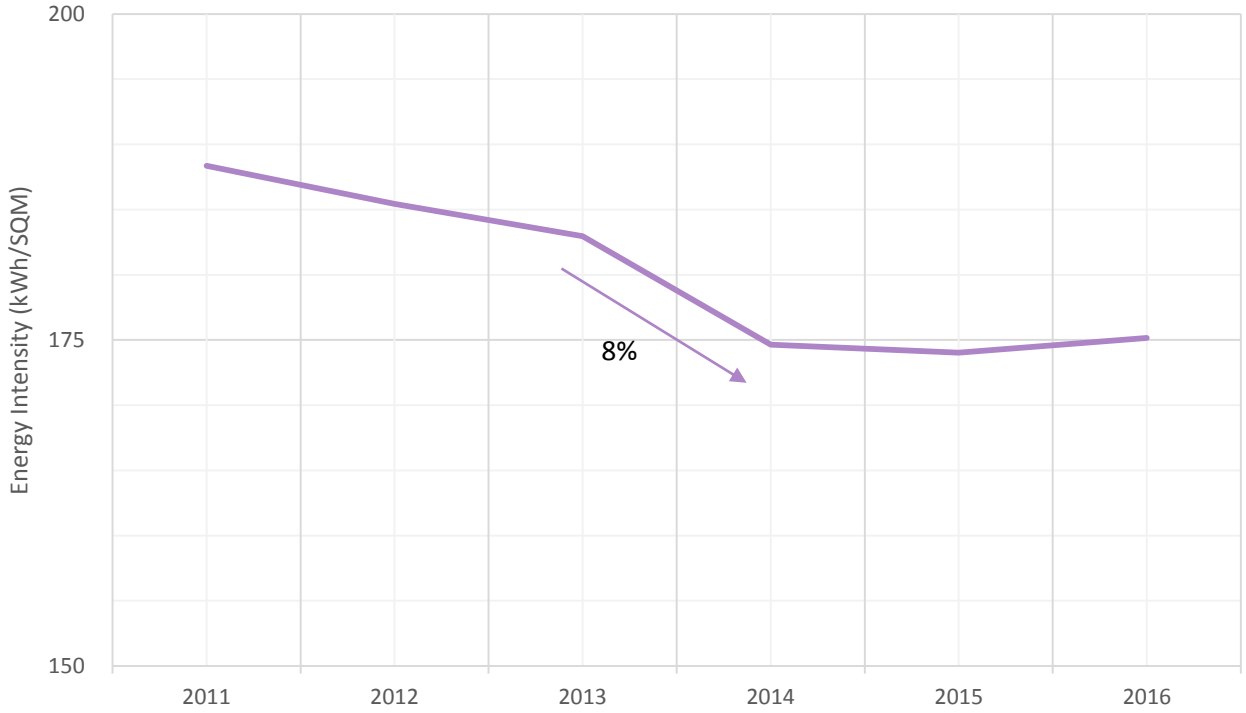
Program Implementation



EcoCampus

Living Laboratory

Campus Energy Intensity



(E-10) Initiatives

Action	Stakeholder(s)	Funding	Energy Savings *
Increase air-condition set-point by 0.5-1.0 ^{0}C (current is 24^{0}C)	Facility Management Office	Nil	1 - 2 %
Review air-tightness of buildings: doors etc.	Facility Management Office	Nil	1 %
Off peak cooling (startup, early/intermittent off)	Facility Management Office	Nil	1 %
Chiller plants - upgrading of controls	Facility Management Office	Budgeted	1 - 2 %
Energy use reduction in ventilation systems (air handling and fan coil units)	Energy Service Company (ESCO)	Net-Zero	1 - 2 %
Additives to reduce fouling in chiller systems	Energy Research Institute @ NTU (ERI@N)	Net-Zero	1 - 2 %
Reduce excessive lighting: car parks/common areas, lux sensors	Facility Management Office	Nil	0.5 - 1 %
High efficiency lighting and other systems (engage ESCO to generate opportunities)	Energy Service Company (ESCO)	Net Zero	1 %
Ownership of Energy Efficiency by Schools, Departments (including Lab air-condition, other electricity loads)	Schools Departments Divisions	Nil	1 - 2 %
Active Participation of Students / Staff in Energy Saving	All	Nil	3-5%

Baseline and Benchmark for NTU Campus Methodology and Approach

DEFINE → MEASURE → ANALYZE

Data Collection → Identify Gap in Baseline → Develop Load Profile → Analyze Load Profile → Discuss Data with Relevant Officers in Schools and FM

CONTROL ← IMPROVE

Identify Savings ← Improve Baseline Data ← Data Collection (New Building) ← Define Baseline

Measurements Availabilities and Gap

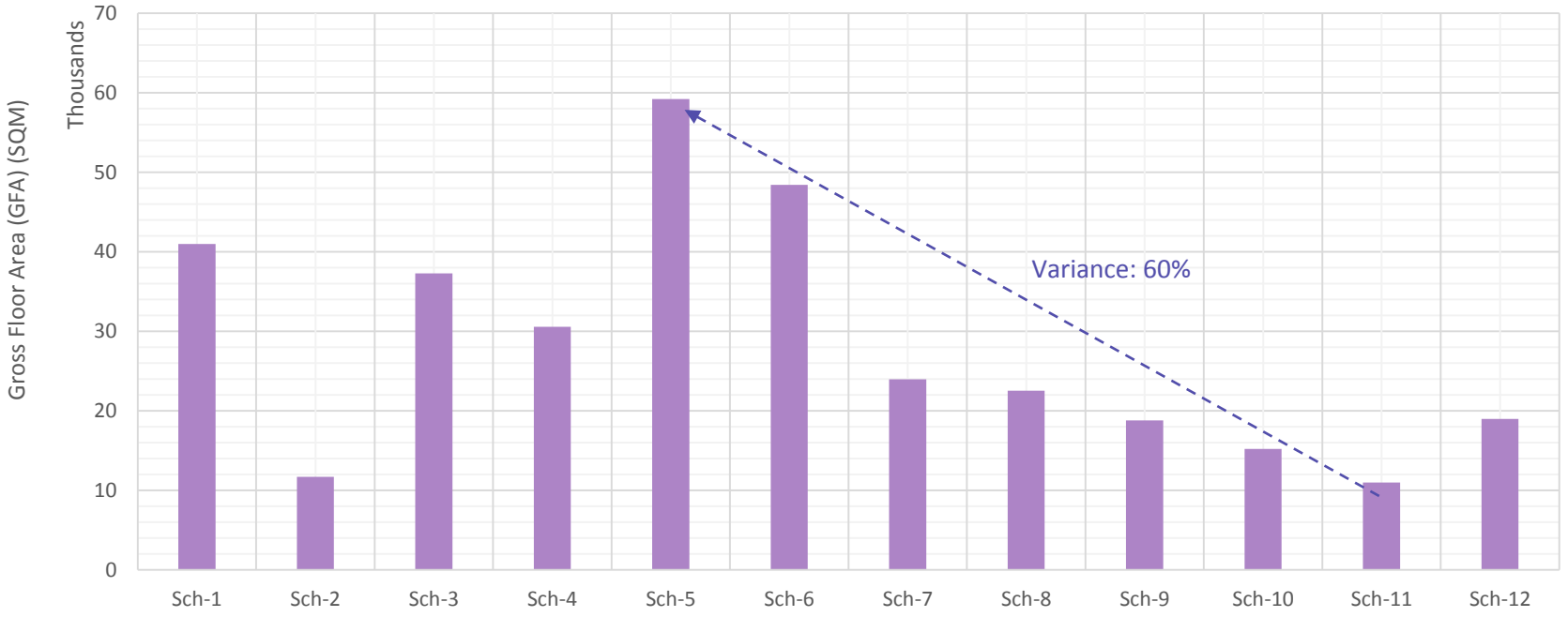
Zones	Measurement System
Campus Level	Digital meter with ICT layer
NTU Academic Buildings	Digital meter integrated with Information and Communication Technology (ICT) layers, and energy bills
Auxiliary and Common Services (including canteens, restaurants etc.)	Digital Meter integrated with ICT layer
Staff, Student and Commercial Housing	Metered data available, to be collected manually by individual staff
National Institute of Education	Digital meter integrated with ICT layer.
Commercial and Retail outlets	Metered data available, to be collected manually by individual staff

Measurement for Intensity Benchmarking

$$Annual\ Energy\ Utilization\ Index\ (EUI) = \frac{Annual\ Energy\ Consumption\ (kWh)}{Gross\ Floor\ Area\ (SQM)}$$

Level	Type of Data
Campus Level	Area, Energy Consumption and Renewable Energy Generation
Building Level	Area & Energy Consumption (Lighting, ACMV (Air Conditioning and Mechanical Ventilation) and Plug load)
Floor Level	Area & Energy Consumption(Lighting, ACMV and Plug load)
Room Level	Area & Energy Consumption(Lighting, ACMV and Plug load)

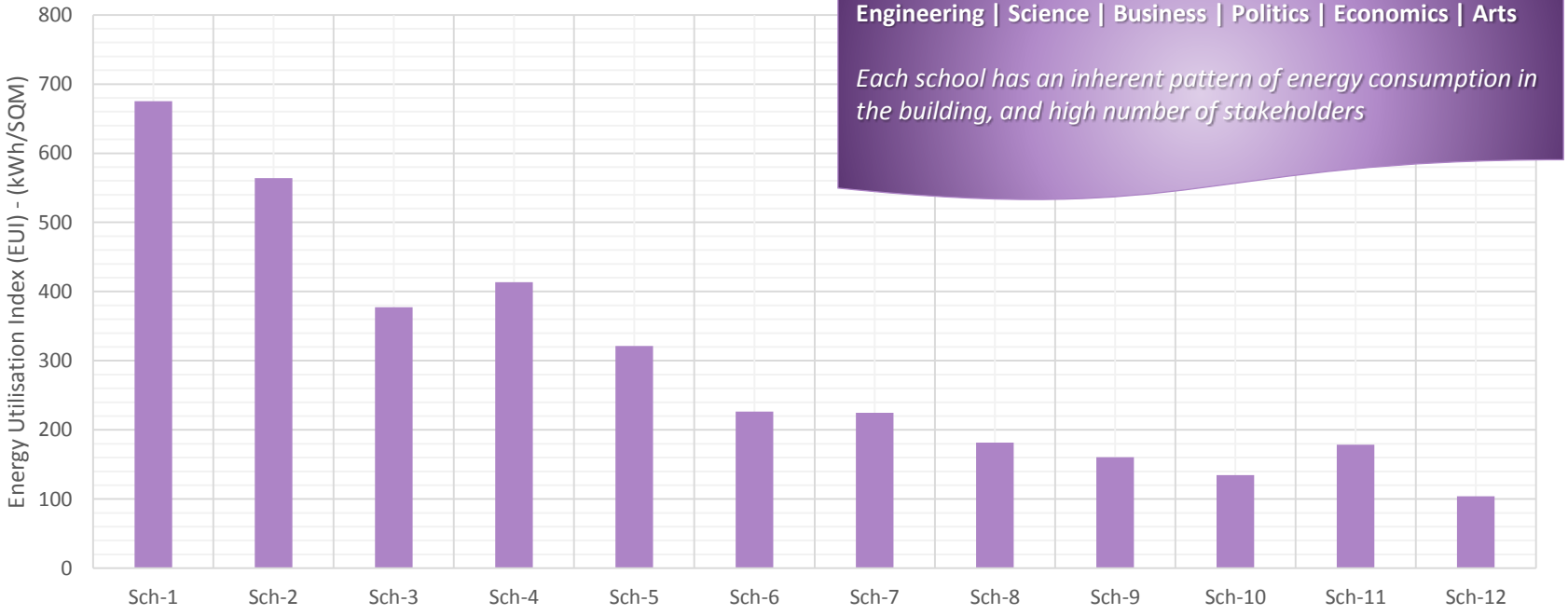
Gross Floor Area of Various Target Buildings



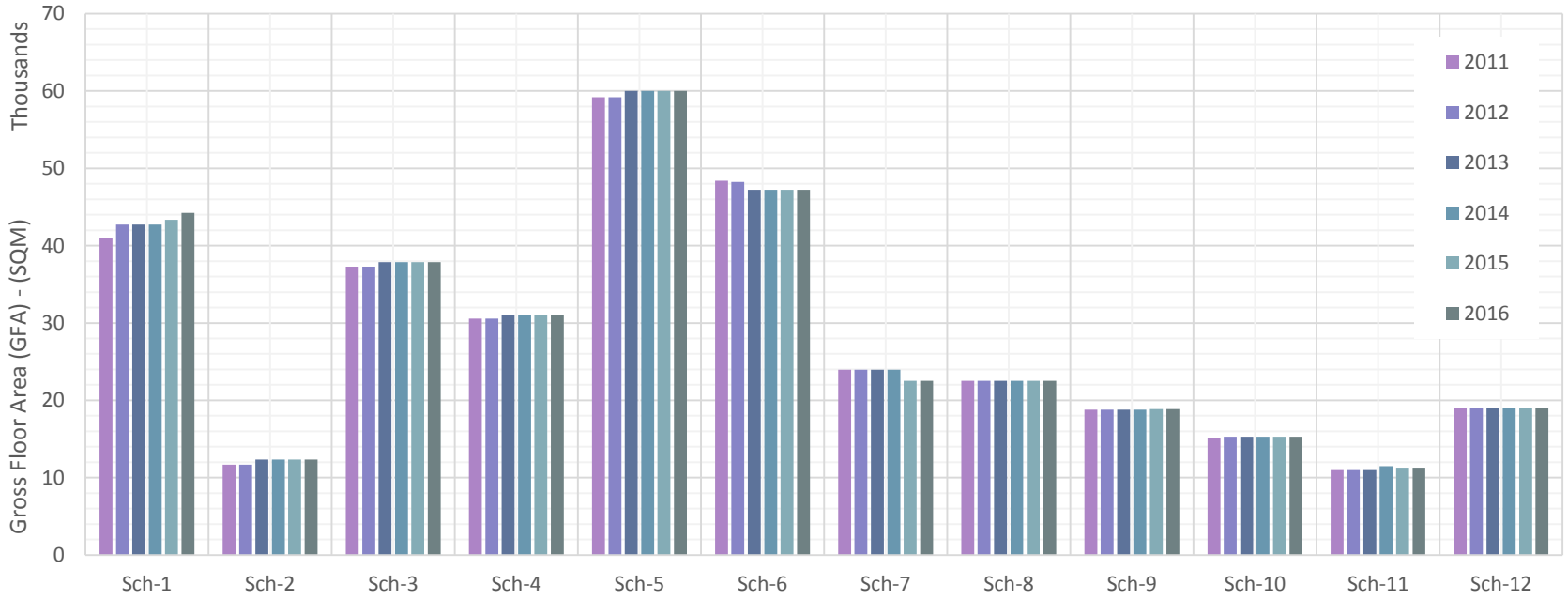
Baseline Year (2011) – Energy Consumption

Engineering | Science | Business | Politics | Economics | Arts

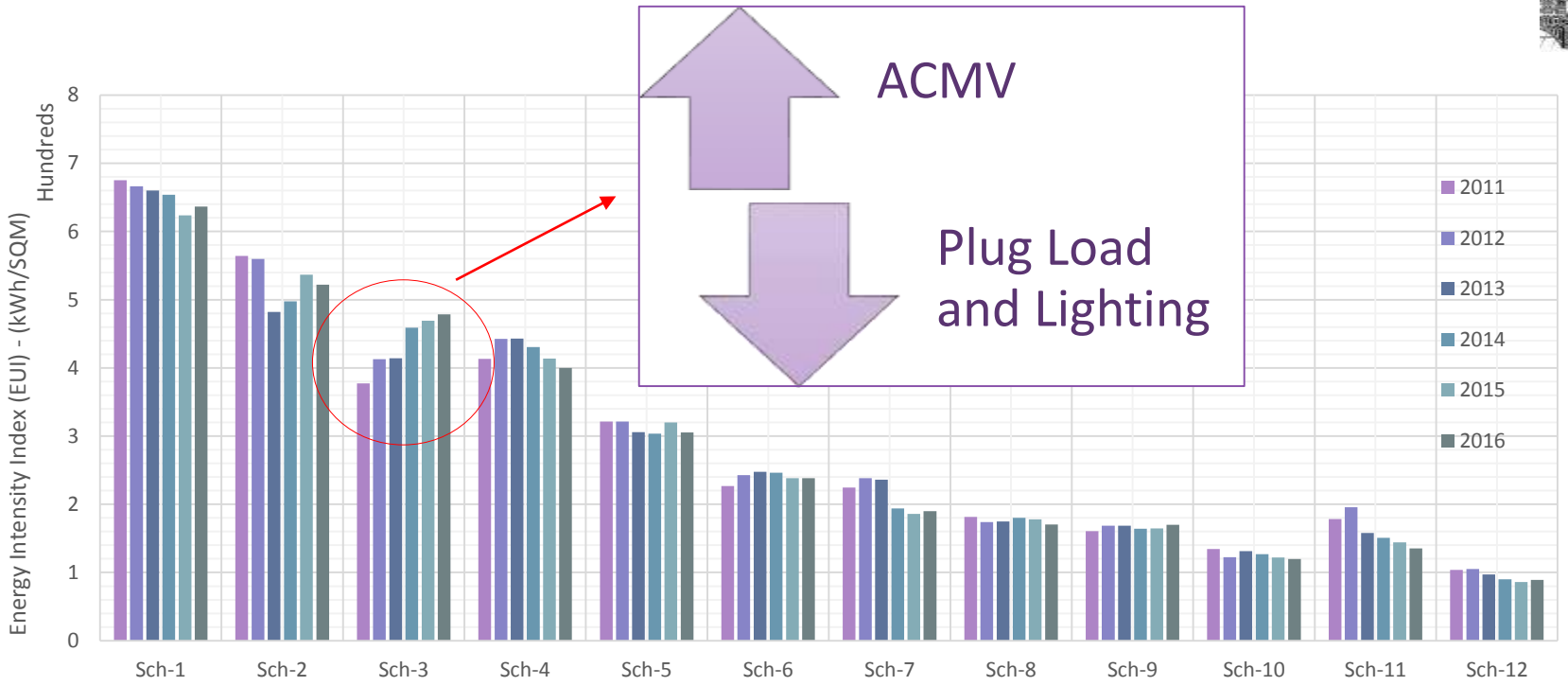
Each school has an inherent pattern of energy consumption in the building, and high number of stakeholders



GFA of The Target Buildings Year-on-Year



EUI of Target Schools Year-on-Year



Conclusion

- The NTU Energy Intensity has reduced by 7% in 2016 in comparison to 2011, without considering growth in research area.
- NTU has been awarded with the highest award: Green Mark Platinum Star Champion by the Building and Construction Authority (BCA) in Singapore
- 5MW Solar Photovoltaic installation have been completed, assist in the peak load reduction.
- NTU GHG emission has been reduced by 3000 Tones per year.
- Influenced change in perspective of the stakeholders, to align the multiple stakeholders agenda towards energy efficiency.

Thank You