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

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Singapore Demographic:

Land Area: 719.7 KM²
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)

Singapore Carbon Intensity
(Per Capita Emissions)

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: A Sustainability Framework

Education & Research

35% Reduction in energy, water and waste intensity

Living Laboratory

Industry Collaboration
Program Implementation

  - Awareness & Planning
  - Energy Savings at NIE Campus
  - E-10 Initiative at NTU Campus
  - Awareness for Energy Efficiency

- Phase 1: Oct. 2013 - 2016
  - Test bedding, Benchmarking, Analysis & Planning
  - Demonstration Projects

- Phase 2: 2014 - 2020
  - Existing Building Maintenance
  - Best solutions from Phase 1 applied in Phase 2

- Phase 3: 2020 - 2022
  - Verification & Documentation
  - Commission Systems & performance review
  - Best practice guidelines

EcoCampus
Campus Energy Intensity
### (E-10) Initiatives

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

**DEFINE**
- Data Collection

**MEASURE**
- Identify Gap in Baseline
- Develop Load Profile
- Analyze Load Profile

**ANALYZE**
- Discuss Data with Relevant Officers in Schools and FM

**CONTROL**
- Identify Savings

**IMPROVE**
- Improve Baseline Data
- Data Collection (New Building)
- Define Baseline
# Measurements Availabilities and Gap

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

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

<table>
<thead>
<tr>
<th>Level</th>
<th>Type of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Campus Level</td>
<td>Area, Energy Consumption and Renewable Energy Generation</td>
</tr>
<tr>
<td>Building Level</td>
<td>Area &amp; Energy Consumption (Lighting, ACMV (Air Conditioning and Mechanical Ventilation) and Plug load)</td>
</tr>
<tr>
<td>Floor Level</td>
<td>Area &amp; Energy Consumption(Lighting, ACMV and Plug load)</td>
</tr>
<tr>
<td>Room Level</td>
<td>Area &amp; Energy Consumption(Lighting, ACMV and Plug load)</td>
</tr>
</tbody>
</table>
Gross Floor Area of Various Target Buildings

Variance: 60%
Baseline Year (2011) – Energy Consumption

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

ACMV
Plug Load and Lighting
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