Net-Zero Energy Building in the Tropics
School of Design and Environment
SDE 4

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SDE4 | Longitudinal Section

Opening: January 2019

Size: 6 Floors
Gross Floor Area: 8514 m²
Site Area: 5044 m²
Site Coverage: 52.6%

Programme: Design Studios
Hot-Desking Areas
Research Centres
Laboratories
Workshops
Library
Seminar Rooms
NUS-CDL Smart Green Home
Staff Offices
Social Plaza and Exhibition Area

Image: Serie Architects
SDE4 | Longitudinal Section

Image: Serie Architects
SDE4 | SPACE AND FORM

WELLNESS

EDUCATIONAL MODEL

FLEXIBILITY

COMMUNITY

Wrap around circulation: breakout spaces

Central Study Platform: undergraduate studios

Green terraces

Social plaza

Front garden

Image: Serie Architects
A net zero energy building is one in which the total amount of energy used by the building on an annual basis is equal to the amount of renewable energy created.

NZEB: Site Energy A, renewable energy collected within Site Boundary

Net Zero Source Energy
Net Zero Energy Costs
Net Zero Energy Emissions
SDE 4 Net Zero Energy Building

- Cooling +
- Plug Load +
- Ventilation +
- Lighting +
- Auxiliary

≤

Renewable Energy Production over a YEAR
ENERGY REDUCTION STRATEGIES
SDE4 | RENEWABLE ENERGY

2000 MWh/year
100% of reference case

Image: Serie Architects
SDE4 | PASSIVE DESIGN, TROPICAL ARCHITECTURE

0. Base Case

The standard architectural form with emphasis on enclosure and architecture as object.

1. Enhancing Natural Ventilation

Loosely stacked planes Occupant controlled glazing Shallow composition depth Optimal North, South opening

Image: Serie Architects
SDE4 | NATURAL VENTILATION

Orientation

Design

Simulation
SDE4 | SOLAR LOAD

Frit Glass To Improve Natural Lighting
Wall Facade & Flooring Material To Reduce Glare
Shading Device
Diffused Light

Image: Surbana Jurong + Serie M’Ply
SDE4 | DAYLIGHTING

Useful Daylight Illuminance: Floor 6

Image: TRANSOLAR KLIMAENGINEERING
2. Over-sailing roof

Uniting the programmatic components is an over-sailing roof. This roof covers the entire plot and shades the whole composition.

3. Solar screens

Massive solar shading panels provide shade in the morning and the evening. These screens also complete the architectural form. The roof accommodates an array of PV cells which generate additional electricity for the building. Minimum East, West facing façade East, West ETTV optimized

Image: Serie Architects
1500 MWh/year
75%
of reference case

Image: Serie Architects
ENERGY REDUCTION STRATEGIES

System COP for mechanical ventilation and FCU

<table>
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<tr>
<th>Building Type</th>
<th>Plug Loads</th>
<th>Light</th>
<th>Auxiliary</th>
<th>Mechanical Ventilation</th>
<th>FCU</th>
<th>Uncertainty</th>
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<tr>
<td>Reference Building</td>
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<tr>
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<td>High Efficient Air Conditioner</td>
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<td>305</td>
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Image: Transsolar Klimaengineering
SDE4 | RENEWABLE ENERGY

Image: Serie Architects
PPD – Predicted Percentage of Dissatisfied
PMV – Predicted Mean Vote and 7-point thermal sensation scale

PMV ± 0.5 / PPD ≤ 10%

high comfort
ASHRAE Standard 55-2013
“...Elevated air speed has long been used in practice as a means to off-setting higher temperatures. Updated in 2013, the ASHRAE Standard 55 includes a procedure for evaluating the cooling effect of elevated air speed using the PMV for elevated air speed (PMV_{eas}).

Rethinking Comfort; A Pathway to Low-energy Buildings
Wolfgang Kessling, Martin Engelhardt and Ina Maia,
Futurarc Magazine, Sept-Oct 2015

Image: TRANSOLAR KLIMAENGINEERING
510 MWh/year
25% of reference case
**SDE4 | ENERGY REDUCTION STRATEGIES**

*Reference building: typical institution with similar occupancy*

- **Passive Design**
  - Reducing solar heat gain
  - Reducing need for AC

- **Active Design (Systems)**
  - Efficient ACMV
  - Tapping on centralised cooling
  - Hybrid System
  - Efficient electrical systems

- **Reducing Usage (Behavior)**
  - Equipment selection
  - Plug load control

- **Solar PV Panels**
  - ~1200 panels
  - ~510 MWh/annum of energy generated
  - 424 installed kWp

*Image: Transsolar Klimaengineering*
Daylight Utilisation
- Daylighting sensors
- Dedicated perimeter circuit
- Greater energy savings

LED Lighting
- >90% of lighting utilizes LED
- >60% in energy savings
- All Light controllable
  - Scenes
  - Dimming

Vacancy Detection
- Automatically switches off lighting when area is not in use

Receptacle Load Control
- Energy consumption meters for each zone
- KNX control over power supply to each zone

Temp. & Air Quality Control
- Regulation via VAV boxes based on sensor feedback
- Further reducing cooling load

Weather Responsiveness
- Energy savings suggestions communicated to occupants based on weather station data

Smart Ceiling Fan
- High Efficiency
- IoT Enabled

Photo by Rory Gardiner
1225 PV Panels, Peak Power : 425 kWp
SDE4 | FIELD MEASUREMENT

Image: Surbana Jurong
Thermal Sensation
85% Cold to Neutral

Thermal Comfort
80% of Comfortable

Thermal Acceptability
88% of Acceptable

Room Condition 26.3-27.3°C, 57-64% RH

Credit: Kuniaki Mihara, NUS, PhD Student
SDE4 | IMPROVED INDOOR AIR QUALITY

100% fresh air with demand control ventilation
SDE4 | METERING

On-site energy sourcing with rooftop photovoltaic panels

Net Meter

Energy Production
Energy Consumption

NUS Power Grid

BTU Meter

NUS Chiller Plant

Chiller Water Supply

Site boundary

Building footprint

West Facade

East Facade
PV Production vs Energy Consumption

Monthy kWh

PV Generation

Building Total Consumption

Series2
Thank You

Q&A