Delivering Low Carbon Buildings

Vincent Cheng, PhD, LEED®AP

Arup Building Sustainability

Green Buildings: Better Quality of Life
June 11, 2010

ARUP

Agenda

- Quality Living and Low Carbon Living
- Design Strategies
- Exemplary projects

1

Quality and Low Carbon Living

ARUP

Built Environment Transformation

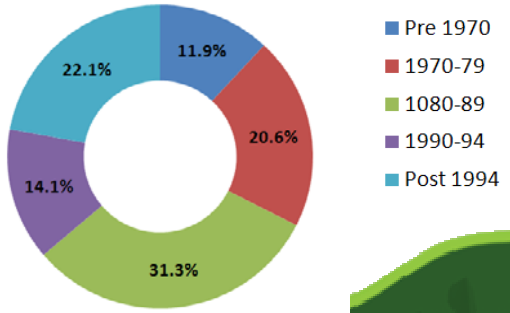
1950s

- Low-rise village
- Low CO_2 emission
- Low quality of living (?)

2010

- High-rise; high-density
- Higher CO2 emission with provisions to sustain human comfort and health & transportation
- Higher quality of living (?)

Composition of our Current Building Stock



ARUP

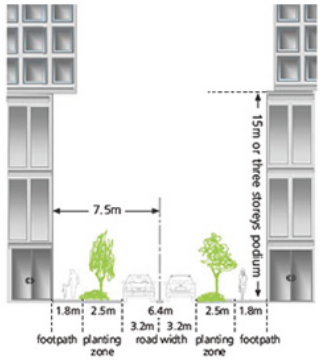
A closer look

… on ventilation, daylight, noise, air quality, heat island..

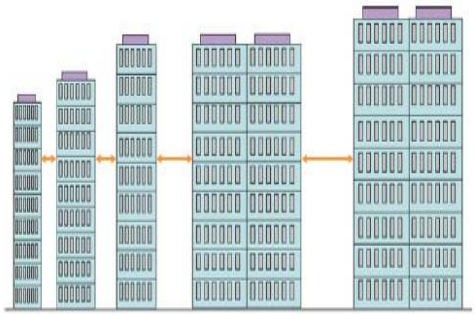
ARUP

Possible Solutions for Quality Living / Environment

Building Setback



Building Separation



Greenery

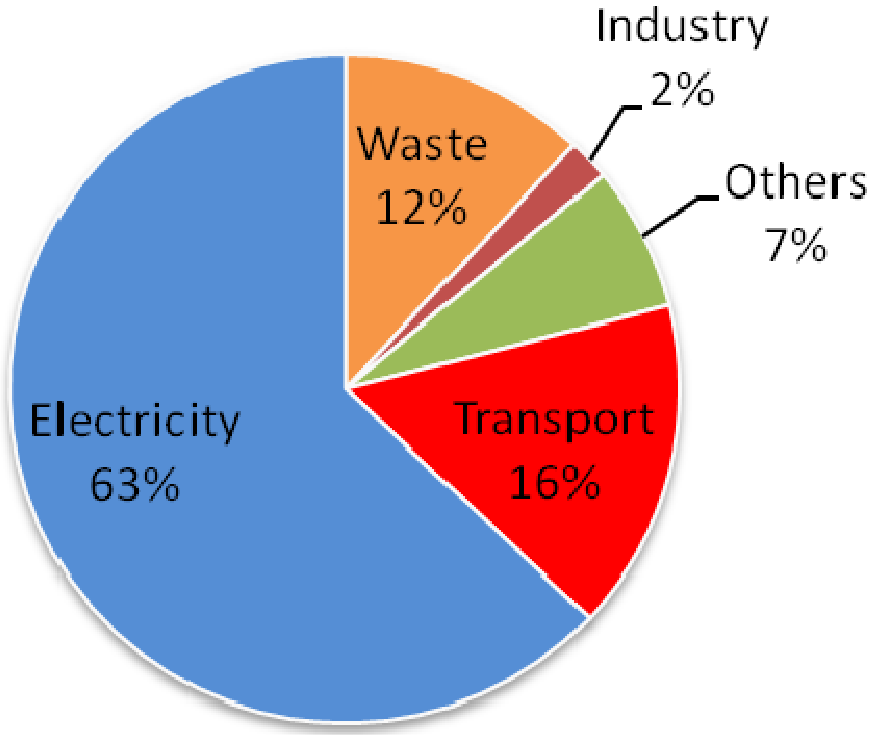
Council for Sustainable Development
Building Design to Foster a Quality and Sustainable Built Environment

ARUP

Costs of Our Living

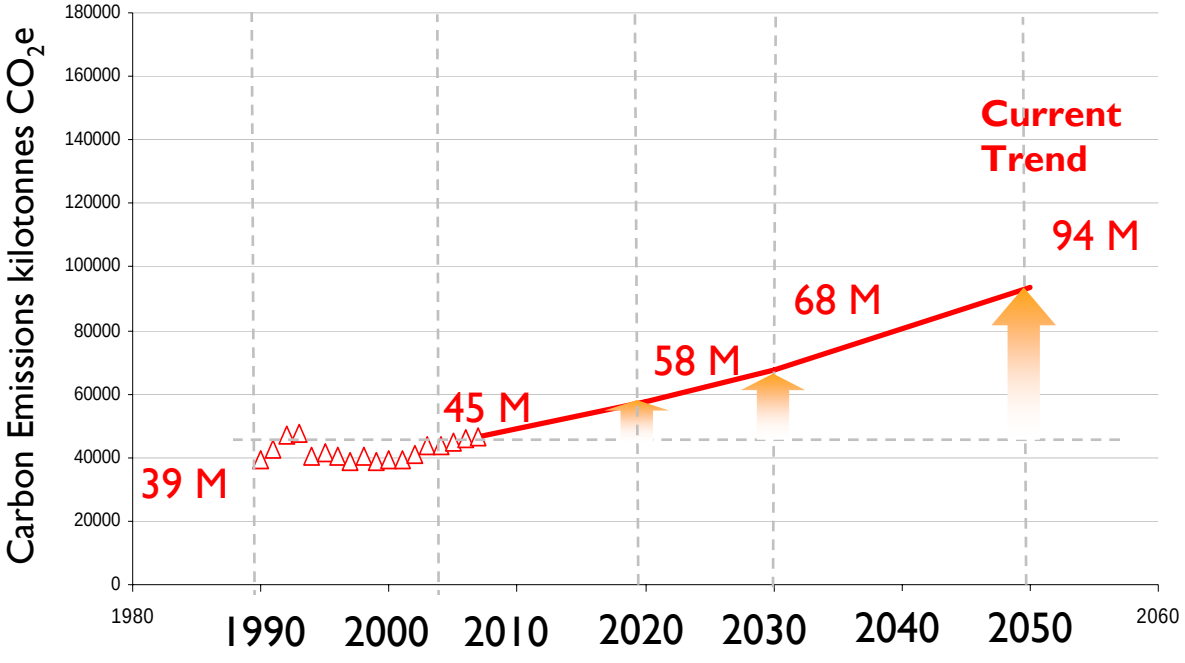
Environmental Loadings to Sustain us:-

- CO_2 emission
  - Currently, the emission rate is approximately at 6.5 tCO_2/capita
  - For a long term target, the emission rate should be lowered to 2.2 tCO_2/capita
- Fuel consumption in HK
  - Gas/LPG 43,363 TJ (15%)
  - Oil & Coal 103,672 TJ (35%)
  - Electricity 147,072 TJ (50%)
- Waste generation
  - Total disposal of solid waste at landfill in 2008 is 13,500 T/d

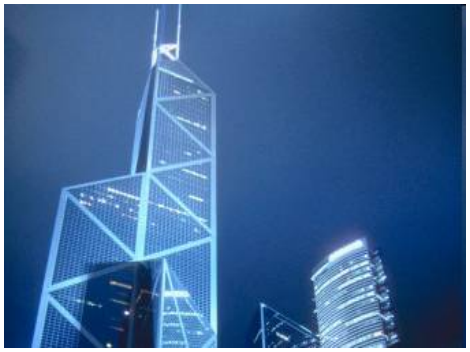


Greenhouse gas emission

Trend of Carbon Emission



EPD (2009) - HONG KONG GREENHOUSE GAS INVENTORY FOR THE PERIOD 1990 – 2007

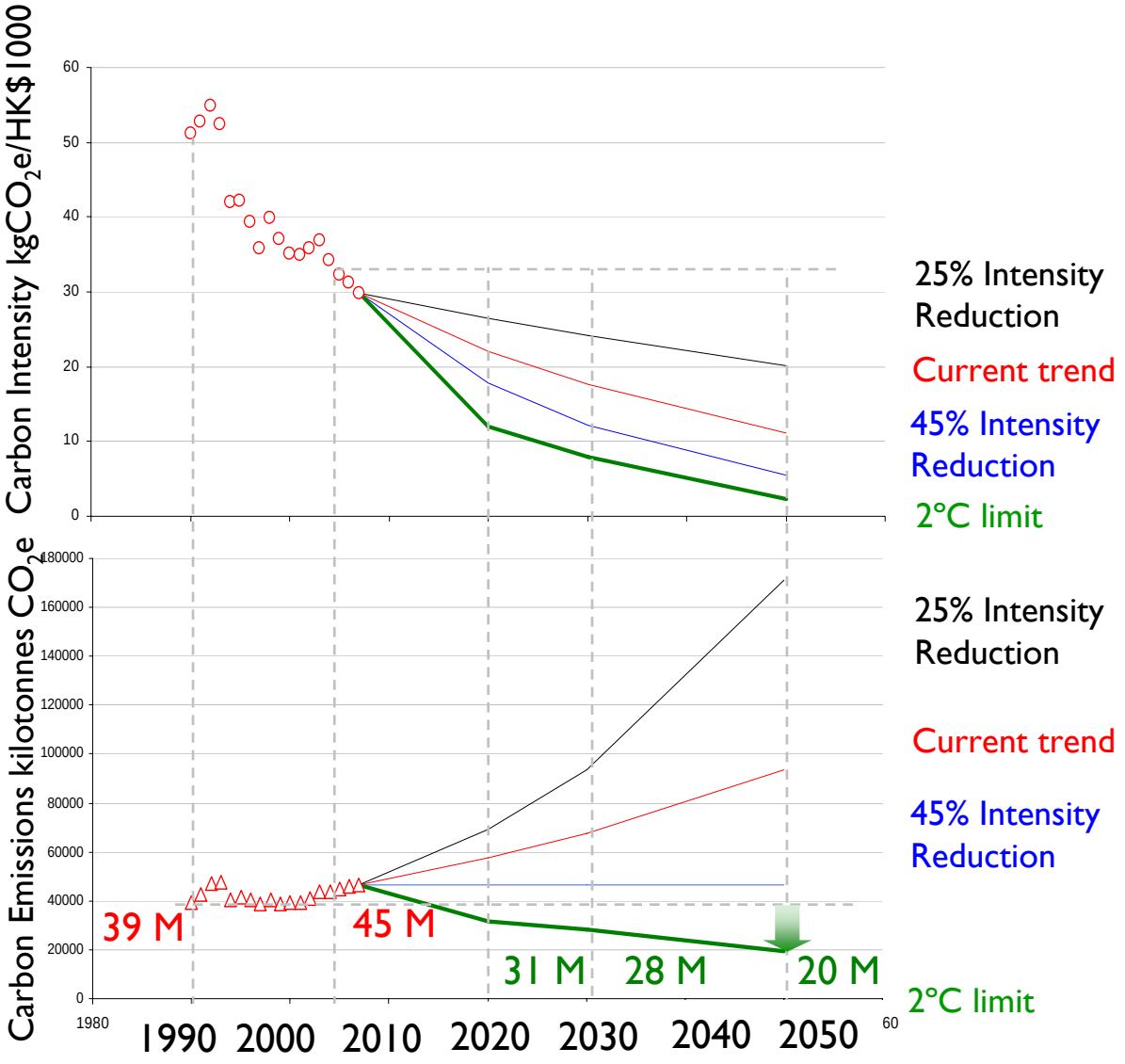


1.6% increase in CO_2 emissions per annum

- Assume no significant changes to fuel mix
- Assume no significant changes to carbon emission behavior
- Extrapolate trend from 10 year average

ARUP

The Ultimate Target - 2°C Limit



Reduce absolute carbon emissions by

- **20% from 1990 levels by 2020**
- **50% from 1990 levels by 2050**

- The IPCC reckons the 2°C limit is the maximum allowable temperature rise before the climate system becomes dangerously unstable.
- The use of absolute emission reduction is typical of most developed countries.

ARUP

2

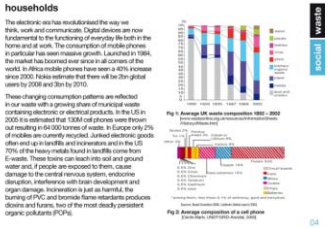
Design Strategies

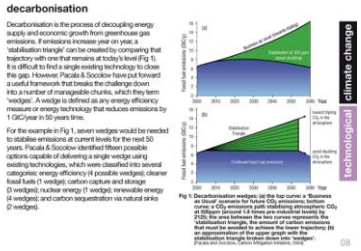
ARUP

Drivers of Change

- Energy
- Water
- Waste
- Climate Change
- Urbanisation
- Demographics

…..these issues will all have a profound impact on how buildings and urban environments are designed in the future

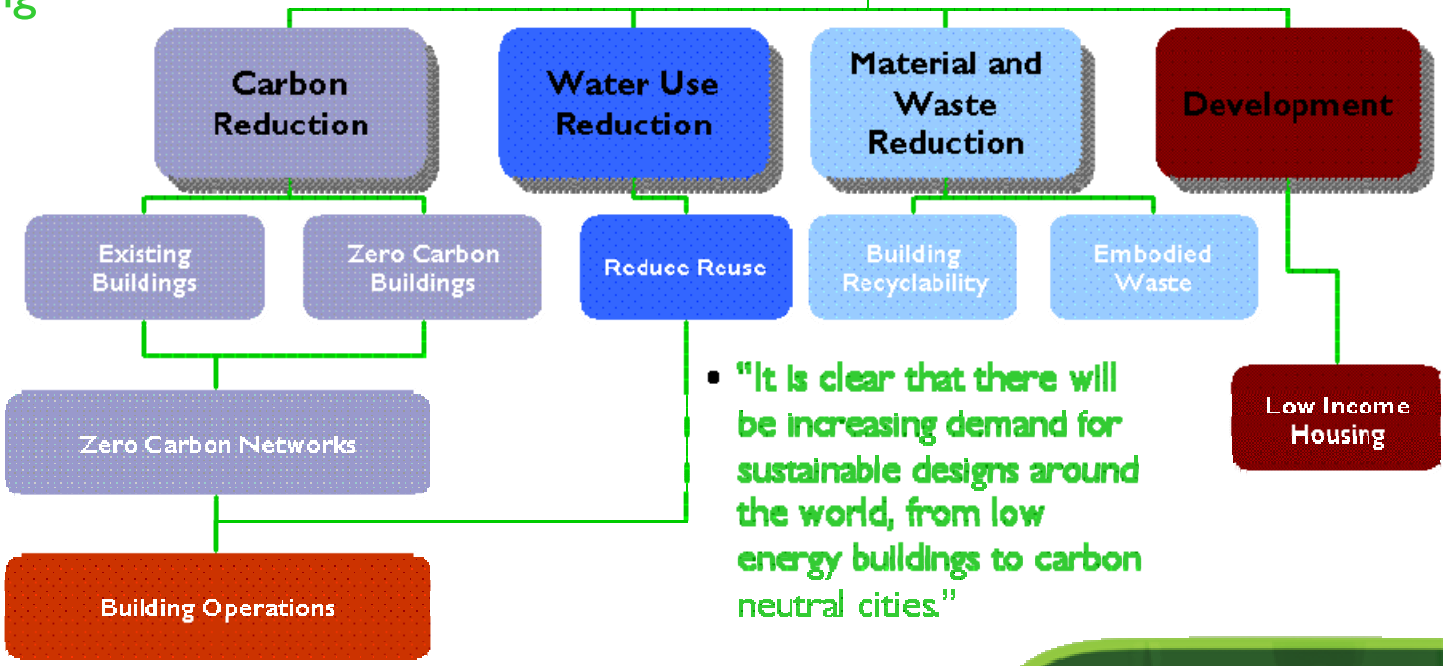




ARUP

The Future of Buildings

- Climate change resilient
- Efficient use of energy and resources
- Healthier and more comfortable living



- "It is clear that there will be increasing demand for sustainable designs around the world, from low energy buildings to carbon neutral cities."

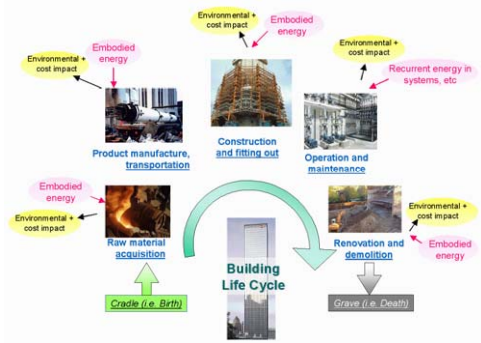
ARUP

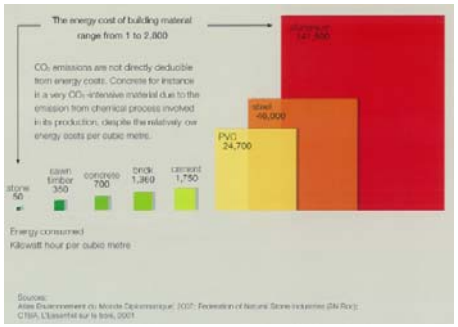
Design Approaches and methodologies

Life Cycle Assessment for Materials Selection

Energy footprint

Carbon footprint

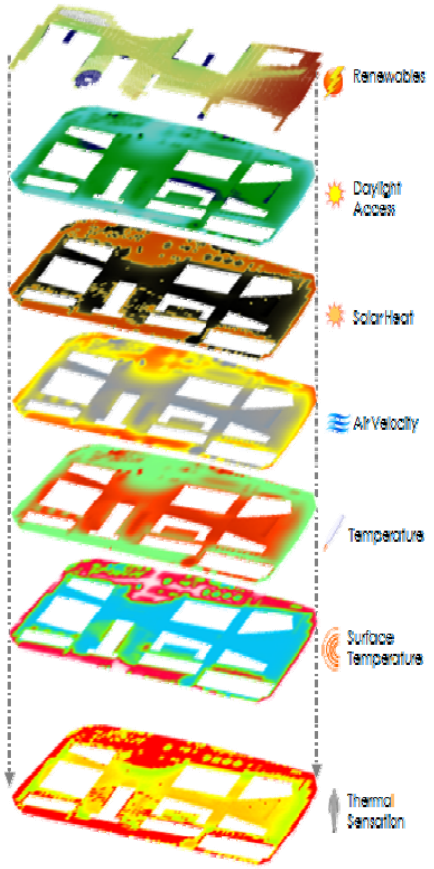




+

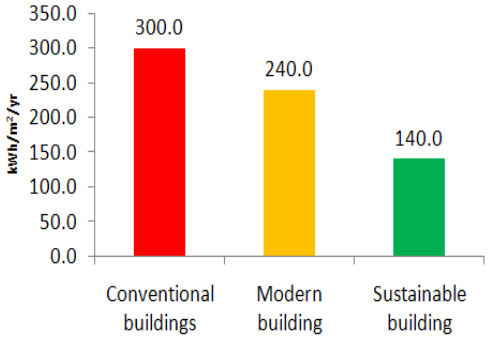
Urban / Microclimate

Urban environment performance

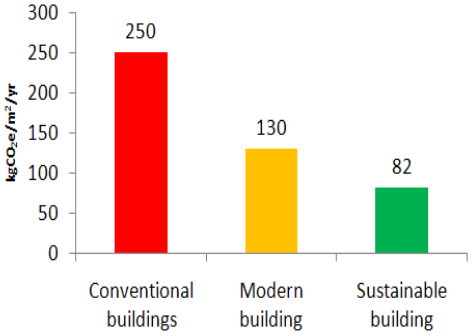


+

Low Carbon / Energy Design



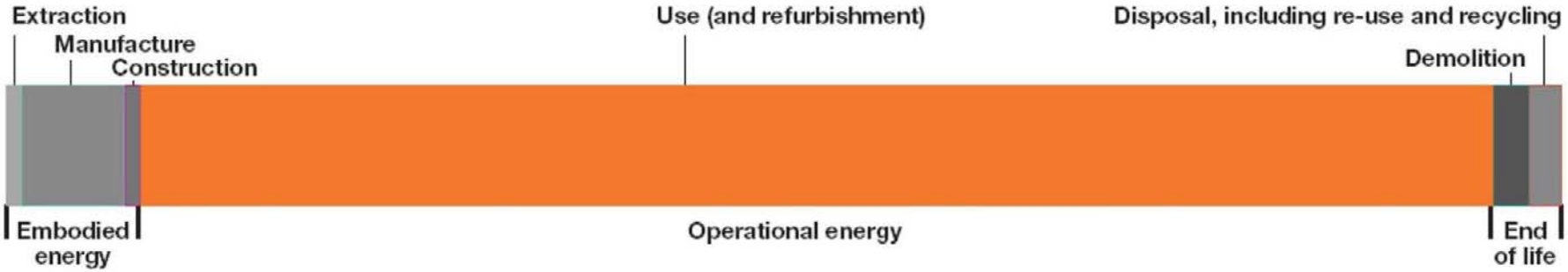
Carbon Reduction strategies



ARUP

Life Cycle Assessment

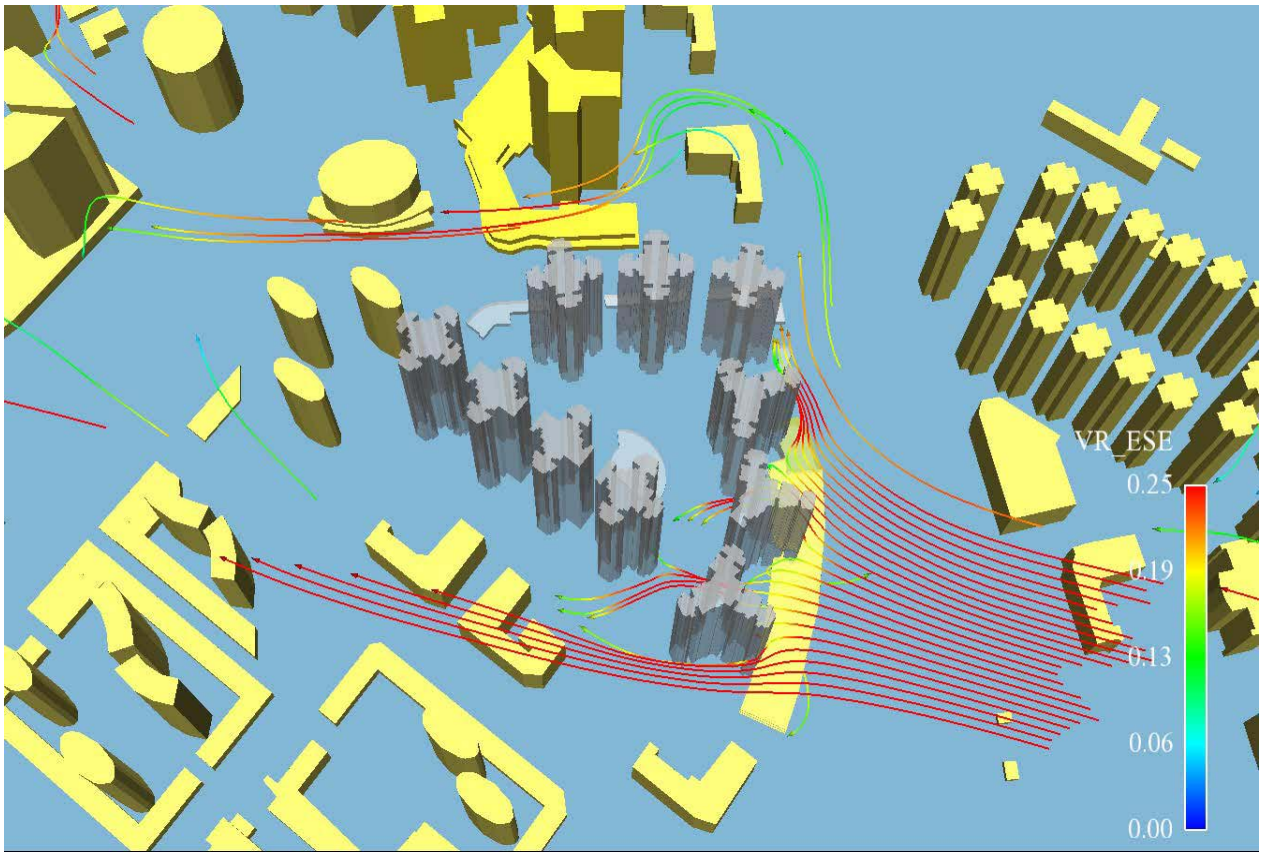
- Operational Energy and Emissions
- Embodied Energy and Emissions
- Demolition Energy and Emissions



ARUP

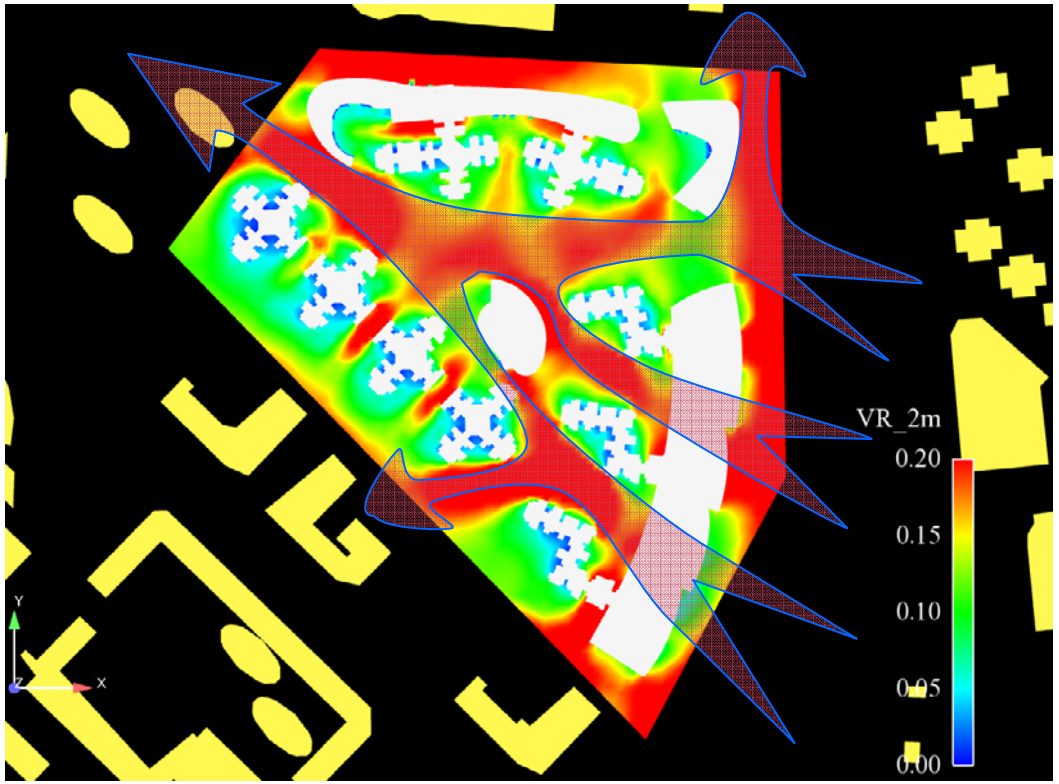
Urban / Microclimatic Study

- Air ventilation
- Daylight
- Thermal comfort
- UHI



Optimized Air Ventilation Design

- Wind corridors
- Building orientation and disposition



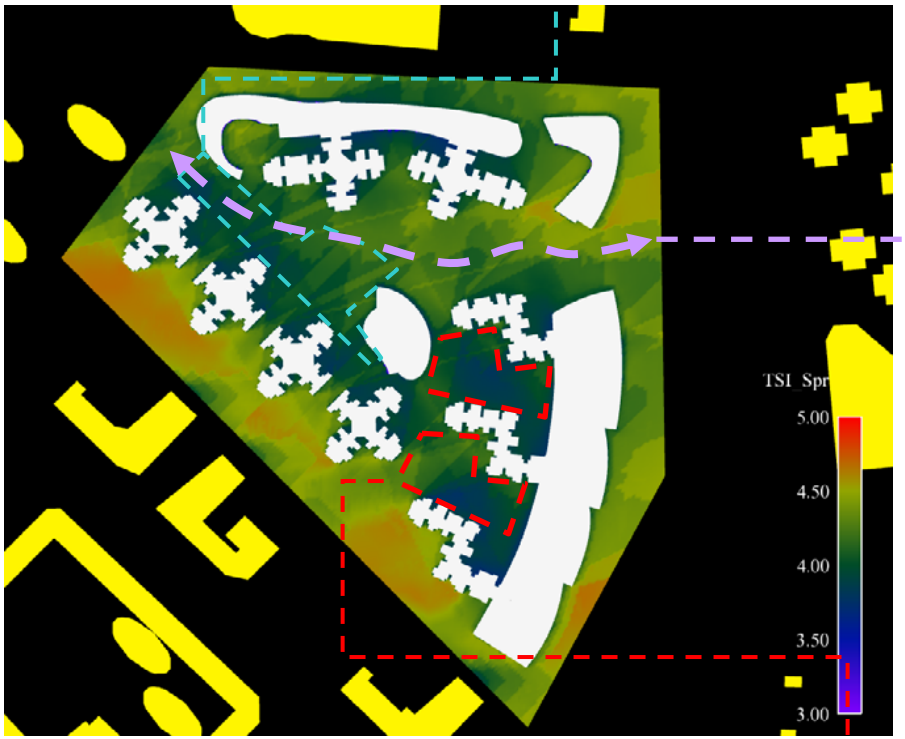
ARUP

Thermal Comfort

- Air temperate and airflow
- Solar radiation and surface temp.
- Humidity

Thermal comfort of pedestrian paths benefits from shade and wind corridor

The massing provides shade over the amphitheatre and exhibition pathway

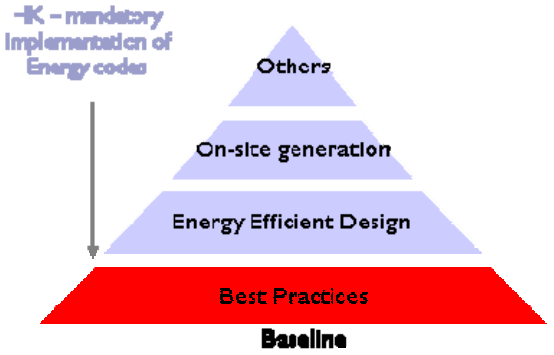


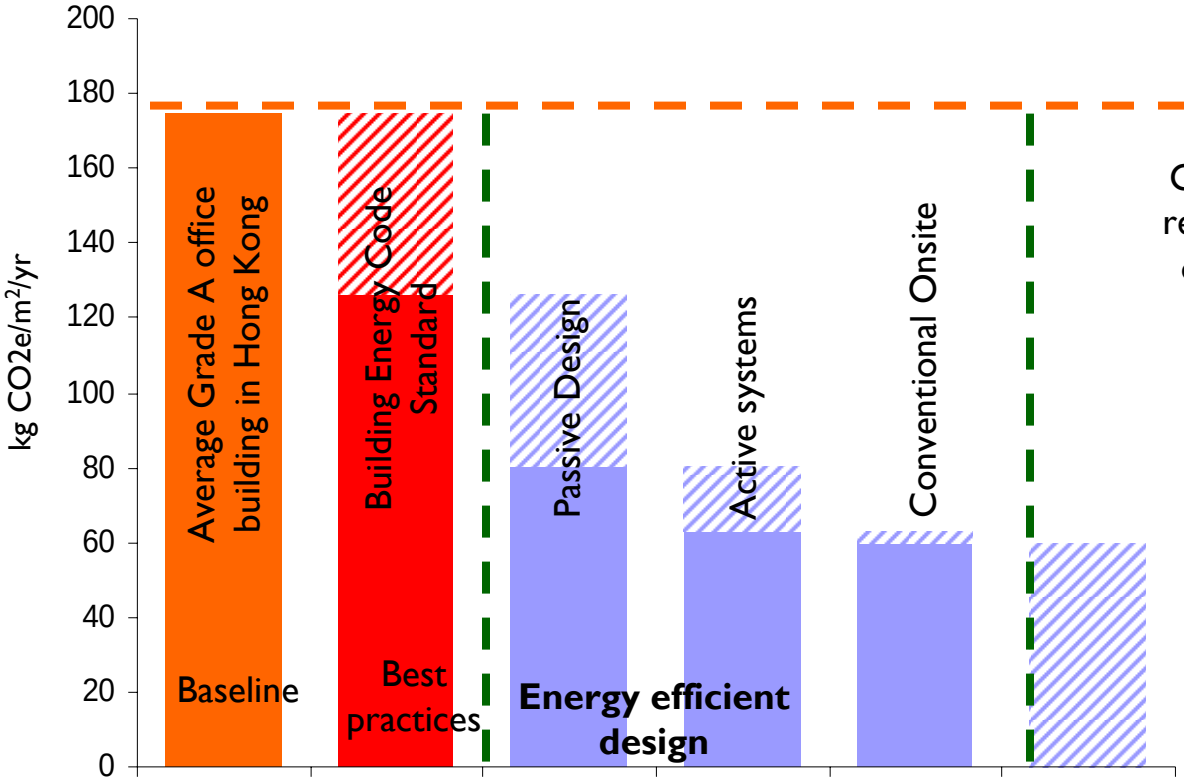
Tai-chi or other morning activities located along the building mass is comfortable during period of usage

ARUP

Low Carbon Design

- Target the largest contribution to life-cycle emissions
- Present a comprehensive and coherent low emission plan





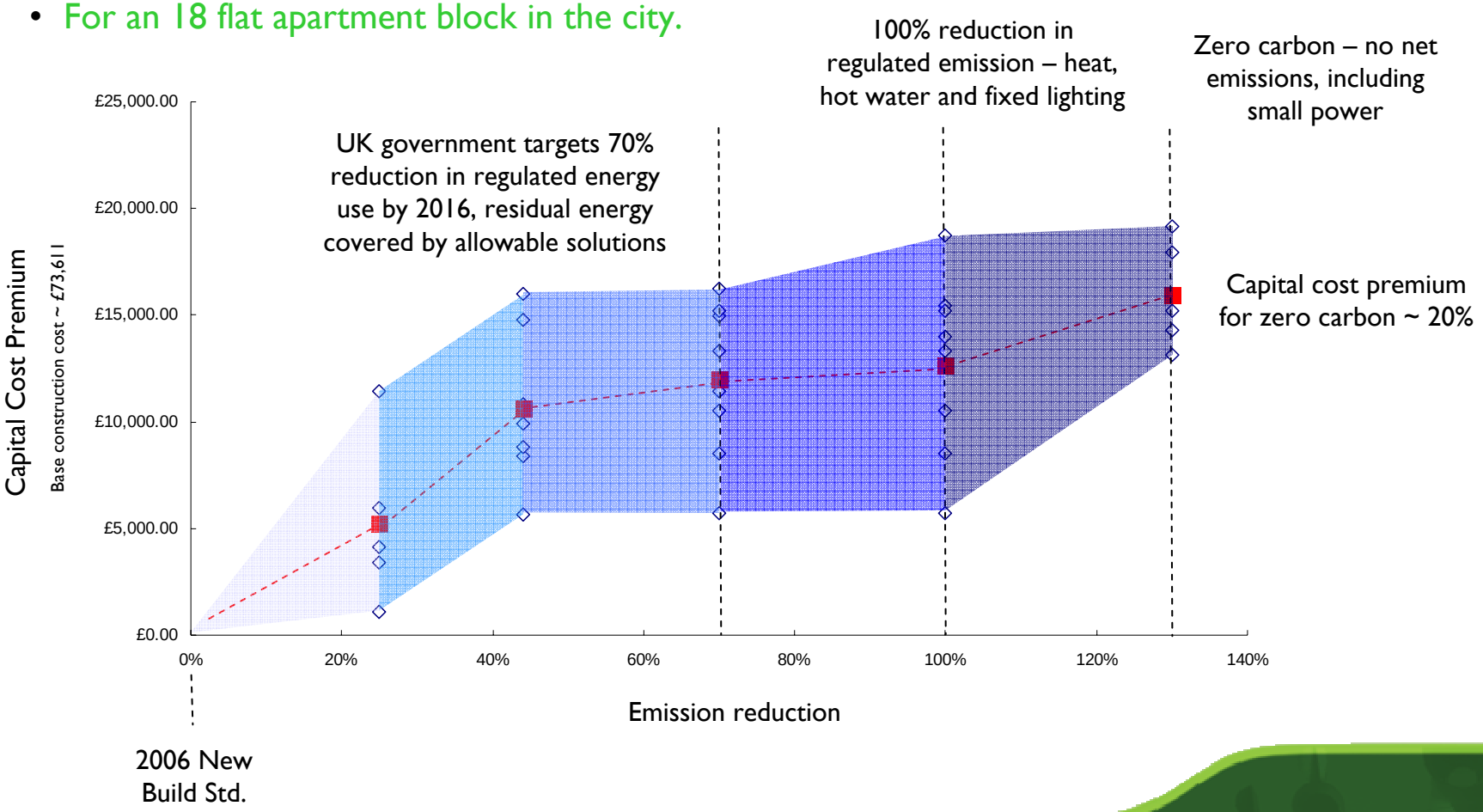
Off-set remaining energy through local renewables green tariffs, carbon credits or other emission reduction projects

Carbon Neutral?

ARUP

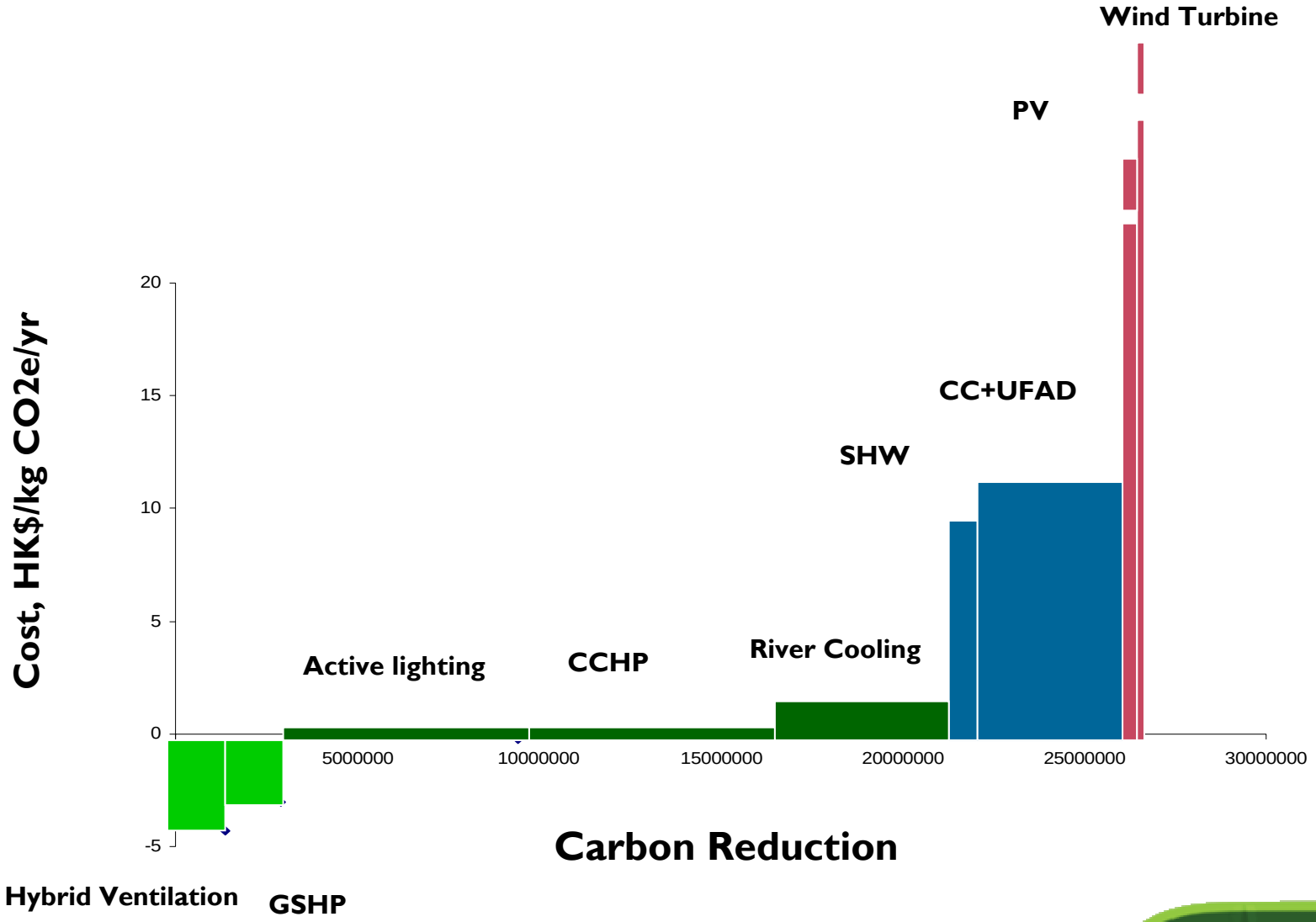
Cost of Low Carbon Design

- Data from – Definition of Zero Carbon Homes and Non-Domestic Buildings Consultation – Published by Communities and Local Government UK
- For an 18 flat apartment block in the city.



ARUP

Cost Abatement Curves



3

Case Study

ARUP

Project Case – 500 Hennessy Road

Rendering Picture from Hysan Development Company Limited

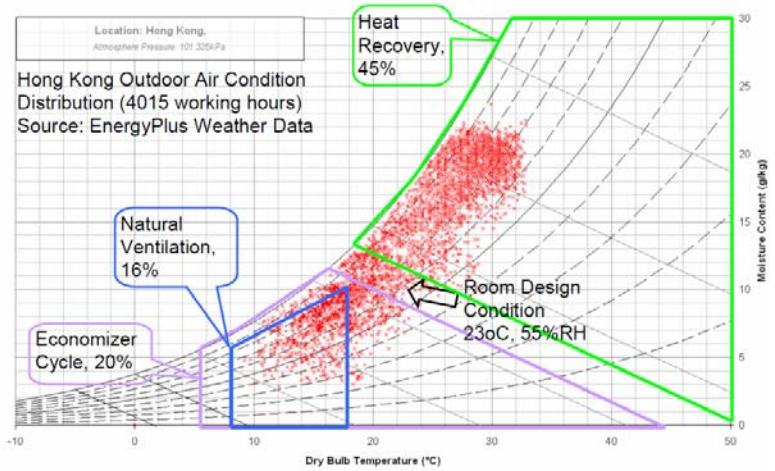
- Location: Causeway, Hong Kong
- GFA: >700,000 ft^2
- LEED-CS 2.0 Pre-Certification Platinum
- BEAM NB 4/04 Provisional Certification Platinum

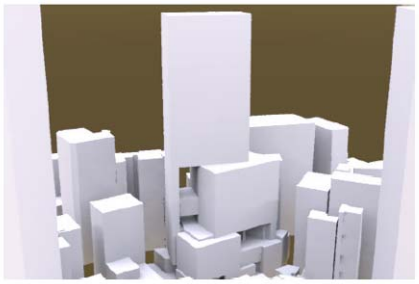
- Sustainable Features
  - Urban Window
  - Optimized Building Orientation
  - High Performance Envelop
  - Light Shelf
  - Operable Vents
  - Heat Recovery
  - Free Cooling
  - Demand Control Ventilation
  - Regenerative Elevator Drive
  - Green Roof
  - Rainwater Harvesting
  - Low Flow Sanitary Fixture
  - Sustainable Construction
  - Recycling and Sorting Facilities
  - Environmental Friendly Materials

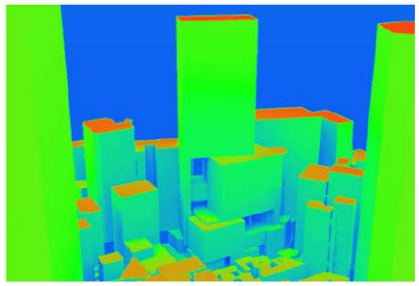
Project Case – 500 Hennessy Road

Optimized Cooling/Ventilation Approach = Free Cooling + Heat Recovery + Natural Ventilation

Air Side Economizer to allow fresh air to direct-cool the office floors in winter/transition weather condition.
Total enthalpy wheel to pre-cool the fresh air in hot summer.

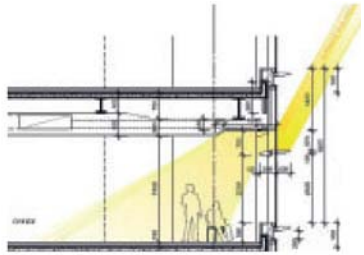


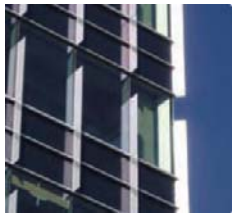


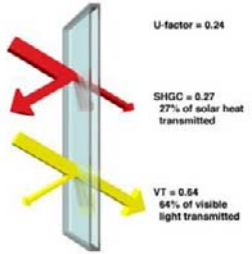


Enhanced Building Envelope = High-Performance Glass + Shadings + Light Shelf

Low-e Glass with low SC and low U-value to reduce the cooling load.
External Shadings to protect the building from excess solar heat. Internal Shadings to maximise the indoor comfort.
Light Shelf to introduce the daylight deep into the inner zones.

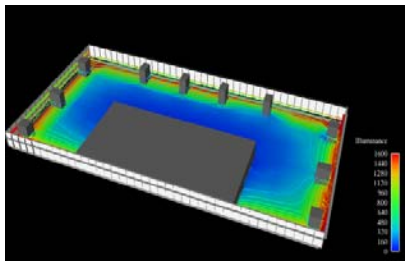


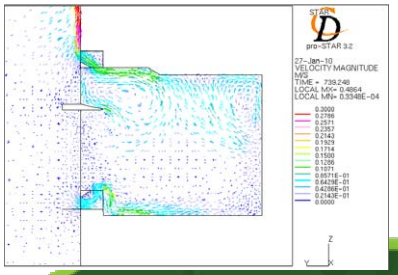




Better Indoor Environmental Quality = Thermal Comfort + More Fresh Air + Daylight & View + Natural Ventilation

Operable vents allow natural ventilation at perimeter zone in working off hours.



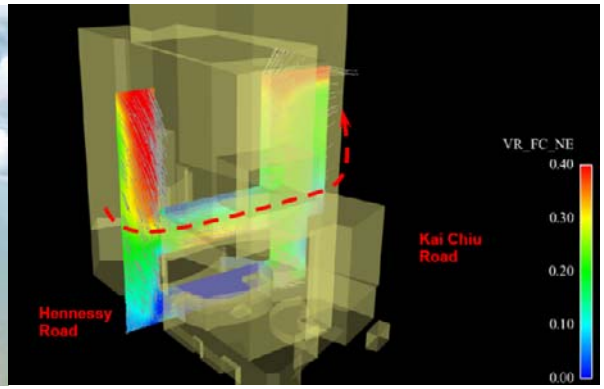


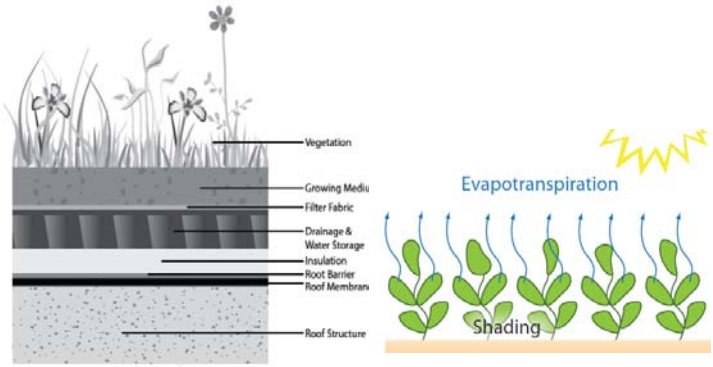
ARUP

Project Case – 500 Hennessy Road

Urban Windows

"Urban Windows" to enhance natural air ventilation and improve the microclimate in the neighborhood





Green Garden/Roof

Green Garden / Roof to provide leisure and open spaces for users and public. Benefits in ecology, energy conservation and stormwater management.

Water Conservation

Low-flow Sanitary Fixtures to minimize the water use.
Rainwater Harvesting System to recycle the available water resource on-site.

Water Efficiency Labelling Scheme
WELS

Environmental Friendly Material

Regional and Recycled Content Materials
Low Emitting Indoor materials
FSC Wood to protect forest / wood resources

RECYCLED CONTENT

500mi
800km
LOCAL MATERIALS

LOW-VOC
LOW VOC PAINT

FSC
100%
From well-managed forests
Cert no. XXX-XXX-XXXX
www.fsc.org
© 1996 Forest Stewardship Council

ARUP

Renovation of China Resources Building

- Challenge - Bring a 25 year-old development into the 21st Century
- Total site area: 6,600sqm, Total GFA: 90,000sqm
- First Renovation Project in Hong Kong to obtain LEED Certification

ARUP

Project Highlights

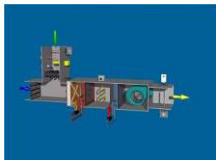
1. **Reuse Structural Frame**
- Reuse the existing structural frame so as to reduce construction waste and the demand of resources

2. **High Performance Facade**
- Low-e Laminated Glass
- Good Air Tightness

3. **High Quality Interior Spaces**
- Increase Ventilation Rate
- Use Low-VOC materials for renovated spaces

4. **Upgrade of Electrical and Mechanical Equipment**
- Upgrade Air Handling Unit (AHU) for the whole buildings
- Install CO2 Demand Control Ventilation System
- Install innovative and high efficient lighting equipment

CO2 Demand Control Ventilation



Upgrade AHU

High Efficiency Lighting

Occupancy Sensor

Daylight Sensor

High Performance Facade

ARUP

Energy Use and GHG Emission Reduction

CO2 Emissions
Reduction: 7.5%

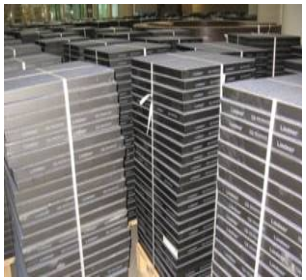
Reduction of 1,370 tons CO2 per year =
Annual absorption of CO2 by approx. 200,000 Pine Trees

Water
Reduction: 30%

Saving 11,180m³ of water per year =
Filling of 4.5 Olympic pools

Power
Reduction:
More than 10%

Energy consumption savings of 1.65 GWh per year =
24-hr operation of 5,200 fluorescent tube for a year



Resources
Reduction: 75%

Already recycled 150 tons of waste (or 93% of the total) generated during construction (as of June 2010)

Target
LEED-CS
Gold Award

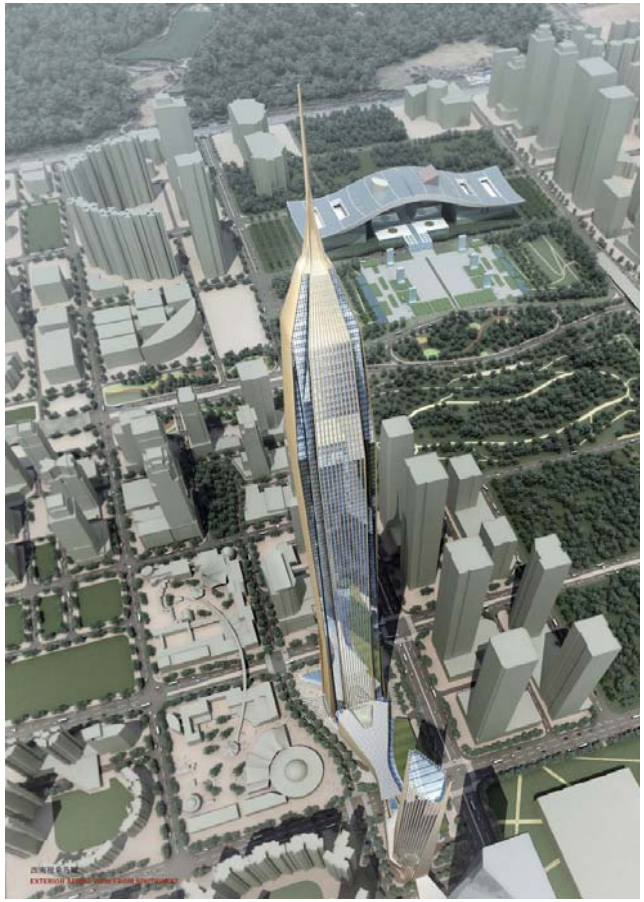
ARUP

Shenzhen PingAn IFC

LEED-CS

LEED for
Core & Shell*

- 580m tall International Financial Center in Shenzhen
- Pre-certified LEED – Gold
- ULTRA-LOW energy consumption – reduced by around 25%
- Water consumption reduced by 30%
- Reduce wastes, recyclable and renewable building materials (reduce over 50% construction wastes)

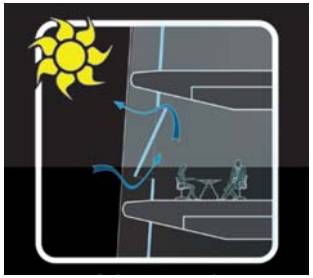


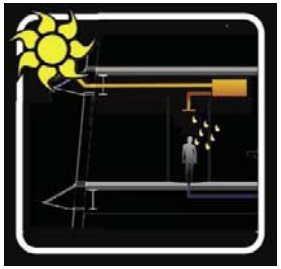
Arup provided Green Design and LEED Consultancy services

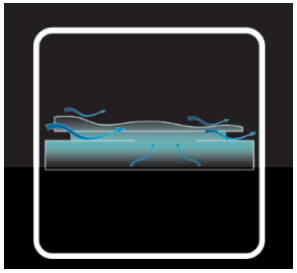
ARUP

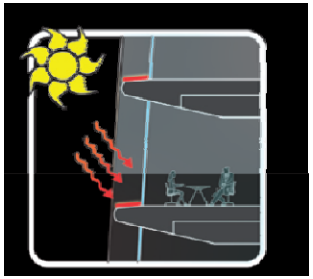
Green Features

- **Passive energy conservation strategies**
  - Smart facade
  - Daylight utilization
  - Solar shading
  - Thermal insulation and air tightness
- **Active Energy Efficient System**
  - Hybrid ventilation
  - Ice storage
  - High efficient lighting system
  - Demand Control Ventilation
  - Energy recovery
  - Lift technology
  - Rainwater collection system
  - Material Recycling
- **Renewable energy**
  - Solar tracking Photovoltaic Panel
  - Structural integrated Wind belt
  - Roof top Wind turbine

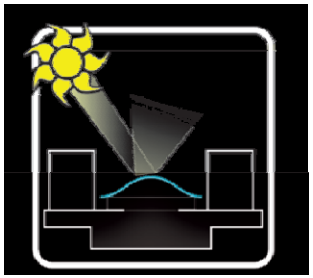

Natural Ventilation

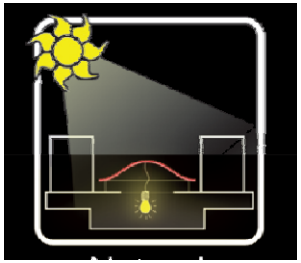

Solar/Thermal


Hybrid Ventilation


Smart Facade


Solar tracking PV


Sun Shading


Natural Daylighting

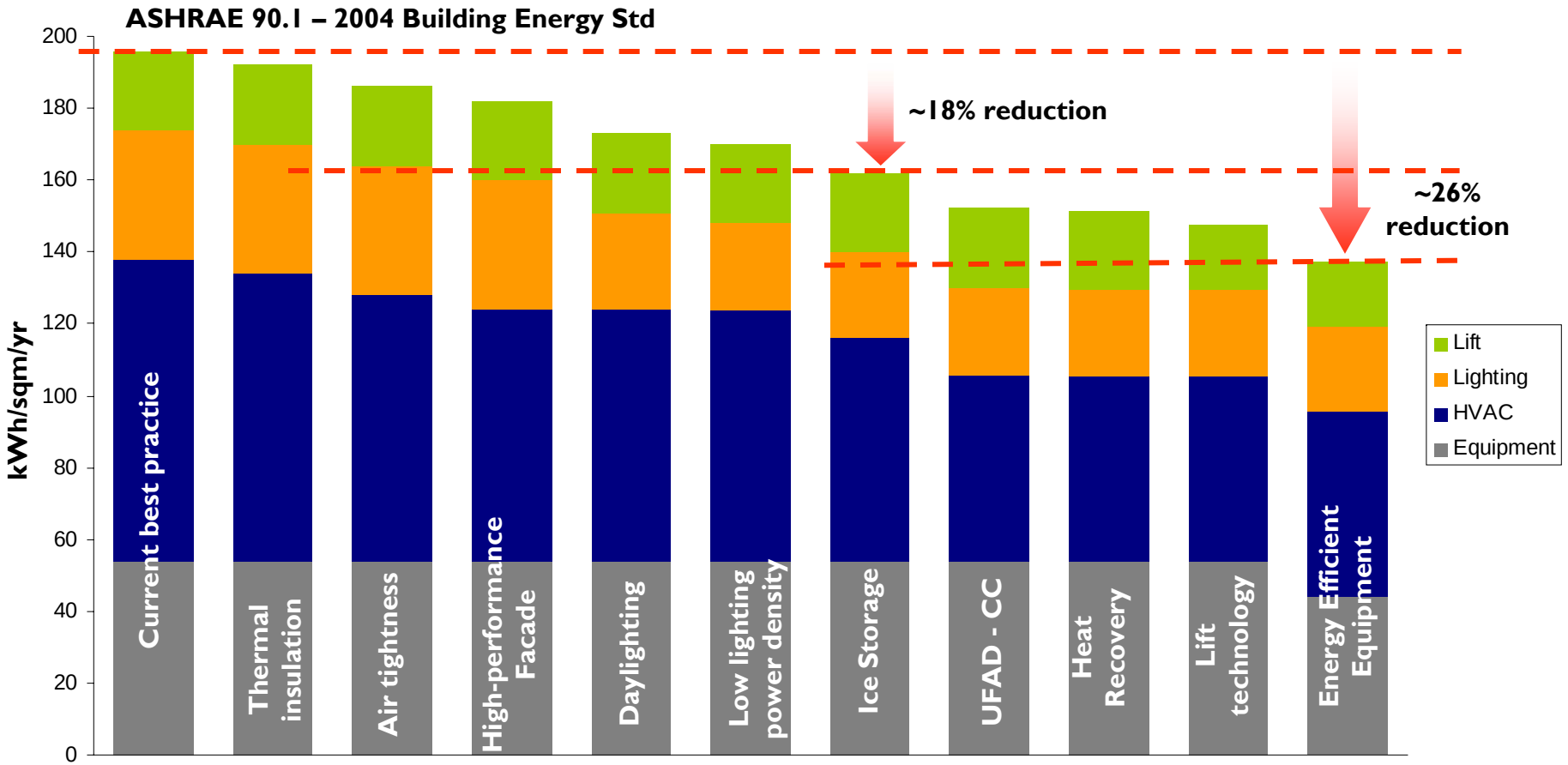

Rainwater Collection


Materials Recycling

ARUP

Overall Energy Plan

- Systematic reduction of energy consumption through efficiency measures



Samsung Zero Energy House

- Total site area: 2456 sqm, Total GFA: 721 sqm
- Carbon Neutral – On-site energy autonomy

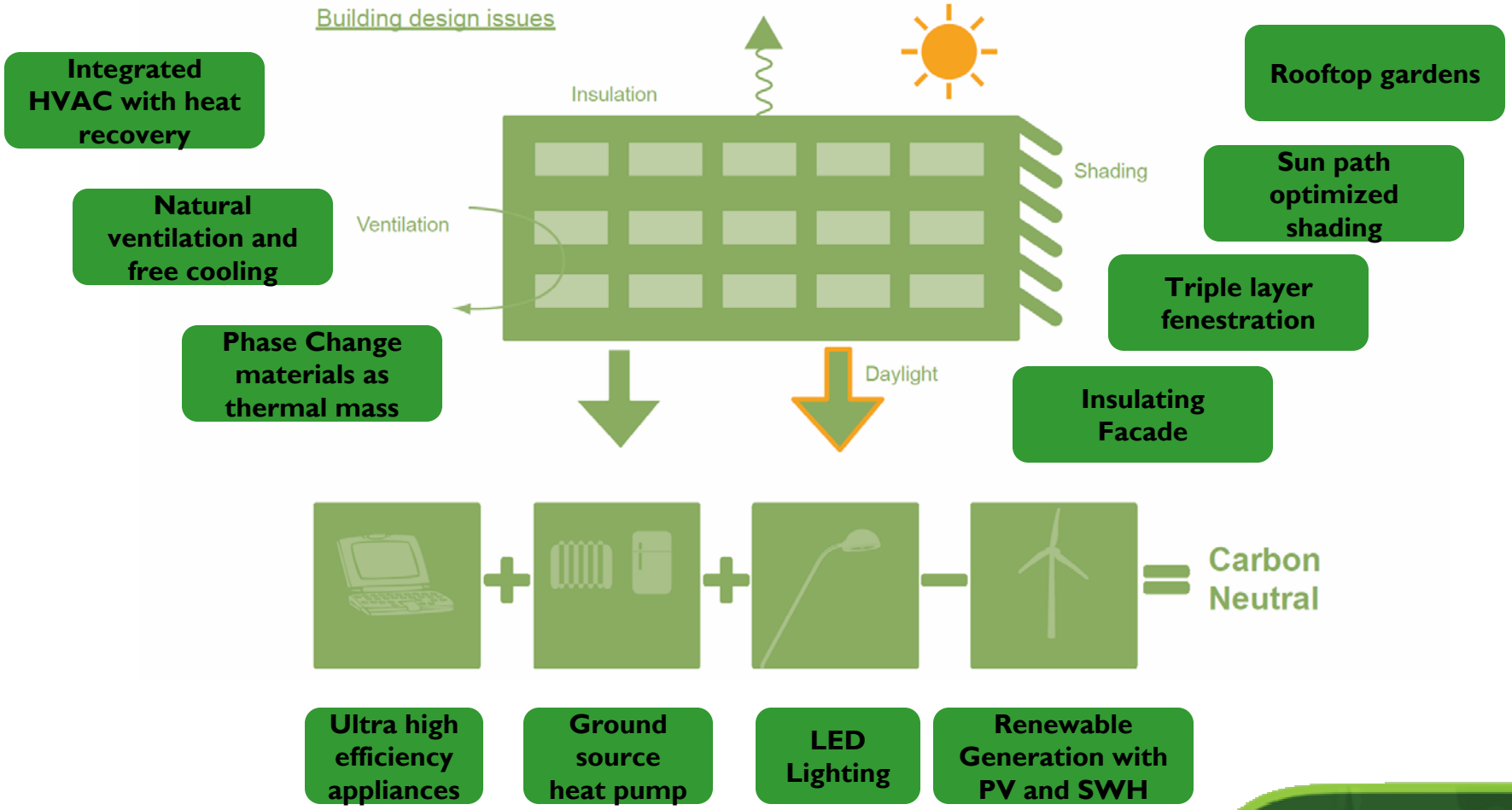
LEED-NC
LEED for
New Construction

Arup pr

ARUP

Samsung Zero Energy House – Zero Carbon Methodology

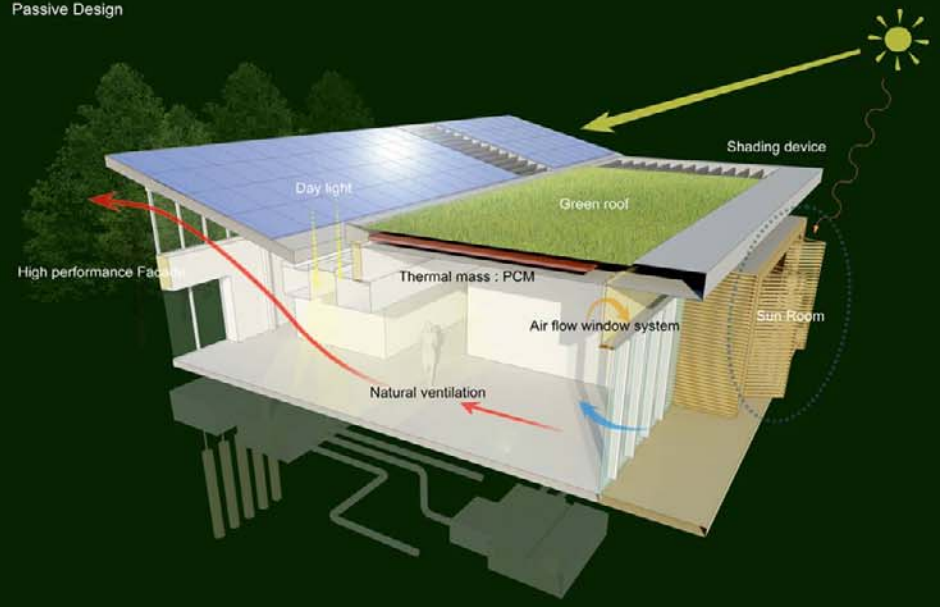
- How do we achieve on-site autonomy in energy?



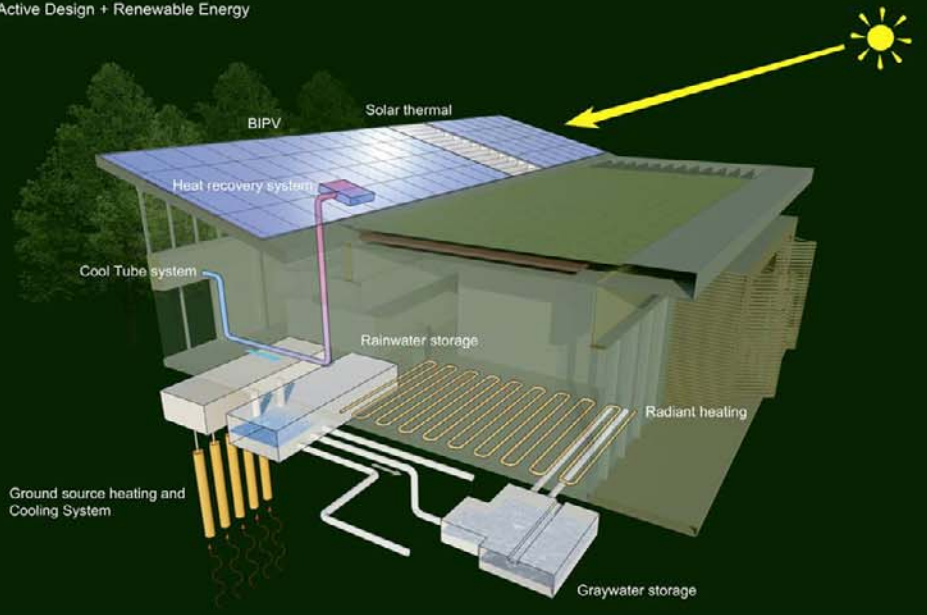
ARUP

ENERGY AND ENVIRONMENTAL

Passive Design



Active Design + Renewable Energy



Optimized Built form and orientation

The main fenestration area is facing south which adopts solar heat gain during winter in order to reduce the space heating load. Reducing the facade area at east and west eliminate the fabric gain which lower the cooling energy consumption during summer.

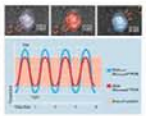
High performance facade

Good building envelope design can eliminate excessive solar penetration into the building and reduce conduction heat loss and heat loss due to infiltration.

- Use of thermal insulated material for envelope (<0.5W/m2K)
  - wall and roof with lower U-value
- Good air tightness (around 1m3/m2 envelope)
  - reduce heat loss due to infiltration
- Green Roof system to reduce the surface temp. of the roof

Phase Change Material (PCM)

The BASF PCM (Phase Change Material) plasterboard and dense cement fiber board would be used at the ceiling and the internal partition in the room. This material helps to absorb daytime heat and then give it up to cooler night time purge ventilation. Phase Change Material absorbs room heat by changing from solid to liquid within microscopic capsules embedded with board. This process is then reversed when the room is cooled with night air.



Roof Integrated Photovoltaics

Using this system, solar energy is converted to electric energy. This building installed solar cell modules are integrated as a roof finishing material.

Geothermal Heating and Cooling system

The annual mean temperature of ground source heat from 10m below the earth surface approx.15c. and Geothermal Heating and Cooling System uses this ground source theat for cooling and heating. Heat pump using geothermal energy us connected to air-conditioning units and air handling unit to saves the overall heating and cooling loads

Radiant Heating System

Enhanced Radiant Floor Heating uses water with the temperature of below 45c and connected to ground source heat pump. The coil pipes are densely installed which enhances the radiation efficiency and reduces heating energy consumption

Shading device

Optimum length of horizontal shading at south with shading angle around 30o help to reduce the direct solar radiation during overheating period and enhance the indoor heat gain during winter time.

12:00 1st July

Triple Layer Glazing + PVC window Frame

Utilization of triple layer glazing with plastic window frame adopts for extremely low thermal insulation for fenestration system (<0.85W/m2K)

Solar Hot Water System

The heat energy from the sunlight is absorbed and stored in bronze plates in the solar collectors, and the hea is used to make hot water.

Heat recovery system + Cool tube

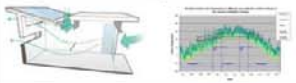
Enthalpy recovery ventilation uses a heat exchanger to raise or lower the outdoor air temperature close to room temperature in order to reduce the energy loss due to ventilation during cooling and heating in building. The rotary type enthalpy wheel has a 87% efficiency in heating mode and a CO2 sensor manages indoor air quality to minimize the ventilation load

DC LED Lighting

DC LED Lighting uses warm white colored LEDs with high luminous efficacy and housing with minimized light loss. DC powered SMPS (Switching Mode Power Supply) is applied to increase the efficiency by eliminating the power conversion loss from AC to DC

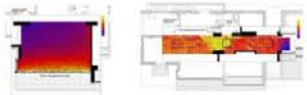
Natural ventilation

Natural ventilation is the process of supplying and removing air through an indoor space by natural means, meaning without the use of a fan or other mechanical system. The use of natural ventilation is definitely an advantage with the raising concerns regarding the cost and environmental impact of energy use. The thermal dynamic modeling – Virtual Environment 5.5 has been adopted for natural ventilation study.



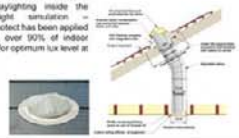
Daylight utilization

Provide sufficient windows enhance the utilization of daylighting inside the building. Daylight simulation – Radiance and Ecotect has been applied and shows that over 90% of indoor spaces adopted for optimum lux level at daytime period.



Light pipe

Provide sufficient windows enhance the utilization of daylighting inside the building. Daylight simulation – Radiance and Ecotect has been applied and shows that over 90% of indoor spaces adopted for optimum lux level at daytime period.



Wind Turbine Generation

This is an energy generating system using the natural wind. The vertical axis wind turbine which is most suitable for the urban area is applied to Green Tomorrow

Air Flow Window System

Air Flow Window System exhausts perimeter air to increase the thermal performance and reduce heating and cooling loads. The system consists of exhaust fan and automatic blinds controlled by temperature sensor.

Energy Saving Lighting Control System

Energy Saving Lighting Control System adjusts lighting according to the amount of incoming daylight. When the room is unoccupied, the lighting fixture turns off automatically by using occupant motion sensor

ARUP

Conclusions

- Low Carbon
  - Step-by-step to achieve high energy-efficient buildings
  - Site-wide coverage of renewable using advanced technology
- Quality living
  - Optimize site opportunities for healthier and more comfortable environment
  - Enhance livability with better outdoor environment

Thank You