Achieving Net Zero:
A Case Study of Hong Kong's First Zero Carbon Building

Justin Li
Assistant Director – Environmental & Sustainability

8 June 2017

# Greenhouse Gas Emissions and Building Energy Consumption

- Energy use in buildings worldwide accounts for over 40% of energy used and one third of global greenhouse gas emissions

- Buildings account for 90% of electricity consumption and over 60% of greenhouse gas emissions in Hong Kong

90% Buildings

70% Electricity

16% Transport

Waste and others

Source: Environment Bureau (2017)

CONSTRUCTION INDUSTRY COUNCIL 建造業議會
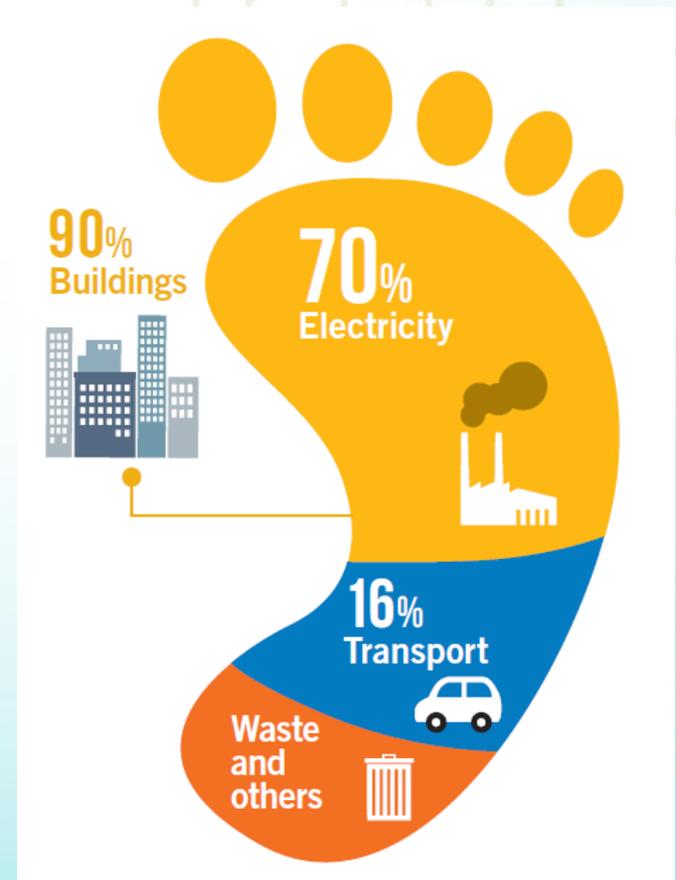
Carbon Reduction

- HKSAR Government aims to reduce carbon intensity by 65-70% by 2030 compared with 2005 level

- Reduction of absolute carbon emission by 26-35% to 3.3-3.8 tonnes per capita
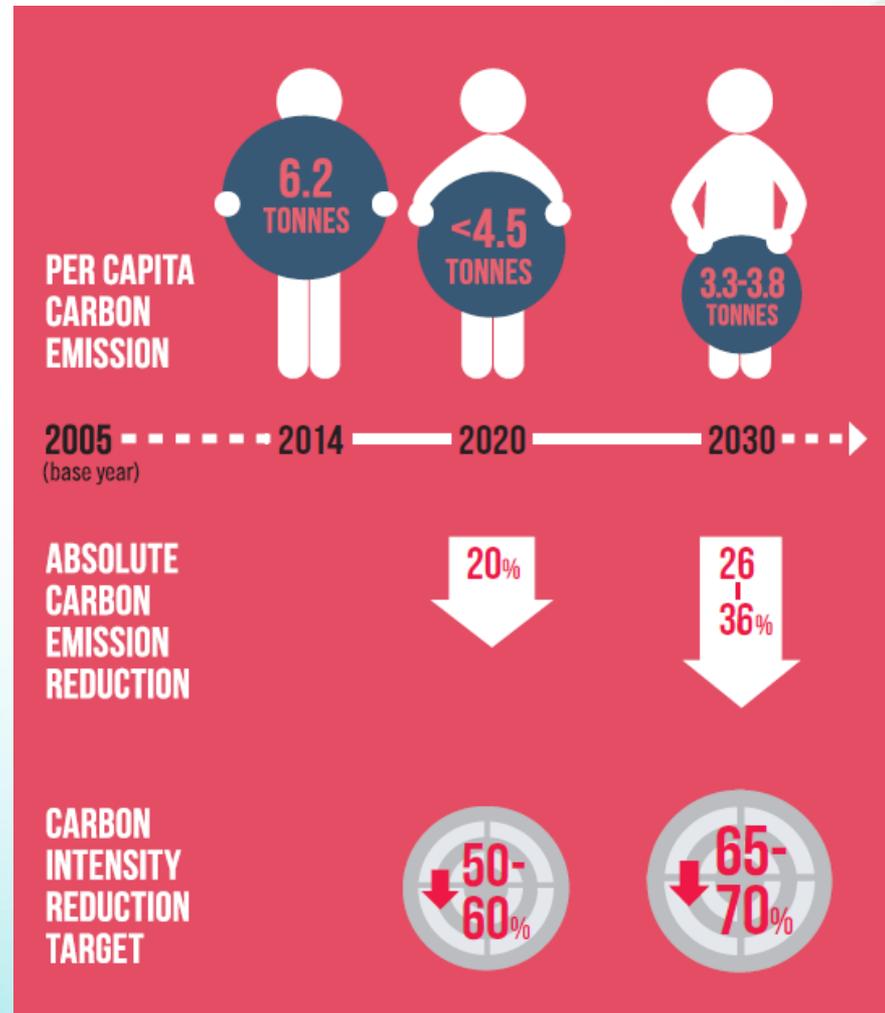
Source: Environment Bureau (2017)

ZCB
Hong Kong's First Zero Carbon Building

Location: Kowloon Bay

Three Storey Building:
- Eco-office
- Eco-home
- Multipurpose Hall
- Indoor Exhibition Areas
- Outdoor Exhibition Areas
- Eco-café & Shop
- Eco-plaza
- Urban Native Woodland

Vision:
- Exhibition Centre
- Education Centre
- Information Centre

Principles:
- Experimental
- Evolving
- Educating
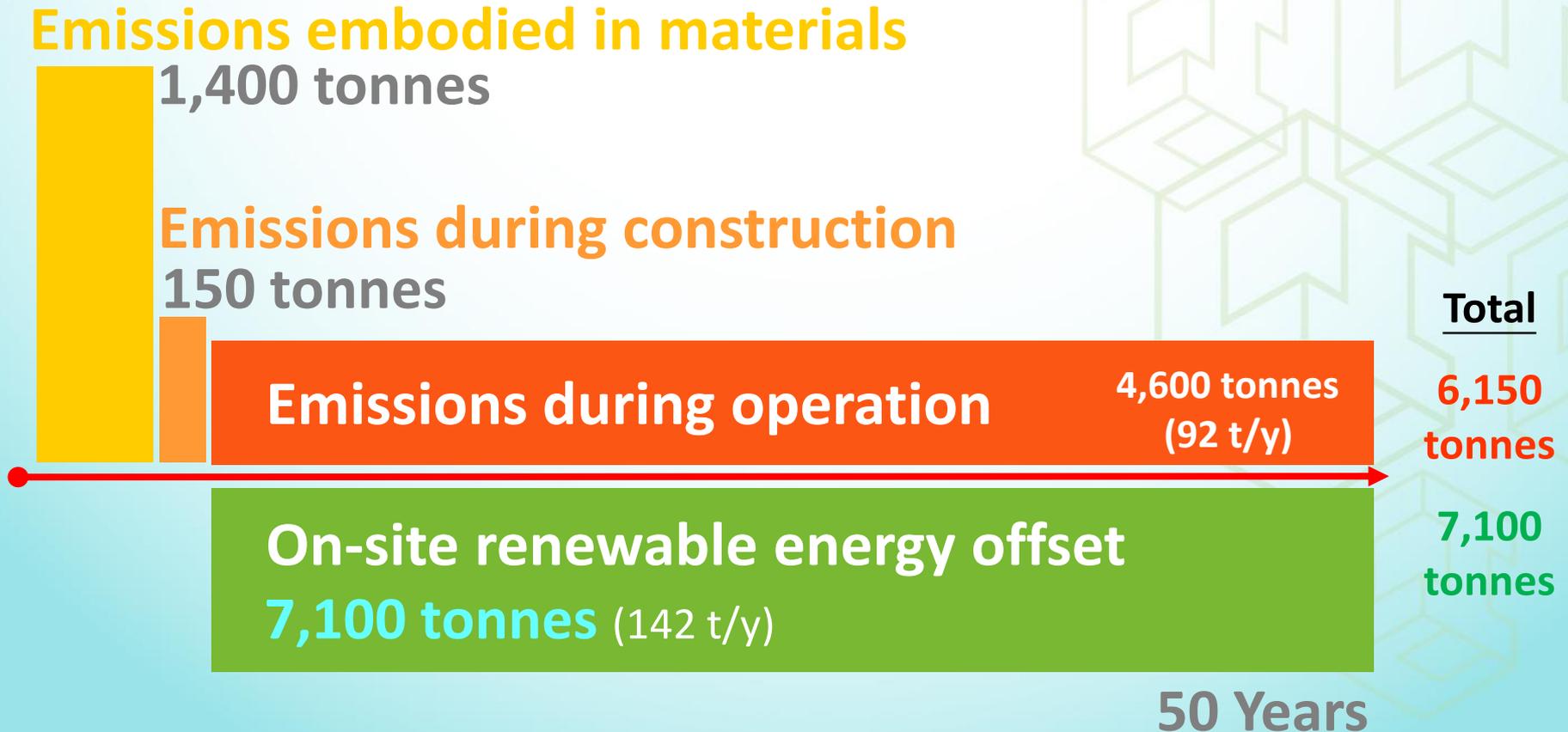- Evaluating

Site Area 14,700m²

Gross Floor Area 3,305m²
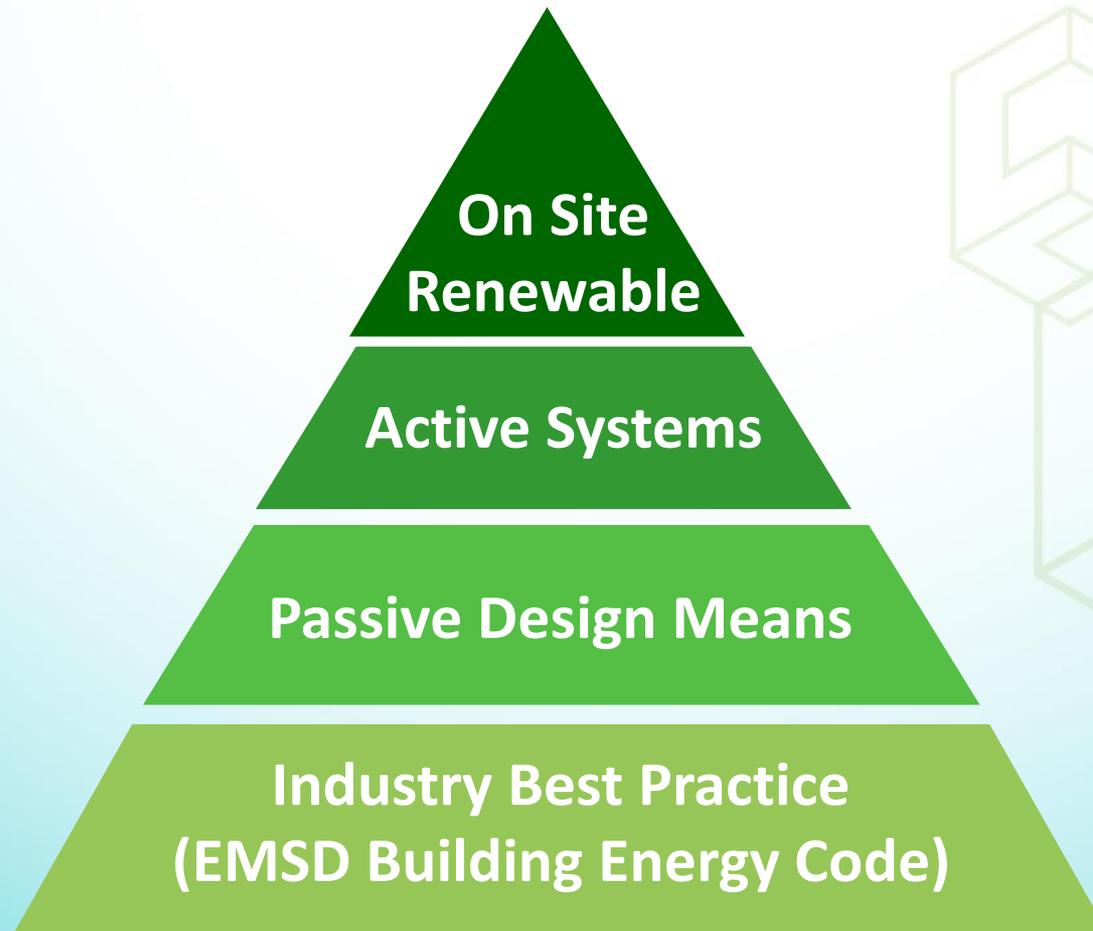
Key Innovations of ZCB

- 1st zero carbon building in Hong Kong

- 1st large scale use of biofuel made from waste cooking oil for electricity generation

- 1st building with grid feed-in in Hong Kong

- 1st urban native woodland

- One of the first buildings awarded BEAM Platinum (Final Rating)

ZCB's Carbon Strategy

Emissions embodied in materials
1,400 tonnes

Emissions during construction
150 tonnes

Total

Emissions during operation 4,600 tonnes (92 t/y) **6,150 tonnes**

On-site renewable energy offset
7,100 tonnes (142 t/y) **7,100 tonnes**

50 Years

Net energy output over operating energy consumption offset the embodied carbon of major structural materials & the construction process

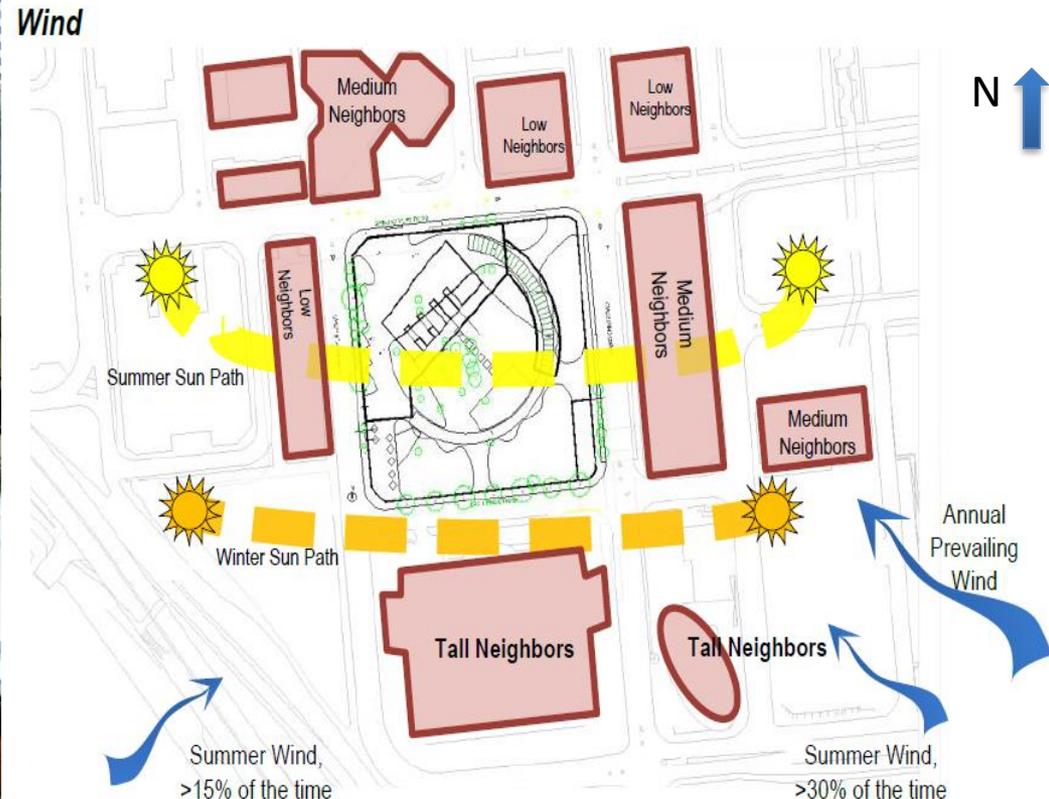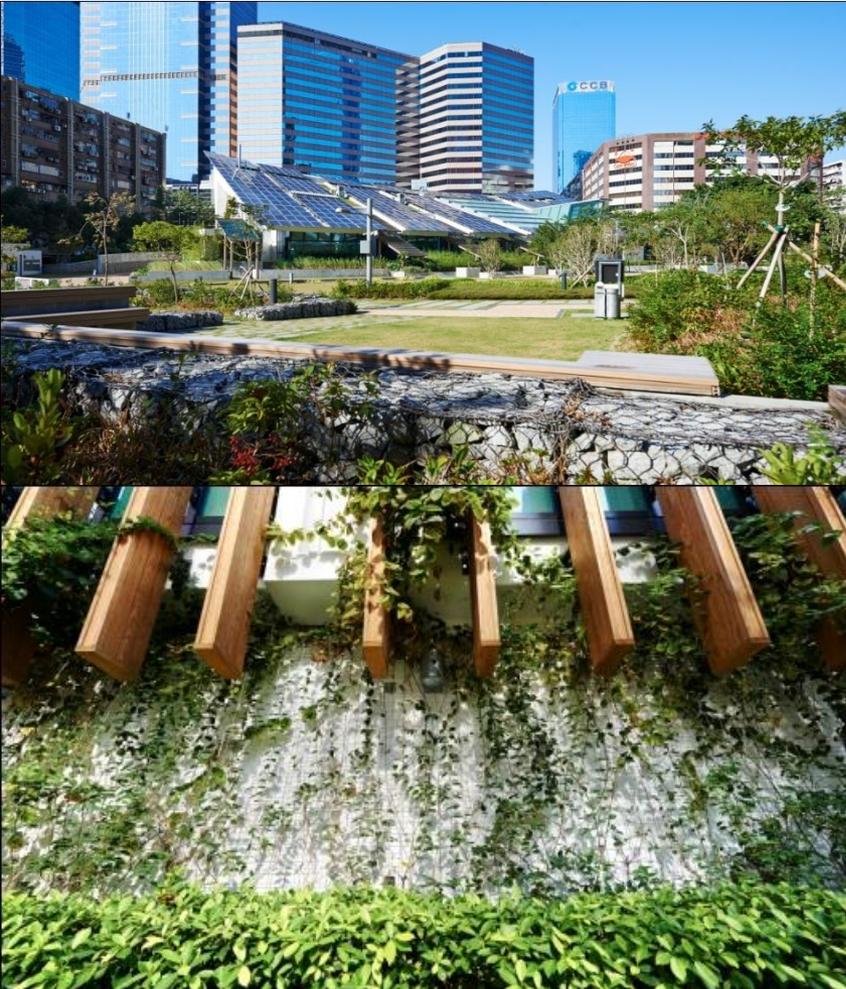# ZCB's Energy Strategy

On Site Renewable

Active Systems

Passive Design Means

Industry Best Practice (EMSD Building Energy Code)

Passive Design Measures

Passive measures reduce energy demand by 20%

- Siting and orientation for solar access, ventilation and daylighting
- Envelope OTTV – 11W/m²

- Open plan for cross ventilation >40% of the year

Passive Design Measures

- Reuse of demolition materials
- Large scale use of recycled materials
- Use of FSC certified timber
- Use of rapidly renewable materials
- Use of low carbon construction materials – a reduction of 30% (660 tonnes) embodied carbon

- Comprise around 400 trees

- 222 native trees integrated in urban native woodland

- Reduces heat island effect and improvement of microclimate

Active Systems

Active measures reduce energy demand by 25%:

- Under floor displacement convective cooling (VAV) supply air at $16°C$

- Chilled beam radiant cooling

- Desiccant dehumidification

- High-Volume-Low-Speed fans for enhanced air flow

- Wind catchers
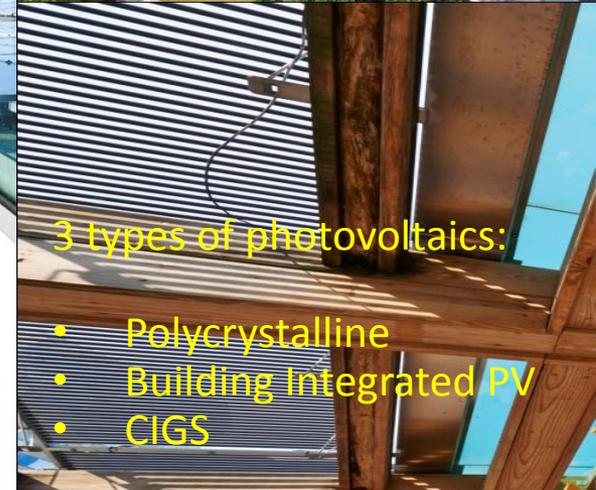
- Intelligent energy efficient lighting system
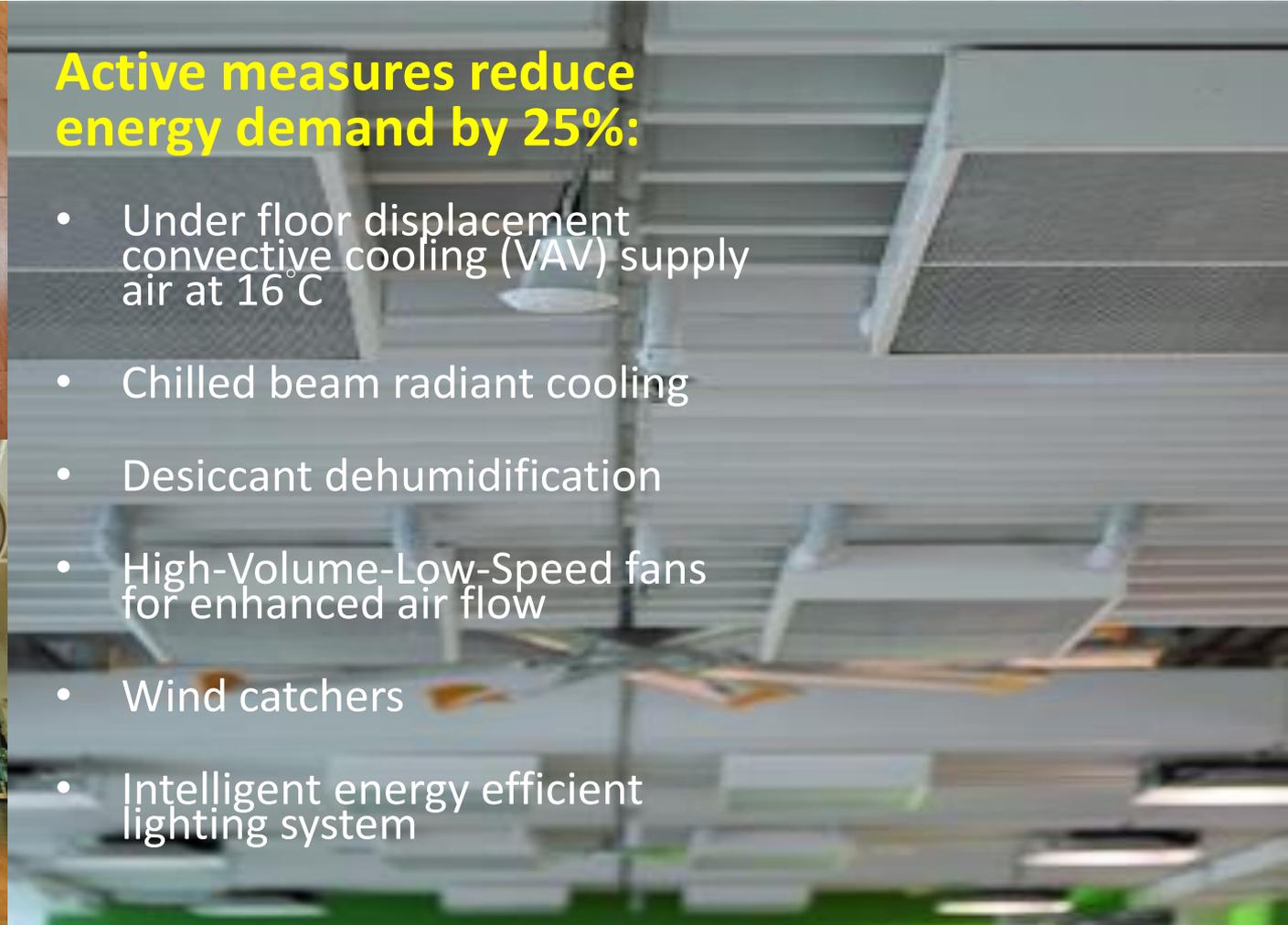
Renewable Energy Generation

- Biodiesel tri-generation with B100 waste cooking oil - power, cooling and dehumidification
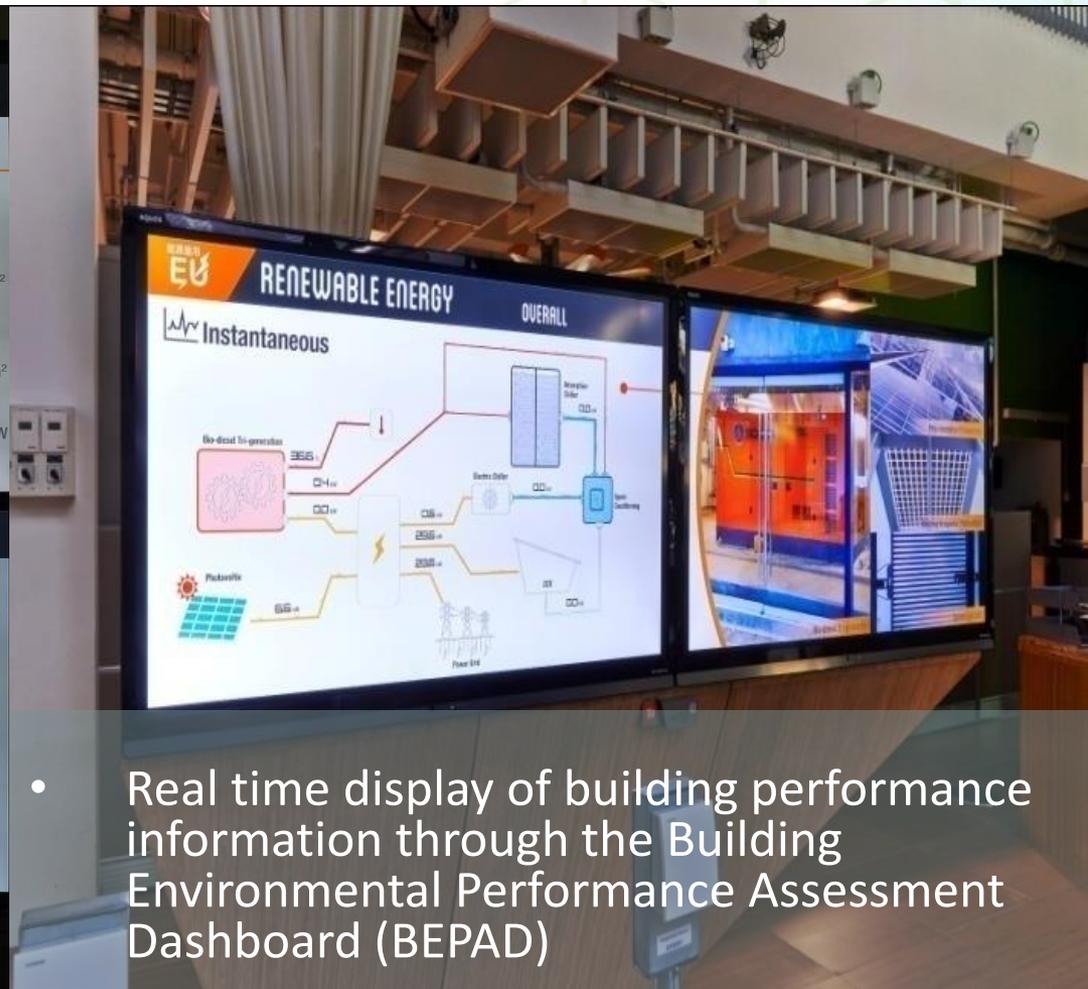
- 70kW adsorption chiller

3 types of photovoltaics:
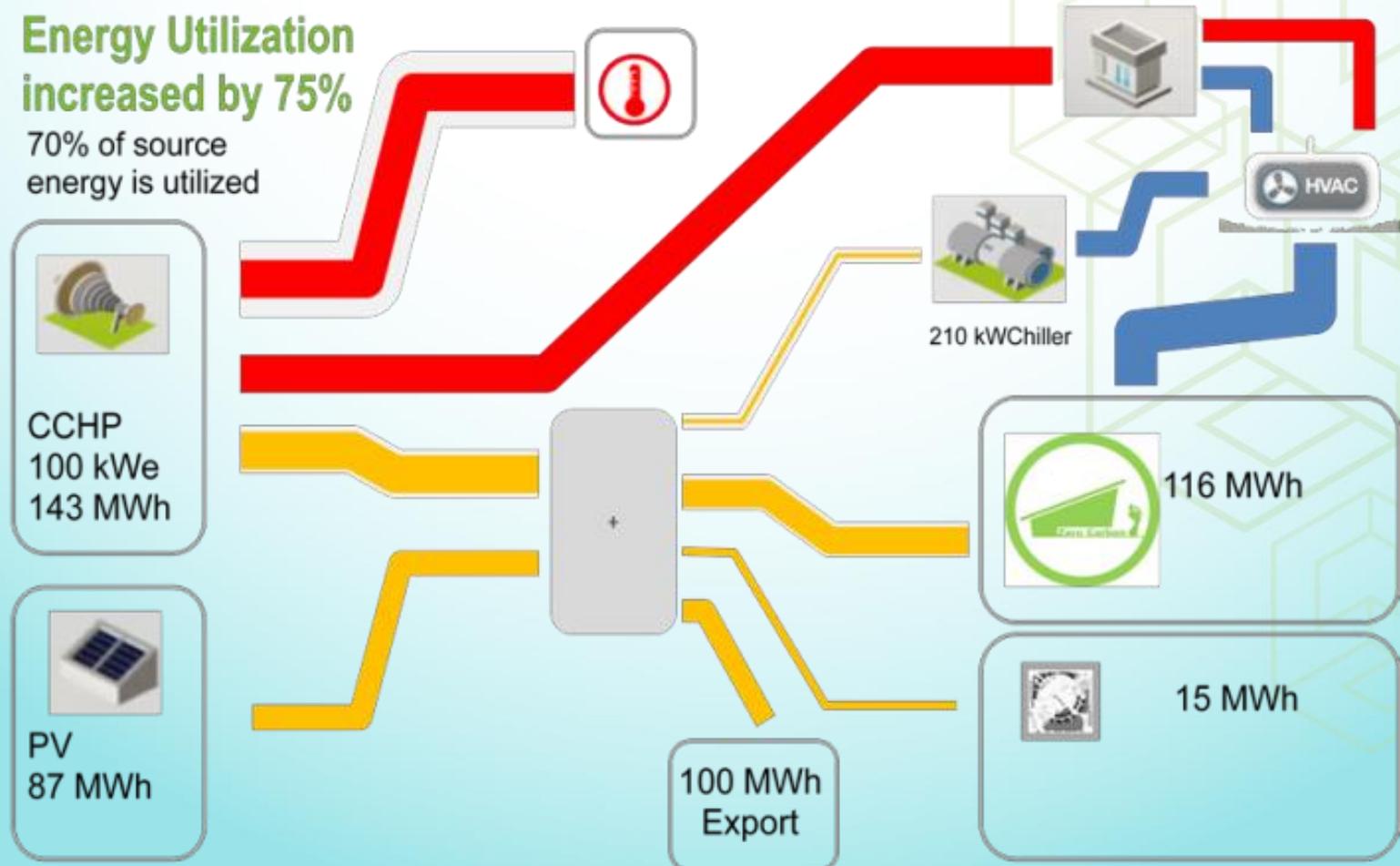
- Polycrystalline
- Building Integrated PV
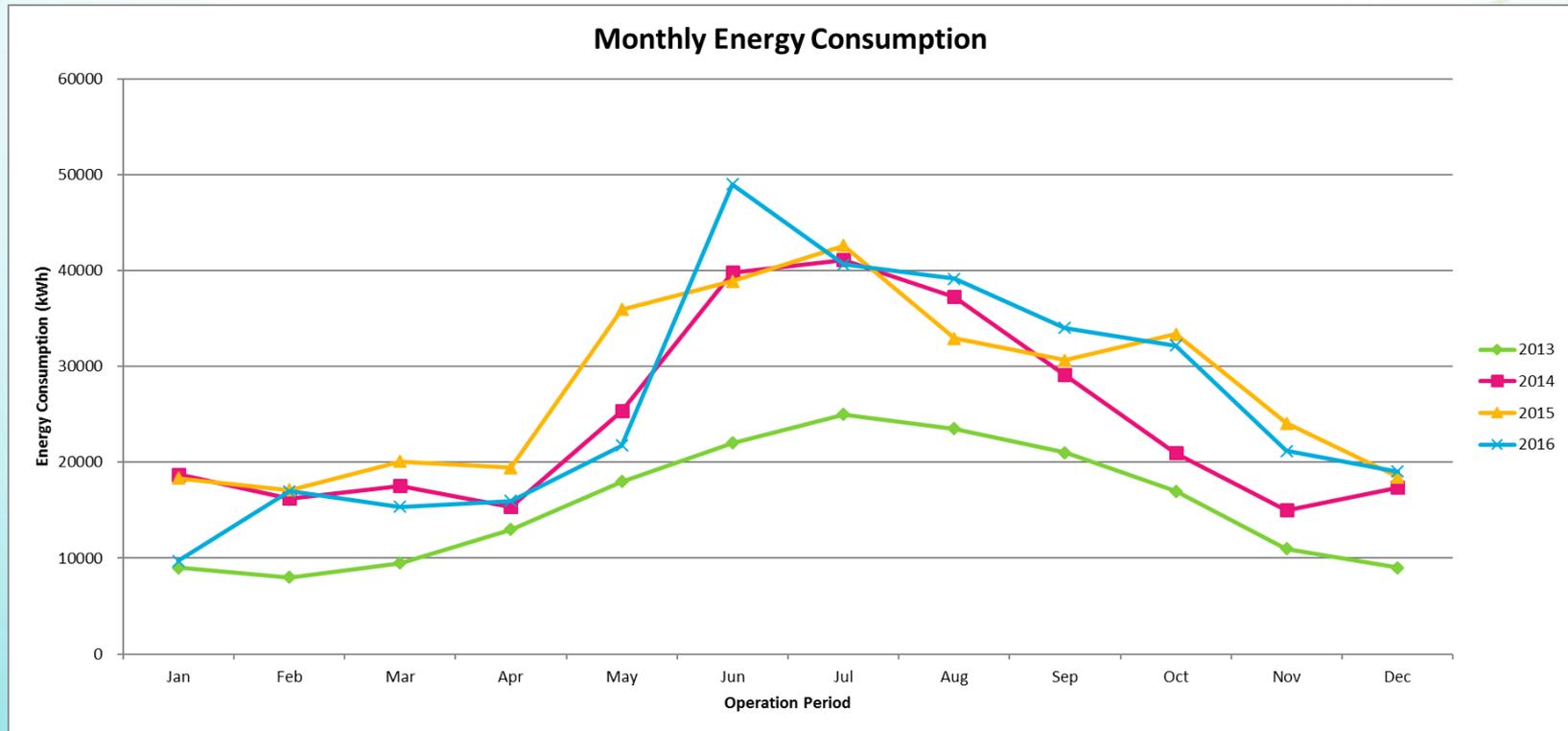- CIGS

Data Collection &
Real Time Performance Display

- Over 2800 sensors and Building Management System for monitoring and data collection for evaluating building performance

- Real time display of building performance information through the Building Environmental Performance Assessment Dashboard (BEPAD)

Designed Performance

Energy Utilization increased by 75%

70% of source energy is utilized

CCHP
100 kWe
143 MWh

PV
87 MWh

210 kWChiller

HVAC

116 MWh

15 MWh

100 MWh Export

Energy Performance – Designed & Actual Performance

Monthly Energy Consumption

Performance gaps attributed to:

- Increased building usage
- Energy consumed outside of working hours
- Energy consumption related to non-essential services

Activities at ZCB

Guide Tour:
- Over 17,000 participants in guide tour /year (2015&2106)
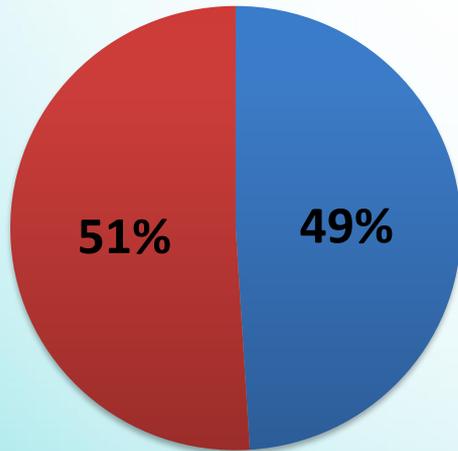
Number of Events
- 128 (2015)
- 162 (2016)

Multi-purpose Hall
- 3.3 events/week (2016)
- 2 events/week (Design)

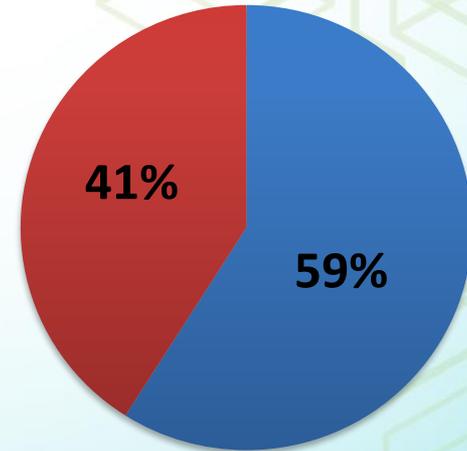# Distribution of Energy Consumption

Energy Consumption Breakdown 2015
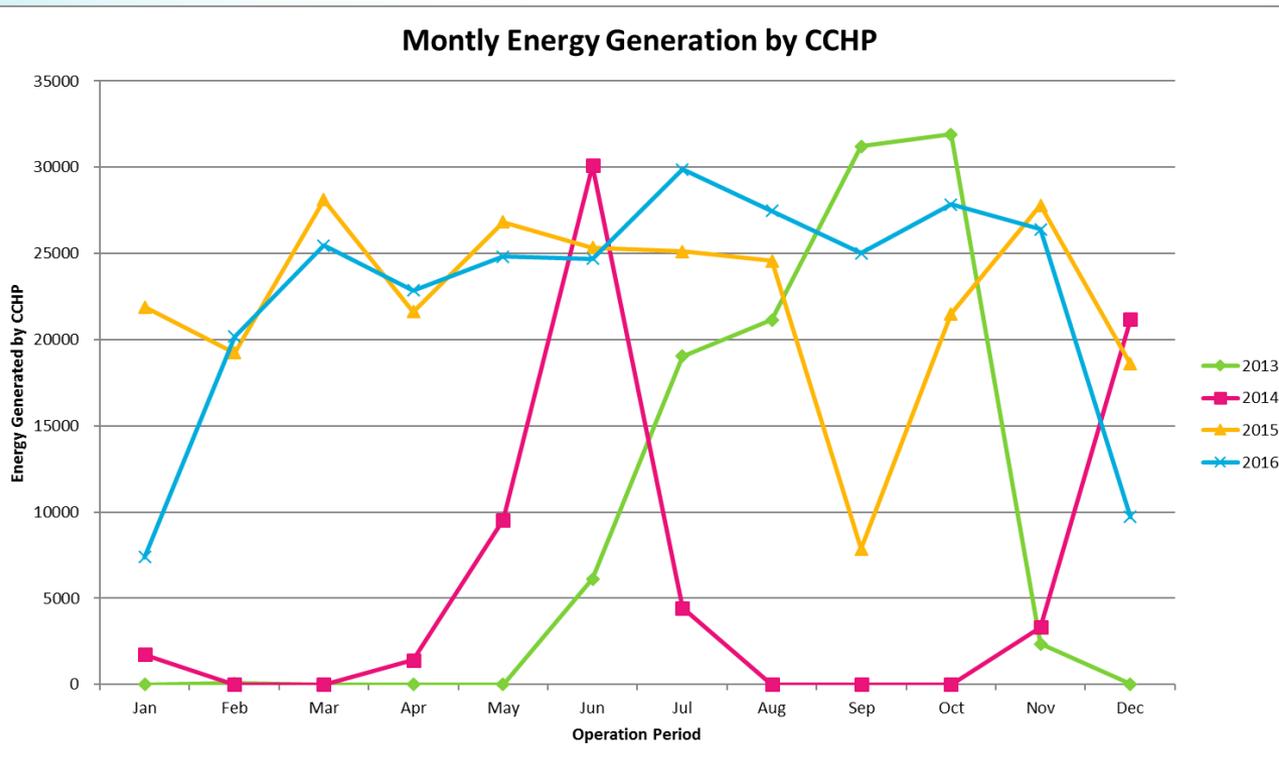
51%   49%

Lighting and Power   HVAC

Energy Consumption Breakdown 2016

41%   59%

Lighting and Power   HVAC

Combined Cooling Heating and Power (CCHP) System Performance


Montly Energy Generation by CCHP

- Biofuel generator suffered breakdowns May – June 2013 and August – November 2014

- With CCHP in full operation (9.5 hours/day) – the biofuel generator produced up to 24MWh/month

- Smooth operation for 6 months could generate 144MWh to align with design target
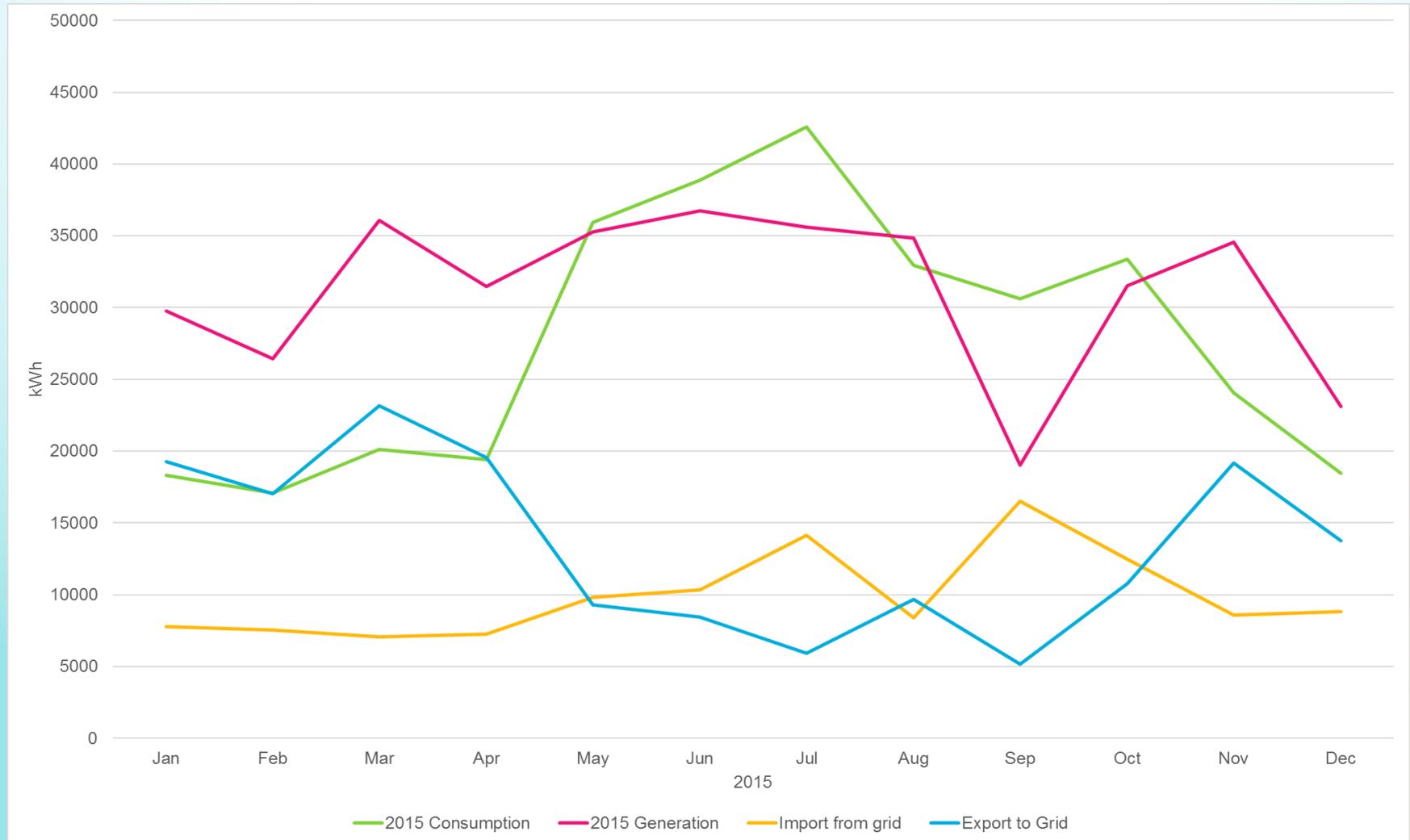
PV Systems Performance
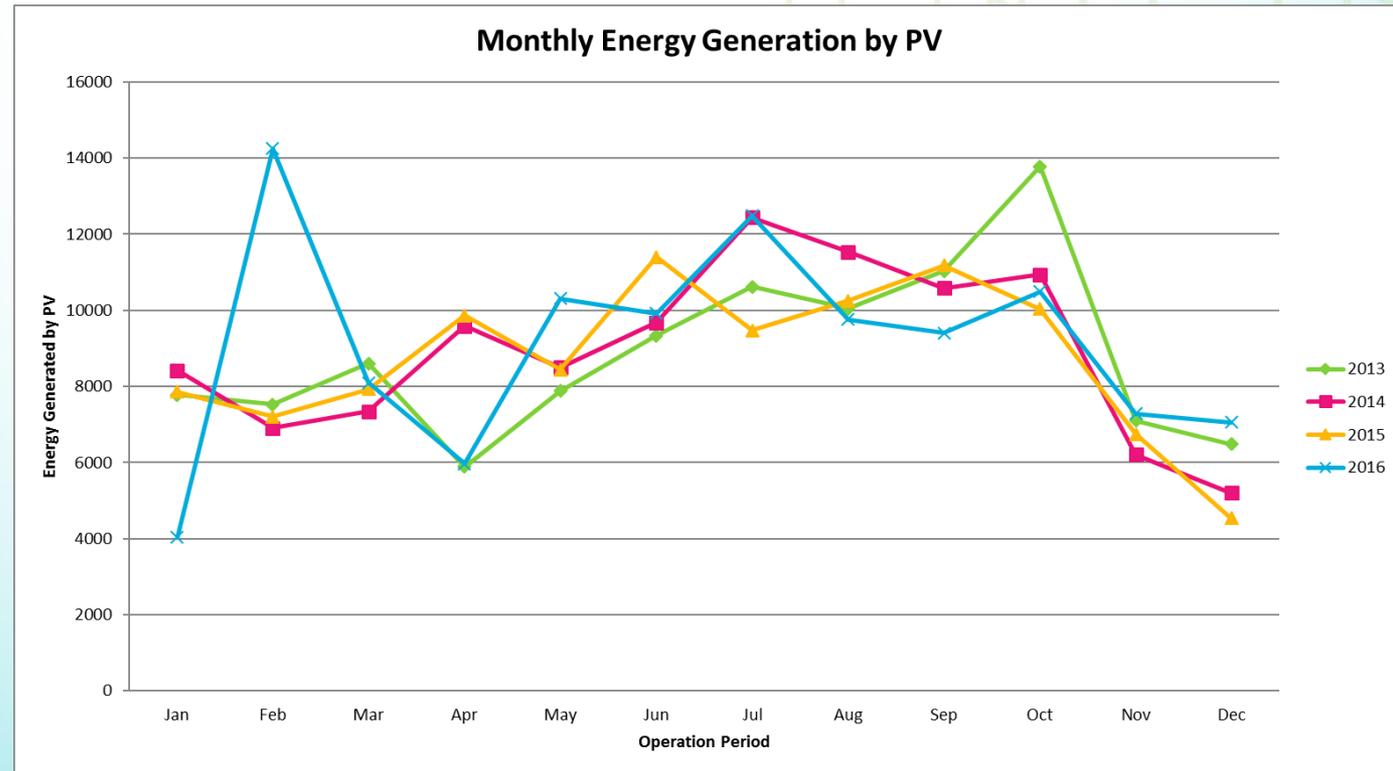
- Electricity Generated:
  2013 - 106MWh
  2014 - 107MWh
  2015 –105MWh
  2016 –109MWh

- Exceeded predicted annual output of 87MWh by:
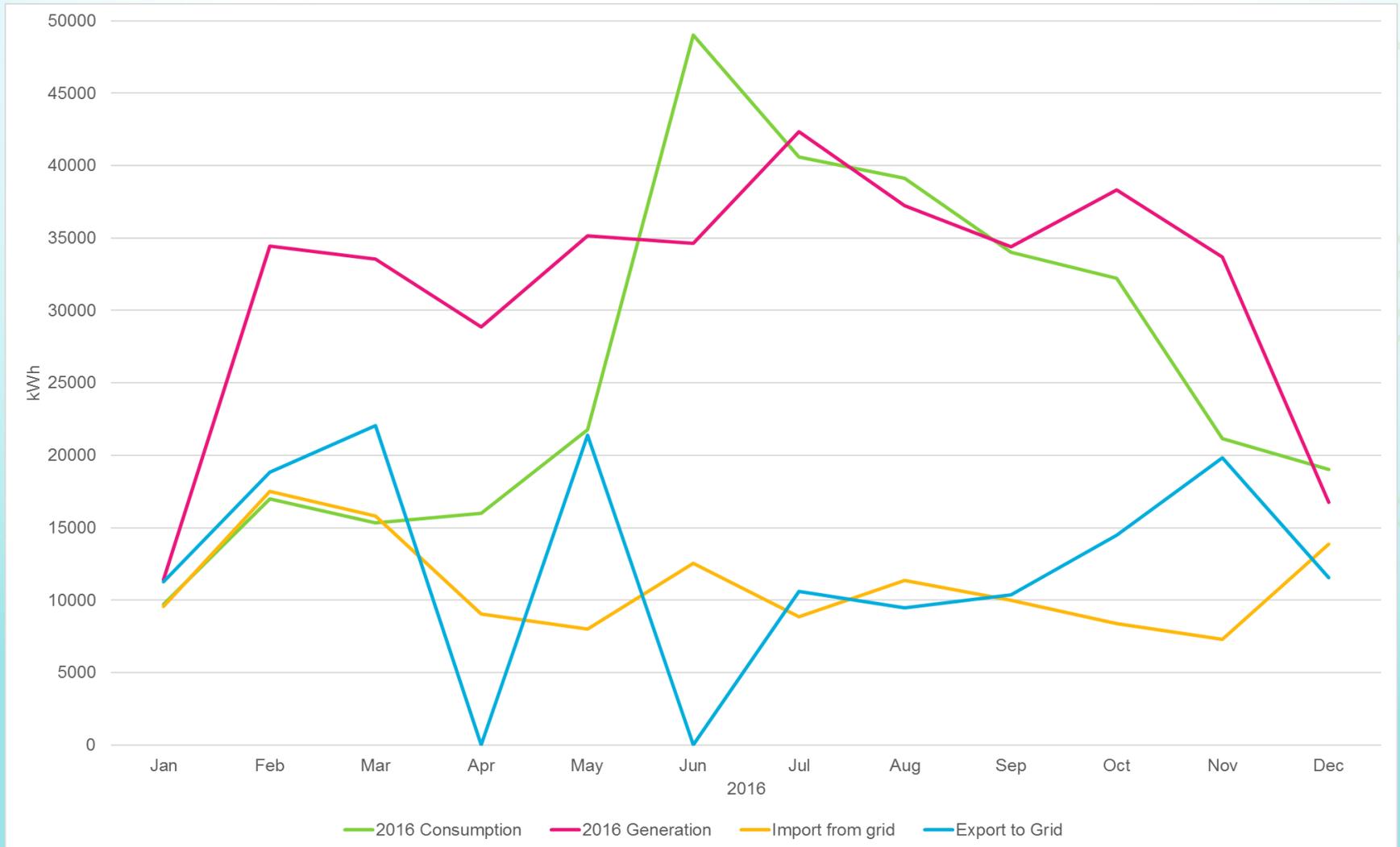 22% in 2013
  24% in 2014
  21% in 2015
  25% in 2015

Monthly Energy Generation by PV

Renewable Energy Generation 2013 - 2016
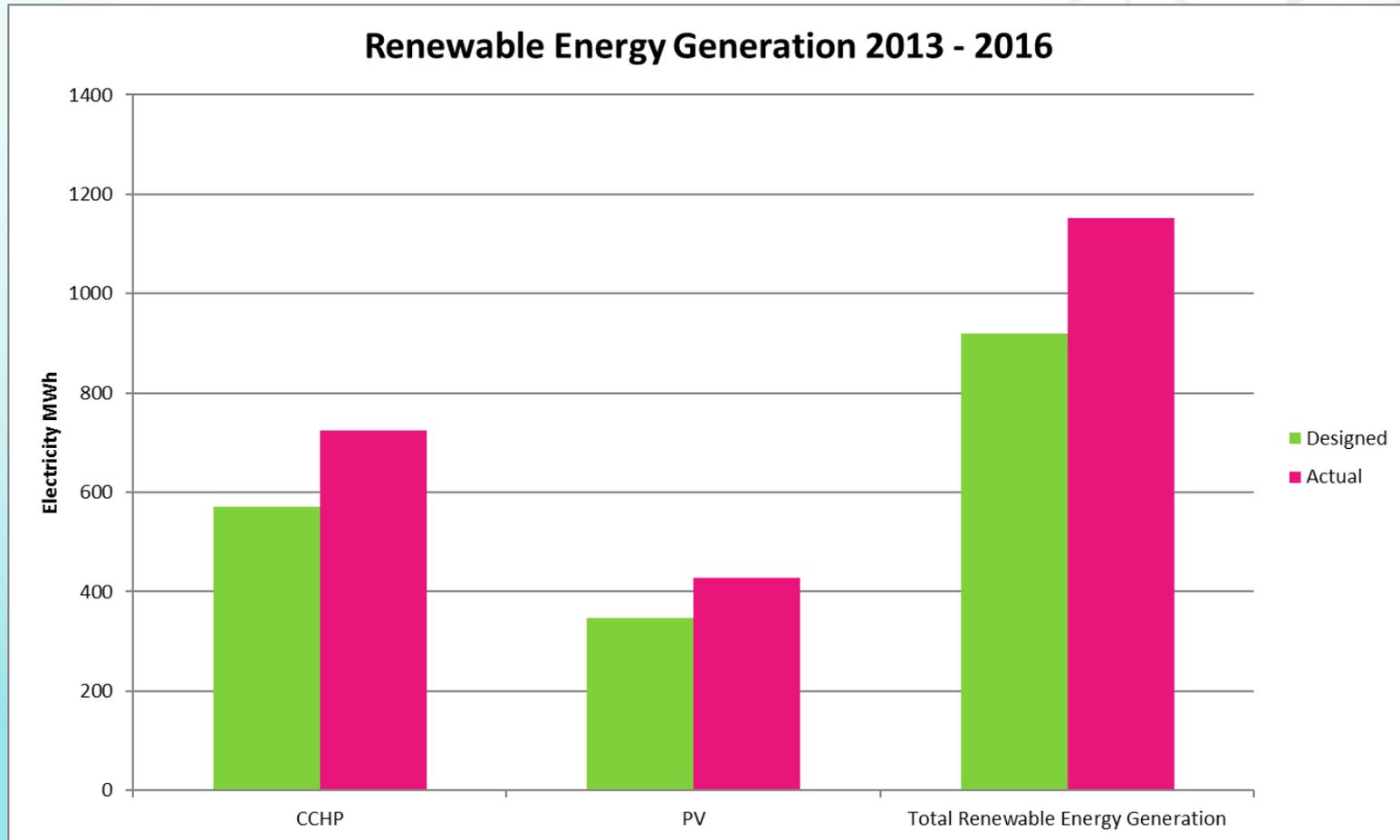
Energy Use, Generation, Import and Export 2015

Energy Use, Generation, Import and Export 2016
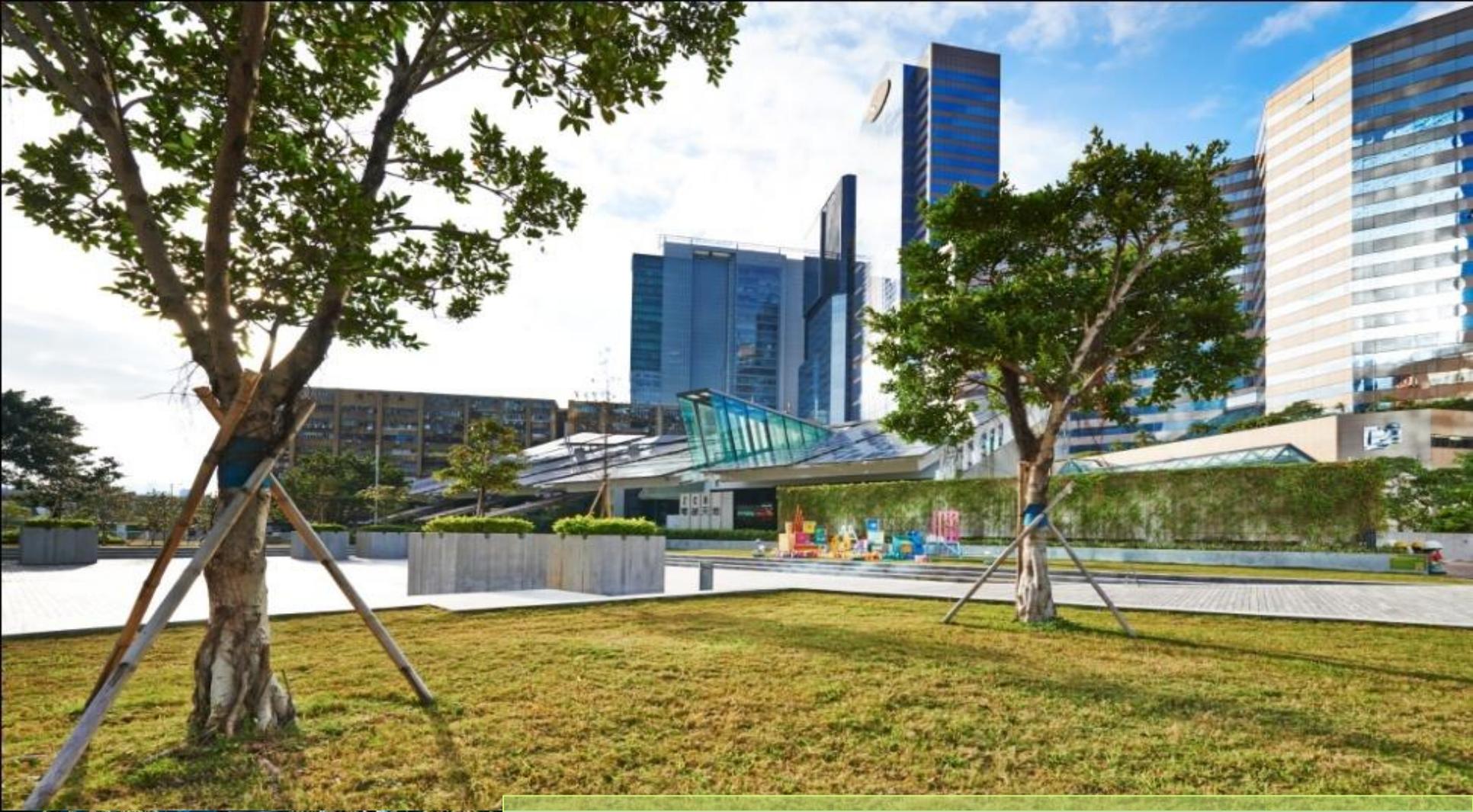
Challenges and Lessons Learned

- Designed target vs. operating target

- Extended and ongoing testing and commissioning

- Strategic maintenance

- Occupant behaviour, provision of a comfortable indoor environment and occupant satisfaction

- Reliable renewable energy generation

- Ongoing monitoring, evaluation and performance improvements

Opportunities for Subtropical Highrise Hong Kong

- **More exemplar net zero energy/carbon building projects**

- **Sharing performance data**

- **Build industry awareness and capacity**

- **Stimulating the private sector**

- **Mobilising diverse stakeholder groups**

- **Develop infrastructures and incentives**

- **Behavioural change**

- **Transfer to highrises**

Source: Drone photo by Andy Yeung "Urban Jungle" series

CONSTRUCTION INDUSTRY COUNCIL 建造業議會

E-Mail: zcb@cic.hk
http://zcb.cic.hk