



International Commerce Centre

2019 ESCI Best Practices Awards Program

Smart Building – Low Energy Buildings Network

No.1 Austin Road West, Hong Kong



環球貿易廣場
INTERNATIONAL
COMMERCE CENTRE

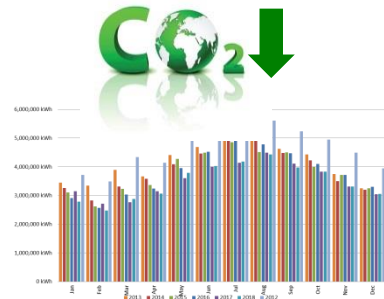
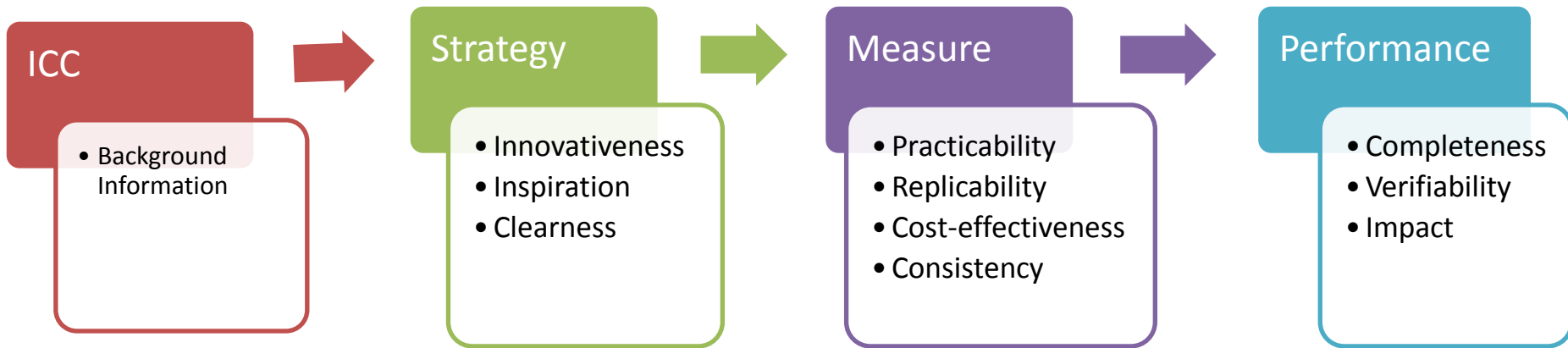


新鴻基地產
Sun Hung Kai Properties



啟勝管理服務有限公司
KAI SHING MANAGEMENT SERVICES LIMITED

Content





Section 1

Introduction

Sun Hung Kai Properties Limited



新鴻基地產發展有限公司
SUN HUNG KAI PROPERTIES LIMITED

Building Homes with Heart



Sun Hung Kai Properties Limited ("SHKP") was publicly listed in **1972** and is now one of the largest **property** companies in Hong Kong.

The Group also has complementary operations in the following property related fields:
Hotels, Construction, Insurance and Mortgage services.

SHKP embraces corporate social responsibility by respecting its staff, the environment and society at large. It has clear green policies for sustainable development in its operations to conserve resources for future generations.

Kai Shing Management Services Limited



啟勝管理服務有限公司

KAI SHING MANAGEMENT SERVICES LIMITED

新鴻基地產成員

A member of Sun Hung Kai Properties



ISO 10002:2004
Certificate No.: CC3043
Limited Sites



ISO 9001:2008
Certificate No.: CC521
Limited Sites



OHSAS 18001:2007
Certificate No.: CC2459
Limited Sites



ISO 90001:2011
Certificate No.: CC5375
Limited Sites



ISO 14001:2004
Certificate No.: CC1096
Limited Sites



ISO 22301:2012
Certificate No.: CC 5709
Limited Sites



Hong Kong Eco-Business
Awards (Grand Award)
香港環保企業獎 (榮譽金獎)



星鋼
服務品牌
SINGTAO
Excellent
Services Brand 2004



2006
THE BEST BRAND ENTERPRISE AWARD
最佳品牌企業獎



caring company
關顧公司



2005 Customer Award



AWARDED
Superbrands
HONG KONG
2004



ICC



Leighton Hill



Yoho Town



apm



Grand Century Place

Kai Shing Management Services Limited (Kai Shing), a member of Sun Hung Kai Properties, was established in 1978. It currently manages over a hundred million square feet of properties including A-grade commercial buildings, large-scale shopping malls, premium residences, large-scale residence estates, commerce and trade buildings, HOS estates, and clubhouse and leisure facilities management across Hong Kong, Kowloon and the New Territories. Kai Shing is one of the largest property management organizations in Hong Kong.

International Commerce Centre

Vision: Harbour Gateway

Location: Central's extension



International Commerce Centre



1st in Hong Kong, 11th tallest in the world

2.5 million square feet of office space, 98% occupied

Source: CTBUH

Connectivity – Union Square



Key Information

- Two MTR Stations Nearby:
 - Austin Station
 - Kowloon Station
- Guangzhou-Shenzhen-Hong Kong Express Rail Link (XRL)
 - West Kowloon Station

All are within **15 minutes** walking distance from ICC

Connectivity – Guangzhou-Shenzhen-Hong Kong Express Rail Link (XRL)



高速鐵路
High Speed Rail

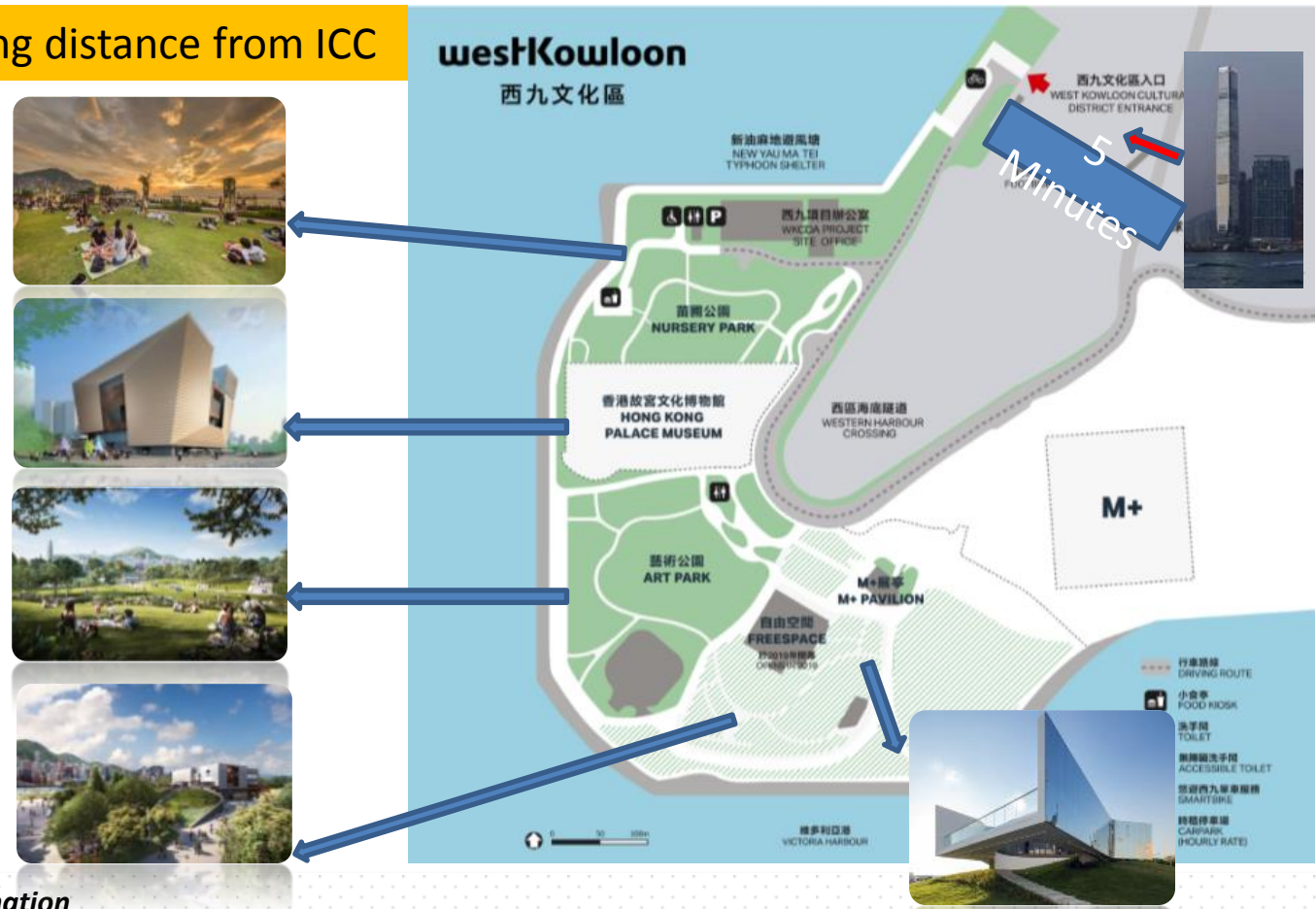


Key Information

- Service commencement date: 23 September 2018
- Estimated daily traffic: 109,200 passengers
- Route Length: Approximately 26 km in Hong Kong
- Direct Links offered: 44 mainland cities

Connectivity - West Kowloon Cultural District (WKCD)

5 minutes walking distance from ICC

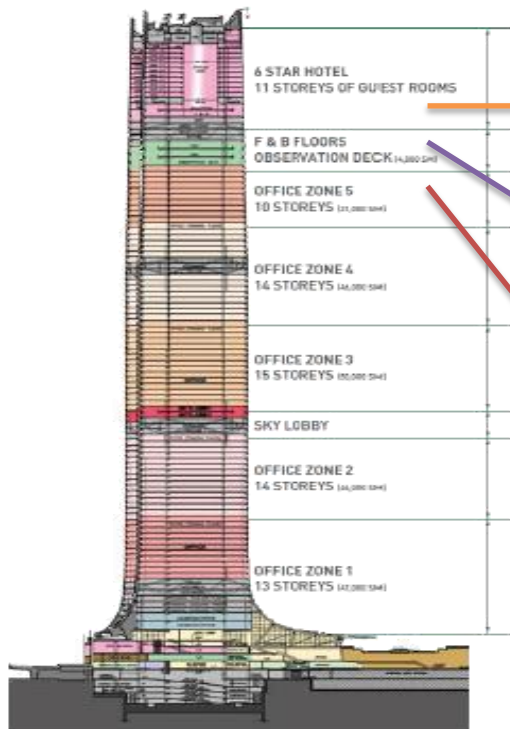


Building Information



- Location: 1 Austin Road West, Kowloon, HK
- Floors: 118-storey
- Height: 490m (1st in Hong Kong)
- Construction period: 2002-2011
- Phases of occupation:
 - Zone 1& 2 - 2008
 - Zone 3 & 4 - 2010
 - Zone 5 - 2011
 - Hotel - 2011
- No. of Staff :170

Building Information



The Ritz-Carlton
Hong Kong
(Level 102 – 118)



天際100
香港觀景台
(Level 100)



Office floors (Level 10 – 99)

Key Information

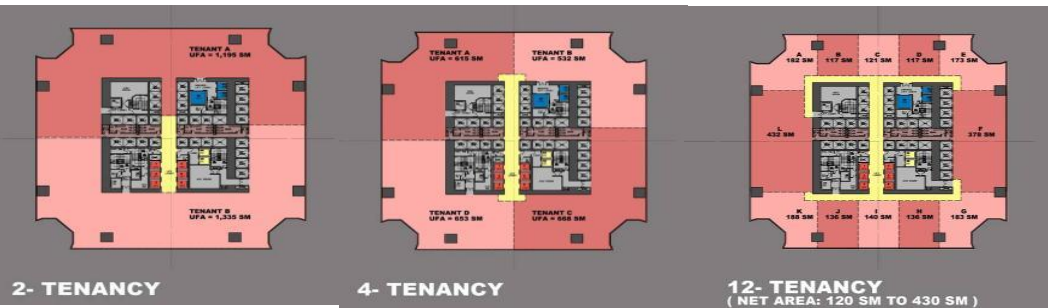
ICC is a multi-function building totaling 3 million s.f.:

- Office: 2.5 million s.f.
- Hotel: 0.38 million s.f.
- Observation Deck + Restaurants: 0.06 million s.f.

Building Information

Highly Efficient Large Floor Plates

- The size of the ICC footprint and the efficiency of the structure produce a highly efficient plan for tenants, each floor can accommodate 1.5 times more population that normal commercial building in Central Business District
- A number of tenant occupation could be easily adopted with uninterrupted panoramic views.
- Span depth varies from 12.6 to 16m to cater for different tenants requirement
- The structural floor system facilitate the multiform tenants to built internal staircases to reduce the reliance on lift system. All the major tenants had subsequently built their internal staircases.



Building Information

Shingled façade design: cut down glare and solar gain while maintaining views out of the tower; brings the sculptural form of the building to life and significantly reduces unwanted reflections.

Curtain Wall Design: The curtain wall design utilizes specially selected glass to cut down glare and solar gain while maintaining views out of the tower. The unique shingled design of the façade brings the sculptural form of the building to life and significantly reduces unwanted reflections.



Building Information



- 95% of the building's tenants are international investment banks that operate 24 hours by 7 days.
- The combined market capitalization of the tenants' businesses amounts to multi-billion dollars.



Section 2

Strategy

Kai Shing Missions and Visions

The backbone of the company

Company Missions

Protect the environment

Put customers first

Gather trade experts

Discover the potential of
Mainland China



啟勝管理服務有限公司
KAI SHING MANAGEMENT SERVICES LIMITED



The 6 Kai Shing Goals

Discipline

Constant progress

Staff training

Technology

Cost control

Eco-friendly



啟勝管理服務有限公司
KAI SHING MANAGEMENT SERVICES LIMITED



ISO 9001 : 2015
Certificate No.: CC 521
Limited Sites



ISO 10002 : 2014
Certificate No.: CC3043
Limited Sites



ISO 14001 : 2015
Certificate No.: CC 1096
Limited Sites



ISO 50001 : 2011
Certificate No.: CC5375
Limited Sites



OHSAS 18001 : 2007
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Limited Sites



ISO 22301 : 2012
Certificate No.: CC 5709
Limited Sites

Objectives and Operation Model

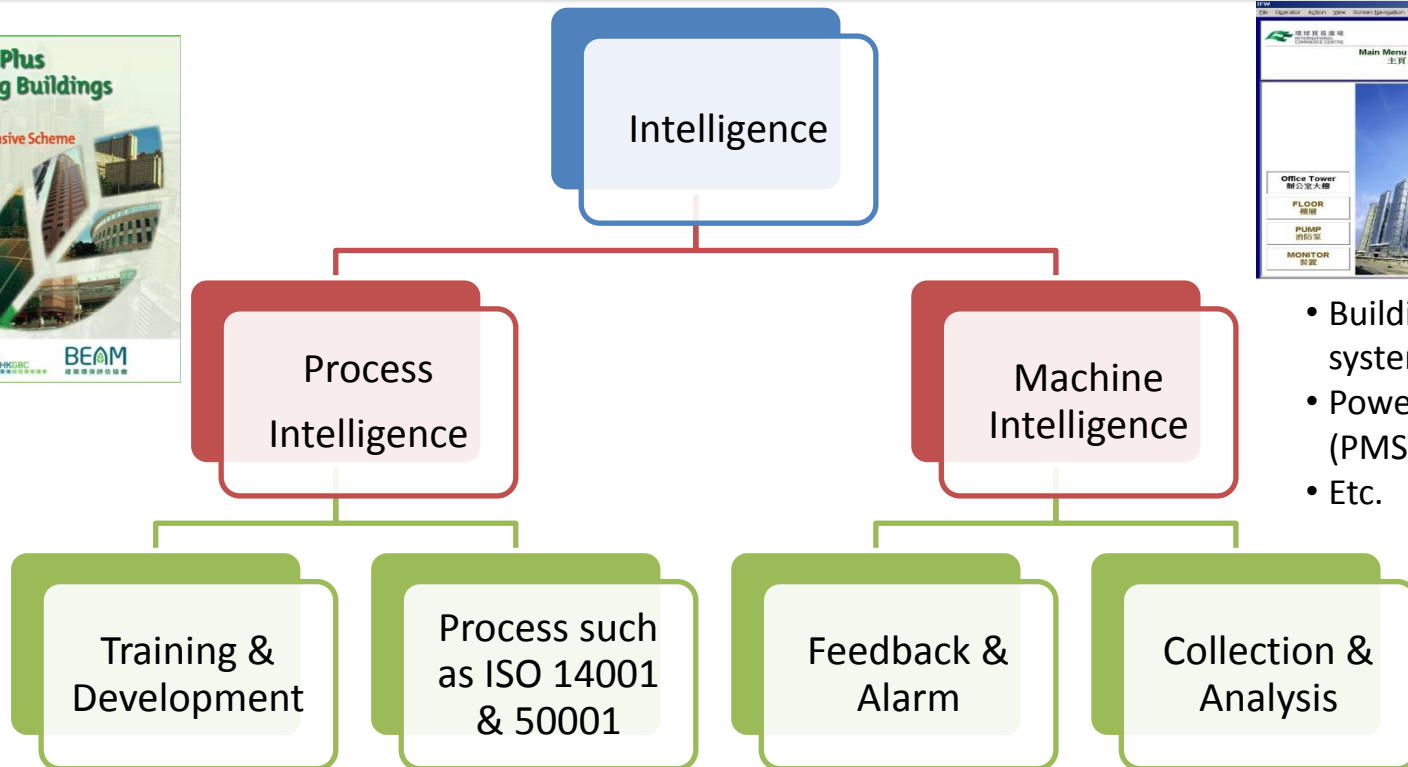
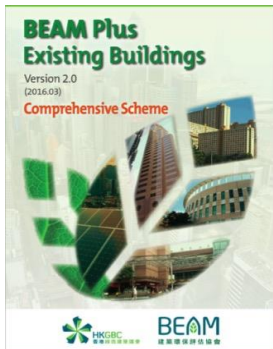
The building management team has incorporated the *three-element management* framework: *Intelligence, Collaboration and Continuity* in operating ICC for green management, smart building development and support of government.



- Contain a wide variety different kinds of sensors to track operational data
- Different systems are connected together to form a holistic operational view of the building
- Tracked data is analyzed with automatic response mechanism to optimize operation

The 3-Sphere Framework - Intelligence

Intelligence - integration of people, place, process and technology

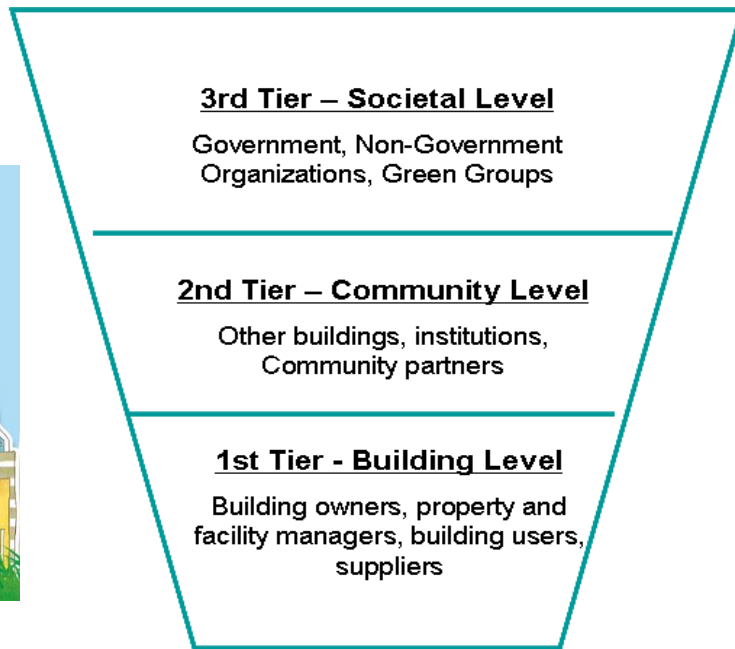


- Building management system (BMS)
- Power monitoring system (PMS)
- Etc.



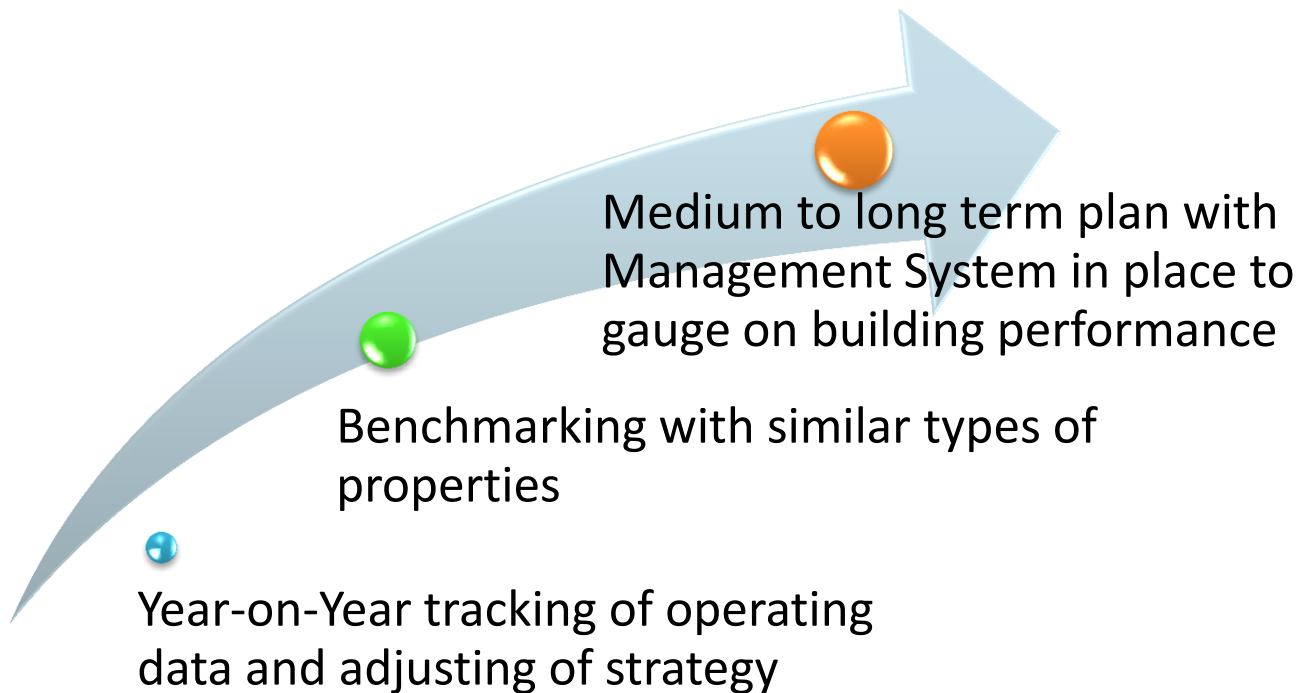
The 3-Sphere Framework - Collaboration

Collaboration - Vitalizing the trade experts and recognizing the contributions from stakeholders from within and outside the building environment



The 3-Sphere Framework - Continuity

Continuity - Working towards a common goal of reducing environmental impacts



- ✓ **BEAM Plus Existing Building V2.0**
- ✓ **Annual Energy Audit**
- ✓ **IoT application**

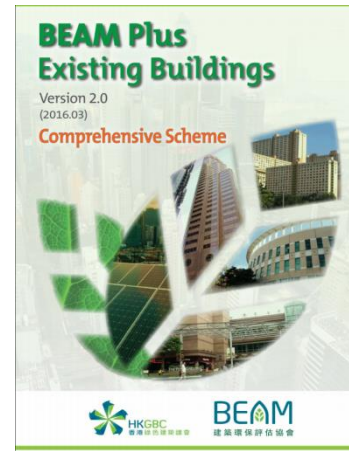


BEAM Plus Existing Building 2.0

ICC is the first HK building received “BEAM Plus Existing Buildings V2.0” Platinum certificate



Existing Buildings V2.0
Final Platinum
Total Score:
79.1



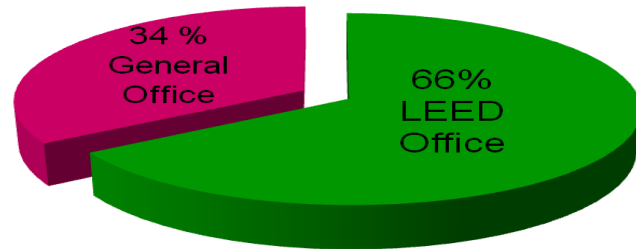
Category	Applicable Credits	Achieved Credits	Achieved Bonus Credits	% of Achieved Credit	Category Weighting	Weighted Achieved Credits	Category Grade
MAN	23.0	16.0	3.0	82.6%	24%	19.8	Platinum
SA	22.0	17.0	0.0	77.3%	10%	7.7	Platinum
MWA	17.0	10.0	1.0	64.7%	14%	9.1	Platinum
EU	39.0	28.0	2.0	76.9%	24%	18.5	Platinum
WU	23.0	11.0	3.0	60.9%	14%	8.5	Platinum
IEQ	26.0	11.0	3.0	53.8%	14%	7.5	Platinum
IA	Max. 10 Bonus		8.0		100%	8.0	
Overall Score:						79.1	Platinum

Indoor Environmental Qualities & LEED Offices



LEED VS General Office
Approx. **40%** Energy Saving

For 66% LEED Offices
Approx. **1,750,000sq.ft**
Approx. **↓ 395,000 kg CO₂**



Higher Rent and Occupancy Rate in Certified Green Buildings

Commercial Property Executive 2016

LEED-certified vs. non-certified buildings in US

3.7%↑

Rent



4%↑

Occupancy Rate



LEED-certified vs. non-certified buildings in Canada

10.2%↑

Rent



8.5%↑

Occupancy Rate



China Green Building Report 2017

LEED-certified vs. non-certified buildings in China

25%↑

Rent



1.5%↑

Occupancy Rate



LEED Platinum vs. Certification below LEED Platinum in China

10%↑

Rent



3.5%↑

Occupancy Rate



Source: Commercial Property Executive; CBRE and U.S. Green Building Council

HK Climate Action Plan 2030+



Target
Energy
Intensity by
2025

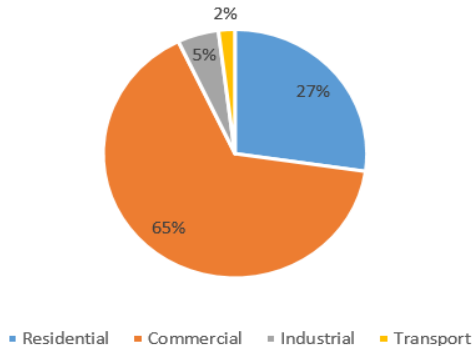


(base year
2005)

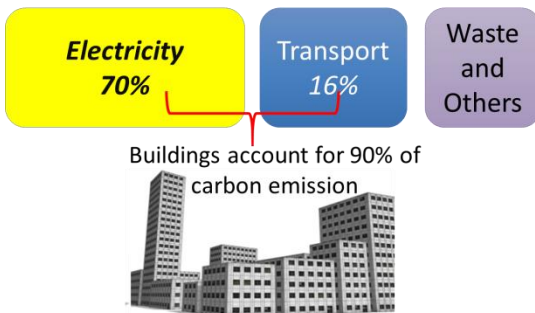


Energy End Use in Hong Kong

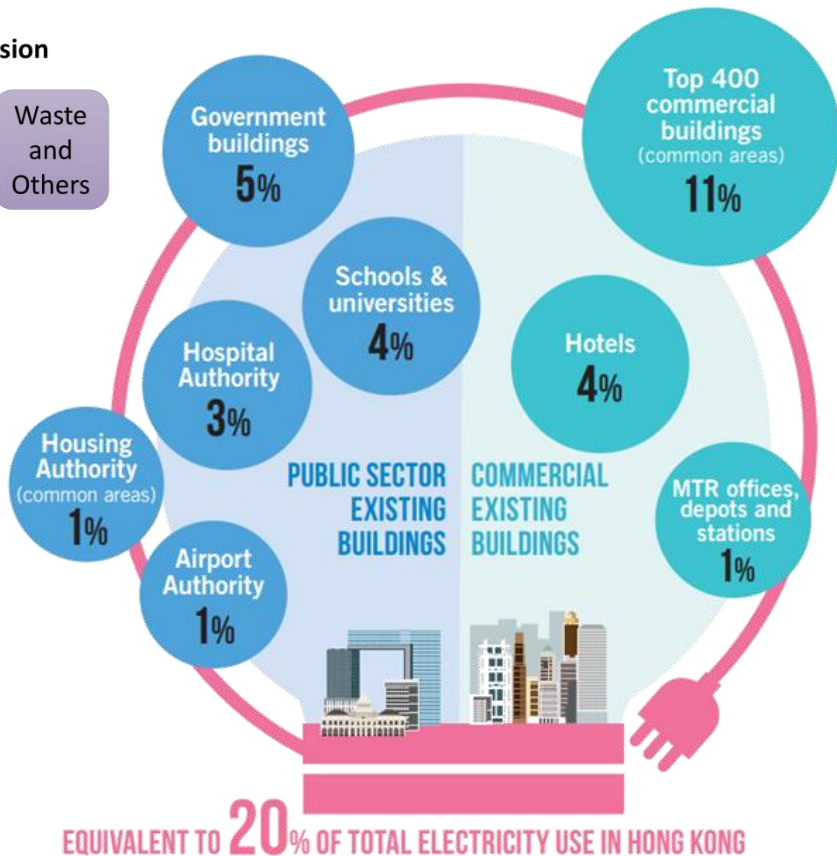
Electricity Consumption By Sectors in 2016



Largest Source of Carbon Emission



Source: Hong Kong Energy
End Use Data 2018



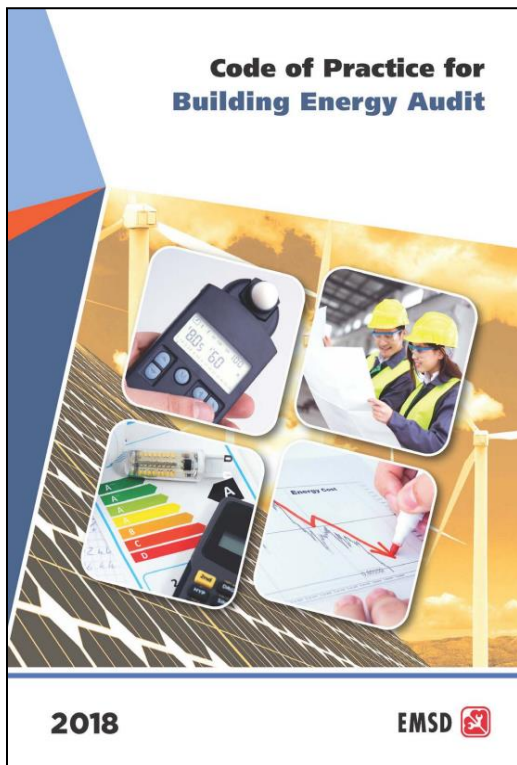
New Buildings vs Existing Buildings

- Over **42,000** existing buildings in Hong Kong
- Potential reduction of **52%** in absolute electricity consumption compared to a Business-As-Usual (BAU) scenario



Source: HK3030 Market Drivers for Transformation of Green Buildings in Hong Kong (Executive Summary)

Energy Audit by Registered Energy Assessor (REA)



<i>Energy Management Opportunity (EMO)</i>	<i>Energy Management Approach</i>
<i>EMO I</i>	<i>Housekeeping practice for saving energy</i>
<i>EMO II</i>	<i>Replacement of less energy efficient apparatus with the more energy efficient one with a reasonable outlay</i>
<i>EMO III</i>	<i>Substantial savings over a long term with capital investment</i>

Energy audit is an effective way to examine the energy use and performance of a building. The annual energy audit conducted in ICC is based on the Building Energy Efficiency Ordinance (BEEO) of Hong Kong Legislation Chapter 610 (Cap.610) which enacted by HKSAR. Through continuously optimizing the energy consumption facilities, the annual audit of ICC showed the *reduction of Energy Utilization Index (EUI)* of ICC.

Source : Electrical and Mechanical Services Department (EMSD), HKSAR Government

ICC Energy Reduction Target

As stated in SHKP Sustainability Report, the *energy reduction target of ICC is 15% by 2021* with 2015 as base year.



Reducing Energy Consumption and Carbon Footprint

Electricity generation currently accounts for about 70% of Hong Kong's carbon footprint, and 90% of the power generated is consumed by buildings. The Group strives to improve energy efficiency in new and existing properties to reduce overall energy consumption and shrink footprints. The Government's 4Ts (Timeline, Targets, Together, Transparency) framework has been followed with the intention to contribute to the Energy Saving Plan's energy reduction target.

The Group's EOC, consisting of 27 building engineering and management specialists, monitors building electricity consumption and disseminates the latest research and international best practices. During the year, a total of 55 buildings in the investment property portfolio were supervised by EOC, resulting in the reduction of electricity consumption by more than 14% over the past six years.

Electricity Consumption for Major Buildings Monitored by the Energy Optimization Committee from 2011-2017



* Data represented covers 54 properties monitored by EOC.

The Group additionally has a long-term Energy Saving Plan 2030+, currently providing 178 energy saving measures across 99 commercial and residential properties through the use of electric cars and help build a low-carbon community. The Group's residential buildings, shopping malls, office buildings, set energy reduction targets.

Examples of Energy Reduction Targets in Different Types of Properties



HK Roadmap in Smart City Development

- In HKSAR, Hong Kong Smart City Blueprint was released in Dec 2017.
- Making use of innovation and technology (I&T) continues to be a trend
- One of the initiatives is the use of the “Internet of Things” (IoT) in buildings.



IoT Initiatives in ICC

Extract of "HK Smart City Blueprint"

Strategy and Initiatives



Climate Action Plan 2030+

- Reduce our carbon intensity by between 65% and 70% by 2030 compared with the 2005 level
- Phase down coal-fired electricity generation gradually and replace with natural gas and non-fossil fuel sources. Coal as a proportion of the fuel mix will be reduced from 47% as of 2016 down to about 25% in 2020
- Apply renewable energy on a wider and larger scale based on mature and commercially available technologies with the public sector taking the lead
- Further promote energy efficiency and conservation in the community with particular focus on buildings
- Implement other measures to achieve carbon emission reduction by phases



Green and Intelligent Buildings, and Energy Efficiency

- Promote retro-commissioning and building-based smart/IT technologies
- Install LED lamps in public lighting systems progressively under the LED Public Lighting Replacement Programme of the Highways Department starting from 2017-18 and encourage retrofitting LED lighting for existing government buildings
- Continue to include requirements, such as green building design, provision of smart water meter system, electric vehicle charging facility and real-time parking vacancy information for new land sale sites in Kowloon East, with a view to developing a green and smart community



SMART ENVIRONMENT

SHKP Sustainability Report

Q Peer companies and suppliers:



Innovative application of technology is a growing trend in property management. It is observed that SHKP has developed smartphone applications, such as the SHKP Malls App and the Intake Easy device, for its customers' convenience. Is the Group also exploring other innovative technological solutions to enhance resource efficiency of its operations?

SHKP is committed to investing in the effective use of innovation and technology. Specifically, the Group sees the potential of the commercial application of IoT (Internet-of-Things) technology as a means to improve operational efficiency and quality. We have been supporting our subsidiaries on the introduction of technologies in property management and across other commercial aspects, such as construction, healthcare, event management and smart city development. During the year, Kai Shing and SmarTone collectively launched a smart management solution in ICC with IoT applied, allowing ICC to meet or exceed the energy-saving target set by the Government for commercial buildings. We believe this innovative system will help to set a new industry standard in smart and eco-friendly property management in Hong Kong. More information on the management solution implemented in ICC can be found in the Value Created for Customers section in this report.

SMART BUILDING MANAGEMENT

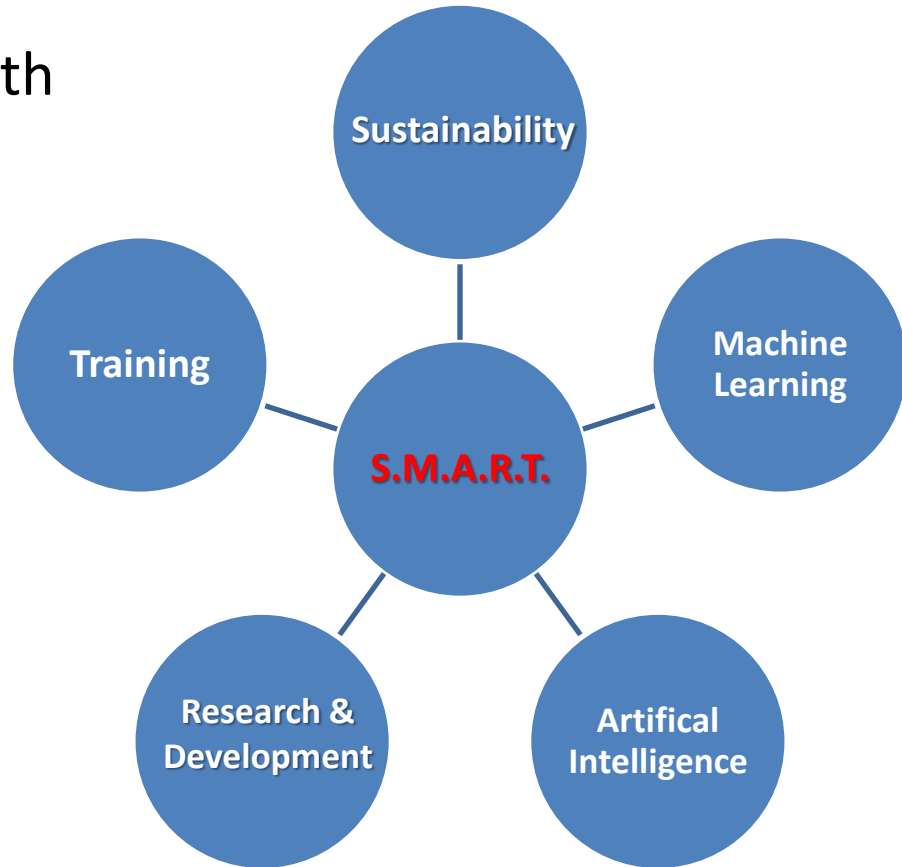
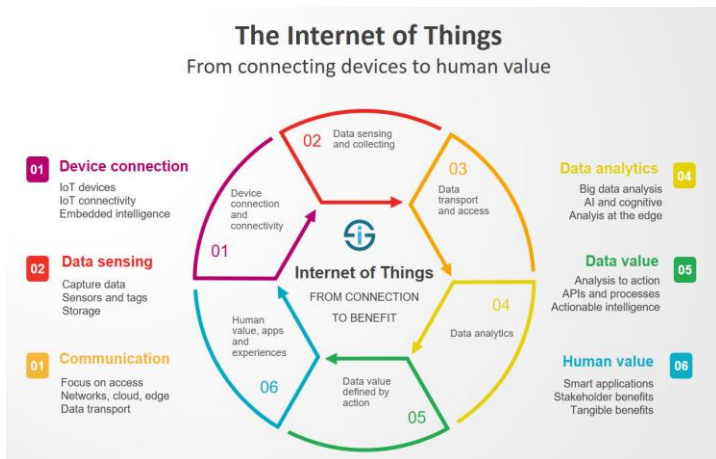


Smart Building Development

Improve efficiency and comfort with

IoT for Smart Buildings

S.M.A.R.T ICC



Support of IoT Development



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 [SHKP e-News](#)

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Press Releases

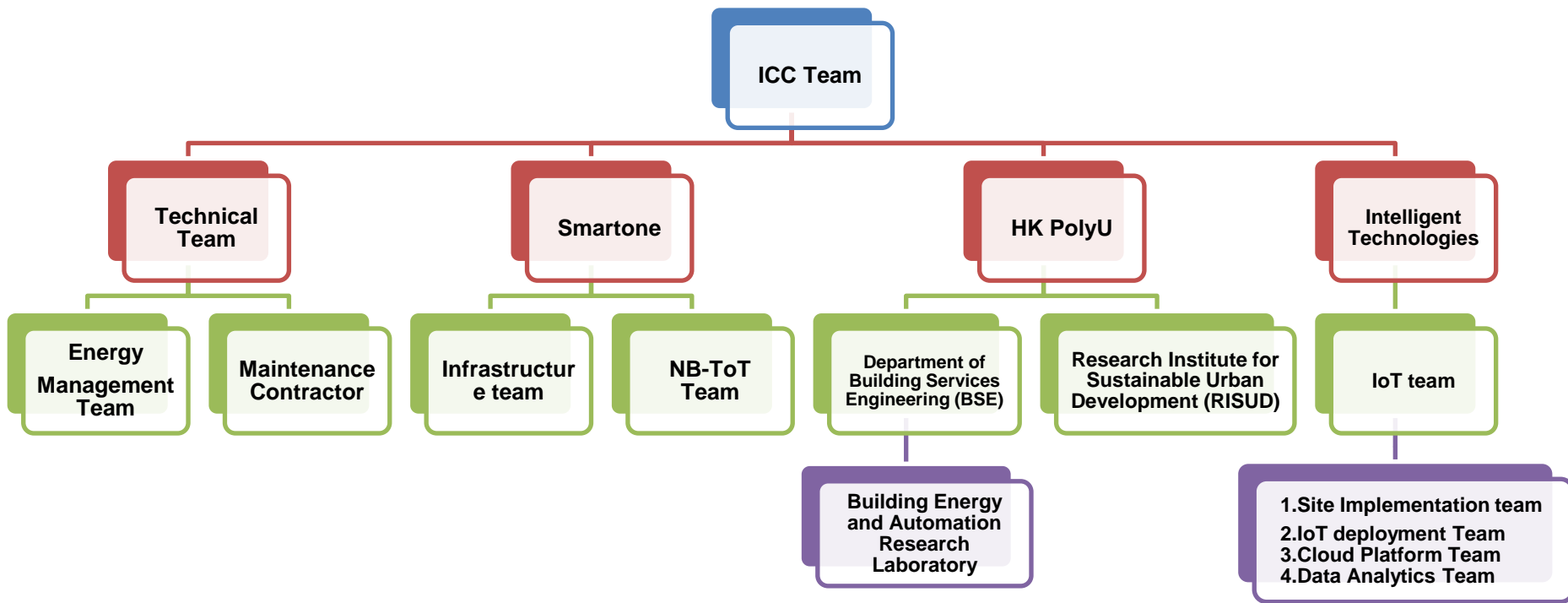
SmarTone and Kai Shing spearhead NB-IoT enabled smart property management solution at Hong Kong's tallest landmark ICC

2018-05-23

SmarTone and Kai Shing Management Services Limited ("Kai Shing") jointly announce today the introduction of a Narrowband Internet-of-Things (NB-IoT) enabled smart property management solution at International Commerce Centre (ICC), bringing property management service level to new heights in this tallest landmark in Hong Kong.



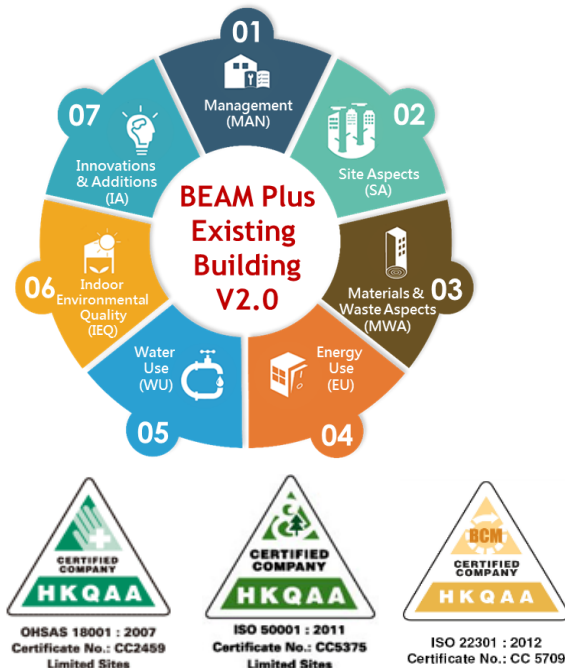
O-chart for IoT Development with Different Partners



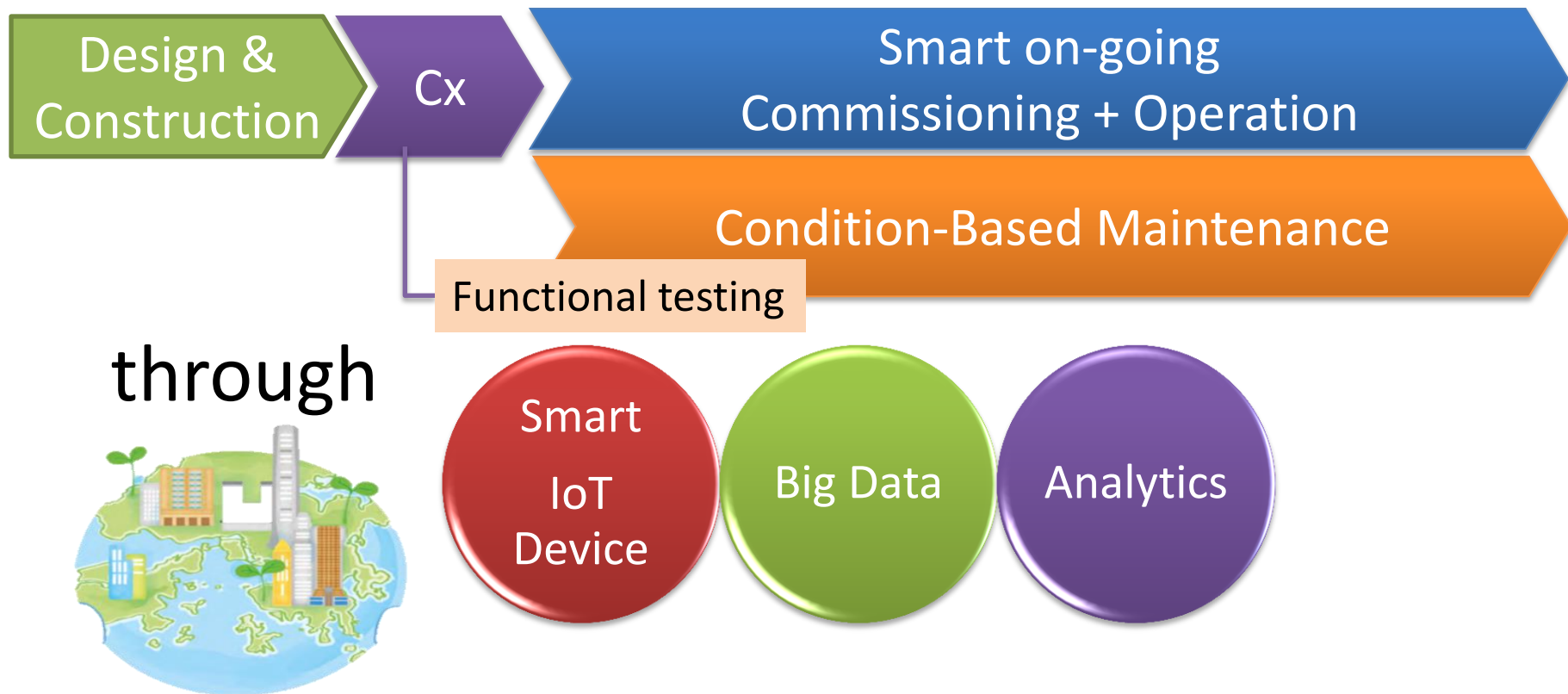
Smart Building Development

Our Management System

- Assesses the policies, procedures and strategies implemented to ensure buildings operate in a sustainable manner
- ICC Management Systems:
 - **BEAMPLUS Existing building v2.0**
 - **OHSAS 18001, ISO 50001, ISO 22301**
 - **Retro-commissioning (RCx) / Lift cycle commissioning**
- Management Policy & Plans:
 - Building Services Maintenance Plan
 - Energy Management Plan
 - Waste Management Plan
 - Environment Purchasing Plan
 - Water Conservation Plan

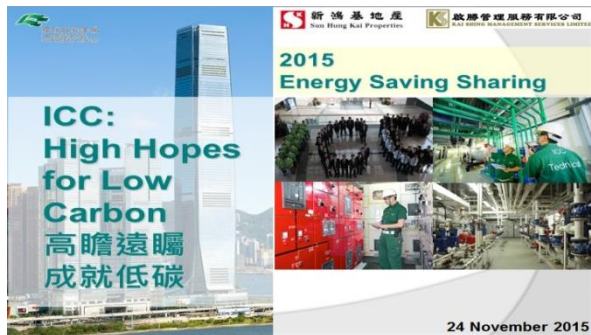


Smart Building Development



Public Seminar/ Visit for Best Practices Sharings

- ICC was invited to share energy saving achievement via the implemented MVAC strategies on **Sun Hung Kai Properties (shkp) 's Internal Sharing Session for Kai Shing, Hong Yip and SHK Real Estate Management**



24th Nov, 2015



26th Oct, 2016



26th Oct, 2018

Public Seminar/ Visit for Best Practices Sharings

Seminars / Sharing

Experience sharing of winners of Energy Saving Championship Scheme 2016

Experience Sharing Seminar with winning teams of Energy Saving Championship Scheme 2016

Environmental Forum on Green and Healthy Buildings

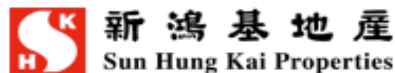
Technical Visit to International Commerce Centre – BEAM Plus for Existing Buildings (EB) v2.0 Comprehensive Scheme A – Final Platinum

Energy Saving Sharing Session for Kai Shing, Hong Yip and SHK Real Estate Management Sharing on 9th Oct, 2018

Experience Sharing Session – Energy Saving Championship Scheme 2017

University Visit - HKU, PolyU, City, THEi, Penn State, etc.

Sky-high experience at Sky 100 for primary & secondary schools



Public Seminar/ Visit for Best Practices Sharings



HKGBC will upload
2 CPD credits to
individual account
for BEAM Pro and
BEAM Affiliate

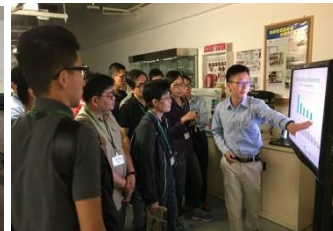
This event is co-organised by the Hong Kong Green Building Council Limited (HKGBC) and The Open University of Hong Kong (OUHK).

Thank you for your support. The event is full house now.



Organised by BEAM Society Limited
Technical Visit to International Commerce Centre –
BEAM Plus for Existing Buildings (EB) v2.0
Comprehensive Scheme A – Final Platinum

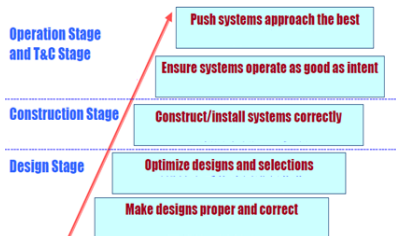
Date: 12 May 2018 (Saturday)
Time: 9:30am – 12:00noon (Registration starts at 9:15am)
Venue: International Commerce Centre
Gathering Point:
Level 3, ICC, 1 Austin Road West, Kowloon
Language: Cantonese supplemented with English as appropriate
Fee: HK\$125 (BEAM Pro & BEAM Affiliate)
HK\$750 (Others)
CPD Entitlement: 2.5 CPD hours for BEAM Pro and BEAM Affiliate
Enquiry: Email: beampromo.training@beamsociety.org.hk
Tel: (852) 3610 5700



Project Extension

ICC has been work with PolyU for *Life Cycle Commissioning* work to optimize the chiller plant system and the collected data & design approach is widely adopted in other buildings for optimize the energy efficiency of chiller plant system and achieve energy saving.

Steps towards Energy Efficient Buildings



Life Cycle Commissioning for ICC

Part 2 Strategy



MTR Station –
To Kwa Wan

Hong Kong
International
Airport office
building

New World
Centre TST



MTR station –
Tsing Yi



Sheung Wan
Holiday Inn
Hotels



Our Communication Chanel (External)



ICC Website



Tenant's Corner



ICC Notice



ICC Publications



Our Communication Channel (External)

啟勝管理服務有限公司
KAI SHING MANAGEMENT SERVICES LIMITED

CRM系統

登出

登入職員編號: 181092

CRM系統主目錄

輸入資料

輸入資料

GO

查看及編輯資料

查看資料

快速搜尋

檔案編號:

物業編號:

物業類別:

客戶名稱:

商標編號 (只適用於商標):

資料有效日期: 至 ☐ 只顯示有輸入日期的資料

紀錄狀況: GO

啟勝管理服務有限公司
KAI SHING MANAGEMENT SERVICES LIMITED

CRM系統

登出

登入職員編號: 181092

搜尋結果

檔案編號	物業編號	單位 / 組別號碼	所佔面積 (平方呎)	客戶名稱	資料有效日期	紀錄狀況	最後更新	功能
5722	ICC	寫字樓	ICC1201A_02A_08-05	Regus Business Solutions Limited	2013/11/05 至 2015/12/31	生效資料	2014/01/12 19:07	
5761	ICC	寫字樓	ICC1206B-07A	W-hotel		生效資料	2014/01/12 19:14	
5762	ICC	寫字樓	ICC1506A	Shinning Capital Management Hong Kong Ltd		生效資料	2014/01/11 17:21	
5763	ICC	寫字樓	ICC101A	Inakaya		生效資料	2014/01/11 16:07	
5764	ICC	寫字樓	ICC101B1	RyuGin		生效資料	2014/01/11 16:06	
5765	ICC	寫字樓	ICC101B2	Sky Crystal		生效資料	2014/01/11 16:05	
5766	ICC	寫字樓	ICC101C	Dragon Seal Restaurant & Bar		生效資料	2014/01/11 16:05	
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5768	ICC	寫字樓	ICC10001A-08B	Sky 100		生效資料	2014/01/11 16:11	
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5772	ICC	寫字樓	ICC1701B-03A	Hana Bank Hong Kong Branch		生效資料	2014/01/12 19:42	
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5774	ICC	寫字樓	ICC8504A	Sunshine Oilseeds Ltd		生效資料	2014/01/12 16:12	

Helpdesk System & Customer Relationship Management (CRM) System

Our Communication Chanel (External)



L3 & L8 e-directories to display building information and performance



Autodesk Viewer System



Section 3 *Measure*

Digital Building for 21st Century

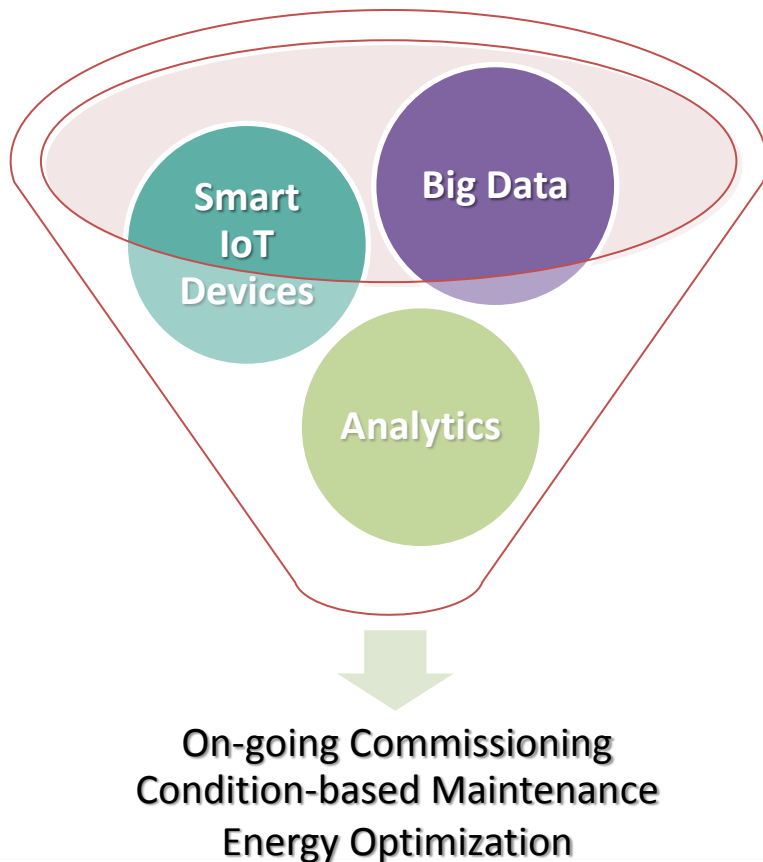
- “a bridge to a **greener future**”
- “a vehicle to reach **occupant health and wellness**”
- “an approach to a new **business model**”

Optimize
Predictive Informative
Adaptive Healthy
Virtual Real-Time
Comfort



Today, Tomorrow & Beyond

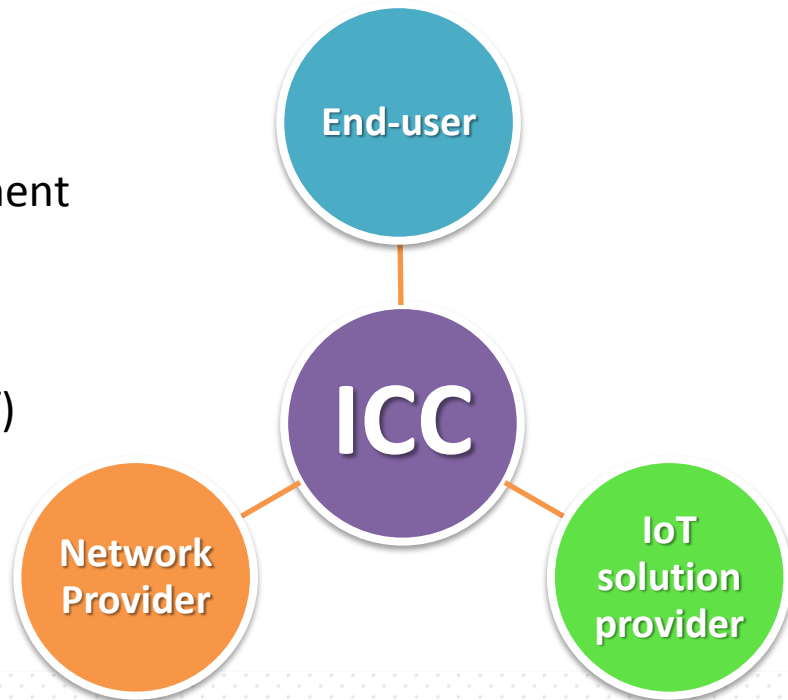
- Turn data into information, and information into insight



Smart Buildings Development

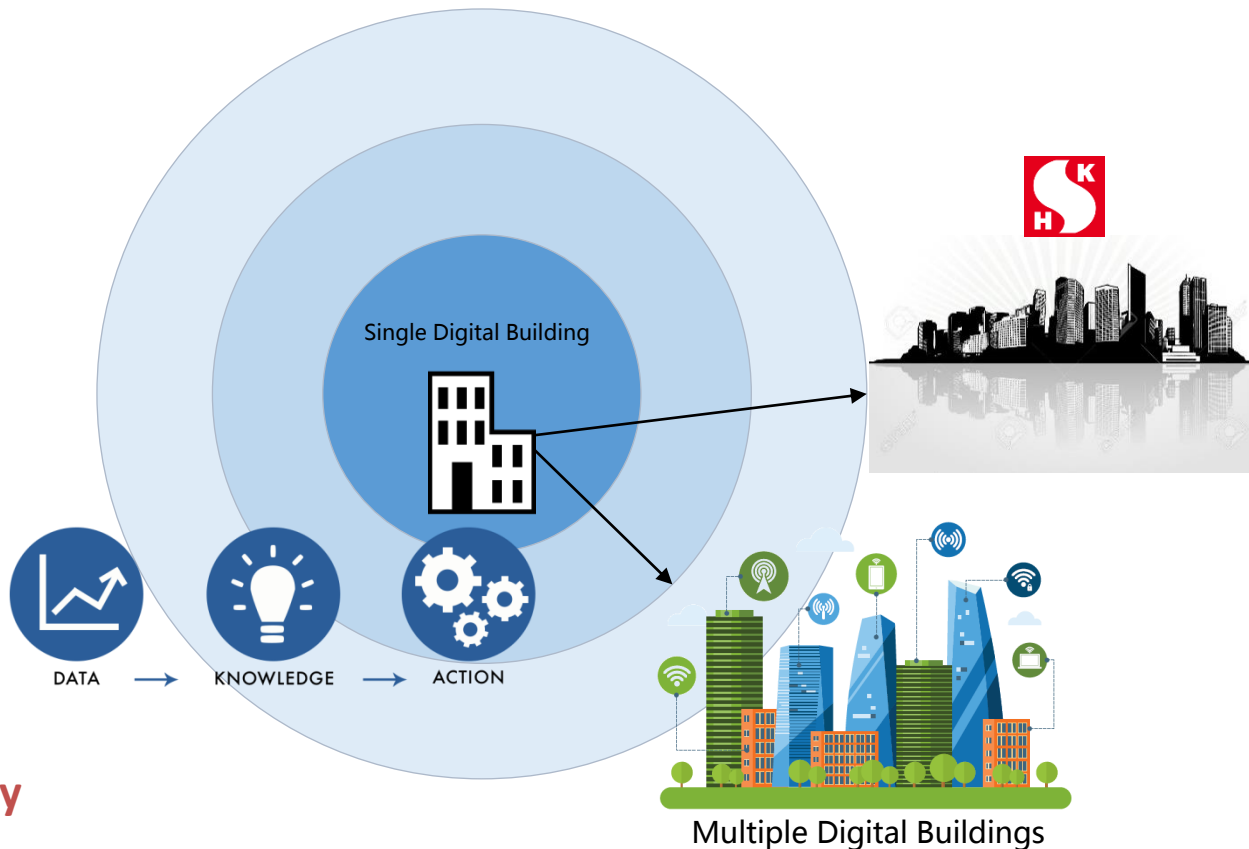
Smart Buildings shall make use of IoT technology to improve energy efficiency and building comfort

- Smart Lighting System
- Smart Lift Control System
- Smart Indoor Air Quality (IAQ) Management
- Optimal Control of Central Cooling & Air Conditioning System
- Air Handler Reborn Project
- Renewable Energy System (Feed-in Tariff)
- Demand Response Programme



Smart Buildings Development

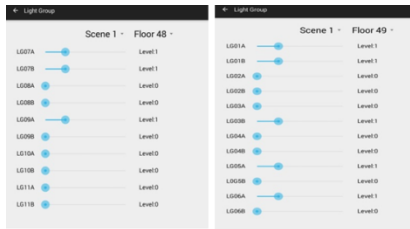
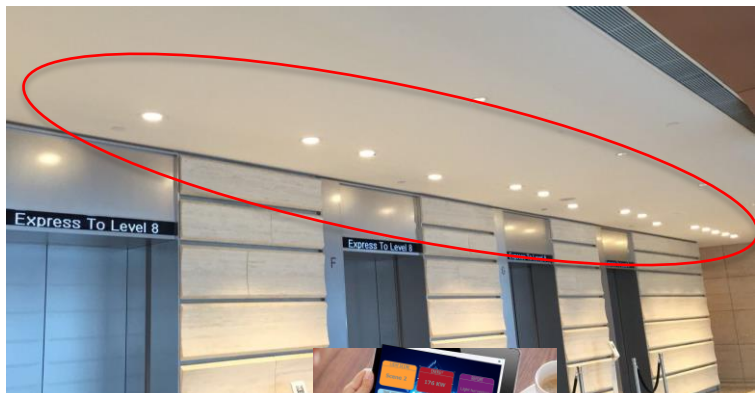
From a single digital building, to multiple digital buildings, and enhance branding of the corporation using digital services



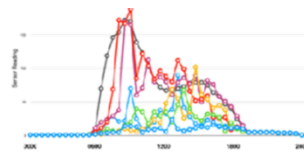
**From Smart Buildings
transform to Smart City**

Smart Lighting System

Smart Control for Lighting Pattern & Energy Use Tracing



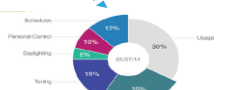
Optimize energy consumption
via different lighting sense



Regroup the Date for
Analysis



Daylight
Harvesting
Reprot



Power
Distribution
Report



FTP Raw Data Files

Capture Date, Time
& Sensor Level

Seq	No.	Date	Time	Level
0054	1	06	00:00	1
0055	2	06	00:00	2
0056	1	06	00:05	1
0057	2	06	00:05	2
0058	1	06	00:10	1
0059	2	06	00:10	2
0060	1	06	00:15	1
0061	2	06	00:15	2
0062	1	06	00:20	1
0063	2	06	00:20	2
0064	1	06	00:25	1
0065	2	06	00:25	2

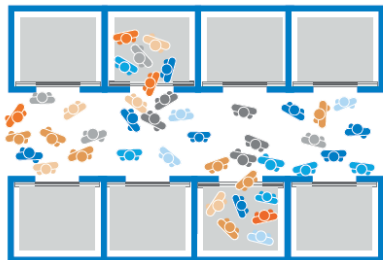
Page	Seq	No.	Date	Time	Level
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0	0055	2	06	00:00	2
0	0056	1	06	00:05	1
0	0057	2	06	00:05	2
0	0058	1	06	00:10	1
0	0059	2	06	00:10	2
0	0060	1	06	00:15	1
0	0061	2	06	00:15	2
0	0062	1	06	00:20	1
0	0063	2	06	00:20	2
0	0064	1	06	00:25	1
0	0065	2	06	00:25	2

Smart Lift Control System

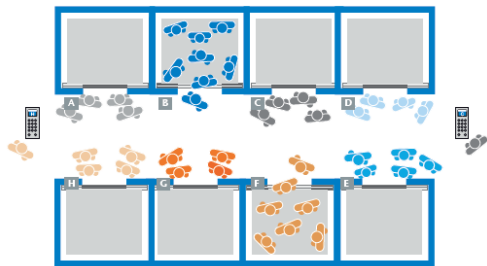
86 lifts (40 double-deck)

Destination Control System

Shorten both travelling and waiting time

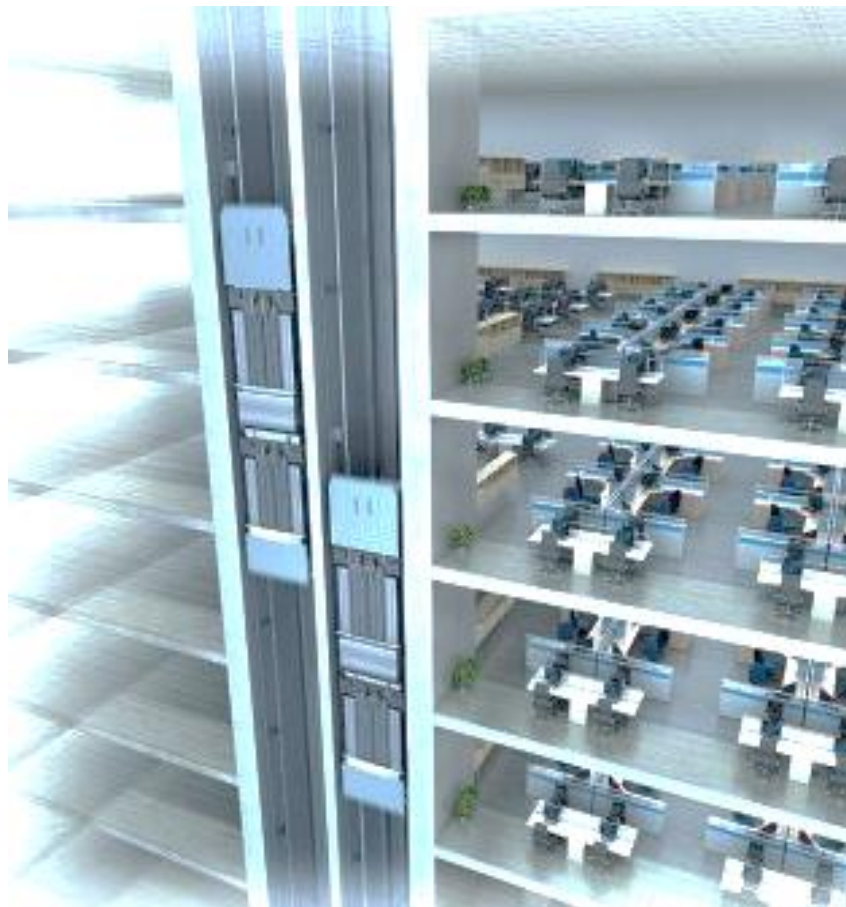


With conventional collective control systems, passengers wait in a crowd then rush into the first car that arrives. They also crowd around the car operating panel to select their destination floor. Those traveling to upper floors suffer from many intermediate stops.



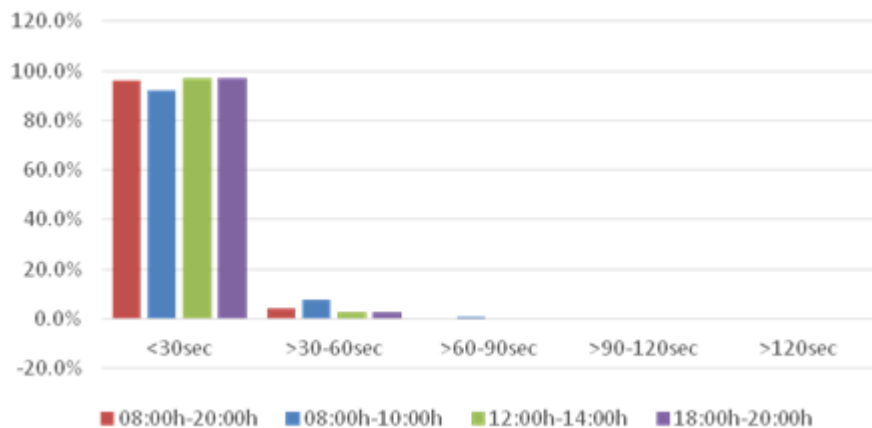
Port

Security for access
control & passenger
reports by Touch-less
system



Smart Lift Control System

Lift Traffic Analysis



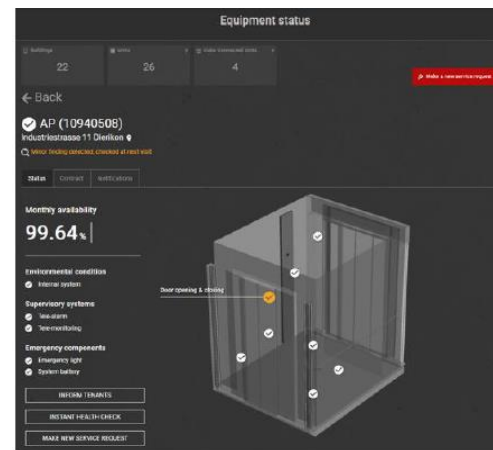
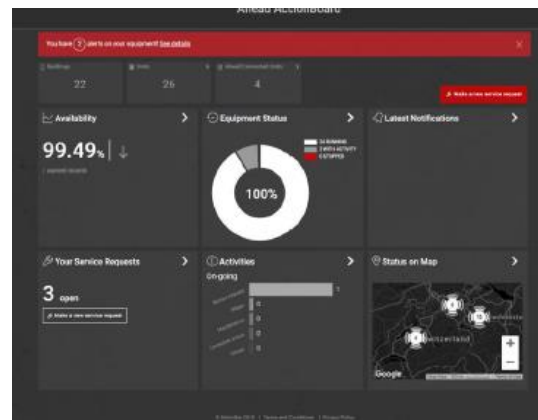
Based on the capability of the lift system to capture key information about traffic patterns of occupants, the availability of lifts will be adjusted to reduce wastage of energy while the facility is idle.

Mon. ~ Fri.		Total. # calls [person]	AWT [sec]	ADT [sec]	Call distribution Waiting Time (in average)				
					<30sec	>30-60sec	>60-90sec	>90-120sec	>120sec
All Day	08:00h-20:00h	31217	5.9	76.9	95.9%	4.1%	0.0%	0.0%	0.0%
Morning peak	08:00h-10:00h	9843	8.5	80.6	92.1%	7.8%	0.1%	0.0%	0.0%
Lunch peak	12:00h-14:00h	7142	5.7	78	97.2%	2.8%	0.0%	0.0%	0.0%
Evening peak	18:00h-20:00h	2901	5.3	76.6	97.3%	2.7%	0.0%	0.0%	0.0%

Smart Lift Control System

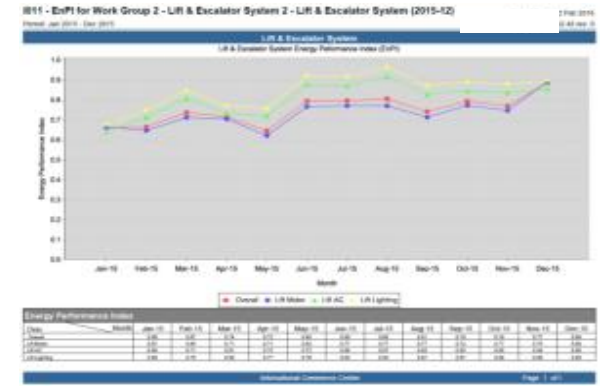
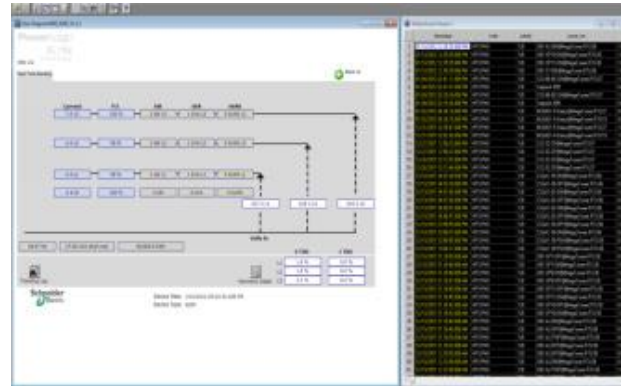
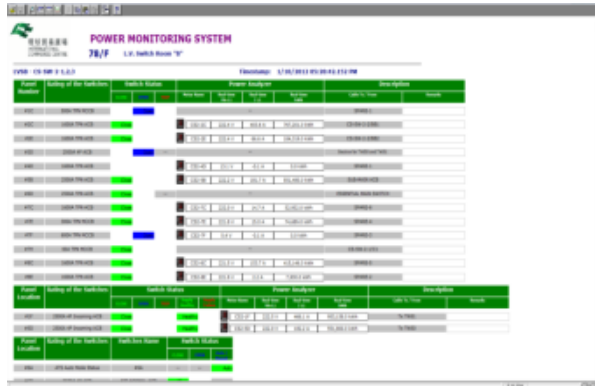
Future Development of Internet of Elevators and Escalators (IoEE.) in ICC

- *Allows proactive on events and to define whom should be informed automatically on equipment status changes*
- *Real-time insights in day-to-day operations and mid-term planning needs, with full transparency on status and maintenance activities notifications.*



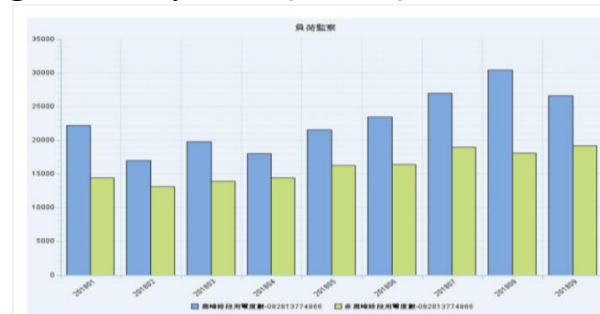
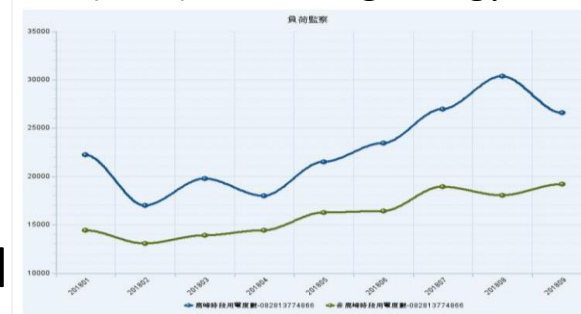
Energy Management System

Use Smart Energy System to record, collect, analyze the power usage data to provide a full picture of each trade, each floor and each time period about energy consumption.



Power Monitoring System (PMS) & Building Energy Management System (BEMS)

- Load Profile
- Load Monitoring
- Energy Analysis
- Forecast Peak Demand



Smart IAQ Management

Whole building of ICC has been awarded “Excellent Class” under Hong Kong IAQ Certification Scheme since 2014.



Smart IAQ Management

Needs for Smart IAQ management

- Fit-out works are a fact of life in Hong Kong office buildings, which may induce dust and odour to indoor environment
- The enhanced working environment lowers the absenteeism while boosts the workforce productivity.
- Closely monitor the indoor air quality during fit-out works can minimize impact for occupancies



Periodic cleaning of air handling units



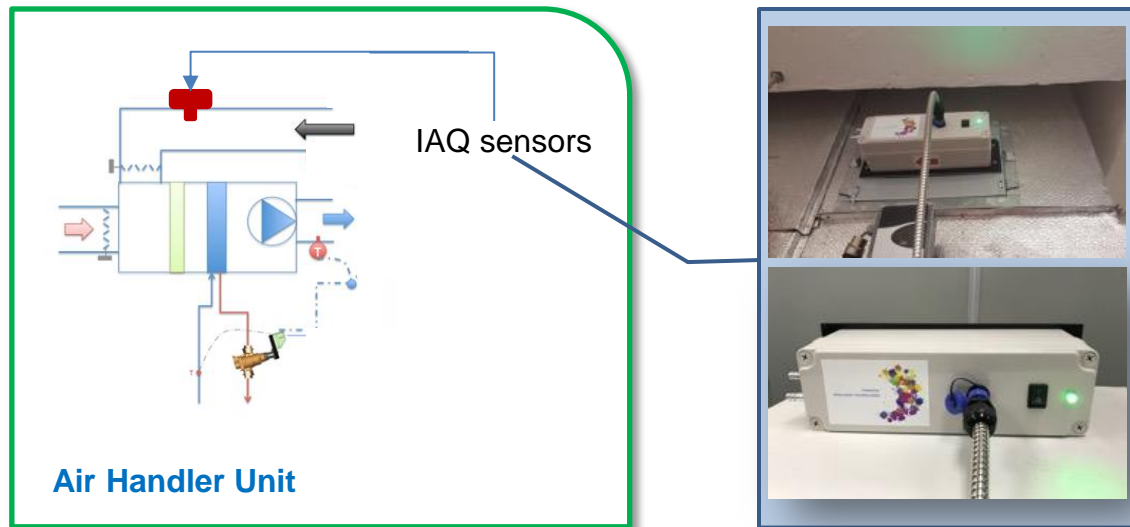
Equip with standalone air purifying devices in public areas



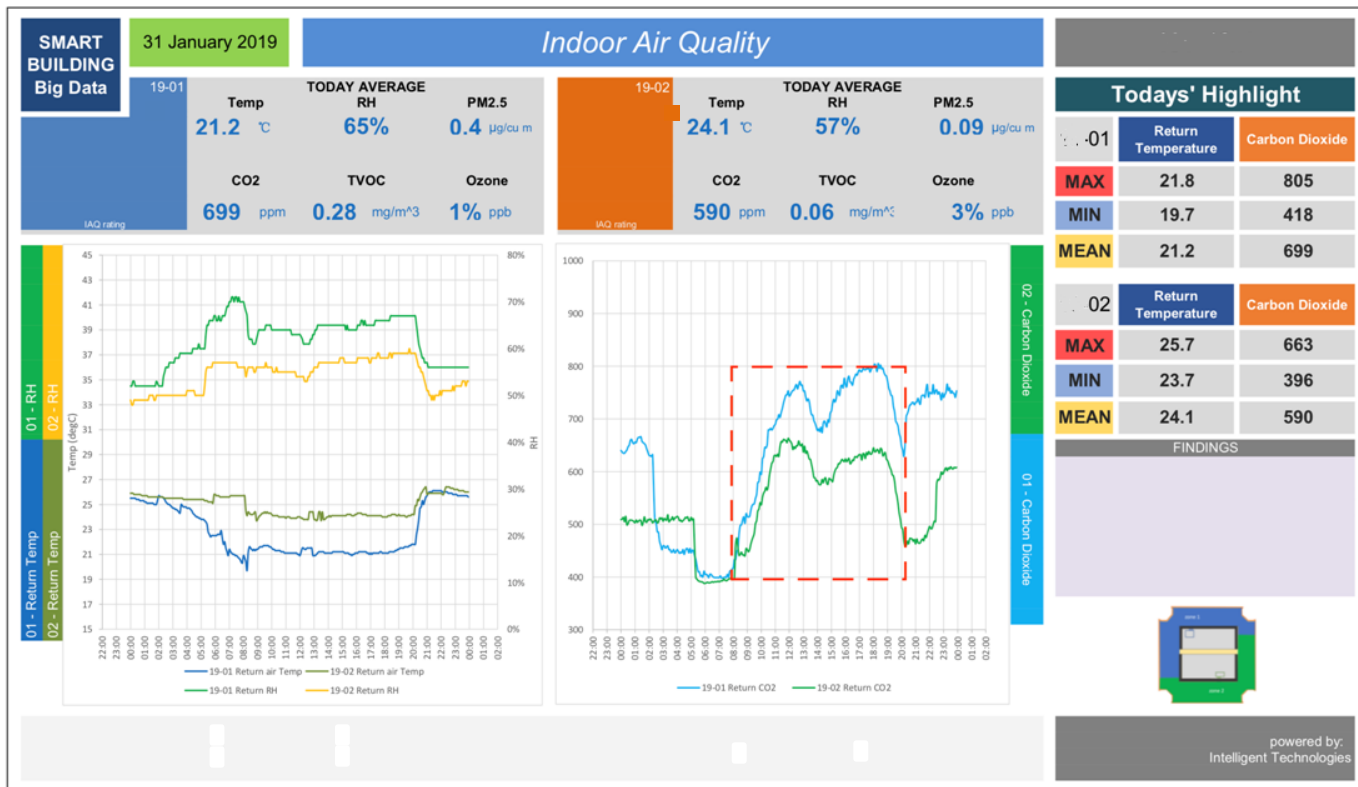
Make use of blowers to enhance air movement during fitting out of premises

Real-time Indoor Air Quality Monitoring System

- With the use of IoT, AHUs are connected for real-time environmental monitoring for **relative humidity, total volatile organic compounds (TVOC), ozone and PM2.5 level**.
- Demand control ventilation is adopted in the office area while IAQ sensors are embedded into the return air duct of AHU.



Real-time Indoor Air Quality Dashboard



Today's Highlight

	Return Temperature	Carbon Dioxide
MAX	21.8	805
MIN	19.7	418
MEAN	21.2	699

	Return Temperature	Carbon Dioxide
MAX	25.7	663
MIN	23.7	396
MEAN	24.1	590

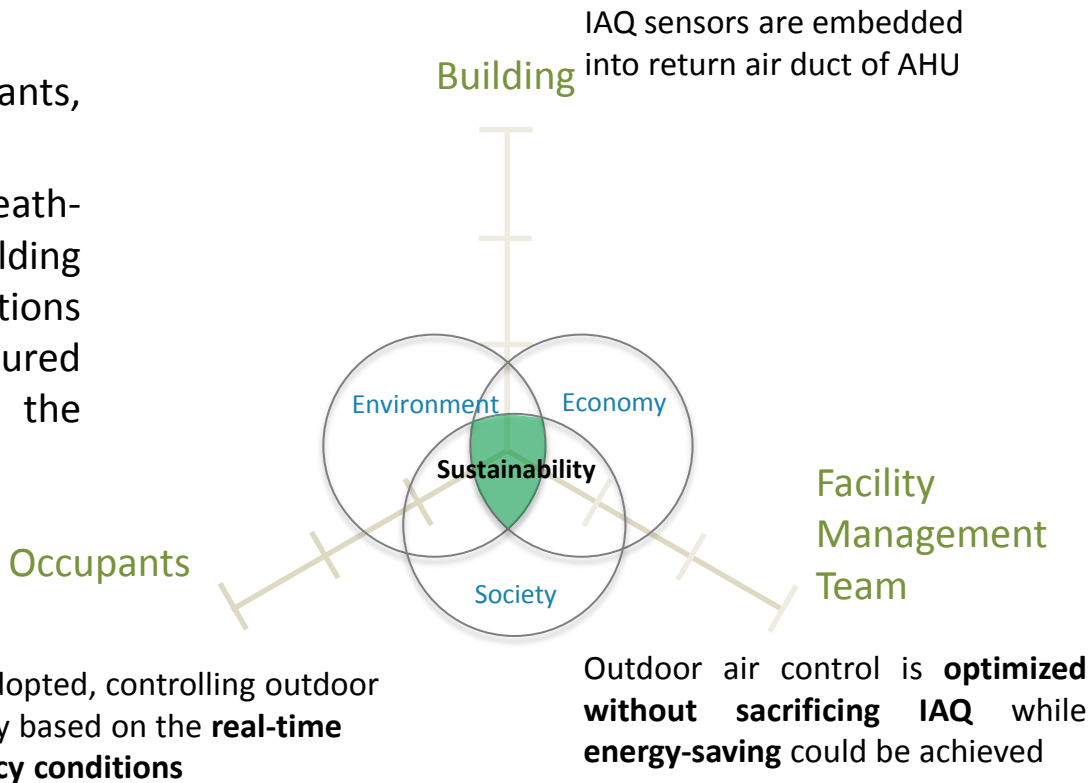
FINDINGS



powered by:
Intelligent Technologies

Real-time Indoor Air Quality Monitoring System

- IoT connects between occupants, building and building landlord.
- Real-time IAQ monitoring allows health-focus environment for building occupants. Immediate remedial actions could be taken in case the measured IAQ parameters fall below the acceptable levels.



IoT PROJECT 1

OPTIMAL CONTROL OF CENTRAL COOLING AND AIR CONDITIONING SYSTEM

Collaboration with Academia



Life Cycle Commissioning Works

Retro-commissioning



Life Cycle-commissioning

Steps towards Energy Efficient Buildings

Operation Stage
and T&C Stage

Push systems approach the best

Ensure systems operate as good as intent

Construction Stage

Construct/install systems correctly

Design Stage

Optimize designs and selections

Make designs proper and correct



THE HONG KONG
POLYTECHNIC UNIVERSITY
香港理工大學

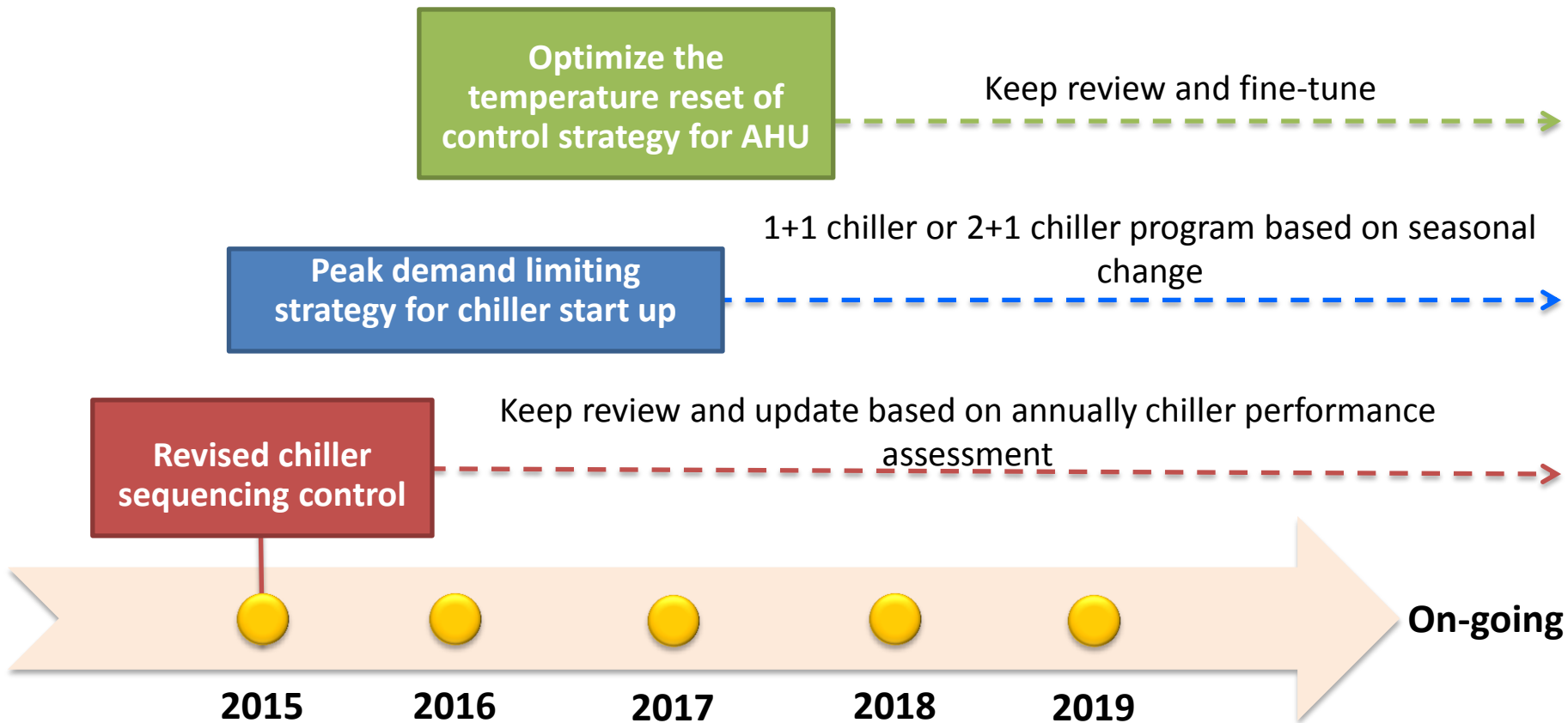


Energy Performance Enhancement Work

Optimal AC Control Strategies

- Revised Chiller Sequencing Control
- Optimized design configuration of PCHWP for HX
- Optimized cooling tower control
- Optimized HX control logic
- Optimized chiller water supply temperature
- Optimized control of secondary pump for AHU
- Peak demand limiting strategy
- Optimized control of AHU supply air static pressure

Energy Performance Enhancement Work

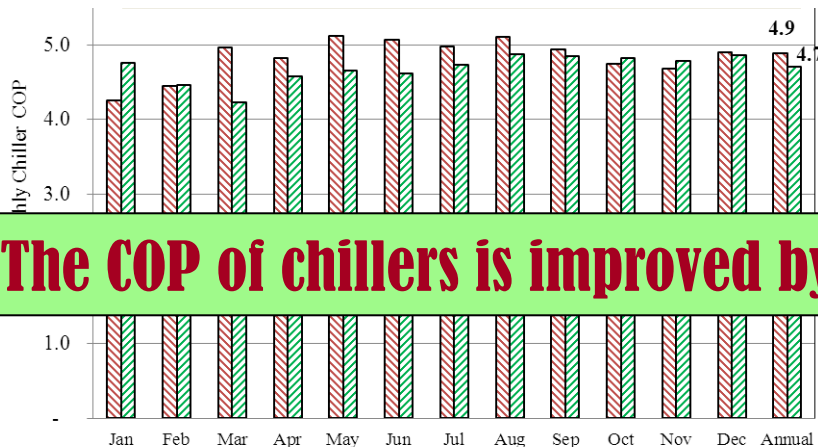


Optimize Chiller Sequence Control

Original Control: If cooling load <1000 RT, then operating chiller 2->1



Revised Control: If cooling load <1500 RT, then operating chiller 2->1



The COP of chillers is improved by 3.7%

Revised Chiller Sequencing Control

Big Data Analysis

The multilinear regression model used in the chiller sequencing control also have to be updated using the most recent operation data

$$Q_{ev,max} = c_0 + c_1 \cdot P_{ev} + c_2 \cdot P_{cd}$$

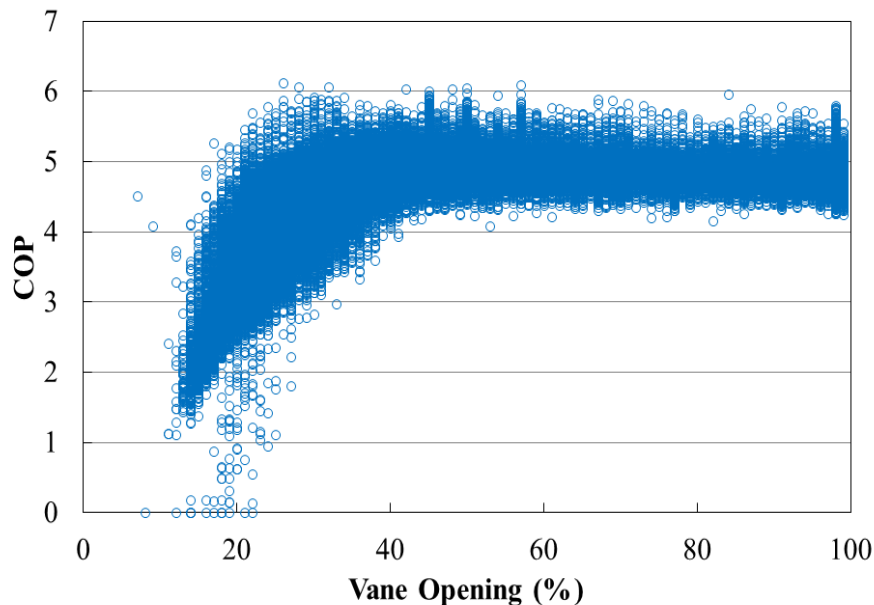
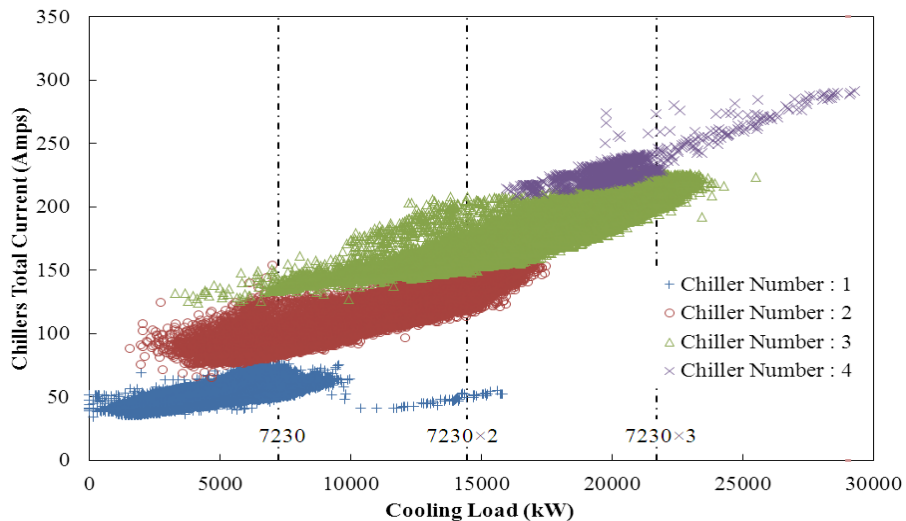
where, c_0 , c_1 , c_2 are regression coefficients based on operating history data. The coefficients shall be updated periodically

Remove chiller
One running chiller vane opening < 50%, and $Q_{max} \cdot 90\% > Q_{tot}$

Chiller #	c_0	c_1	c_2
1	3679.002	25.518	-3.462
2	3632.291	35.282	-5.607
3	2583.231	38.515	-5.073
4	10457.785	6.401	-3.741
5	3582.208	29.722	-4.199
6	4396.750	17.025	-2.367

The estimated saving is about 3%

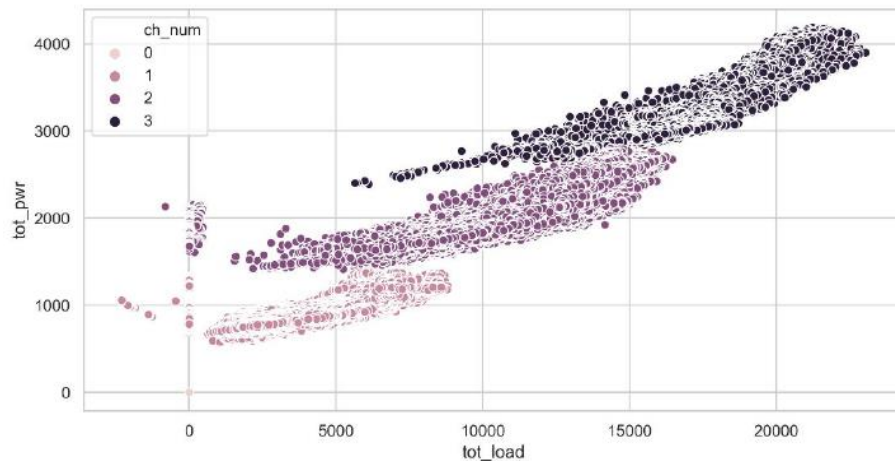
Further Improved Chiller Sequencing Control



COP is high if chiller vane opening is above 40%

COP is high if chiller vane opening is above 40%

Further Improved Chiller Sequencing Control



Chiller #	c_0	c_1	c_2
1	4192.728	21.588	-2.705
2	3422.679	27.446	-2.988
3	4418.941	37.989	-8.1444
4	9793.504	7.729	-5.222
5	5207.251	16.0198	-1.9788
6	8928.752	1.2137	-3.0327

Table 1 Percentage of time of different chiller number in the two years

Chiller number	0	1	2	3	4
2014	0.10%	59.80%	25.50%	14.40%	0.30%
2015	0.30%	59.50%	26.20%	14.10%	0
2016	0.40%	43.10%	31.70%	12.70%	12.10%
2017	0.10%	66.40%	21.80%	11.70%	0
2018	0.00%	65.50%	22.20%	12.30%	0

$$Q_{ev,max} = c_0 + c_1 \cdot P_{ev} + c_2 \cdot P_{cd}$$

Coefficients are reviewed regularly and was updated in Feb 2019

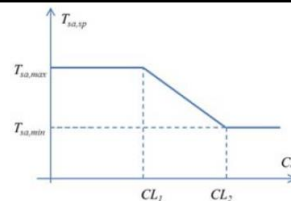
Optimize Temperature Reset Control Strategy for AHU

- Find the optimal supply air temp set point
- (Original) By supply air fan speed
- (New) Calculate cooling load of individual AHU by real-time cooling load through air side sensors
- Prevent the downstream effect during low cooling demand season, therefore guarantees indoor thermal comfort.
- Annual energy saving: 250,000 kWh

Original Control

Increase set-point	Decrease set-point	constrains
AHU VSD < 60% for 700s (+0.5 DegC)	AHU VSD > 70% for 300s (-0.5 DegC)	Max: 18 DegC (Summer), 20 DegC (Winter) Min: 13 DegC (Summer), 16 DegC (Winter)

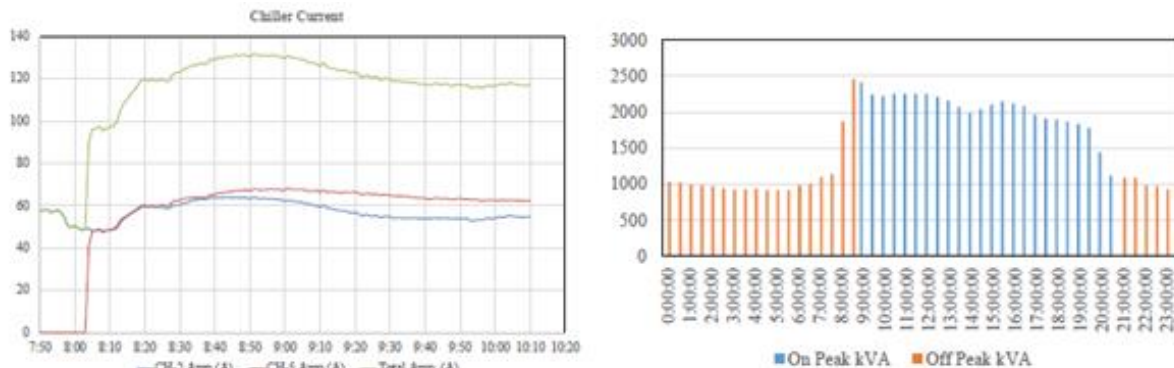
Modified Control



$$CL = M_{sa} \cdot (\rho_{sa} \cdot h_{ra} - \rho_{ra} \cdot h_{sa})$$

Peak Demand Limiting Strategy for Chiller Start Up

- Peak demand affects electricity cost and thus, there is room of electricity cost savings
- Applied area: all AHUs start at 8:00am simultaneously which would result in a peak in demand curve with high probability
- A deep analysis on the impact of morning peak demand was conducted to evaluate the possibility of reducing electricity cost, as well as energy consumption



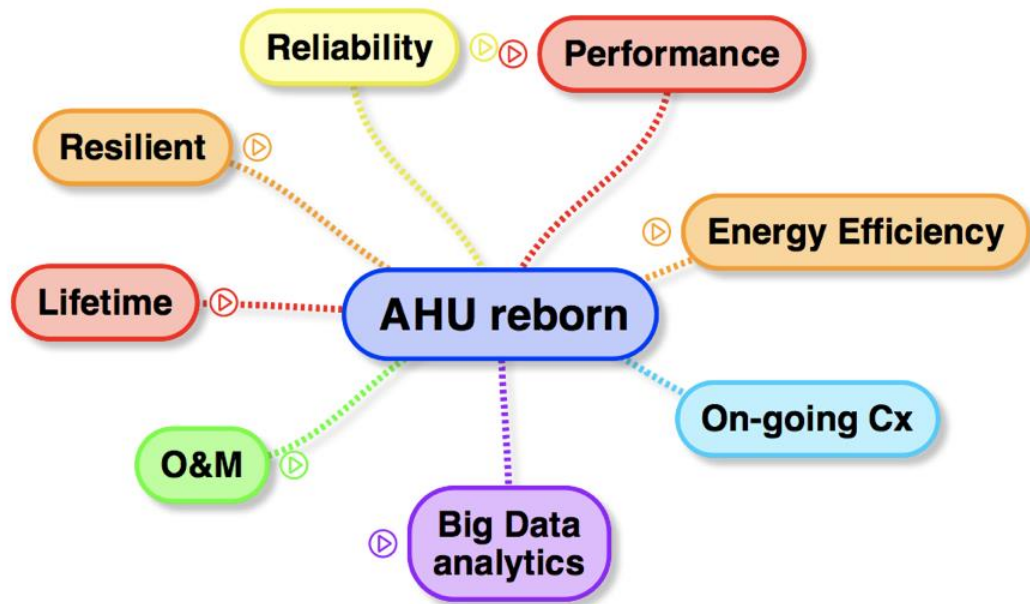
Chiller current and load profile in CLP online meter

IoT PROJECT 2 AIR HANDLER REBORN PROJECT

Collaboration with Industrial Partner

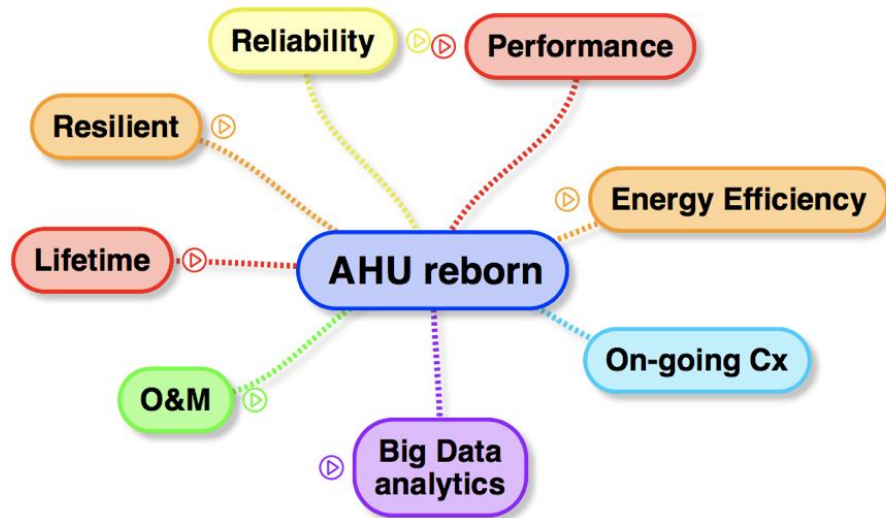


On-going Commissioning Works for AHUs



On-going Commissioning Works for AHUs

- Reliability improvement
- Improve energy efficiency
- Performance improvement
- **On-going commissioning**
- Predictive maintenance
- **Get CONNECTED**
- Data analytics
- Lift cycle improvement



Air Handler Reborn Project

IoT Based Energy Monitoring System

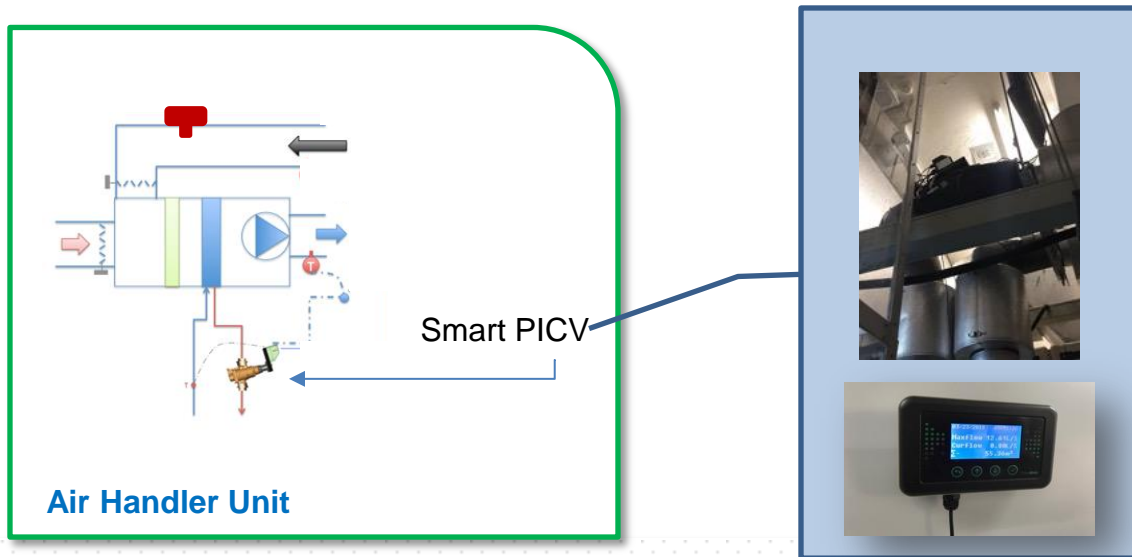


- Provide continuous retro-commissioning for the HVAC system
- Better optimization of energy saving and comfort
- Further saving real-time energy costs by weather forecast
- Help condition-based maintenance by machine learning algorithms
- Achieve energy conservation by enhanced operation control strategies based on past operational pattern and real-time data
- Real-time data visualization and big data analysis (trends of cooling load and energy profiles) allow the identification of needs and improvement opportunities across time and seasonal changes.

Air Handler Reborn Project

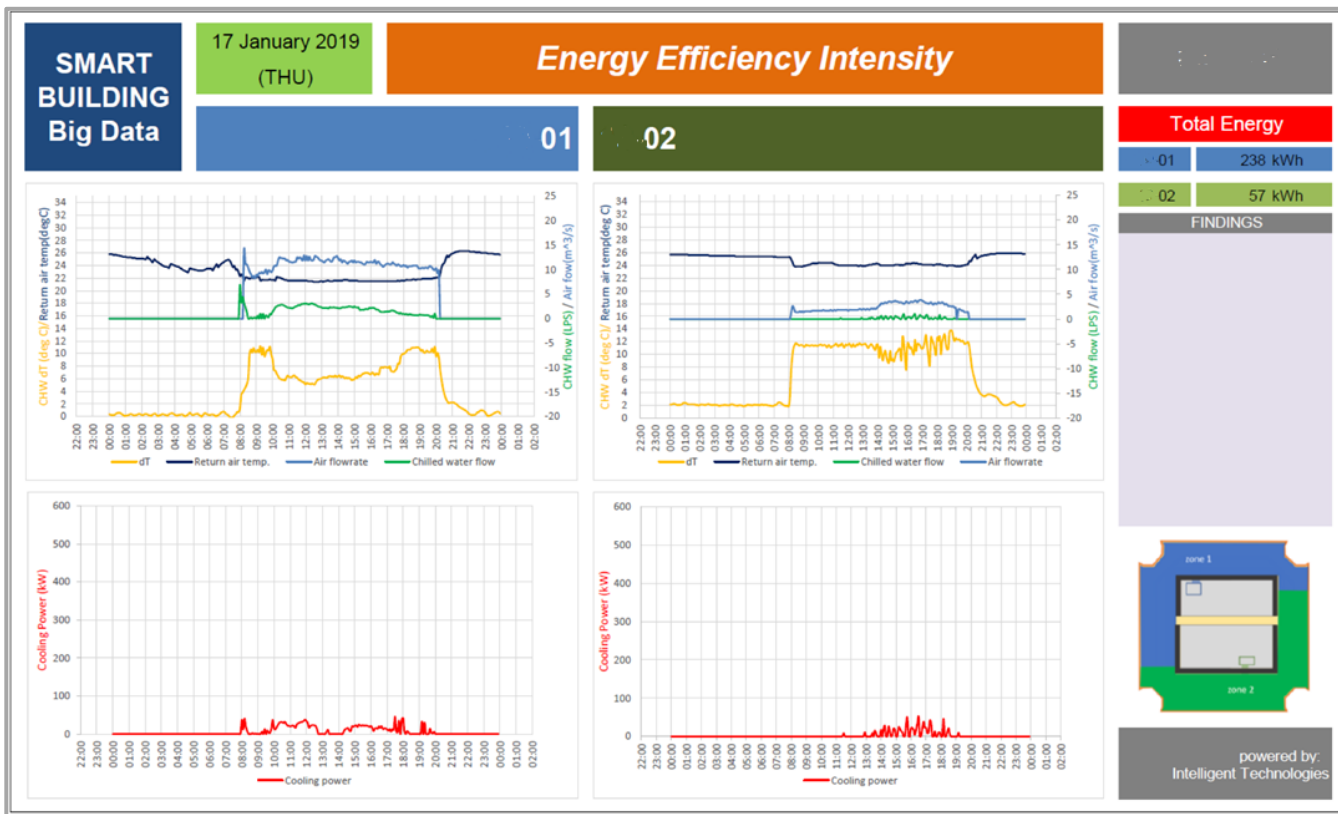
IoT Based Energy Monitoring System

- AHUs are connected by IoT devices, SMART pressure independent control valve.
- Real-time data monitoring includes air volume, chilled water delta temperature & flow rate, cooling energy and power consumption.
- Day-to-day energy consumption of air-side system is monitored closely.



Air Handler Reborn Project

Energy Efficiency Dashboard

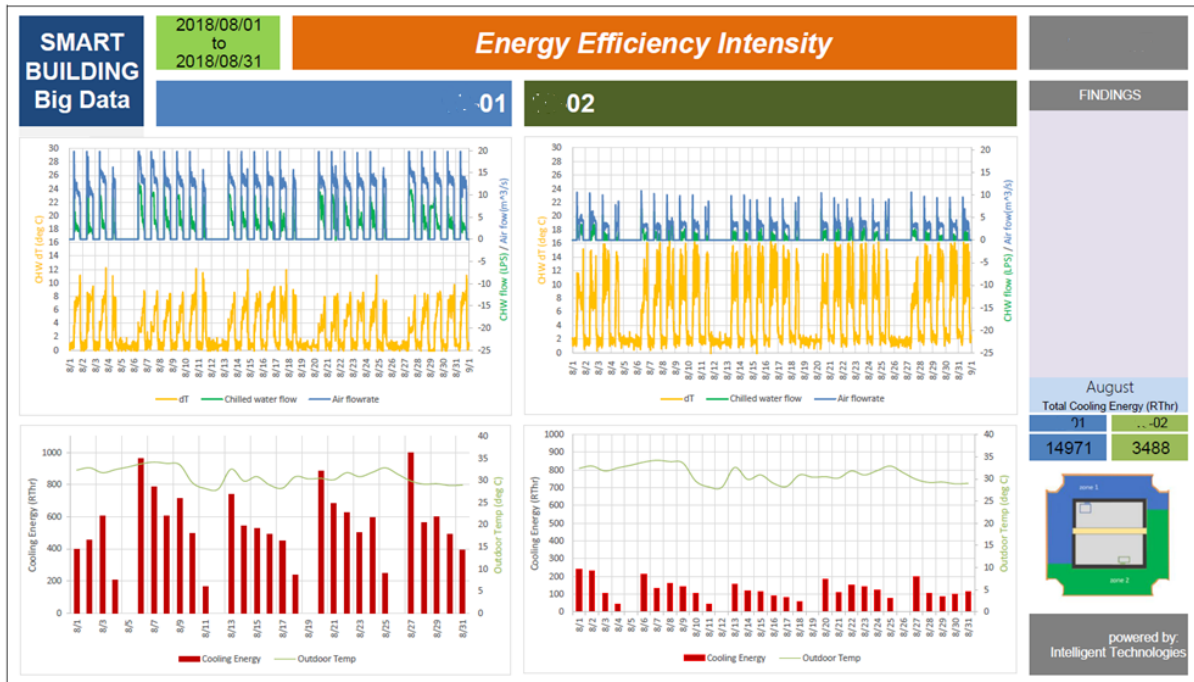


Air Handler Reborn Project

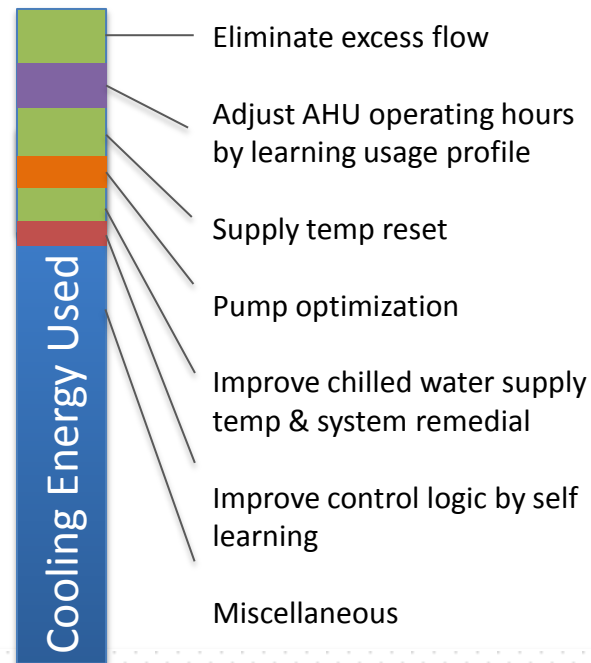
Big Data Analytics

IMPROVE COMFORT

IMPROVE ENERGY PERFORMANCE



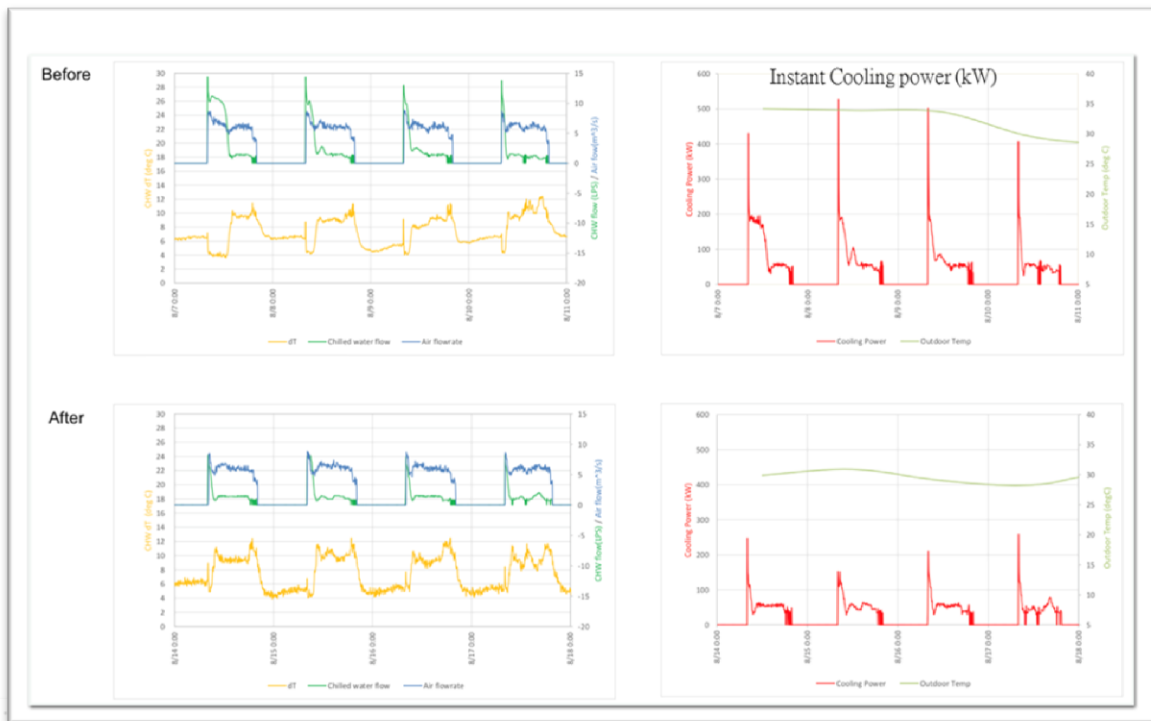
Energy saving categories:



Air Handler Reborn Project

Big Data Analytics for On-going Commissioning

- To identify energy saving opportunities & implement on-going commissioning



Air Handler Reborn Project

Big Data Analytics for On-going Commissioning

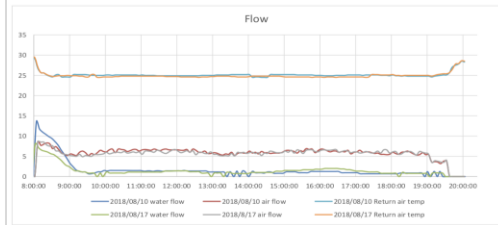
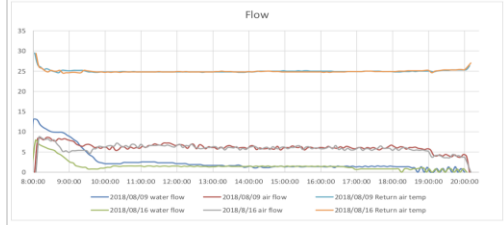
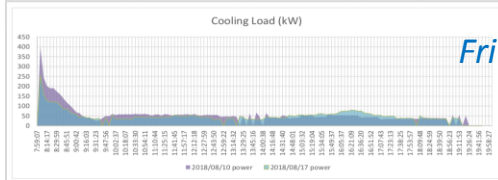
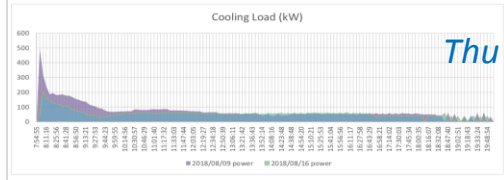
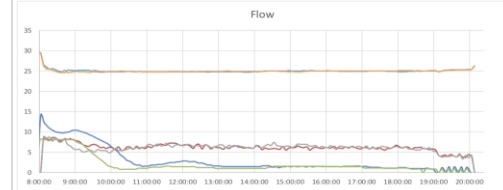
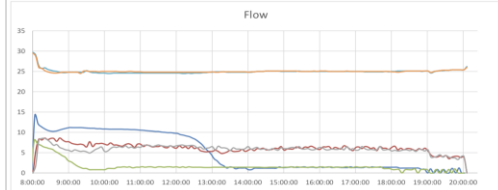
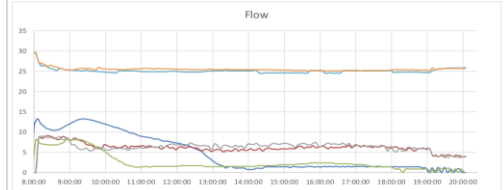
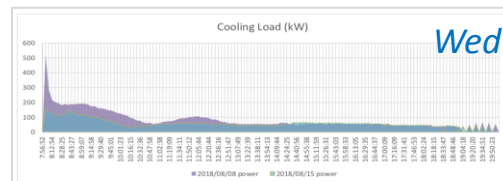
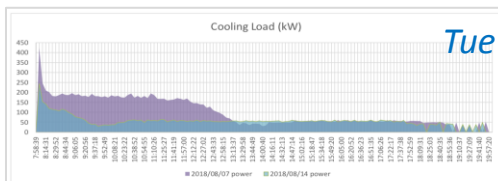
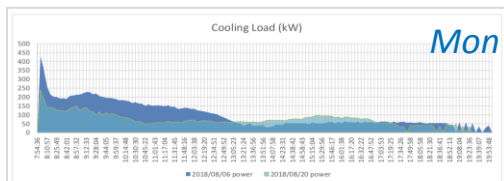
- Retro-commissioning the system based on the load trend analytics.
- By simulation algorithm, we optimize the flow control to achieve energy saving but not affecting the comfort level (return air temperature)



Return air temp

Air Handler Reborn Project

Big Data Analytics for On-going Commissioning



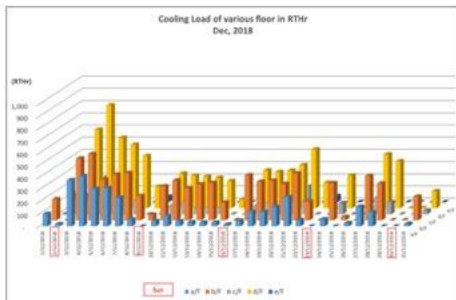
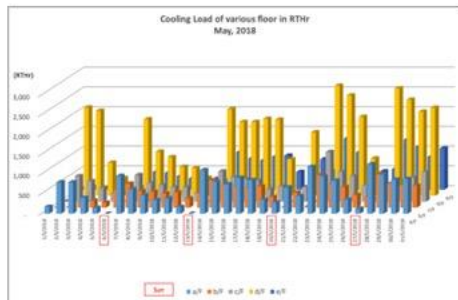
- Each zone has its own profile/characteristic
- Optimization for each zone based on the zone weekly profile & characteristic
- Maximize energy saving is achieved responding to the zone characteristic

Air Handler Reborn Project

Big Data Analytics for On-going Commissioning

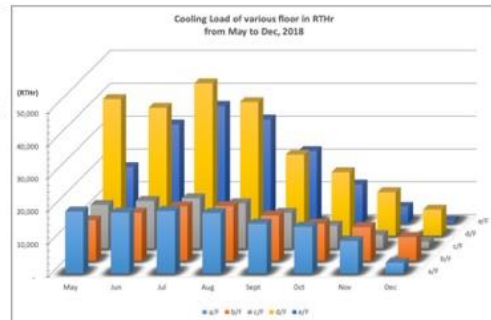
Continuous Improvement through Analytics

monthly Performance Analytics of each floor



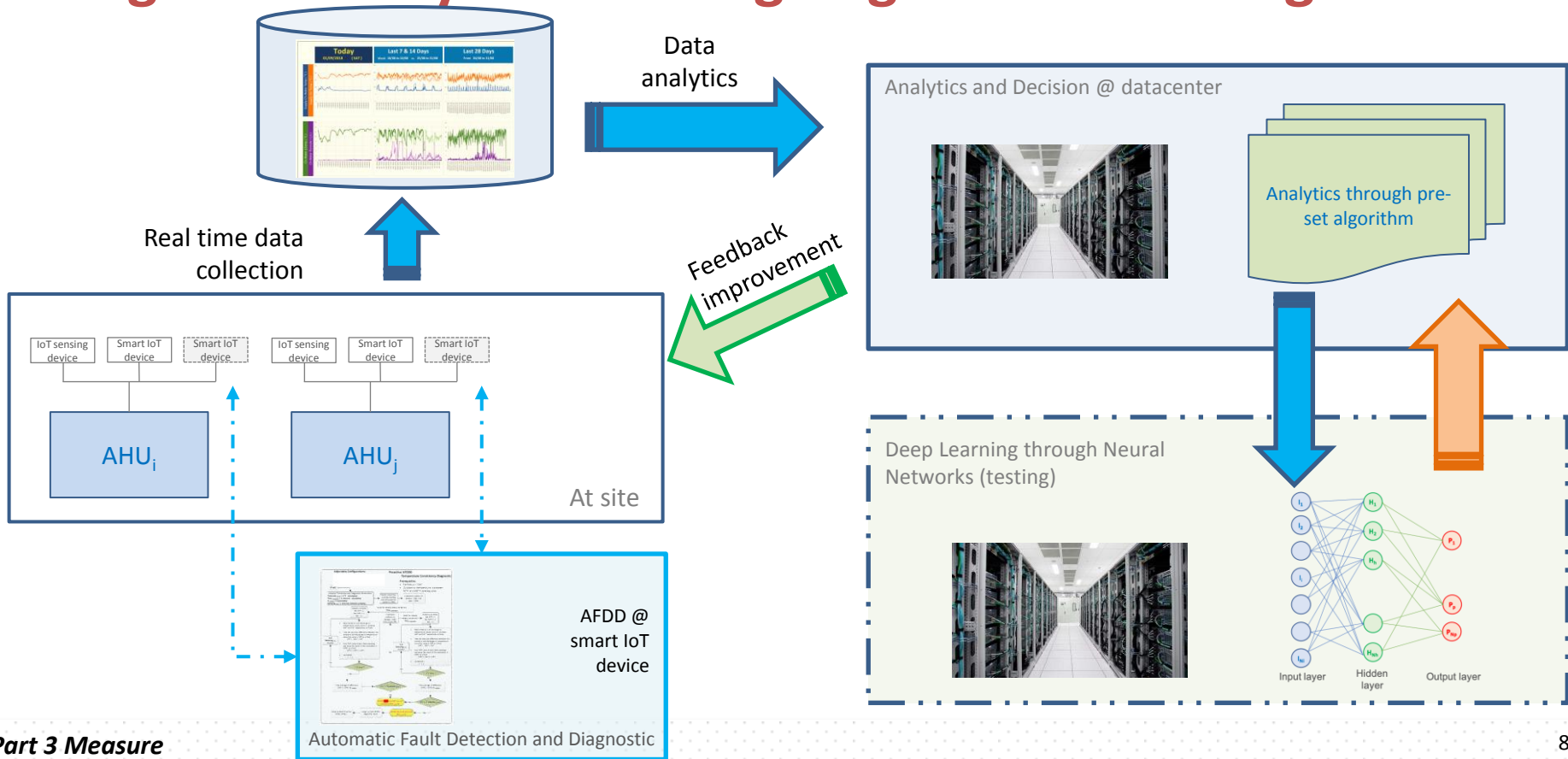
Performance Monitoring

- On-going energy saving monitoring;
- On-going Commissioning;
- Proactive maintenance action;
- Quick fault detection and diagnostics;



Air Handler Reborn Project

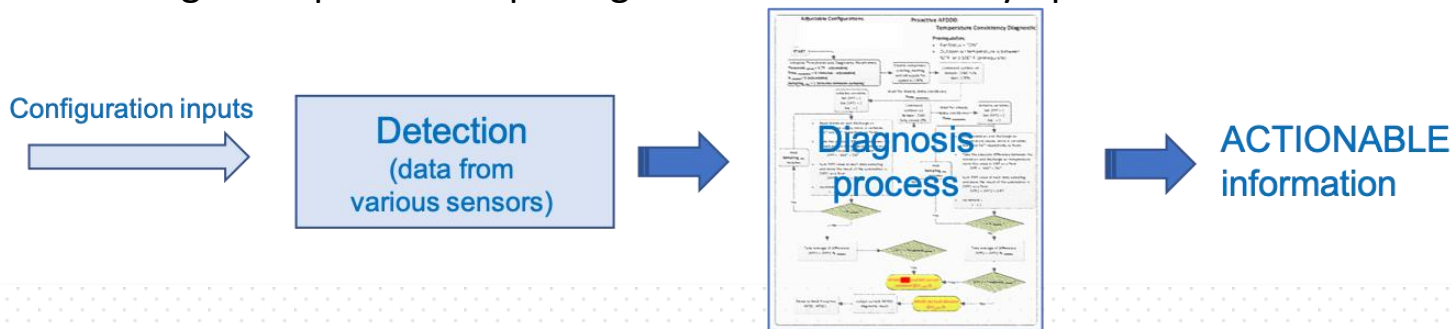
Big Data Analytics for On-going Commissioning



Air Handler Reborn Project

Automatic Fault Detection and Diagnostic

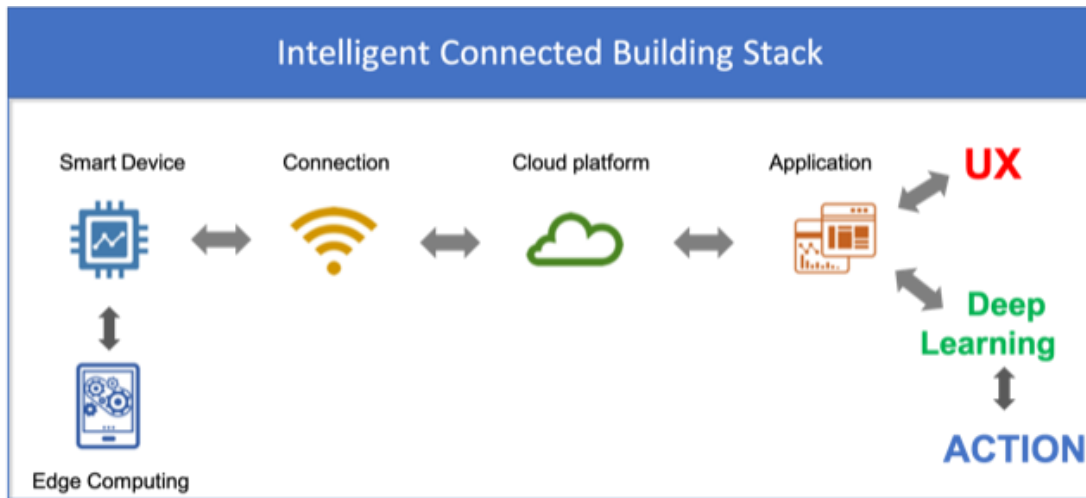
- Smart IoT devices with built-in automated fault detection and diagnostic process are employed
- Some algorithms include:
 - Detection of AHU/valve status/fault
 - Detection of actuator modulating status/fault
 - Detection of temperature sensor status/fault
 - Comparison of air/chilled water temperature for consistency
- Passive diagnostic process helps identify the failure in order to improve ACTION time
- Proactive diagnostic process helps diagnose and isolate faulty operations



Air Handler Reborn Project

Cloud Technologies

- Emerging Cloud technologies are used for data acquisition, analytics, storage; which benefit in faster setup, flexible resources and economies of scale
- Enable us to do data-mining in cross databases
- Enable us to share data in various applications to enhances our services



Air Handler Reborn Project

Energy Saving & Payback

Weekly Energy Saving of one AHU in August 2018

809 kWh

HK\$970

Annual Saving for All Office Floors

65 Floors

> 3,005,000 kWh

HK\$3.75 million

ROI = 1.3 Years

Summary of Air Handler Reborn Project

- *Retro-commissioning* of HVAC system beyond chiller plant is not easy, but we did it
- Result achieved in the area deployed:
 - *Cut Peak kW by 40%;*
 - *Estimated energy saving over 3 million HK dollar after applying to all office floors;*
 - *ROI 1.3 years;*
- Emerging technologies were used:
 - *IoT technologies*
 - *Cloud technologies*
 - *Big-Data analytics*
- Provide a **retro-commissioning model** for existing buildings
- Not only retro-Commissioning, but an **on-going Cx** solution
- Energy saving, but not compromise in human comfort
- **Quick** deployment and result model through emerging technologies

PROJECT 3 DEMAND RESPONSE PROGRAMME

Collaboration with Power Company and NGOs



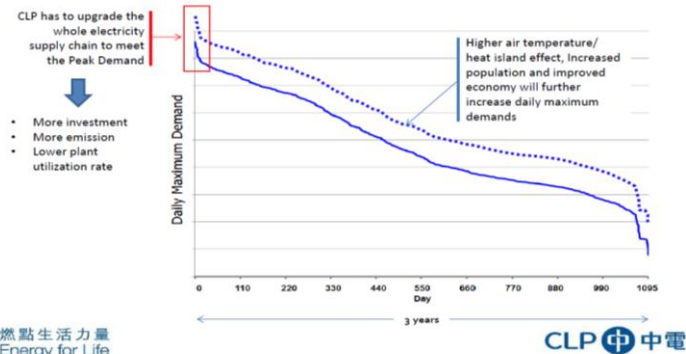
Demand Response Programme

CLP's Bi-lateral Demand Response (BDR) Programme

ICC joined the Bi-lateral Demand Response (BDR) programme launched by Power Company - CLP for reduce electricity demand during CLP peak demand hours and achieved **463 kWh saving** as well as acquired an incentive cost of HK\$6,685



Critical Peak Demand Appears A Few Hours in a Year



Demand Response Helps to Trim Peak Demands

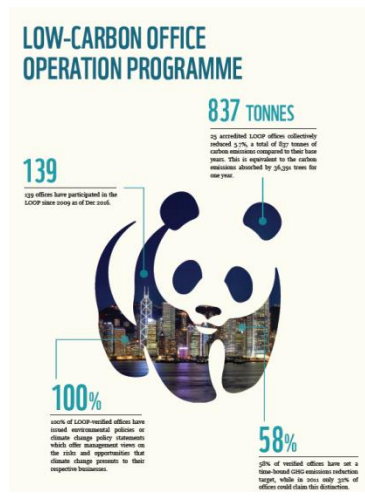


EVENT & INCENTIVE PAYMENT							
Event ID	Type	Date	Starting Time	Duration (hr)	Execution Status	Participated (Y/N) ?	Incentive Payment (HK\$)
AP-DO-170822	DAY-OF	22.08.2017	1400	2	Executed	Y	6,165
DR-DA-170821	DAY-AHEAD	21.08.2017	1800	4	Executed	Y	520
Total:							6,685

Low Carbon Programme



承諾支持世界自然基金會地球一小時
IS COMMITTED TO WWF'S EARTH HOUR



節能約章2018 Energy Saving Charter



為應對氣候變化，提倡全民節能
我們支持政府的《節能約章2018》

我們承諾

- (1) 在2018年夏季6月至9月期間，將室內平均溫度維持在攝氏24至26度之間；
- (2) 在2018年6月至2019年5月期間，關掉不使用的電器及系統；並且採購具能源效益的產品（如貼有一般能源標籤的電器用具、有門凍櫃）及系統；及
- (3) 與員工 / 學生共同實踐以上節約能源措施。

To encourage community-wide participation in saving energy
we support the Government's Energy Saving Charter 2018

We pledge

- (a) maintain average indoor air temperature between 24 – 26 °C during the summer months of June to September in 2018;
- (b) switch off electrical appliances & systems when not in use and procure energy efficient electrical appliances (such as those with Grade 1 energy labels, fridge with door) & systems from June 2018 to May 2019; and
- (c) engage staff / students to adopt the above energy saving practices together.



PROJECT 4 RENEWABLE ENERGY

Collaboration with Power Company



Renewable Energy System

HK Government launches Feed-in Tariff Rate

news.gov.hk

政府新聞網

March 28, 2019 (Thursday)

 26°C
  78%(14:03)
 

Home

Categories ▾

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Features

2019-20 Budget


ENVIRONMENT

Home > Environment > Feed-in tariff rates set

Feed-in tariff rates set

April 17, 2018

Like 0





The Government has decided to set the Feed-in Tariff rates at \$3, \$4 and \$5 per unit of electricity depending on the generation capacity of the renewable energy system concerned.

Feed-in Tariff (FiT) Rates

FiT rates will be offered according to the generation capacity of renewable energy power systems (REPS). The FiT rates effective from 1 January 2019 are:

REPS capacity (kW) (Note 1)	 ≤10	 >10 – ≤200	 >200 – ≤1,000
FiT rate (HK\$ per unit) (Note 2)	\$ 5	\$ 4	\$ 3



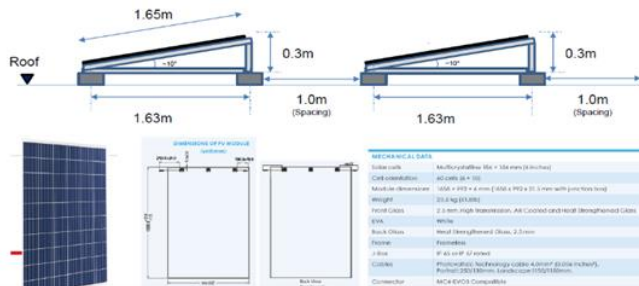
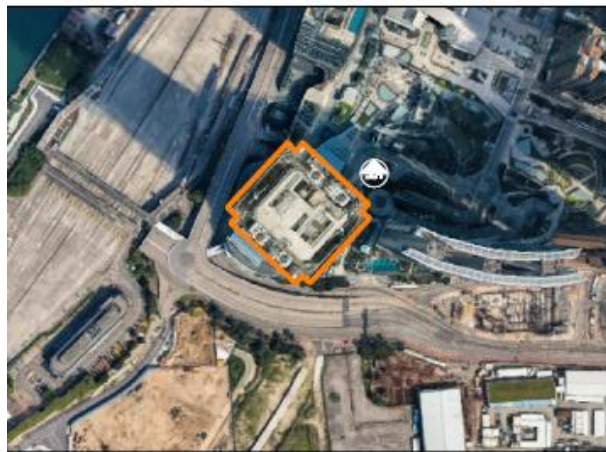
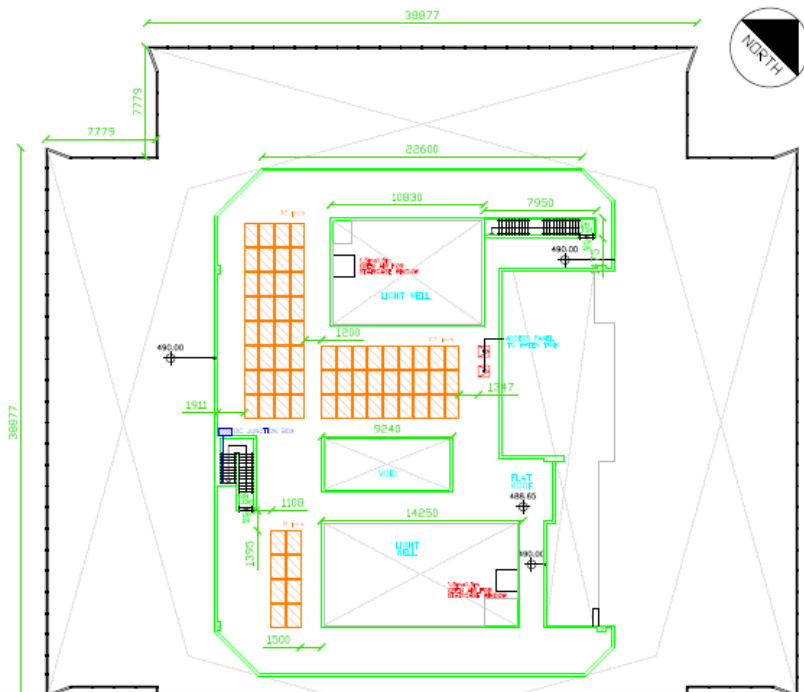
Key Information

Under the post-2018 Scheme of Control Agreements (SCAs) with the two power companies, Feed-in Tariff (FiT) is one important new initiatives to promote the development of distributed Renewable Energy (RE).

FiT will help encourage the private sector to consider investing in RE as the power generated could be sold to the power companies (HK Electric and CLP) at a rate higher than the normal electricity tariff rate to help recover the costs of investment in the RE systems and generation.

Renewable Energy System

Feed-in Tariff



Estimated 20,000 kWh Energy Generated Annually in ICC



Section 4

Performance

Key Energy Saving Performance Highlights

Energy Efficient Optimal Controls and Smart Energy Management of Buildings

- ICC Case

Shengwei Wang

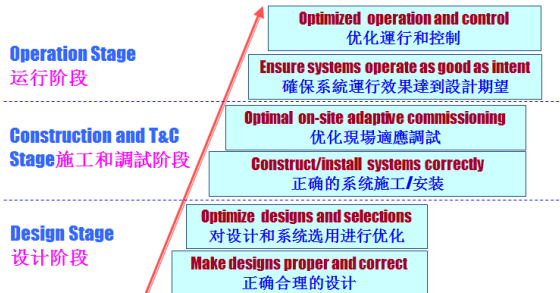
Chair Professor of Building Services Engineering
 Building Energy and Automation Research Laboratory

Department of Building Services Engineering/Research Institute for Sustainable Urban Development, The Hong Kong Polytechnic University
 beswwang@polyu.edu.hk

1,000,000 kWh energy consumption is saved due to the modification on the secondary water loops of Zone 3 & 4

2,360,000 kWh, (about **5.1%** of annual energy consumption of chillers and cooling towers) of the cooling system can be saving due to the change from single speed to variable speed using VFD

Our System Approach towards Energy Efficient Buildings



607,000 kWh, (about **2.8%** of annual energy consumption of chillers and cooling towers) of the cooling system will be wasted when the lowest frequency is limited at 37 Hz

3,500,000 kWh (about **7%**) of the total energy consumption of HVAC system) can be saved using PolyU control strategies based on the original design

Key Energy Saving Performance Highlights

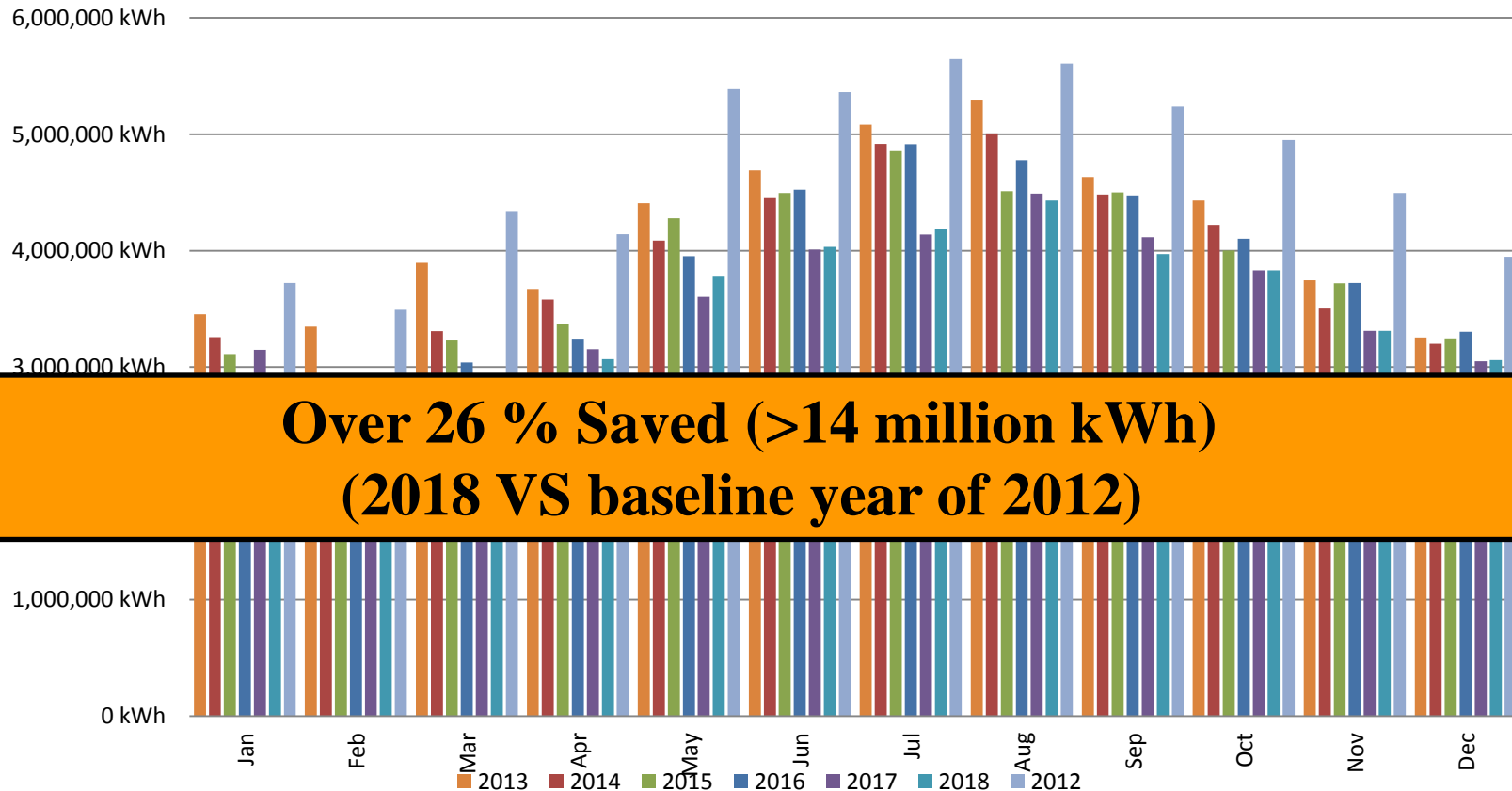
Saving by Design Optimization (Improving the system configuration and selection)** – compared with the original design. **About 3.5 M per year

Saving by Control Optimization** – compared with the case when the HVAC system operates correctly as the original design intent. **3.5M per year

***Saving by continuous commissioning and optimization :**
About 3.0 M per year*

**The Annual Total Energy Saving is
about 10.0M kWh**

Energy Saving Performance



Energy Saving Performance

Energy Utilization Index (EUI)



Energy Audit is conducted annually. The Energy Audit Form EE-5 obtained with Energy Utilization Index (kWh/m²/annum) from Registered Energy Assessor (REA) should display the Form at building main entrance.

Form EE5 表格 EE5
機電工程署
EMSD

The Government of the Hong Kong
Special Administrative Region
Buildings Energy Efficiency Ordinance
(Chapter 610, Section 22)
Energy Audit Form
能源審核表格

Section A 甲部: General Information 一般資料

Name of Building 建築物名稱	English 英文	International Commerce Centre
Address of Building 建築物地址	Street 街道	1 Austin Road West 九龍彌敦道西
District 地區	English 英文	Kowloon

Section B 乙部: Declaration 聲明

To: Building owner 建築物擁有人
cc: The Director of Electrical and Mechanical Services 機電工程署署長

In accordance with section 22 of the Buildings Energy Efficiency Ordinance (Chapter 610), I (full name) Eric S. M. Chan, Registered Energy Auditor (Registration No. EA001540), certify that an energy audit in respect of the above building was completed on 29/10/2017 (DDMMYYYY). This Energy Audit Form will expire on 29/10/2018 (DDMMYYYY) (see note 4).

The energy utilization index (EUI) per annum of the past 12-month period of the above building is 483.02 MJ/m²/annum, equivalent to 138.17 kWh/m²/annum. (see note 5)

茲證明建築物能源審核員 (第 610 章) 第 22 條之規定, 本人 (姓名) 嚴國基 作為註冊能源審核員 (註冊編號 EA001540), 現證明上述建築物的能源審核已於 2017 年 10 月 29 日完成。本能源審核表格將於 2017 年 10 月 29 日 (即滿一年) 失效。

有關上述建築物過去 12 個月期間的按年計劃能源使用指數為 483.02 兆焦耳/平方米/年, 相當於 138.17 千瓦小時/平方米/年。(見附註第 5)

Signature of Registered Energy Assessor
註冊能源審核員簽名

Date of issue (DDMMYYYY)
簽署日期 (日/月/年)

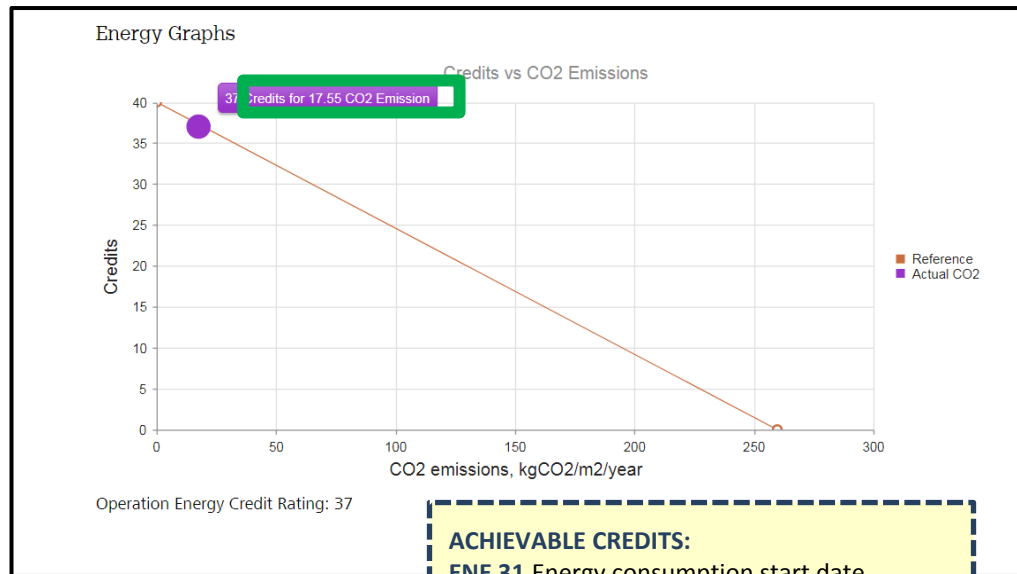
29 / 10 / 2017

EMSD Form EE5 (Rev. 11/13)

Energy Audit
Form EE-5

Key Energy Saving Performance Highlights

**Attained an energy credit rating of 37 out of 40
(equivalent to low CO₂ emissions)**



ACHIEVABLE CREDITS:

- ENE 31 Energy consumption start date
- ENE 32 Energy consumption end date
- ENE 33 Electricity consumption
- ENE 49, 52, 55, 58 & 61
- Non-standard energy consumption floor area



In shkp Sustainability Report, energy saving target of 15% by 2021 (as VS 2015), 9.74% saving was achieved for whole year of 2018

Energy Saving Performance



Building Energy Performance Assessment of ICC:

The first half-year Report of 2018

This report aims at providing an assessment of the monthly energy performance of ICC in the first half-year of 2018. In this report, the energy consumption data of the whole building and the historical operating data of the HVAC system are analyzed. The energy performance of the overall HVAC system and the individual sub-systems (e.g. chiller, cooling tower system, chilled water distribution system, air-side system) are assessed respectively.

1. Energy Consumption of whole building

Table-1 summarizes the total energy saving in the first half-year based on the original and days-corrected bill data respectively. From the original energy bill, the total energy saving of the whole building in the first half-year of 2018 was 367,532 kWh.

Table-1 Original and corrected energy bill data in the first half-year of 2018 and 2017

	Actual days	Unit count days		Original bill data		Days-corrected bill data	
		2017	2018	(kWh)		(kWh)	
		2017	2018	2017	2018	2017	2018
Jan	31	31	31	3,147,165	2,789,787	3,147,165	2,789,787
Feb	28	28	28	2,715,977	2,472,152	2,715,977	2,472,152
Mar	31	31	31	2,765,502	2,879,398	2,765,502	2,879,398
Apr	30	30	30	3,152,155	3,068,763	3,152,155	3,068,763
May	31	31	31	3,603,335	3,784,789	3,603,335	3,784,789
Jun	30	30	30	4,010,209	4,031,923	4,010,209	4,031,923
Sum	-	-	-	19,394,344	19,026,812	19,394,344	19,026,812
Savings	-	-	-	-	367,532	-	367,532

1

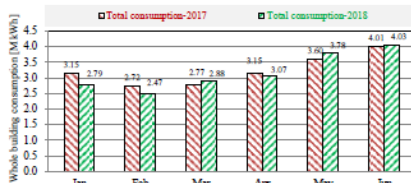


Figure-1 Whole building consumption in the first half-year of 2017 and 2018

Figure-1 shows the comparison of the total energy consumption of the whole building between the first half-year in 2017 and 2018. Significant energy consumption reductions can be observed in Jan, Feb, and Apr. In summary, the total energy consumption in the first half-year was reduced by 1.9 %.

Table-2 Energy Consumption of Main systems in the first half-year of 2017 and 2018

End-users	2017		2018		Energy Saving (M kWh)	Energy Saving Rate
	Consumption (M kWh)	Percentage	Consumption (M kWh)	Percentage		
HVAC	11.88	61.23%	11.65	61.21%	0.23	1.93%
Lighting & Equipment	4.65	23.98%	4.56	23.94%	0.09	1.98%
Lift	2.87	14.79%	2.82	14.83%	0.05	1.63%
Whole building	19.39	100.00%	19.03	100.00%	0.37	1.90%

The total energy consumption of the whole building is further broken down into the individual consumption of different systems, which provides more details about the energy usage and energy savings, as shown in Table-2. All energy consumers of ICC are classified into three

2

Regular Building Energy Performance Assessment Reports are conducted by PolyU. In the report, energy consumption data of the whole building and the historical operating data of the HVAC system are analyzed. The **energy performance of the overall HVAC system and the individual sub-systems** (e.g. chiller, cooling tower system, chilled water distribution system, air-side system) **are assessed** respectively

Over 20 Publications had been generated based on on-site implementations of new technologies

Automation in Construction 65 (2016) 79–85

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Development and validation of an effective and robust chiller sequence control strategy using data-driven models

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ARTICLE INFO

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Optimal chiller loading
Robust control
Measurement error
Certified chiller
Data-driven models

1. Introduction

1.1. Background

As the largest energy consumers in central air-conditioning systems, chillers can consume about 40% of the energy consumed by air-conditioning systems, and there is a strong potential to reduce the energy consumption of air-conditioning systems by enhancing the efficiency of chillers [1].

Optimal chiller sequence control, also known as optimal chiller loading, plays an important role in enhancing the chiller efficiency. In a well-designed large central air-conditioning system, multiple chillers are commonly used to fulfill the cooling load demand. The control of these chillers becomes important as they affect the cooling supply and the overall efficiency of chillers.

If the chillers are not well sequenced, they may either operate at low efficiency or fail to fulfill the demanded cooling load. In practical operations, chillers usually operate with low coefficients of performance (COP) due to the use of over-conservative control strategies. These strategies force extra chillers to operate, resulting in a low partial load ratio (PLR) of all operating chillers. They also increase the operation time of water pumps, which further increases the energy consumption of the chiller plants.

Various advanced strategies are developed by researchers to solve the problem. For instance, data fusion technology [2] is used for chiller

sequence control, which is validated using online data [3]. This technology takes the advantages of two cooling load calculation methods. Although the two methods suffer from measurement noise or model systematic errors, the fused cooling load could have better accuracy [4]. Other available strategies include particle swarm optimization [4], Lagrangian method [5], genetic algorithm [6], differential evolution algorithm [7], and stochastic control method [8].

However, these technologies involve complicated operations and large storage capacity and cannot be implemented easily in current building management systems (BMS). BMS engineers and operators also find them to be difficult to understand because they are less logically deductive than the control strategies in practice and are uncertain of their reliability. Consequently, these complicated control strategies are not widely implemented in real air-conditioning systems.

To address these issues, the fault tolerant control method can be used [9]. In this paper, a chiller sequence control method that is tolerant to sensor errors is developed based on typical strategies using basic principles.

1.2. Typical chiller sequence control strategies

Different methods would use different measurements to control chillers. Typical measurements used for chiller sequence controls are marked in Fig. 1.

1.2.1. Chilled water temperature based sequence control

The method determines chiller ON/OFF based on the return chilled water temperature [10,11]. If the return chilled water temperature is

80

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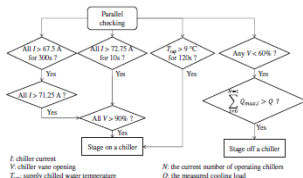


Fig. 3. Logic of the proposed chiller sequence control strategy.

difference in operation conditions. Since the bend at the peak of manufacturer's catalog data curve is not clear in real operation data. Considering measurement errors, it may not be practical or necessary to control chiller sequence through optimizing PLR at its optimal range specified in manufacturer's catalog data.

3.2. Chiller vane opening

A constant speed centrifugal chiller maintains its supply chilled water temperature at the set point by adjusting its refrigerant inlet guide vane opening and hence its capacity. This means that the vane opening should indicate chillers' operating capacities and efficiencies. Fig. 4 shows the correlation between chiller COP and its vane opening using its operation data. Obviously, chiller COP is maintained at a high level when the vane opening is higher than 40%. In other words, the chiller is operating at its highest efficiency if its vane is widely open. The curve shape in Fig. 4 is very suitable for optimal control since COP is not sensitive to the vane opening in the high efficiency range.

4. Building air-conditioning system and arrangement of online validation test

4.1. The building and its air-conditioning system

The proposed strategy is validated by an air-conditioning system in the tallest high-rise building in Hong Kong. The building has a height

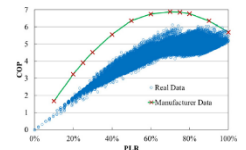


Fig. 3. The correlation between COP and PLR.

of 400 m and consists of 108 floors. It is divided into three parts: a car park (24,000 m²) on the ground floor, shopping arcade (57,000 m²), which are located between the ground floor and the fifth floor; and the building tower (230,000 m²), which consists of commercial offices and a six-star hotel on the top floors.

A large and complex air-conditioning system serves all floors of this building except the hotel on the floors above the 100th floor. Fig. 5 demonstrates the chilled water production and delivery system. Table 1 shows specifications of main equipment in the system. The six high voltage centrifugal chillers (3 phase, 11,000 V) are designed to supply the building with chilled water at 5 °C. Each chiller is associated with a chilled water pump and a cooling water pump. Both of them are constant speed pumps, and their on/off are interlocked with chillers.

Eleven cooling towers of two types (types A and B) are used to cool the condensers of the chillers. They are equipped with variable speed fans. The six type A cooling towers are controlled by one variable speed drive (VSD) system, while the other five type B cooling towers are controlled by another VSD. Their fan speeds are modulated by load controllers to achieve the cooling water temperature set point. Chilled water is supplied to three sections containing four zones as marked with A, B, C and D. Each chilled water zone has 5. Heat exchangers are used to isolate chilled water for individual zones in order to avoid high pressure in water pipes caused by the weight of water in rigid pipes and a higher floor.

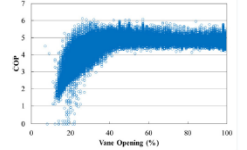


Fig. 4. The correlation between COP and vane opening using its operation data.

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Direct chiller power limiting for peak demand limiting control in buildings—Methodology and on-site validation

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Demand response
Model predictive control
Building thermal mass

ABSTRACT

Large electricity consumers are often charged of a high price for their peak demand for the purpose of reducing the capacity and cost, as well as the operation reliability of electricity transmission facilities. As a result, even on-site in the monthly demand profile would result in a significant increase in electricity bill. Peak demand limiting techniques provide an effective and efficient means to reduce such cost. For instance, the methods to allow cooling/heating stored in building thermal mass by controlling space air temperature set-point have been proved effective in many studies. This study proposes a direct chiller power limiting control strategy for peak demand limiting control in buildings, particularly during the period of chiller starting when the peak demand occurs mostly. Validation tests were conducted on-site in a super high-rise building and on a dynamic simulation platform. Results showed the strategy was effective in reducing the peak demand during chiller starting periods.

1. Introduction

Large electricity consumers are often charged of a high price for their peak demand for the purpose of reducing the capacity and cost, as well as the operation reliability of electricity transmission facilities. The electricity bill of a large consumer commonly consists of two major parts: the energy cost which is based on the total energy consumption in kWh over a billing period, e.g. a month, and the demand cost which is based on the peak demand in kVA during the billing period. Therefore, even on-site in the monthly demand profile would result in a significant increase in electricity bill. Actually, peak demand in commercial buildings lasts only for a short period of time, but its costs could be up to 50% of the overall bill [1,2].

Demand management techniques provide an effective and efficient means to reduce such high cost, particularly with the emerging technology of smart grid [3,4]. Demand limiting control targets at limiting power consumption over a certain period. Demand limiting control systems often reduce electricity bills by 15% to 20% in industrial buildings and commercial buildings [2].

Demand management methods are classified into three main categories, i.e. demand shedding (also named as demand curtail, demand curtailment, etc.), demand shifting and on-site generation [5]. Demand shedding refers to remove some of the non-essential loads during on-peak periods. Demand shifting is to shift loads from on-peak periods to off-peak periods. For instance, building thermal mass or thermal energy

storage systems could be used to shift space cooling/heating loads. On-site generation is to generate electricity on-site instead of using grid electricity. Since on-site generation requires extra equipment and energy resources on-site, it can hardly be widely used. The demand shedding and demand shifting methods are the dominant approaches in real practice.

The control of energy systems in buildings for demand limiting mainly consists of three methods: global temperature adjustment, system adjustment, and schedule of equipment [5,6]. As the dynamic method in literature and practice, global temperature adjustment method is to reduce building cooling/heating load by controlling room temperature to be closer to the ambient temperature during on-peak periods. Building thermal mass or thermal storage systems are used as buffers to alleviate the impact of such adjustment on thermal comfort in air-conditioned space [7]. Systemic adjustment method refers to those methods in which limits are directly placed on certain equipment in a HVAC system. Such methods provide a quick response to the grid, but should be carefully selected to avoid causing system imbalance or unstable to the entire system [5]. Schedule of equipment method means to dynamically schedule the operation time of equipment according to electricity price or the offered incentive during on-peak periods.

Many studies have addressed peak demand limiting in buildings. Studies on the use of global temperature adjustment have been conducted based on simulation and on-site test [7,8,9]. Dynamic inverse building model has been built for determining the proper zone

K. Shan et al.

temperature set-points in global temperature adjustment method [10,11,12]. Some other studies have developed strategies that combined global temperature adjustment methods with systemic adjustment methods [13,14,15,16].

Most of these existing methods for HVAC systems targeted at reducing cooling supply during on-peak periods. However, according to the study based on the real operation data in a high-rise building, peak demand of chillers occurs mostly during the period when a chiller is starting. Such peak demand may be caused by the increase in cooling load, or the sudden starting of a constant speed chiller, or both. Reducing peak demand during chiller starting period has not yet been particularly addressed in literature. Therefore, a direct chiller power limiting control strategy is proposed in this study to reduce the peak demand that occurs during the short periods of chiller starting.

This paper is organized as follows: Section 2 highlights the issue of peak demand during chiller starting period based on real operation history data of a super large HVAC system for a high-rise commercial building. Section 3 describes the proposed direct chiller power limiting control strategy for peak demand limiting. Section 4 presents the arrangement of on-site and simulation validation tests, which includes the super large HVAC system, a dynamic simulation platform built based on the same super large HVAC system, and the electricity tariff used in electricity bill. Section 5 presents the validation test results and discussion. Section 6 presents the conclusion.

2. The problem of peak demand during chiller starting period

The sequencing control of chillers is commonly based on real-time cooling load and capacity of chillers [17]. Specifically, when cooling load increases and the current running chiller could not provide sufficient capacity to fulfill the required cooling load, the control system will start another idling chiller. This newly started chiller will run to its maximum capacity in the first few minutes in order to quickly achieve the supply chilled water temperature set-point. Considering the fact that the previously running chillers have already been fully loaded, all the operating chillers will be running at their maximum capacities during this period. This would result in a high power demand after a short period after the chiller started. Such problem exists particularly in HVAC systems installed with constant speed chillers.

An analysis was conducted based on one year operation data and electricity meter data of a high-rise building. The electricity cost of the whole building is divided into 23 bill accounts, each is charged separately. The bill account which most incur is the one consisting of the six large constant speed centrifugal chillers for air-conditioning.

The analysis was focused on the peak days of two months in 2015, representing different weather conditions. The data of peak days in February and May are shown in Fig. 1. It can be seen that the total power demand of all running chillers always goes up dramatically after a certain period. The peak demand occurred at 15:30 on the peak days in February, and at 8:30 on the peak day in May. There are two other small peak-like power profiles of the peak day in May when the chiller number did not change. But the two small peaks were lower than the one occurred in the morning after two chillers were added.

It can therefore be concluded that the electricity cost would be reduced if a proper demand limiting control strategy is applied during chiller starting periods.

3. Proposed direct chiller power limiting control strategy

3.1. Capacity control of centrifugal chillers

Because of the high capacity and efficiency they can provide, centrifugal chillers are typically used for large buildings, factories or even districts with huge cooling load for space cooling or production process. Since the cooling load is always varying, the annual load of cooling provided by the chillers has to be controlled accordingly. As

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summarized below, three major methods are commonly used by centrifugal chillers to achieve the goal of capacity control.

(a) The inlet guide vanes

Inlet guide vanes are located in the suction port of compressor. The refrigerant gas enters into the impeller changes with the change of inlet guide vane opening. Therefore, the refrigerant flow and capacity in capacity varies as the vane opening changes. This method is generally used by constant speed centrifugal chillers.

(b) The variable speed drivers (VSD)

The refrigerant flow can also be changed by varying motor speed of chillers by using VSD. Typically, the speed is only reduced to 60% of the maximum speed. Centrifugal chillers installed with VSDs also have inlet guide vanes. Inlet guide vanes and variable speed drivers are combined to control chiller capacity. Beside of capacity control, it is worth noting that VSDs can be used as soft starters, which can avoid too high electric current during chiller starting periods.

(c) The hot gas bypass valves

The hot gas bypass process is used to protect compressors by avoiding surging or stalling of compressors in low load conditions. The hot gas from compressor discharge port is recirculated back into the evaporator, and the hot gas bypass valve is used to control the amount of bypassed refrigerant. The use of this method should be avoided whenever possible, because the recirculated refrigerant gas generates no cooling effect, but has already consumed electricity in compression process.

3.2. Direct chiller power limiting control

By adopting an effective soft chiller starting method, the developed strategy in this study aims to reduce peak demand during chiller starting period while limit minimum impact on thermal comfort in the air-conditioned spaces.

Fig. 2 shows the concept of the proposed direct chiller power limiting control strategy. The strategy consists of three steps: (1) start a chiller normally, (2) limit the power consumption of the previously running chillers (3) while continuously checking supply chilled water temperature, (3) remove the limitation gradually.

Upon the request of adding a chiller, one of the idling chillers is put into operation immediately. Meanwhile, a limitation is added to all the other previously operating chillers to reduce their power consumption. A coefficient $(0.9M_{ch}/(M_{ch} + 1)) < \alpha < 100\%$, where M_{ch} is the previously operating chiller number) is used to measure the limitation, which is defined to be the ratio of the allowed maximum chiller power to the rated chiller power. In this way, the power of a previously running chiller will not be higher than C_{max}/α (where C_{max} is the rated chiller power). The limitation cannot be placed on the starting chiller, because it has to run at its full capacity in order to quickly attain the chilled water temperature set-point. However, the output capacity of the previously operating chillers can be limited to achieve a lower total demand of all chillers.

Because the priority of thermal comfort in the air-conditioned space is set to be higher than reducing electricity cost, the supply chilled water temperature is used as a constraint in the proposed control strategy. The temperature is frequently checked at a certain sampling period and compared with its set-point. If the measurement is higher than the set-point by ΔT , the constraint on chillers will be relaxed by a certain degree which is determined according to the delay time and system characteristics. If the limitation is not completely relaxed within a certain period δ , it will be relaxed gradually and completely. This is chosen based on the demand interval of electricity tariff and the

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Direct chiller power limiting for peak demand limiting control in buildings—Methodology and on-site validation

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Development and validation of an effective and robust chiller sequence control strategy using data-driven models

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1. Introduction

1.1. Background

As the largest energy consumers in central air-conditioning systems, chillers consume about 40% of the energy consumed by air-conditioning systems, and there is a strong potential to reduce the energy consumption of air-conditioning systems by enhancing the efficiency of chillers [1].

Optimal chiller sequence control, also known as optimal chiller loading, plays an important role in enhancing the chiller efficiency in a well-designed large central air-conditioning system, multiple chillers are commonly used to fulfill the cooling load demand. The control of these chillers becomes important as they affect the cooling supply and the overall efficiency of chillers.

If the chillers are not well sequenced, they may either operate at low efficiency or fail to fulfill the demanded cooling load. In practical operation, chillers usually operate with low coefficients of performance (COP) due to the use of over-conservative control strategies. These strategies force extra chillers to operate, resulting in a low partial load ratio (PLR) of all operating chillers. They also increase the operation time of water pumps, which further increases the energy consumption of the chiller plants.

Various advanced strategies are developed by researchers to solve the problem. For instance, data fusion technology [2] is used for chiller

sequence control, which is validated using online data [3]. This technology takes the advantages of two cooling load calculation methods. Although the two methods suffer from measurement noise or model/systematic errors, the fused cooling load could have better accuracy [4]. Other available strategies include particle swarm optimization [4], Lagrangian method [5], genetic algorithm [6], differential evolution algorithm [7], and stochastic control method [8].

However, these technologies involve complicated operations and large storage capacity and cannot be implemented easily in common building management systems (BMS). BMS engineers and operators also find them difficult to understand because they are less logically deductive than the control strategies in practice and are uncertain of their reliability. Consequently, these complicated control strategies are not widely implemented in real air-conditioning systems.

To address these issues, the fault-tolerant control method can be used [9]. In this paper, a chiller sequence control method that is tolerant to sensor errors is developed based on typical strategies using basic principles.

1.2. Typical chiller sequence control strategies

Different methods used different measurements to control chillers. Typical measurements used for chiller sequence controls are marked in Fig. 1.

1.2.1. Chilled water temperature based sequence control

The method determines chiller ON/OFF based on the return chilled water temperature [10,11]. If the return chilled water temperature is

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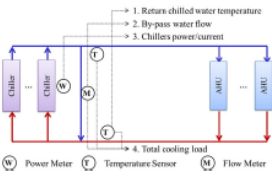


Fig. 1. Parameters required by different types of chiller sequence control strategies.

higher than a predefined maximum, an idling chiller will be staged on. If it becomes lower than a predefined minimum, a running chiller will be staged off. This method highly relies on the control of secondary chilled water pumps to ensure that the return chilled water temperature is a good indicator of the cooling demand. However, this method is neither precise nor reliable due to its complexity in practice.

1.2.2. Bypass water flow based sequence control

This strategy utilizes the water flow and the flow direction in the bypass line [10,11]. If the bypass water flow exceeds the design flow of a chiller plant, a running chiller will be staged off. If the flow is reversed, an idling chiller will be staged on. This strategy is also not precise or reliable in practice because the bypass water flow also depends on proper control of secondary chilled water pumps.

1.2.3. Chiller current or power based sequence control [10]

Chiller current or power consumption can be a reliable indicator of chiller cooling load. This strategy stages on an extra chiller if its current or power consumption is near their rated values, and it stages off a running chiller if its current or power consumption is low. This method is not accurate because chiller COP and cooling capacity vary significantly with its operating conditions.

1.2.4. Total cooling load based sequence control

This strategy determines the number of operating chillers by comparing the maximum capacity of chillers with the cooling load [10]. It estimates the chiller cooling load by the chilled water flow and the difference between supply and return chilled water temperatures as demonstrated in Eq. (1). Although this strategy is considered as the best strategy in principle [10], its precision is vulnerable to measurement errors and uncertainties [10].

$$Q = c_p \cdot M_{ch} \cdot (T_{ch,in} - T_{ch,out}) \quad (1)$$

where Q is the cooling load, c_p is the water specific heat, M_{ch} is chilled water flow, and $T_{ch,in}$ and $T_{ch,out}$ are return (evaporator inlet) and supply (evaporator outlet) chilled water temperatures, respectively.

1.3. The proposed strategy and its innovation

This paper proposes an effective and robust chiller sequence control strategy to overcome the limitations of current control methods. The strategy eliminates the effects of the measurement errors on the control decisions and provides a method simpler to execute than the strategies in literature. This is mainly achieved by its use of inlet guide vane as a main and reliable indicator of the chiller efficiency. Although it is normally available in centralized multiple centrifugal chiller plants, its use in chiller sequence control is rare in both literature and practice.

The rest of the paper is organized into six sections. Section 2 presents the proposed effective and robust chiller sequence control strategy. Section 3 provides an in situ validation of the reliability of using chiller vane opening as chiller efficiency and load indicator. Section 4 describes the building and its air-conditioning system used for test and validation, the test platform built for evaluating the studied strategies, as well as the two reference strategies used for comparison. Section 5 presents the performance and limitations of a reference strategy in real application. The validation of the test platform is also conducted using in situ chiller operation data. Section 6 illustrates the comparison and discussion on the online test results, followed by the conclusion section.

2. The proposed effective and robust chiller sequence control strategy

Fig. 2 describes the logic of the proposed control strategy developed for a chiller plant in a high-rise building. Whether to stage on a chiller depends on the electric currents of operating chillers, vane opening, and supply chilled water temperatures. Specifically, a chiller is about to be staged on when the currents of all operating chillers have been near the full load current for a certain time threshold. This avoids frequent chiller on-off actions. The full load conditions of the operating chillers are far from confirmed by monitoring their vane openings. By monitoring the temperature of supply chilled water to all individual zones, the strategy guarantees a sufficient cooling supply. If the chillers cannot satisfy the cooling demand, the supply chilled water temperature will be higher than its set point.

Whether to stage off a chiller is determined based on the chiller vane opening and the measured cooling load. The logic for staging off a chiller is activated only when one of the operating chillers has its vane opening less than 60%. This saves computational resources and may avoid staging off chillers unnecessarily. The control strategy then predicts the maximum cooling capacity of the chillers with one less operating chiller by a data-driven model in Eq. (2). It uses the multi-linear regression method [12], which is a type of machine learning algorithm, due to its simplicity and effectiveness. This model uses the evaporating and condensing pressures to predict the maximum cooling capacity and is trained using chiller full load operation data with a vane opening higher than 80%. Noticeably, even for identical chillers, they may have different coefficients in their corresponding models.

$$Q_{max,i} \sim \ln(P_{evap,i} P_{cond,i}) \quad (2)$$

where $Q_{max,i}$ is predicted maximum cooling capacity of the i th chiller, $P_{evap,i}$ and $P_{cond,i}$ are the evaporating and condensing pressure of the i th chiller, respectively, and $\ln(\cdot)$ represents the multi-linear regression model.

3. Chiller vane opening vs energy efficiency and load—in situ validation

This section presents the evaluation on the key parameters that are used as simple and reliable chiller efficiency indicators based on analyzing in situ operation data. Two parameters (i.e., PLR and chiller vane opening) are assessed.

3.1. Partial load ratio

PLR is defined as the ratio of the actual refrigeration (or cooling) load of a chiller to its full load capacity. It is well understood that high overall COP can be achieved by controlling a chiller to operate at its optimum PLR as they have strong correlation. Fig. 3 demonstrates such correlation between the two variables of a chiller in the studied building by using in situ operation data and manufacturer's catalog data obtained from test according to the ARI standard 550/590–1998 [13]. The COP of real operation data is lower than that in manufacturer's catalog due to

Research Title: Development and validation of an effective and robust chiller sequence control strategy using data-driven models

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Publications

- **Over 20 Undergraduate students** participated in their final year projects.
- **Over 6 PhD students** have been trained based on practical and innovative project

Number	Name	Thesis title	Year
1	Ma Zhenjun	Online supervisory and optimal control of complex building central chilling systems	2008
2	Sun Yongjun	Online optimal control of multiple-chiller systems in large buildings	2010
3	Sun Zhongwei	Ventilation control and ventilation performance of multi-zone air conditioning systems	2010
4	Gao Dican-ce	Diagnosis and robust control of complex building central chilling systems for enhanced energy performance	2012
5	SHAN Kui	Sensitivity and uncertainty analysis, and robust optimal control strategies for air-conditioning systems with low quality measurements	2013
6	Fan Chen	Development of data mining-based big data analysis methodologies for building energy management	2016



Publications

We shared our Best Practices in various institutes



World Sustainable Built Environment Conference 2017 Hong Kong
Transforming Our Built Environment through Innovation and Integration: Putting Ideas into Action
5-7 June 2017

Registration ID: 2236
Intelligence, Collaboration, Continuity - A case study of improving the environmental performance of an office building

ABSTRACT
Commercial Buildings Consume A Large Portion Of The Total Energy Consumption In Hong Kong. And Energy Use Is A Major Element Contributing To The Emission Of Carbon And Global Warming. Facilities Managers Have To Be Conscious Of Their Roles In Shaping The Use Of Energy Of Buildings. Through Employing Available Technologies, Collaborating With Stakeholders From Within The Building And The Community, As Well As Continuing Sustainable Facilities Management Practices, It Is Possible To Improve The Environmental Performance Of Commercial Buildings. The Tallest Commerce Building In Hong Kong Would Be Used As A Case Study To Illustrate How This Mode Could Be Applied And The Results That Have Been Achieved That Could Drive A Motivation For Businesses And The Society.

Keywords: high-performance building; Corporate Social Responsibility; Energy

1. INTRODUCTION
1.1. Our present environmental challenges

From construction to demolition, stocks of buildings in the built environment are the major consumer of energy. Over 60% of the greenhouse gas that leads to global warming is attributed to the burning of fossil fuels to produce energy. According to the Electrical and Mechanical Services Department (EMSD) in Hong Kong (HK), among all facilities in commercial buildings, air conditioning system consumes most of the energy (26%).^[1] Other mechanical systems such as lifts and escalators are also at the top of the chart. This pattern of energy consumption among HK's buildings is no different from other metropolitan cities worldwide, thus making this issue of global significance.

Apart from energy, waste management is another important issue in HK. Based on 2015's data from the Environmental Protection Department, 63% of the municipal solid waste went to landfill with 37% waste could be recycled.^[2] The existing 3 landfill sites in HK are about to saturate with one as early as 2017. With little alternatives to handle municipal solid waste, there is an urgent need in HK for all to act immediately to support the waste reduction movement.

Unlike new buildings that could take advantage of the latest energy efficient technology and waste separation facilities during the design stage, the performance of the existing building stocks would have to resort to other ways to improve their environmental performance. With proactive management strategy, diligent and practical work approach, it is feasible to achieve energy and waste reduction in existing buildings. This does not give rise to instant upgrading of facilities and render the existing facilities immediately useless.

CTBUH Research Paper
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Title: ICC Hong Kong: Exemplary Performance

Authors: Patrick Leung, Senior Technical Services Manager, Sun Hung Kai Properties Limited
Howard Yeung, Senior Technical Services Manager, Sun Hung Kai Properties Limited

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Property Ownership/Management
Sustainability/Green/Energy

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3. Conference proceeding
4. Unpublished conference paper
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6. Unpublished

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ICC Hong Kong: Exemplary Performance

Patrick Leung, Senior Technical Services Manager & Howard Yeung, Senior Technical Services Manager, Sun Hung Kai Properties

The International Commerce Centre (ICC) is a landmark skyscraper located in Hong Kong in the central business district. It is a 100-story building with 1,000,000 sq ft of office space, five dining restaurants, an observation deck and a world-class hotel. ICC has firmly established itself as a world-class business address that offers the highest quality in property and facilities management, providing quick and responsive service while maintaining an environmentally friendly and sustainable operation. Its management has pursued high performance building, a life cycle commissioning and optimisation approach is adopted and ISO 50001:2011 energy management system is implemented to continuously exploring various innovative technologies and the application of many energy saving strategies, environmental impacts of the building are reduced while delivering benefits in terms of energy efficiency, indoor air quality and cost savings to building occupants.

Introduction
Standing at the south western tip of the Kowloon Peninsula, the International Commerce Centre (ICC) is an iconic building in Hong Kong. The 100-storey tall building, with its glass curtain wall, is currently the 6th tallest building in the world and the tallest in Hong Kong. Apart from providing Grade A office premises, ICC also contains one of the first observation decks in Hong Kong - "Sky100" - as well as a premium Class hotel, the Ritz Carlton Hong Kong. ICC is showcasing the property of the city. The 3 million square feet development is also a 21st century engineering wonder in the view of Hong Kong people.

With an aim to reduce the environmental impacts to the surrounding environment, ICC was designed and built based on a number of green design principles. The International Commerce Centre (ICC) is a landmark skyscraper located in Hong Kong in the central business district. It is a 100-story building with 1,000,000 sq ft of office space, five dining restaurants, an observation deck and a world-class hotel. ICC has firmly established itself as a world-class business address that offers the highest quality in property and facilities management, providing quick and responsive service while maintaining an environmentally friendly and sustainable operation. Its management has pursued high performance building, a life cycle commissioning and optimisation approach is adopted and ISO 50001:2011 energy management system is implemented to continuously exploring various innovative technologies and the application of many energy saving strategies, environmental impacts of the building are reduced while delivering benefits in terms of energy efficiency, indoor air quality and cost savings to building occupants.

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Doing Right by Planet and People
The Business Case for Health and Wellbeing in Green Building

ZERO CARBON BUILDING (ZCB)

The ZCB, constructed in 2012, achieved BEAM Plus Platinum in 2015 and was the first building in Hong Kong with net zero carbon emissions.

- Cross-ventilation, low VOC materials, and wind-catchers helped the building achieve IAQ 'Good'
- Daylighting and natural ventilation improves thermal comfort and also reduces energy use by 20% compared to normal buildings
- All offices have an outdoor view, with some looking out on the first urban native woodland in Hong Kong



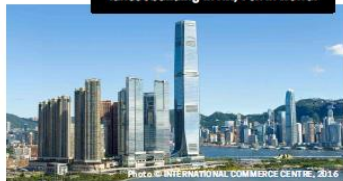
SHATIN COMMUNICATIONS AND TECHNOLOGY CENTRE (SCTC)
SCTC is the latest addition to the Hong Kong Jockey Club's extensive property portfolio, BEAM Plus Gold.

- By using demand control CO₂ sensors, 30% more fresh air is ventilated inside the building
- Core placement on the NNW façade reduced solar gain by 32%, improving thermal comfort
- 64% of the rooftop is covered in accessible green roofs
- Employees reported 97% satisfaction with the new office

INTERNATIONAL COMMERCE CENTRE (ICC)

The ICC is the tallest building in Hong Kong and seventh tallest in the world. With over 250,000 m² of office space, it uses its health and wellbeing features as a selling point to potential occupants, including:

- Central core design to maximise daylight IAQ Excellent Class Certificate
- Pedestrian access to retail, hotels, and services in the West Kowloon Cultural District as well as public transportation
- A shingled curtain wall façade was designed to maximise views and daylight while reducing solar gain and maintaining comfort



Awards and Recognitions



RICS - Sustainability Achievement of the Year 2018



HKGBC BEAM Plus EB V2.0 Comprehensive Scheme - Final Platinum

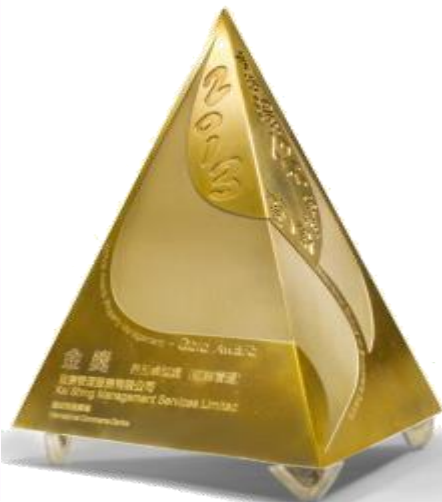


Asia Pacific Intelligent Green Building Alliance (APIGBA) "Excellent Intelligence Green Building - Performance Award"

Awards and Recognitions



ASHRAE Technology
Award 2014 Honorable
Mention



Hong Kong Awards
for Environmental
Excellence (HKAEE)
Gold Award



World Wide Fund - Low
Carbon Office Operation
Programme (LOOP)



Hong Kong Awards
for Industries
Productivity and
Quality Award 2014



Awards and Recognitions

ICC Awarded Hong Kong Energy Saving Championship Scheme 2016 – 2017



Energy Saving Championship Scheme 2017
- Hanson Supreme Grand Award (Group 1)



機電工程署
EMSD



Environment Bureau
The Government of the Hong Kong Special Administrative Region

Energy Saving Championship Scheme 2017
- Hanson Grand Award

Awards and Recognitions



CLP Smart Energy
Award 2018



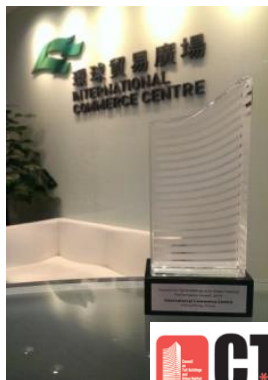
IFMA Asia-Pacific Facility Management Awards 2018



Green Organization Certification - Energywi\$e &
Carbon Reduction Certificate



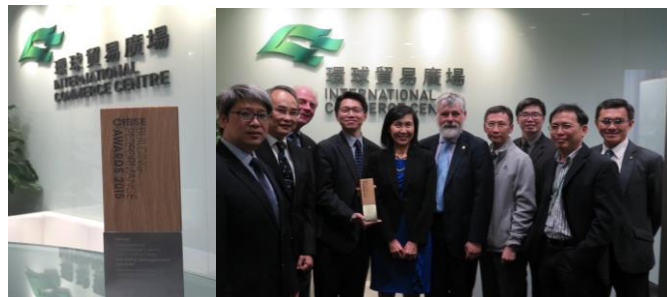
HK Q-Mark Scheme
Certificate
Part 4 Performance



CTBUH Performance
Award 2014



BIFM Awards - Impact on the
Environment (Highly Commended)



CIBSE Building Performance Awards 2015



環球貿易廣場
INTERNATIONAL
COMMERCE CENTRE

Awards and Recognitions



Corporate Environmental Leadership Awards 2016



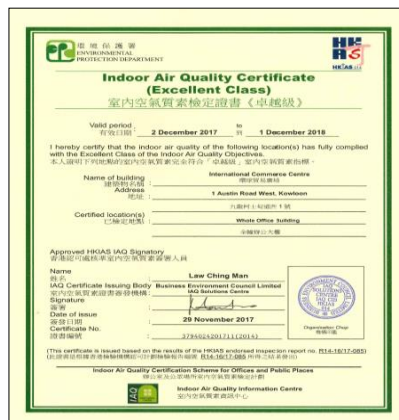
2016 Corporate Citizenship
Award - Silver Award



2017 Green Pioneer - Green Office & Eco - Healthy
Workplace Awards Labelling Scheme



2017 Energywi\$e Label



Indoor Air Quality Certificate
(Excellent Class-whole building)



Caring Company Certificate



HSBC - Green Achievement Award 2016

Conclusion

Highlighted Green Initiatives – Energy Use



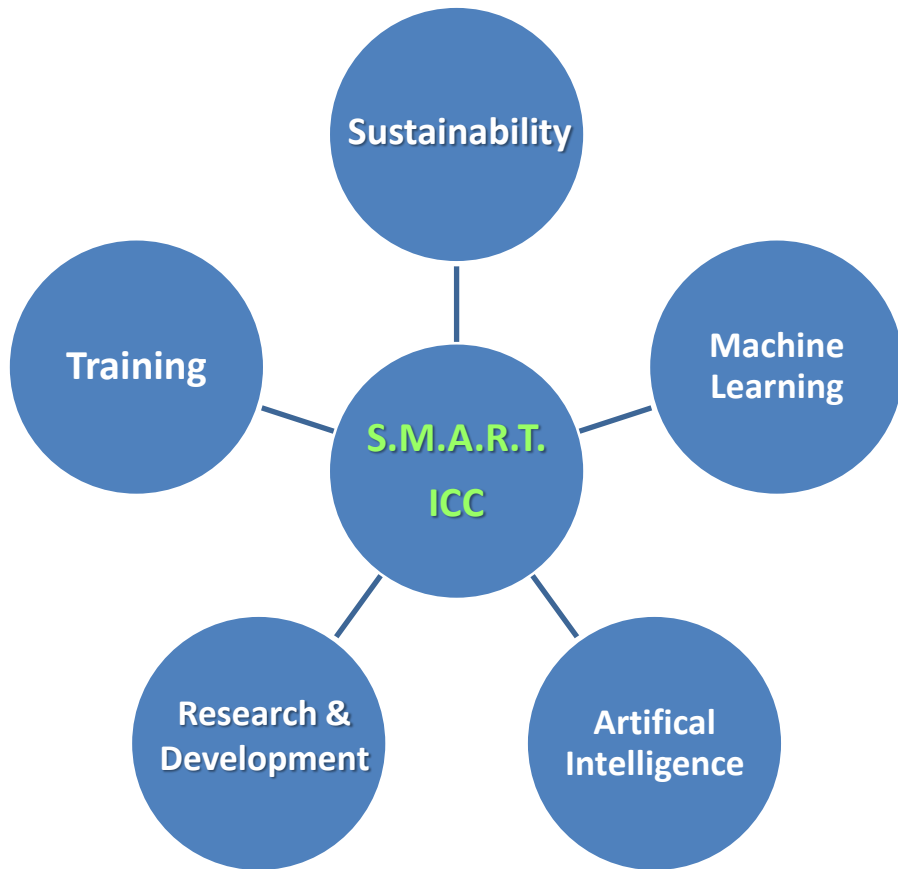
- **Management System:**
 - Energy Management Policy
 - Energy Management Plan
 - Appointment of Energy Warden
- **Energy sub-metering and BMS and data logging system**
- **Carry out Energy Audit more frequently (Bi-yearly cycle instead of 10 years)**
- **Comprehensive data analysis:**
 - Energy Use intensity (EUI)
 - Abnormal Usage and Peak Analysis
 - Energy Saving Opportunities
 - Continuous self-Improvement in energy use
 - Assist in setting short term long term energy / carbon reduction targets
- **Building retro commissioning and ongoing commissioning**



PLATINUM
鉑金級
EB 既有建築
V2.0 2017
HKGBC
BEAM Plus
綠建環評



Conclusion





環球貿易廣場
INTERNATIONAL
COMMERCE CENTRE

The End

