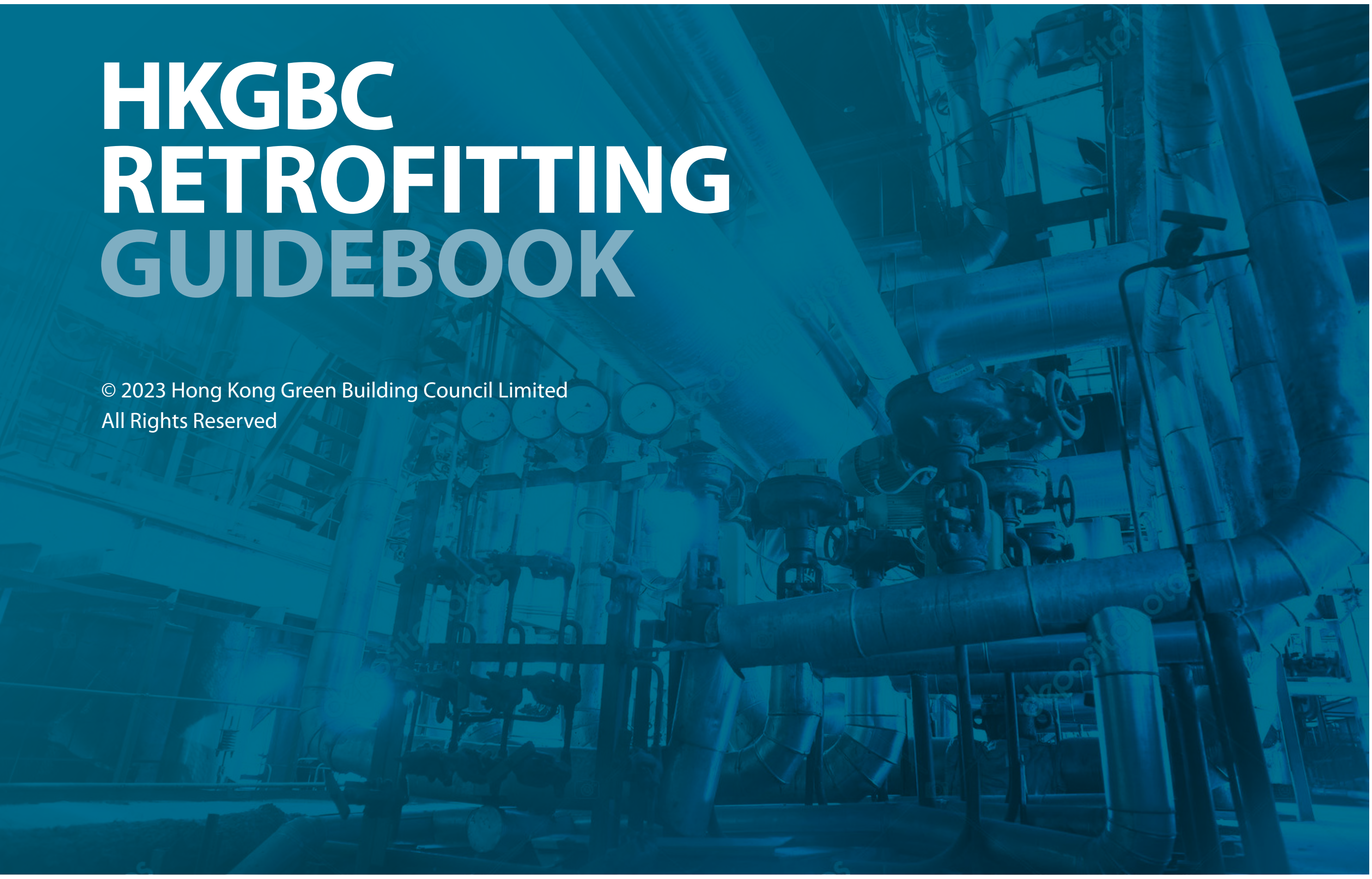
HKGBC RETROFITTING GUIDEBOOK

Latest Update: January 2023



HKGBC RETROFITTING GUIDEBOOK

Disclaimer

The information provided in the HKGBC Retrofitting Guidebook ("this Guide") including but not limited to all text, graphics, drawings, diagrams, photographs and compilation of data or other materials, is only reflective of the situation as at the time stated or prepared and is for general reference and indicative purpose only. Hong Kong Green Building Council Limited ("HKGBC") makes no guarantee, representation or warranty as to the truthfulness, timeliness, accuracy or completeness of this Guide or of the information and the data gleaned from the other sources in the preparation of, and asset out in, this Guide. References to and of sources do not constitute an endorsement or recommendation by HKGBC of the third parties or their products/services (if any). Whilst reasonable effort has been made to ensure the accuracy of this Guide, this Guide is provided "as is" and "as available". HKGBC accepts no responsibility for any errors (negligent or otherwise) in this Guide. Furthermore, HKGBC will not accept and shall not be responsible for any liability whatsoever (whether in tort, contract or otherwise) for any loss or damage that maybe caused to any person howsoever arising from the use of and/or reliance on this Guide. To the fullest extent permitted by law, HKGBC expressly excludes any warranty or representation of any kind, either express or implied. Moreover, any cost and predicted performance mentioned in this Guide are intended for guidance and reference only and in no way constitute advice or an offer. These cost information and estimations are based on a simplified and idealised version of a building and circumstances that do not and cannot fully represent all of the intricacies of the building in operation. The actual performance may be influenced by factors such as but not limited to weather, construction and fit-out, performance of plants and facilities, operation and maintenance, etc. Prior to carrying out minor works and environmental improvement of the building, the landlords, tenants and occupants should consult an Authorized Person under the Buildings Ordinance, Cap. 123 on the choices of green features to be adopted and on relevant statutory requirements. The links to external websites listed in this Guide are provided purely for the convenience of reference. Their inclusion here does not constitute an endorsement or an approval by HKGBC of any of the products, services, or opinions of the organisations or individuals concerned. HKGBC bears no responsibility for the accuracy or the content of external sites or for those of the subsequent links, and does not accept any responsibilities for any loss and/or damage whatsoever arising from any cause whatsoever in connection with these websites to the extent permitted by law. Users are responsible for making their own assessments of all information contained in or in connection with this site and are advised to verify such information by making reference to its original publication and obtain independent advice before acting on it. To the maximum extent permitted by the applicable law, HKGBC shall not be liable in tort, contract, or otherwise for any losses, damages, demands, claims, judgments, actions, costs, legal fees, expenses, fines or penalties, whatsoever (including, without limitation, any special, indirect, direct, punitive, incidental or consequential losses, loss of business, loss of data or loss of profit), which may arise in relation to this Guide and the contents therein. This clause applies irrespective of whether or not HKGBC was advised of or should have been aware of the possibility of such losses to you.

All intellectual property (including but not limited to any copyright, trademarks, service marks, logos, trade names, corporate names, Internet domain names, patents, designs, database rights, rights in designs, topography, know-how, trade secrets or any similar right or proprietary right, whether registered or not, and all applications or rights to apply for the same (where such applications can be made), whether presently existing or created in the future, anywhere in the world, and all benefits, privileges, or rights to sue, recover damages and obtain relief for any past, current or future infringement, misappropriation or violation of any of the foregoing rights) and the rights in this Guide ("Intellectual Property") belong to HKGBC, unless otherwise stated. You have no right to use any of HKGBC's Intellectual Property. You may not copy, distribute, modify, transmit, publish or use this Guide in any manner for public or commercial purposes without prior written permission from HKGBC. The terms of the Disclaimer may be amended by HKGBC from time to time in their sole and absolute discretion without any notice or liability to you. The latest version of the Disclaimer shall be published on the HKGBC website. If you continue to use this Guide after an amended version of the Disclaimer has been published, you agree to be bound by such amendments to the Disclaimer. It is your responsibility to regularly check to see if there are any amendments to the Disclaimer. If there is any inconsistency or ambiguity between the English version and the Chinese version of the Disclaimer, the English version shall prevail.

About HKGBC

The Hong Kong Green Building Council (HKGBC) is a non-profit, member-led organisation established in 2009 and has become a public body under the Prevention of Bribery Ordinance since 2016. The HKGBC strives to promote the standard and development of sustainable buildings in Hong Kong. The HKGBC also aims to raise green building awareness by engaging the government, the industry and the public, and to develop practical solutions for Hong Kong's unique, subtropical built environment of high-rise, high density urban area, leading Hong Kong to achieve carbon neutrality by 2050 and to become a world's exemplar of green building development.

Our passion for a sustainable built environment is the motivating force to achieve our goals. The wide experience and deep insight of our members and experts is the underlying foundation for real results.

To learn more about the HKGBC, please visit www.hkgbc.org.hk

Our Vision

To help save the planet and improve the wellbeing of the people of Hong Kong by transforming the city into a greener built environment.

Our Mission

To lead market transformation by advocating green policies to the Government; introducing green building practices to all stakeholders; setting design, construction and management standards for the building profession; and promoting green living to the people of Hong Kong.

TABLE OF CONTENT

FOREWORD

EMSD

Director

Mr PANG Yiu-hung, JP
Director of Electrical & Mechanical Services,
The Government of the Hong Kong Special Administrative Region

It is my great pleasure to congratulate the Hong Kong Green Building Council (HKGBC) for taking the lead to develop HKGBC's Retrofitting Guidebook in moving the trade and community towards carbon neutrality. The Electrical and Mechanical Services Department (EMSD) enforces the Buildings Energy Efficiency Ordinance (BEEO), and we strive to promote and drive for carbon neutrality in the local community. We are very pleased to work with the HKGBC, one of our major partners, with full momentum in decarbonisation efforts, and to promote energy retrofitting in existing buildings with a view to outperforming the statutory requirements of the BEEO.

In 2021, the HKSAR Government announced the ambitious Hong Kong's Climate Action Plan 2050, aiming at achieving carbon neutrality before 2050. The plan sets out the vision of "Zero-carbon Emissions•Liveable City•Sustainable Development" and outlines four major decarbonisation strategies, namely "Net-zero electricity generation", "Green transport", "Waste reduction" and "Energy saving as well as green buildings" to achieve carbon neutrality.

In Hong Kong, building energy contributes around 90% of total electricity consumption and about 60% of total carbon emissions. The BEEO has been in force for ten years since 2012 to enhance the energy efficiency performance of buildings. We have regularly reviewed and uplifted the building energy efficiency requirements stipulated in the Building Energy Code (BEC) and the Energy Audit Code (EAC) in collaboration with diverse professional institutions, trade associations, academia, and government departments. Looking ahead, we shall continue to embrace innovative and low carbon technologies, as well as international best practices, to further our contribution in improving energy efficiency in buildings to meet public aspiration.

The HKGBC's Retrofitting Guidebook is an excellent reference tool for the trade to share the successful experience and cases on energy retrofitting projects, including specifically the use of smart technologies. This echoes with the aspiration of our EMSD InnoPortal (*https://inno.emsd.gov.hk/en/home*) in assisting the trade to identify innovative and technological solutions to meet new challenges on energy efficiency and conservation.

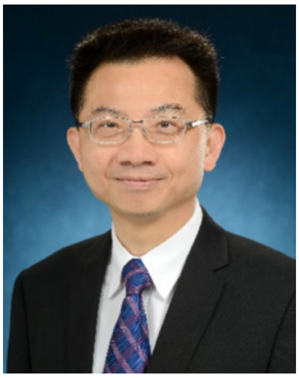
Many existing buildings, especially those with aged building services equipment, would likely have tremendous potential to perform better through energy retrofitting. The public and private sectors can now make reference to the EAC, BEC and HKGBC's Retrofitting Guidebook to prioritise and implement energy retrofitting in their asset management plan to enhance building energy efficiency as well as reduce energy costs. I would also encourage building owners to join our voluntary Energy Efficiency Registration Scheme for Buildings (EERSB[1]) to recognise their extra effort in ensuring their buildings having achieved better energy performance beyond the requirements as stipulated in the BEEO. Building owners and property management can also use the Online Building Based Electricity Utilization Index Benchmarking Tool (*https://eui.emsd.gov.hk/en/EUI_introduction.html*) to compare their own electricity utilisation performance with other buildings of similar usage.

Through the concerted effort of the trade and the whole community in adopting energy retrofitting in existing buildings, we will undoubtedly be moving towards our ultimate long term carbon neutrality target.

1 https://www.emsd.gov.hk/en/energy_efficiency/energy_efficiency_registration_scheme_for_building/index.html

FOREWORD

HKGBC Chairman



Dr CHEUNG Tin-cheung, SBS
Chairman, Hong Kong Green Building Council

On behalf of the Hong Kong Green Building Council (HKGBC), we take great pleasure in presenting the HKGBC Retrofitting Guidebook to the building industry.

Founded in 2009, the HKGBC is committed to introducing and promoting green building solutions or practices to industry practitioners and the public. The Hong Kong's Climate Action Plan 2050, announced by the Hong Kong Special Administrative Region Government in 2021, outlined the strategies and targets for combating climate change and achieving carbon neutrality before 2050. It highlighted that a large proportion of Hong Kong's total electricity consumption is related to activities in buildings which reflects the importance and need to improve existing buildings' energy performance. To this end, the HKGBC launched a programme in 2016 to mainstream retro-commissioning. This includes development of related best practices and building up the capacity of the industry.

This guidebook provides different retrofitting solutions that help reduce energy consumption in existing buildings and can serve as a useful reference for the industry practitioners when they carry out retrofitting work in their buildings. This Guidebook also helps promote and mainstream the adoption of retrofitting solutions within the green building industry, and makes a contribution to the carbon neutrality roadmap of Hong Kong through enhancing energy efficiency.

We would like to take this opportunity to thank the Industry Standards and Practices Committee and Retrofitting Expert Group for their contributions to the development of the Guidebook.

We hope that the publishing of this Guidebook for the building industry can increase all practitioners' understanding and awareness towards retrofitting. Working together, we can create a greener future for Hong Kong.

FOREWORD

ISPC Chairman

Mr Donald CHOI, JP

Chairman, Industry Standards and Practices Committee (ISPC)

Director, Hong Kong Green Building Council

Climate change is one of the greatest global issues and it is urgent for us to find solutions to tackle this problem. Among the total electricity consumption in Hong Kong, the building sector accounts for 90% of energy consumption which implies the importance of increasing the buildings' energy performance. Being part of Government's Climate Action Plan, retro-commissioning (RCx) is one of the key promulgated measures to reduce Hong Kong's carbon emissions. Since 2016, ISPC has been working closely with the Government on the promotion of RCx, which can help the existing buildings to review and improve their energy efficiency.

The HKGBC has launched the RCx Training and Registration Scheme in 2019 to the industry practitioners and services provider, with the support by Electrical and Mechanical Services Department (EMSD) and other professional institutions. The Scheme helps equip more building industry practitioners with the knowledge on RCx and transform the industry on the adoption of RCx works.

To further our expertise on enhancing building energy efficiency, our committee has indicated the development of this HKGBC Retrofitting Guidebook, which captures and provides the retrofitting solutions and case studies for readers to have a comprehensive understanding on retrofitting. We hope that industry practitioners who need to carry out retrofitting projects in the future can refer to this guidebook for more information.

We believe that the project can help industry to advance their knowledge in retrofitting. And more innovative energy saving strategies will be used by the industry in the future. Let's construct a green society together!

MESSAGE FROM EXECUTIVE DIRECTOR

Ir Dr Cary CHAN, JP
Executive Director, Hong Kong Green Building Council

The 6th assessment report by the Intergovernmental Panel on Climate Change (IPCC) stated that "The scientific evidence is unequivocal: climate change is a threat to human well-being and the health of the planet. Any further delay in concerted global action will miss the brief, rapidly closing window to secure a liveable future". This presents a strong case of climate emergency and "No Action" is no longer an option.

In China, the ambition is to retrofit the entire building stock to meet their carbon neutrality target by 2060. It is reckoned that retrofit by adopting matured technologies can be able to meet two-thirds of their target already and the rest will require the development of new technologies.

Hong Kong has committed to carbon neutrality by 2050. Since the existing building stock is contributing to 60% of the carbon emission, successfully improving the energy efficiency of the existing building stock will be critical to meet the target. In a commentary by International Energy Agency (IEA) described that "Energy efficiency is the first fuel and the demand for it must grow".

A number of developers in Hong Kong, over the past 10 years, have been actively reducing the energy intensity of their building stocks through retro-commissioning (RCx) and retrofitting. However, the majority of the existing building stocks have not been following suit. Meeting the target in the climate change roadmap of reducing the energy intensity by 30%-40% for the whole building stock, would thus be a huge challenge.

To meet the challenge, the HKGBC has already been a close partner with the Electrical and Mechanical Services Department (EMSD) to promote the adoption of RCx and retrofitting to the industry.

The objective of this Retrofitting Guidebook is to promote and facilitate the industry to implement retrofitting for better operational performance in energy efficiency for their building stocks. It contains various retrofitting options and considerations, case studies and other resources such as available funds in the market that can facilitate building owners to perform retrofitting works in their buildings. This is intended to be a living document which will be updated from time to time, with the latest best practices and technological advancements.

Some of the technologies listed in the guidebook are relatively new and may have limited choices at the moment. It is the intent that this guidebook can increase the demand of such technologies and eventually lead to the emerging of more alternative solutions.

The cost and benefits of each initiative can be different between retrofitting projects and also most of the retrofitting projects adopt more than one initiative. This makes it inappropriate to work out a cost and payback period for each individual initiative. Other non-monetary benefits and value need to be accounted for to make the retrofitting project justifiable. So case studies are used to illustrate those benefits.

Mainstreaming retrofitting is one of the key focuses of HKGBC's advancing net zero ambition. The HKGBC is and will be launching a number of initiatives with the aim of mainstreaming retrofitting to further reduce the overall energy intensity of the existing building stock.

We hope that the industry will find this guidebook useful in improving the energy efficiency of their building and meeting their own carbon reduction targets.

PLANNING FOR RETROFITTING WORKS 01

Understanding the building's condition and performance

Carry out energy audit and RCx study to have a good understanding on:

1. Operation of the building and optimal operating parameters based on plant operating experience and data
2. Performance of various equipment and systems
3. Conditions and limitations of the systems and equipment to meet user expectation for future operational and maintenance needs

Determining the objectives of the retrofitting project

A holistic view on what you could and should be achieved such as:

1. Energy saving and carbon emission reduction
2. Replacing equipment near the end of its life cycle
3. Serviceability of aged equipment
4. Resilience and reliability of equipment and operation.
5. Fulfilling the future needs of the building or systems e.g. upgrading of the building, loading needs, digitalisation and smart control, enhancement to the management of the facilities
6. Reducing the need for future RCx and resources for energy audit
7. Corporate Social Responsibility (CSR)
8. Complying with the latest editions of the Building Energy Code (BEC) and/or Energy Audit Code (EAC), and the Buildings Energy Efficiency Ordinance (BEEO), Chapter 610

Justifying the retrofitting project

The cost and benefits should not be just using the simple payback analysis with the energy cost saving. The following should be taken into consideration:

1. Discount the service life of the equipment to be replaced, cost to achieve the added objectives not related directly to the energy saving as mentioned above
2. Take into account values (tangible and intangible) on top of energy saving such as reduction in future maintenance and RCx cost, indoor environmental quality (IEQ) and CSR etc.

RETROFITTING STRATEGIES 02

1. Heating, Ventilation, and Air Conditioning – Water-side

General introduction

Central air-conditioning systems are commonly adopted for commercial buildings in Hong Kong.

Such air-conditioning system consists of water-side system and air-side system.

This session describes some of the common retrofitting measures to enhance the energy efficiency of the water-side system.

Description of the water-side system

The water-side system consists of a combination of chillers that generate chilled water and through a combination of chilled water pumps, circulate the chilled water to the air-side equipment to cool the conditioned space.

Chillers have two types of heat rejection systems for condensing the refrigerant, air-cooled or water-cooled. Water-cooled chillers are further divided into heat rejection by fresh water cooling towers or direct seawater cooling.

Common objectives of retrofitting the water-side system of a chiller plant

The key objectives for retrofitting water-side systems are to reduce the energy input to:

- The compressor of the chillers' refrigeration circuit
- The chilled water and condensing water pumps
- The cooling tower fans

The key measures include:

- Improving the efficiency of the refrigerant circuit and the coefficient of performance (COP) of the chillers
- Lowering the condensing temperature and/or raising the evaporating temperature
- Minimising the system pressure and flowrate of chilled water circuit
- Minimising the operating speed of cooling tower fans
- Optimising the system performance through the adoption of smart technologies
- Reducing conduction losses in pipework

Replacement of inefficient chillers with more efficient chillers and review of new chiller combination during life cycle replacement

Efficiency of existing chillers will drop after operating for several years. Latest generation of chillers have higher efficiency as technology advances and have different performance characteristics to suit different operational profiles and conditions. Efficiency of existing chillers should be monitored and planned for replacement when there is a reasonable improvement opportunity.

Considerations:

- Compare the chiller efficiency with the latest BEC.
- Review the cooling load profile of the existing system and determine the new chiller combination.
- The new combination may consist of chillers of different capacities, constant speed and/or variable speed chillers to best suit the loading profile of the system. A good combination that matches the performance characteristics of different types of chillers can optimise the efficiency of the chiller plant.
- Use water-cooled chillers, if possible.
- Installation of energy metering device.

Conversion of air-cooled chillers to water-cooled chillers

The restriction of using water-cooled system has been widely lifted in 2008. Water-cooled chillers are more efficient as they can achieve a lower condensing temperature. Conversion of an air-cooled chiller system to a water-cooled chiller system can have significant enhancement on the chiller plant efficiency.

Considerations:

- Check EMSD's, Water Supplies Department (WSD)'s and Buildings Department (BD)'s approval for using fresh water cooling tower scheme or seawater cooling system in that district.
- Conduct energy audit and prepare load profile of the existing air-conditioning systems.
- Design a new chiller combination based on the principles mentioned above.
- Prepare life cycle cost analysis for replacing air-cooled chillers with water-cooled chillers.

Replacement of cooling tower constant speed fan by variable speed fan

Cooling towers will not be operating at full load all the time. Replacing the constant speed fan with a variable speed fan for cooling tower can reduce fan power during part load conditions by optimising the airflow needed for heat rejection.

Consideration:

- Use plant optimisation systems to adjust the fan speed together with the operation of other equipment to improve the overall efficiency of the chilled water system.

Installation of tube cleaning and other cleaning systems for chiller's water-cooled condenser

Scale inside the surface of condenser tubes will build up over time resulting in the increase of fouling factor. Tube cleaning systems can maintain a low fouling factor for the condenser and hence can help maintain the rated efficiency and capacity of the chillers.

There are different types of tube cleaning systems. One type is using sponge balls either with or without circulation pumps and another type is using brushes that operate by reversing the flow within the condenser.

Considerations:

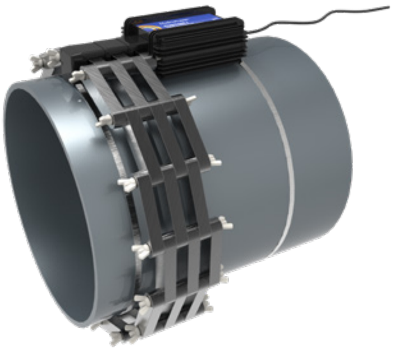
- The efficiency of the chillers can be maintained, and the cost and resources for manual cleaning of the condenser tubes can also be reduced.
- Tube cleaning balls need to be replaced from time to time.
- Tube cleaning systems using brushes require more space for the reverse flow mechanism.

Installation of electromagnetic clamp-on device for condensing water system

Electromagnetic clamp-on device is a non-chemical alternative for purifying and softening condensing water through an electromagnetic field. It does not require the addition of any chemicals to remove impurities and kill bacteria for the condensing water system.

Considerations:

- Reduce the cost for using chemicals.
- Reduce water consumption for flushing and bleed-off.
- Reduce scaling and corrosion inside condenser tubes and maintain the surface roughness in good condition.
- Maintain the heat rejection capacity of condenser.

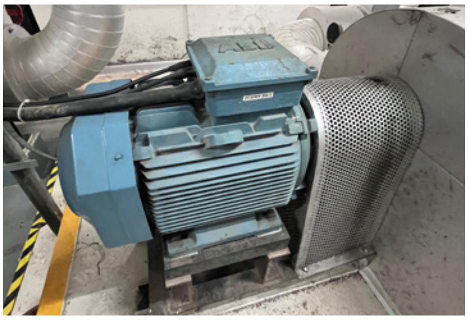


Conversion of the chilled water system to variable flow by replacing constant speed pumps with variable speed pumps

Conventional de-coupler or differential by-pass chilled water system uses constant speed pumps. Most of the time, the system will be operating in part load conditions. Converting the constant speed pump to a variable speed pump with the corresponding control system can reduce the overall system pressure and hence reduce the energy consumption of the chilled water pumps.

Consideration:

- A review on the whole system should be first carried out to determine the plant conversion scenario in order to maximise the benefits of the retrofitting works such as converting the de-coupler system to a primary variable flow system (refer to the following measure), the replacement plan of the existing chillers and the future control systems use.



Conversion of de-coupler or differential by-pass chilled water system to variable primary flow system

Conventional de-coupler or differential by-pass chilled water system may result in a low differential temperature difference across the chillers, especially during part load operations.

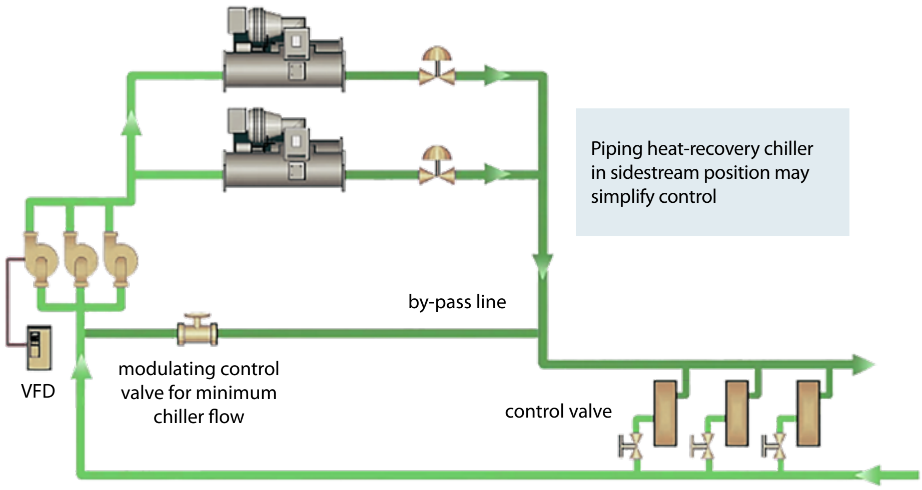
Converting the chilled water system into one single loop with variable flow rate (variable primary flow) can maintain an appropriate temperature across the chillers and enhance the overall efficiency of the chillers.

For de-coupler system, after conversion, it can reduce the overall system pressure due to elimination of one set of pump accessories such as strainers and valves.

Considerations:

- The converted plant will reduce space and resources for maintenance.
- Minimum chilled water flow for the chiller to be maintained as referred to the chiller requirement.

system configurations
Variable Primary Flow



Conversion of centralised chilled water pumps circuit to de-centralised pumping systems with in-line pumps on each equipment/floor/zone

Central chilled water systems use large central pumps to deliver chilled water to terminal devices such as air handling units (AHUs) and fan coil units (FCUs). Adequate amount of chilled water for the terminal devices is controlled by adjusting the pressure drop across the control valves. De-centralised pumping systems replace the large central pumps with small in-line pumps to the terminal devices which will pump just the right chilled water flow through it for cooling the conditioned space. It will save energy by having a lower pressure head.

Considerations:

- The converted system requires fewer resources for balancing and RCx.
- The conversion process is relatively complicated and should be well-planned.

Installation of automatic valves to control chilled water flowrate by the design temperature difference between the supply and return chilled water of terminal devices (e.g. AHUs) or sub-circuits (risers, zones).

The installation of the automatic valves can improve the low Delta-T syndrome (small temperature difference between supply and return chilled water across terminal devices) and ultimately reduces energy consumption.

Considerations:

- Pump energy can be reduced as the flow will be automatically driven by demand.
- It can also reduce the need for system balancing and enhance the temperature control of the terminal devices.

Separation of risers, circuits or systems for different equipment (e.g., AHU, FCU, chilled ceiling, computer room air conditioning (CRAC) unit, etc.) with different chilled water requirements so that some chillers can operate at a higher chilled water supply temperature all or part of a year

Some spaces have a stricter requirement on chilled water supply temperature to their premises such as data centres. While other general spaces such as general offices usually only require the air-conditioning system to satisfy their cooling load needed instead of satisfying the requirement of chilled water supply temperature. Some buildings may be cooled by chilled ceiling which needs a higher chilled water supply temperature. Buildings having only one chilled water supply system will require the supply temperature set to the minimum temperature required by the most critical terminal device for the whole building.

The building can have two separate chiller and riser systems, one that is set for the most critical device for temperature requirement and the other one that can have a more flexible temperature setting. The latter can enable the supply chilled water temperature to be raised to just satisfy the cooling load. With a higher supply chilled water temperature setting, the chillers can run at a higher efficiency.

Considerations:

- More space is needed to accommodate the extra riser and accessories.
- Rearrangement of the chilled water pipes is required.
- At least two chiller sets will be required and may add cost for services.

2. Heating, Ventilation, and Air Conditioning – Air-side

The key objectives for the air-side equipment are to:

- Reduce fan power
- Reduce cooling load
- Improve motor efficiency
- Reduce conduction losses in air duct

The key measures include:

- Improving fan efficiency
- Reducing airflow rate
- Reducing system pressure
- Applying free cooling and
- Using heat recovery

Replacement of traditional induction motor FCU with variable speed direct current (DC) permanent magnet motor incorporated with smart control thermostat or direct digital control (DDC) controller

DC permanent magnet motor efficiency is often above 90%, allowing fans to consume up to 70% less energy when compared to conventional fans.

Considerations:

- Smart control thermostat can provide precise temperature control as well as automatic control of fan speed based on measured room temperature.
- By using intelligent networking thermostats, more advanced energy saving strategies can be achieved such as interlocking with lighting control, remote control, occupancy detection, etc.

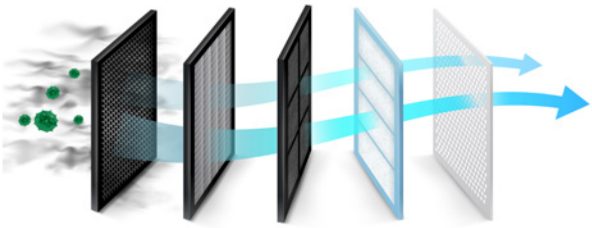
Replacement of air filters with lower pressure drop air filters using sonic, ionisation or other new technologies which can improve filter efficiency

Adopting provisions that can enhance the filtering efficiency can allow the use of filters with lower pressure drop while having similar filtration efficiency. This can reduce the fan power of AHUs.

Considerations:

There are different technologies available which include:

- Energy Saving Sonic (ESS) Technology. A new technology that utilises sonic energy to induce rapid vibration of the particles in air. It can greatly improve the filtration efficiency and reduce energy use and cost of consumables for sustainable air filtration.
- Ionisation technology that uses negative ions to remove small particles in the air. This can help reduce odours and inhibit viruses, bacteria and mould species.



Replacement of centrifugal fan in AHU/ pre-cooling air handling unit (PAU) using electronically commutated (EC) plug fan

The traditional centrifugal fan technology in ventilation system has low efficiency. Replacing centrifugal fans of AHUs with EC plug fans can save 30-50% energy consumption. The EC fan's built-in variable speed drive (VSD) and controller inside the motor get the signal from the temperature or pressure sensor to control the speed of drive.

Considerations:

- EC plug fans do not have belt and pulley or gear, so there will be less maintenance and consumables required.
- EC fan grid provides increased reliability to operation. If one fan fails, only a portion of the airflow is lost; if one fan loses its air flow, the rest will work faster to recover.
- Noise level is lower than centrifugal fans and may require fewer noise attenuation provisions.

Enlargement of fresh air inlet and air duct to allow higher % or 100% of fresh air for free cooling in autumn and winter seasons on days with low outdoor relative humidity (RH)

During autumn and winter seasons, the outside air is often cooler and dryer than the air inside the building. If the outside air enthalpy (temperature and humidity) is lower than the indoor environment, free cooling mode will be activated to bring in full fresh air from outside to cool the building without using the central chiller plant.

Considerations:

- Needs to have adequate space for the extra ducting arrangement.
- Requires additional air louvre area. provisions.
- May require additional pusher fan to provide fresh air.

Conversion of constant air volume (CAV) system to variable air volume (VAV) system

The air conditioning system operates at part load for most of the time. Common CAV system delivers a constant air flow all the time while changing the supply air temperature to control the temperature of the space. By changing the fan to variable speed, the space temperature can be controlled by varying the supply air flow rate at constant temperature. This can significantly reduce the fan power during part load.

For a simple ducting system supplying conditioned air to a small part of a shopping centre, a frequency inverter can be added to change the fan speed.

For an AHU system supplying air-conditioned air to an office where temperature of different zones can have individual temperature control, the ducting needs to be rearranged with VAV box to control each zone's temperature.

VAV systems offer superior performance in applications where the conditioned space is subject to frequent part-load conditions. VAV systems typically offer energy savings above 30% compared with CAV systems.

Considerations:

- The constant speed fans can be converted to variable speed by adding frequency inverters or replaced by EC plug fans which are more energy efficient (refer to the above).
- The fan speed is controlled by the duct static pressure which can be reset according to the damper positions of VAV box to reduce the fan's energy consumption.
- Need to ensure that there is enough fresh air delivered to the conditioned space when the supply flow rate reduces due to low load conditions.

Conversion of VAV system to dry fan coil unit systems with pre-treated fresh air using desiccant dehumidification

The latent load of the fresh air intake is removed by using desiccant dehumidification system. The FCU is designed to remove only the sensible load. The chilled water supply temperature to the FCU can be higher than the indoor dew point temperature and no condensation occurs in the chilled water coil.

With higher chilled water temperature in the system, the chiller will be running at higher efficiency resulting in energy saving.

Considerations:

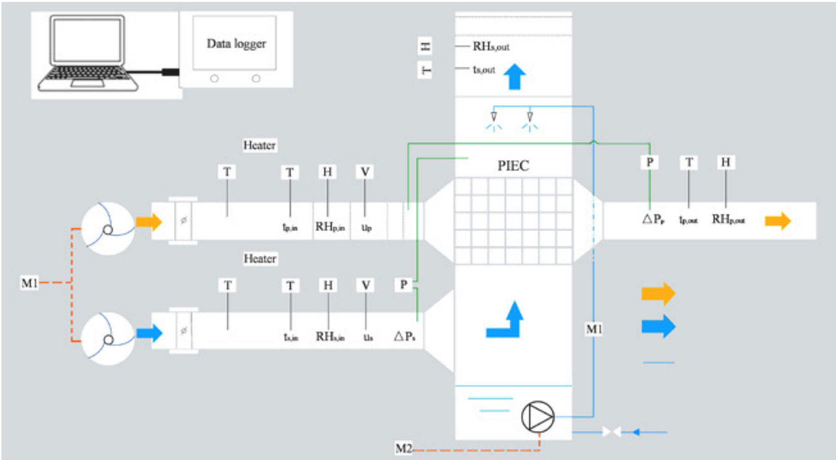
- The indoor environment can be improved as the humidity is controlled at a lower RH. Thermal comfort can be improved and a higher indoor temperature can be set with equivalent thermal comfort and hence reduce the cooling load (1°C increase in indoor temperature can reduce 3 % of air-conditioning load).
- Since the FCU only cater for the sensible load, it can respond faster to maintain the set indoor temperature. Hence the thermal comfort can be improved.
- Space temperature can be better controlled with the FCU vs VAV boxes.
- The fan power of FCU is lower than AHU as the system pressure is much lower due to less ducting and accessories such as VAV box.

Use of heat exchanger or regenerative indirect evaporative cooling system to pre-cool the primary fresh air by the exhaust air

Indirect evaporative cooling involves two air streams – the air supplied to the indoor spaces and a secondary stream that is exhausted outside. In operation, an indirect evaporative process cools air or water on one side of an impermeable heat-exchange surface such as a thin plastic plate or tube. The wet side cools the dry side without adding moisture (because there is no direct contact between the water and the airstream to be cooled).

Considerations:

- The exhaust air needs to flow back to the heat exchanger of the PAU. The air path or ducting needs to be designed.
- Needs to have central exhaust and PAU on each floor.

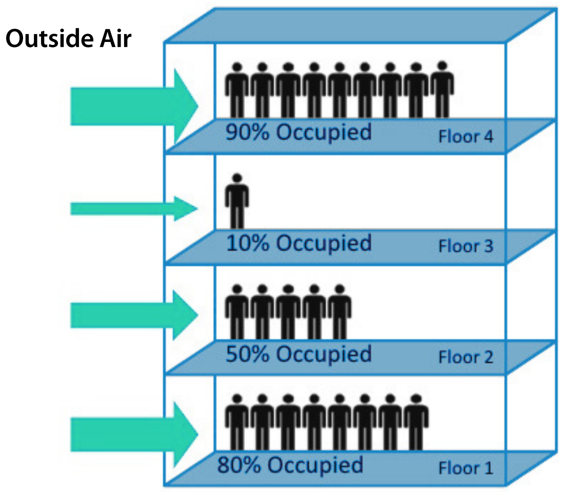


Use of demand control fresh air system to reduce fresh air amount when the indoor air quality (IAQ) meets the desired level according to IAQ sensor input while coupling with variable exhaust system

Demand-controlled fresh air system adjusts fresh air intake based on actual need at any given time instead of at a fixed rate for full occupancy. IAQ sensors measure carbon dioxide levels to signal the heating, ventilation, and air conditioning (HVAC) system to adjust the amount of fresh air brought into the space.

Considerations:

- Ensure that the carbon dioxide sensors are located at locations that can reflect the carbon dioxide level of the occupied zone.
- Carbon dioxide sensors need to be calibrated from time to time.



Use of radiant cooling technologies such as chilled beam or chilled ceiling

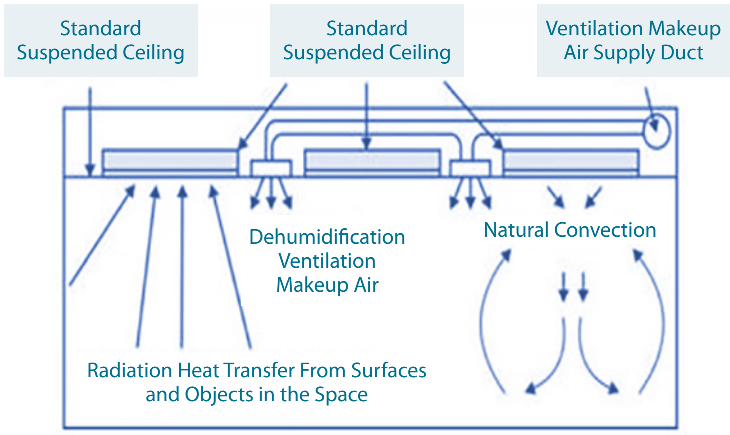
Chilled beam/ceiling system incorporates pipes in the false ceilings through which chilled water flows. The pipes lie close to the ceiling surfaces or in panels and cool the room via natural convection and radiation.

It operates with higher chilled water temperature, generally 3-5°C higher than the conventional chilled water systems, allowing the chiller evaporator temperature to be correspondingly higher, and thus reducing the chiller energy consumption.

It also saves energy by reducing the air flow (only pre-treated fresh air is supplied to the conditioned space) and by handling sensible cooling loads more efficiently.

Consideration:

- Infiltrations have to be controlled to prevent condensation.



Use of spot cooling, ceiling fans for certain locations such as corridors and lift lobbies

Spot cooling is designed to provide cooling air to limited required area or certain time period without the need to cool the entire area that is not normally occupied.

Energy-efficient ceiling fans can be used to provide quiet air movement to cool semi-outdoor areas.

Consideration:

- Ceiling fans can generate a higher air velocity which can provide the same thermal comfort with a higher indoor temperature to reduce the cooling load.

3. Electrical Systems

3.1 Lighting

The key objectives for lighting are to:

- Reduce the direct energy consumption of the lighting system
- Indirectly reduce the air-conditioning load and energy consumption

The key measures include:

- Reducing the need or operating time for using artificial lighting
- Rationalising the lux level of the spaces based on their function or need
- Replacing light sources/luminaires with those having higher efficacy and suitable light distribution patterns.

Retrofit of office layout to maximise the utilisation of natural day light

Office can be renovated to maximise the utilisation of natural day light.

Considerations:

- Barriers to natural lights such as high cabinets, and partitions should be reduced.
- Light-coloured furniture and wall painting should be used.
- Light shelf can be installed if suitable, to reflect external light to the ceiling of inner zones of the space.
- Daylight sensors can be used to dim down the perimeter zone lighting level when natural light is adequate. Care is to be taken as to contradicting the operation of the curtain for preventing glare when the curtain comes down and the artificial lights are at max lux level.

Use of occupancy sensor

Occupancy sensors can be used to operate (switch off or dim) lightings of different zones or individual lights to reduce the energy consumption of the lighting system.

Considerations:

- The amount of energy saving highly depends on the occupancy pattern of the controlled space. Care should be taken to use the lighting sources/lamps that the life expectancy of which is not adversely affected by the frequent on and off operation.
- The occupancy sensors should be well chosen and adjusted so that they can truly determine if the space is occupied or not. For instance, the sensors should not be affected by people passing by a transparent partition.
- The legislation requirement on lighting intensity especially for escape route.

Use of smart lighting control

Addressable lighting system can integrate occupancy and day light sensors, timer etc. to control individual lights or by separate zones.

Consideration:

- This can maximise the energy savings and also best suit the conditions and preference of individuals or different zone areas.

Adoption of task light with lower background lighting

This can reduce the energy consumption of the lighting system because of a lower lux level overall.

Consideration:

- The system needs to be carefully designed so as not to jeopardise IEQ for the purpose of the space.

Adoption of lighting source of high efficacy

Retrofit the lighting system using lighting source of higher lighting efficacy can reduce the lighting energy intensity of the space

Consideration:

- The layout of the new lighting system should be reviewed or redesigned as the lighting characteristic of the new lighting source will be different from the replaced lighting source.

Adoption of luminaires with high efficacy and distribution pattern matching the need of the space

The higher the efficacy of the lighting source/luminaire and the better the distribution pattern, the lower will be the energy used to produce the same or even better lighting effect for the space. (e.g. Nano coated reflector)

Consideration:

- Review of the lighting layout to suit the characteristics of the new luminaires should be done to see if the lighting layout needs to be rearranged. There may be opportunities for reducing the number of luminaires.

Upgrade of light fittings from fluorescent tubes and halogen bulbs to more efficient, longer lasting light emitting diodes (LEDs)

LED lightings enable energy saving and durability. It provides higher efficacy compared with traditional form of light fittings and is far more durable. LED lightings also emit lower heat energy and which requires less energy for ventilation.

3.2
Electricity Distribution System

The key objectives for electricity distribution system are to:

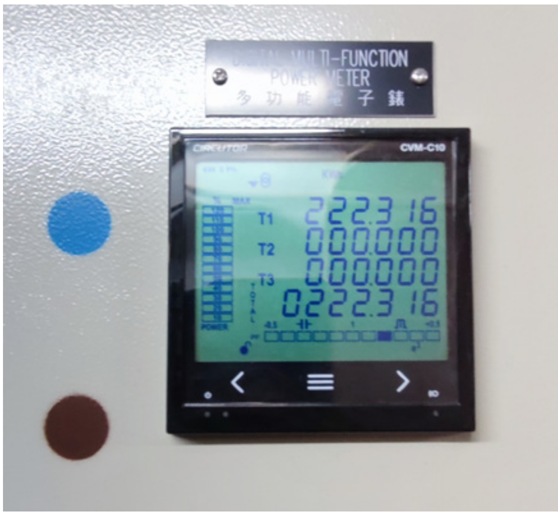
- Maintain a highly reliable electricity distribution system to reduce energy loss
- Enable users to be aware of their energy consumption

The key measures include:

- Monitoring the performance and conditions of the distribution system
- Maintaining balanced load among the 3 phases
- Maintaining low harmonic
- Installing smart meters

Power and Harmonic Analyser

Install power and harmonic analysers to monitor the quality of electricity and the distribution of load among the 3 phases, the power factors and high harmonic loading. Rectify the problem by re-balancing the loading and installing active or passive filters to improve power factor and eliminate excessive harmonic. These can reduce energy loss due to copper loss arising from the impedance of the circuits and eddy current loss in rotating machine and transformers.



Provision of smart metering

Install smart meters so that users can have information on their real-time energy consumption and the consumption patterns to facilitate users to make informed decisions to manage their consumptions such as peak load shedding or switch-off unused appliances.

Consideration:

- The distribution circuit should be reviewed or use addressable equipment to maximise the benefit.

3.3
Lift & Escalator

The key objective for lift and escalator is to reduce the energy consumption for the vertical transportation systems of buildings.

The key measures include:

- Modernising the lift machines
- Reducing the speed of escalators based on demand
- Reducing the weight of interior decorations

Considerations:

- All alterations need to be designed and implemented by the Registered Lift or Escalator Contractor.
- The cost of modernising the lift system can be high and have an unreasonable long payback period. Other benefits or need for the modernising project needs to be considered such as life cycle of the lift machine, supply of spare parts, reliability, safety and quality of services etc.

Installation of regenerative drive for lifts

For conventional lifts, when

i. the car is lightly loaded and moving up, or heavily loaded and moving down and

ii. the lift is slowing down or in braking motion.

The power generated by the traction machine is dissipated as heat.

A regenerative drive is capable to recycle the energy produced and feedback to the building power network. This can greatly reduce the heat dissipation, thus saving overall power consumption of lifts.

As the drives generate less heat, additional energy savings are achieved through reductions in machine room cooling.

Modernisation of aged lifts with gearless machine

By applying permanent magnet (PM) gearless motor of modern technology, the efficiency of the lift hoisting machine is greatly increased, allowing for reduced energy consumption.

PM machines are also lighter in weight compared with conventional geared machine systems, and more compact in size without extra accommodation for gearboxes, which is not only cost saving but also environmentally friendly without hazards of oil pollution by any chance. Advantage of maximising operational efficiency and flexibility is significant.

Upgrade of lift controllers with standby mode features

Replace the electromechanical relays control with software- and microprocessor-based controls with in-cab sensors automatic detection to switch lift into standby mode.

It enables the lift switch to idle or sleep mode, turning off the lights, ventilation and video screen when the lift is not in use. The lift will return to normal when activated again by passenger call.

The microprocessor-based controls release less heat and the low voltage operation definitely saves energy.

Reduce the weight of interior decorations

Consider retrofitting the lift car decorations to reduce the weight of the lift car.

Consideration:

- To consult the Registered Lift Contractor on the feasibility and how to optimise the savings such as the performance characteristics of the motor set and the need to adjust the counter weight.

Modernisation of escalators with standby speed/on demand start function

Upgrading the escalator controller drive to variable voltage variable frequency (VVVF) drive and with the standby speed/on demand start function will maintain the escalator in stop/crawl speed until passenger is detected by the specific sensors to resume the rated speed operation.

This drive system rectifies alternating current (AC) voltages from the mains supply into DC, then converts it into AC voltage with variable amplitude and frequency. The variable voltage and variable frequency enable infinitely variable speed regulation of the motor.

The operation depends on the passenger flow. Significant energy can be saved when the escalator is not being occupied.

4. Smart Control Systems

The key objectives for smart control systems are to:

- Have an information management platform for data collection, data analytics, data display and reporting
- Have a network of internet of things (IoT) so that all sensors and controllers can be inter-operable and inter-communicable through various data communication infrastructure
- Have the ability to carry out optimisation of the building services systems to achieve a high performance building
- Have the function of carrying out fault detection and condition-based maintenance

The key measures include:

- Installing smart control systems with IoT sensors and controllers
- Using smart technologies that can optimise various building services systems by rule-based, Artificial Intelligent (AI), prediction models or digital twin technologies, etc.

Considerations:

- The technical staff needs to be well trained on the analysis of data from the smart system and the performance characteristics of the systems that the smart system is going to be optimised. Training on RCx will be a good start.
- The objectives of the retrofitting project need to be determined so that the best options can be identified such as total replacement of the existing building management system (BMS), adding on a smart system for some specific functions, replacing in part only or a long term total replacement.
- The smart system needs to have adequate sensors to cover the system to be optimised. For example, if the chilled water plant is going to be optimised, the root problem may be on the air-side systems and so must have adequate sensors to identify the root cause of the problems for optimal effect.
- Start from knowing the information that is needed before working out the data to be collected.

Incorporation of smart building energy management platform with IoT infrastructure that can collect building operation data, perform monitoring and evaluation; demand control and optimisation of the various systems

The smart building energy management platform is a cloud-based AI-based platform. The IoT infrastructure allows integration with different IoT sensors and BMS to collect operation data of the building.

The platform will use AI and machine learning to analyse, optimise and automate operations. It can identify unnoticed faults, predict failures, identify root causes of failures and energy saving opportunities as well as optimise the HVAC operation to save energy.

The platform allows users to configure and customise their dashboards for remote monitoring of energy and operation performance of the plants.

Consideration:

- The connectivity of the wireless method in various locations for applying IoT infrastructure should be considered.

Installation of meters or by other means to visualise energy consumption data for demand side energy management

A smart metering platform is used to facilitate energy audit and determining of consumption profile of the building operation and for facilitating demand-side energy management.

The platform comes with analytics and energy management functions for providing analytic reports for the optimisation of energy usage, triggering alert for abnormal consumption, forecasting energy consumption and providing data for the implementation of RCx measures.

Implementation of various AI energy optimisation solutions to all major equipment with high energy consumptions

With advanced BMS, smart meters and IoT technologies, vast amount of data from building operation can be obtained. These real-time data collected can uncover the energy-saving opportunities and reveal the actual performance of major building services systems, such as chiller plants, AHU and VAV system.

By using AI energy optimisation platform which utilises machine learning, advanced data management techniques and physical principles, the representative models for real-time plant optimisation can be developed holistically to achieve the overall optimal operation.

Big data analytics can also be used to support fault detection and diagnosis, enabling predictive maintenance to discover faults, investigate root problems and recommend best-suited solutions for achieving optimal performance and energy efficiency.

The platform can provide holistic control of the whole chiller plant including chillers, cooling towers, pumps, etc. It determines the most efficient point of operation and overrides the BMS control to run the chiller plant at the optimal point.

Integration of people counting sensors with water-side & air-side optimisation and smart lift control

Different types of people counting technologies are available in the market. Popular choices include infrared beam counter, thermal count sensor, video-based count senor and light detection and ranging (LiDAR) sensor.

By integrating people data into BMS or AI energy optimisation platform, HVAC system operation can be better optimised.

Knowing the number of people in and out of the building, the AI energy optimisation platform can accurately predict the cooling load required and operate the optimal number of chillers to be operated. Fresh air intake can also be reduced to meet the minimum occupancy requirements.

By counting people inside lift car and waiting in lobby, the smart lift system can perform many functions such as triggering by-pass (skip floors) when the lift is full or no people waiting in the lobby, sending a right number of lifts to serve the people in the lobby, etc.

5. Server Room / Data Centre

The key objective for server room/data centre is to:

- Reduce the power usage effectiveness (PUE), which is the ratio of the total amount of energy used by a computer data centre facility to the energy delivered to computing equipment. PUE is the inverse of data centre infrastructure efficiency (DCiE)

The key measure includes:

- Reducing the energy used for rejecting the heat from the information technology (IT) equipment

Considerations:

- The retrofit has to be well-planned with risk management and contingency plan to prevent any unpredicted interruption to the data centre.
- Use Lithium battery instead of Lead Acid battery that can sustain at the higher space temperature.
- Eliminate isolation transformer if the power condition is suitable to reduce the power loss.

Replacement of Uninterrupted Power System (UPS) by more energy efficient system

UPS is a continuously operating system that provides reliable power supply to the critical equipment especially IT servers. Higher efficiency UPS can lower the power loss substantially.

- Using insulated-gate bipolar transistor (IGBT) rectifier with power factor correction to ensure that current distortion is lower and power factor >0.99
- Using transformerless UPS that improves the energy efficiency
- Using Modular UPS to improve the flexibility

Installation of enclosure to separate hot-aisle/ cold-aisle (hot aisle containment / cold aisle containment)

Hot/cold aisle is a layout design for server racks in a data centre. The goal of it is to increase the effectiveness of cooling system by managing air flow in data centre. This design involves lining up server racks in different rows withdrawing cold air at the same aisle and exhausting hot air to another aisle to minimise cross-over between hot air and cold air. The servers are positioned back-to-back such that hot air is discharged to the same aisle.

With cold aisles containment, cold air is directed only to the front of the servers, where it is pulled through the servers into a warm aisle or a space near a warm air return to be re-cooled. Except for the cold aisle, other space in the data centre hall is at higher temperature.

With hot aisle containment design, the hot air is efficiently captured and channelled back to the CRAC.

Considerations:

- With cold aisle containment, the cooling effectiveness is higher, but most of the area in the data centre hall may not be suitable for people working.
- Additional fire detection and firefighting requirement for the contained aisles.

Use of emerging technologies such as immersion cooling and heat pipes for cooling the data centre servers

Immersion cooling involves immersing system components, such as a motherboard or an entire computer system, in a fluid which, ideally, has a high coefficient of heat rejection and low thermal resistance. These fluids need to be "dielectric" meaning that they do not conduct electricity. Because immersion cooling is more energy- and space-efficient, interest in the technology has steadily grown over the years, and the technology itself has evolved considerably.

Heat pipe energy recovery modules provide a passive cooling effect to reduce loads and downsize the mechanical cooling system in indirect cooling applications, whether chilled water or direct expansion. As air passes over the warm side (hot air aisle from data centre return air) of the heat pipe, the refrigerant vaporises, absorbing energy, then travels to the cold side (outside air) where it condenses, releasing energy, then flows back to the warm side.

Consideration:

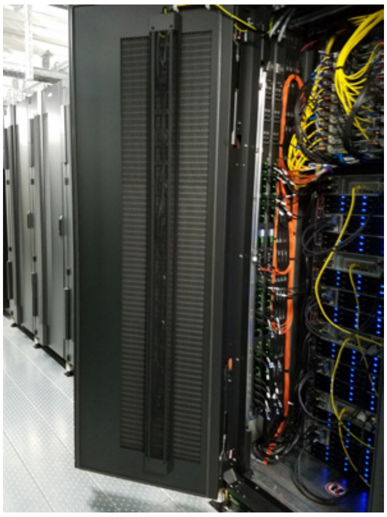
- Immersion type heat rejection system may only be considered when the data centre is undergoing a major replacement plan for the IT equipment.

Use of cold door for server racks cooling instead of using CRAC Unit

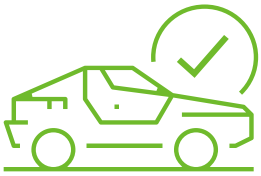
Cold door is a cooling coil installed at the door of the hot air discharge side of the equipment rack. It absorbs the heat directly before it leaves the equipment rack. It requires no fan power and supply temperature of the cooling media can be maintained at a much higher temperature than a typical chilled water system, say 21°C. Besides, the whole data centre hall can be maintained in a better environment.

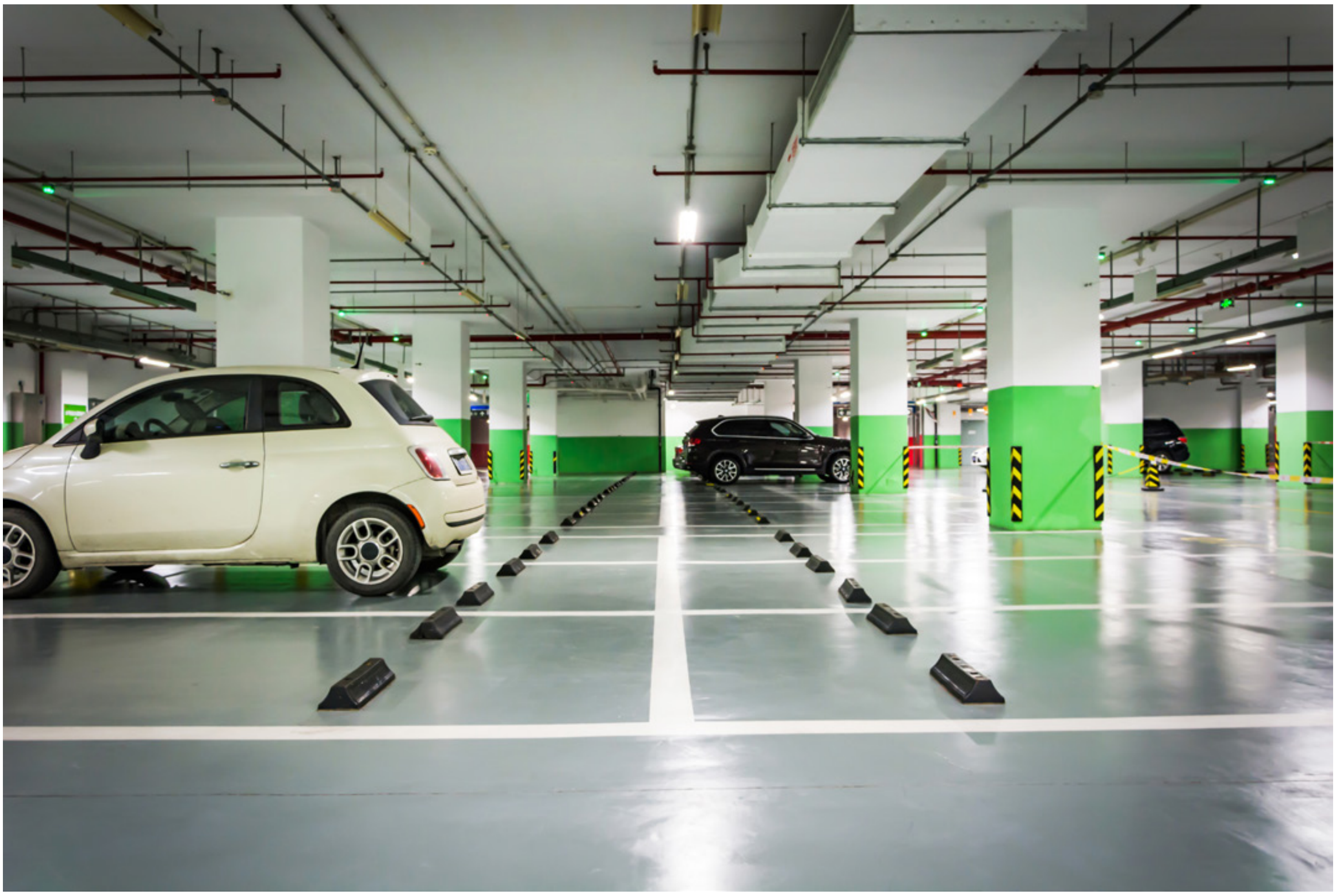
Consideration:

- Cold door normally supplied with the equipment rack and thus the size of the equipment rack has limited selection.



6. Carpark





The key objective for carpark is to:

- Reduce the energy consumption of the ventilation and lighting systems

The key measures include:

- Reducing the air flow rate by demand
- Zoning the carpark
- Using induction system

Use of zoning for carpark operation

Divide the carpark into zones and close down some zones during night time or non-peak hours so that lighting and ventilation needs can be reduced.

Considerations:

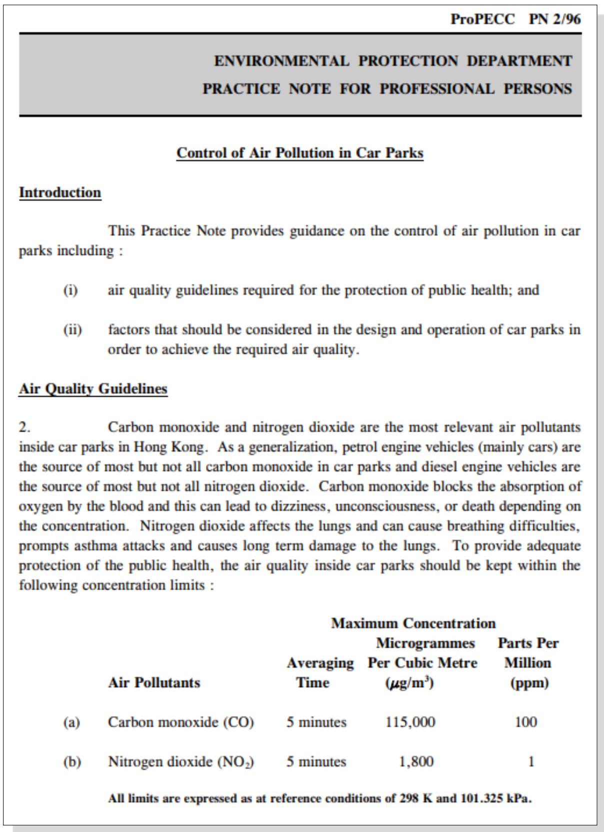
- Security risks need to be addressed and planned for.
- May need to rearrange the zoning for monthly or sold carparks to maximise the benefit of the retrofit.

Use of demand control to vary exhaust air/fresh air by carbon monoxide (CO) and temperature sensors

According to Environmental Protection Department (EPD) guideline ProPECC PN 2/96, the CO concentration inside car parks should be kept within 100ppm. If the CO concentration is under this limit, the ventilation rate can be reduced to save energy.

Consideration:

- Thermal comfort needs to be considered during hot seasons. May need other means to maintain an acceptable thermal comfort level during adverse conditions such as fans.



ProPECC PN 2/96

ENVIRONMENTAL PROTECTION DEPARTMENT
PRACTICE NOTE FOR PROFESSIONAL PERSONS

Control of Air Pollution in Car Parks

Introduction

This Practice Note provides guidance on the control of air pollution in car parks including :

(i) air quality guidelines required for the protection of public health; and

(ii) factors that should be considered in the design and operation of car parks in order to achieve the required air quality.

Air Quality Guidelines

2. Carbon monoxide and nitrogen dioxide are the most relevant air pollutants inside car parks in Hong Kong. As a generalization, petrol engine vehicles (mainly cars) are the source of most but not all carbon monoxide in car parks and diesel engine vehicles are the source of most but not all nitrogen dioxide. Carbon monoxide blocks the absorption of oxygen by the blood and this can lead to dizziness, unconsciousness, or death depending on the concentration. Nitrogen dioxide affects the lungs and can cause breathing difficulties, prompts asthma attacks and causes long term damage to the lungs. To provide adequate protection of the public health, the air quality inside car parks should be kept within the following concentration limits :

			Maximum Concentration	
	Air Pollutants	Averaging Time	Microgrammes Per Cubic Metre ($\mu g/m^3$)	Parts Per Million (ppm)
(a)	Carbon monoxide (CO)	5 minutes	115,000	100
(b)	Nitrogen dioxide (NO_2)	5 minutes	1,800	1

All limits are expressed as at reference conditions of 298 K and 101.325 kPa.

Use of induction units to eliminate ducting and hence reduce fan power

The jet fan ventilation system is based on a number of small high velocity jet fans that replaces traditional air distribution ductwork in enclosed car parks. The mechanical supply and exhaust systems have less resistance and therefore require smaller fans that consume less power.

Consideration:

- The air flow path needs to be properly designed so that it can induce the exhaust air towards the exhaust louvre.

7. Others

7.1 Heating

Replacement of electric or gas heater with heat pump as the heat source to reduce the energy consumption for heating

Heat pump works on the principle of drawing heat from air or water heat source through a refrigerant cycle. Efficiency of heat pumps is much higher than direct heating by electric or gas heater. It can be used for:

- Providing heating for indoor space requiring heating. There are air-conditioning units with reverse cycle function that can provide heating in the winter and cooling in the summer.
- Generating heating water for central HVAC systems.
- Generating hot water for domestic or commercial hot water system.
- Through recovery devices, hot water can be generated at the condenser of central or packaged air-conditioning systems.

Considerations:

- Ensure the electricity supply has the spare capacity to operate the heat pumps if the conversion is from gas to heat pump.
- Where feasible, solar heaters may be installed for preheating the water to the heat pump to save electricity consumption.

7.2 Building Envelope

The key objectives for building envelope are to:

- Reduce heat entering the building or infiltration to reduce the cooling load of the air-conditioning system
- Have less air-conditioned space

The key measures include:

- Means to reduce heat entering the building through the glazing or roof by radiation or conduction
- Minimising infiltration into the building through the entrants

Solar film, spray or solar reflective blind on building façade

Solar radiations to indoor space can be reduced by attaching a solar film on the window, using spray-on solar coating or installing reflective solar blind. Energy consumption of the air-conditioning system can be lowered as a result of the reduction in solar load.

Considerations:

- Life span of the added-on film or coating to the life of the glazing should be considered as to how those can be maintained or replaced.
- The safety features of the glazing should not be jeopardised. For example, the feature of tempered glass is that it will break into small pieces when damaged either by external force or spontaneous breakage from within. However, if a film is applied, the broken glass is still intact and may fall as a large glass piece, increasing the risk of serious injury to pedestrians.

Installation of a second plane of glazing behind the building façade

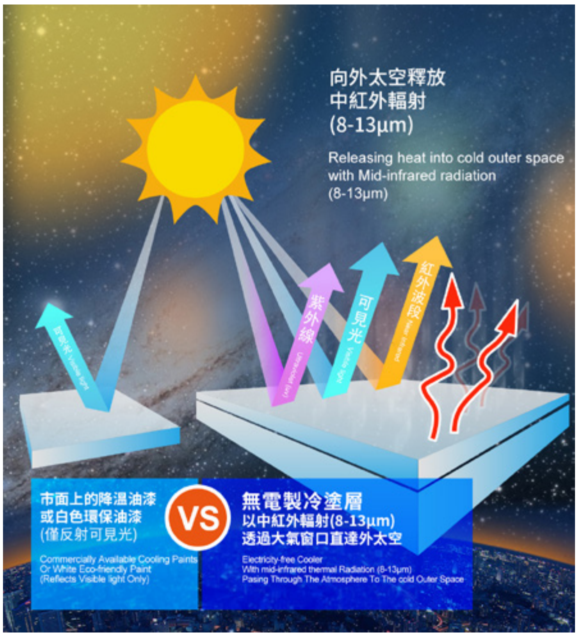
A lot of existing buildings are using single glazing. The heat entering the building through solar radiation and conduction can be reduced by installing a second piece of glazing at the internal side of the window. Energy consumption for the air-conditioning system can be lowered due to the reduction of overall thermal transfer value (OTTV).

Considerations:

- Load calculation should be carried out to make sure that the window framework can stand the weight of the additional glass.
- Check if submission to BD is required or can be handled as minor works.
- Apply it just to windows that are subject to prolonged solar radiation which could have a much shorter payback period despite a smaller energy reduction.
- The second glazing should have good shading and insulation performance and should have minimal effect on the aesthetic of the window.
- Other benefits of indoor environment should be considered such as noise reduction and indoor thermal comfort.

Application of coating on roof that can irradiate heat to the atmosphere

Apply special coating on the roof that can irradiate heat from the roof surface to the atmosphere to reduce the OTTV of the building in order to reduce energy consumption of the air-conditioning system.



Installation of green roofs

Green roofs can lower the surface temperature of the roof which can reduce the heat conducted from the roof to the top floor to lower the energy consumption of the air-conditioning system.

Green roofs can also lower the temperature of the surroundings and may reduce the heat island effect and improve pedestrian comfort.

Considerations:

- Structural loadings and usage of the roof need to be checked.
- How to maintain the water proofing and the plants should be considered.

Use of double door or revolving door or air curtain to reduce infiltration

Using air curtain, double door or revolving door can reduce the energy consumption of air-conditioning for cooling the air infiltrated into the building. It can also improve IAQ.

Consideration:

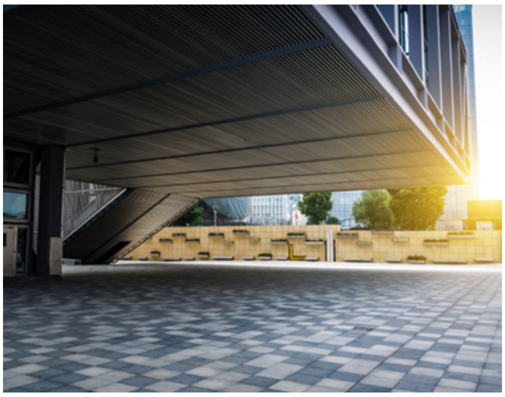
- Extra space is needed for revolving or double doors.

Natural ventilation and lighting

Convert some enclosed space to allow natural ventilation and lighting during appropriate outdoor weather conditions to reduce energy usage of air-conditioning and lighting system.

Consideration:

- Suitable for areas for circulation, common activities etc.



Renewable energy

Add renewable energy source on roof such as solar panel, photovoltaic (PV) panel or wind turbine.

Considerations:

- The two utility companies offer feed-in-tariff to incentivise the installation of PV panels and wind turbines.
- A number of options available including different types of PV panels, hybrid type wind turbine with PV panels, building integrated photovoltaic (BIPV) panels, solar panels for hot water etc.
- There are regulations limiting the height of the PV panel from the roof floor.
- Structural loading needs to be checked.

USEFUL RESOURCES AND LINKS FOR RETROFITTING

03

To motivate the building owners and facility management operators to initiate their retrofitting projects, government departments and serval corporations provide their support or incentives for retrofitting projects, including EMSD, CLP Power Hong Kong Limited (CLP Power), The Hongkong Electric Company, Limited (HK Electric), Construction Industry Council (CIC), etc.

Useful Links

EMSD is enforcing the Buildings Energy Efficiency Ordinance (BEEO), Chapter 610 and has a regulatory role in retrofitting works in buildings. Under the BEEO, certain prescribed types of buildings have to comply with BEC and/or EAC, etc.

- **Link:**

  Buildings Energy Efficiency Ordinance (CAP.610)

Fundings

CIC gives their support in doing research for retrofitting projects.

- **Link:**

  1907018_CIC_ResearchSummaryReport_CICRS22_G_V02

CLP Power has serval initiatives that support retrofitting projects including advisory services and funding programmes.

- **Advisory Services:**

  Energy Audit (clp.com.hk)

  Retro-commissioning Charter Programme (clp.com.hk)

- **Energy Management Tool:**

  Smart Energy Online (clp.com.hk)

- **Funding Schemes:**

  Eco Building Fund (clp.com.hk)

  Electrical Equipment Upgrade Scheme (clp.com.hk)

HK Electric provides advisory service and funding programme for retrofitting projects.

- **Advisory projects' link:**

  Smart Power Energy Audit – HK Electric

- **Funding projects' link:**

  Smart Power Building Fund – HK Electric

CASE STUDIES

04

HKGBC does not conduct its own assessment of the case studies included in this Guidebook. The results presented here are those shared by the case study contributor and their project team. HKGBC staff have scrutinised the findings and asked for follow-up where necessary to ensure the accuracy of the details provided, but cannot attest to their accuracy. HKGBC encourages readers of this Guidebook to engage with the case study contributor where questions or clarifications arise.

CASE 1

Information of Building

Building owner:

PCCW-HKT Telephone Limited

Building name:

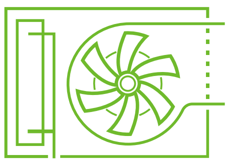
Ngau Tau Kok Engineering Centre

Description of the building:

- A 10-storey building with offices, a 24 hours call centre and canteen
- Fully air-conditioned with water cooled central chilled water system & constant speed pumps
- Water cooled central chiller water system controlled by Building Monitoring System round the clock
- Air Handling Unit and Fan Coil Unit for offices, call centre and canteen with pre-treated fresh air

Information of Retrofitting Project

Retrofitted system involved:

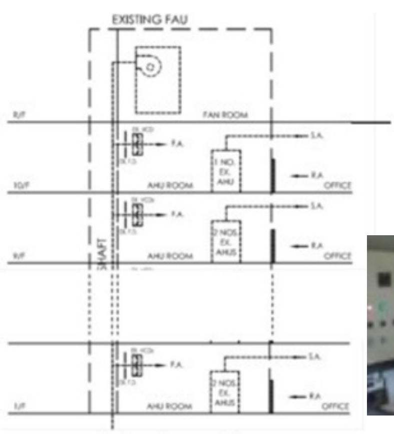


Retrofitted initiatives:

- Converted the fresh air supply system to demand control ventilation.
- Fresh air supply on every floor is controlled by the indoor carbon dioxide level instead of fixed amount of fresh air intake.
- Building Management System is engaged to control the amount of fresh air intake in each floor.
- Speed of fresh air fan is controlled by the static air pressure level at the supply air duct.
- Free Cooling Mode will be activated to allow 100% of fresh air intake while ambient temperature is under 20°C by Building Management System.

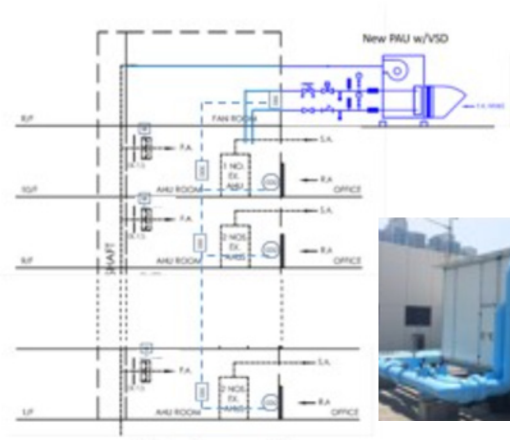
Conceptual Drawing indicating the changes

Before Renovation



Old FAU

After Renovation



New PAU

04 CASE STUDIES | **CASE 1** | **PCCW-HKT Telephone Limited**
• Ngau Tau Kok Engineering Centre

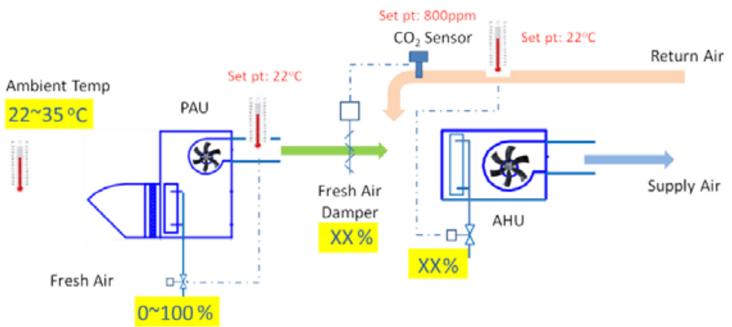
Observed benefits other than energy saving:

- Improved cooling capacity in each floor and reduced complaint for poor indoor air temperature.
- Improved indoor air quality and Nil complaint for insufficient fresh air.

General observations of the retrofitting project:

- Fresh air supply system retrofit has not affected the users in general.
- Standard retrofitting initiatives with proven technologies and straight forward.
- Retrofit requires shut down of fresh air supply temporarily. Some disturbance to tenants but manageable.
- Overall a well justified project with good outcomes with tangible and non-tangible benefits.

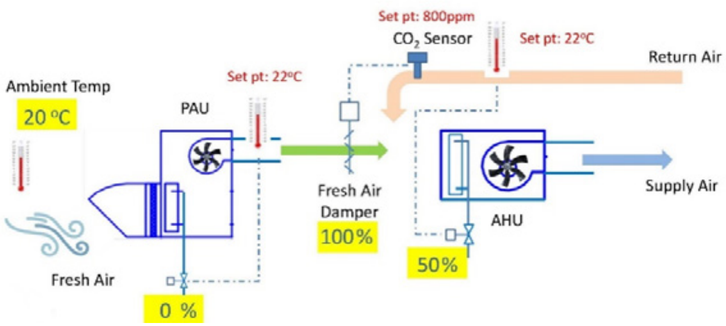
Conceptual Diagram indicating the Control Logic



Ambient Temp:
22 to 35 °C

PAU water valve:
controlled under PAU set point

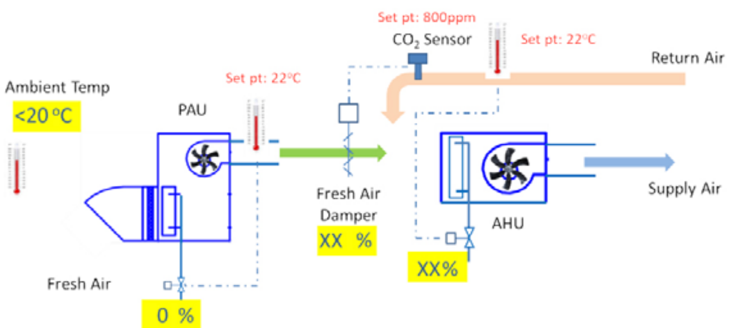
Fresh Air damper:
Control under CO_2 setpoint



Ambient Temp:
20 °C

PAU water valve:
closed

Fresh Air damper:
by-pass CO_2 setpoint & fully open



Ambient Temp:
below 20 °C

PAU water valve:
closed

Fresh Air damper:
by-pass CO_2 setpoint & room temperature control the opening to minimise cooling requirement

Cost		Saving	
Total cost:	HKD 1,200,000	Total savings/year:	170,000 kWh
		Payback:	7 years

04 CASE STUDIES

CASE 2

Information of Building

Building owner:

PCCW-HKT Telephone Limited

Building name:

East Exchange Tower

Description of the building:

- A 24-storey building with offices, exchanges and a carpark
- The 2-storey carpark located in basement equipped with 16 parking space

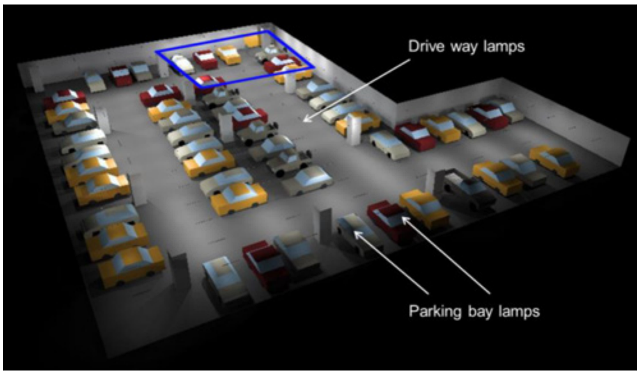
Information of Retrofitting Project

Retrofitted system involved:

Retrofitted initiatives:

- Replaced the original T8 lighting with LED tubes that integrated with a microwave motion sensor at B1, B2 & LG floor.
- The LED lamp operates at full power when the sensor sensed motion.
- The LED lamp within escape route would be dimmed to 30% automatically when the sensor sensed no motion along access path after 1 minute. The minimum lux level will be maintained at 30 lux for meeting the requirement of Mean of Escape.
- Other LED lamps would be switched off automatically when the sensor sensed no motion within carpark space after 1 minute.

Floor/Premises	Operating hrs/ Mth	Original Lighting	Original Lighting Wattage	Original Quantity	LED Brand/Type	LED Lighting Wattage	LED Quantity	Completion Date
Carpark B1	720	1x600 mm FL fixture	18	38	CET / CL2810FNW	10	38	Mar 2018
Carpark B2	720	1x1200 mm FL fixture	36	69	CET / CL4820FNW	20	69	Mar 2018
Carpark LG	720	1x1200 mm FL fixture	36	12	CET / CL4820FNW	20	12	Apr 2018



Source from CET 中國光電有限公司

New LED Lighting System with dimming

Type of Tube	Quantity	Wattage	Operating Hours	Daily kWh used
1200 mm tube	63	7	21	9.261
1200 mm tube	18	0	21	0
1200 mm tube	81	20	3	4.86
600 mm tube	38	4	21	3.192
600 mm tube	38	10	3	1.14
				18.453

Old T8 Lighting System without dimming

Type of Tube	Quantity	Wattage	Operating Hours	Daily kWh used
1200 mm tube	81	36	24	69.984
600 mm tube	38	18	24	16.416
				86.4

kWh saved per day	67.947
kWh saved per year	24800.655

04 CASE STUDIES | **CASE 2** | **PCCW-HKT Telephone Limited**
• East Exchange Tower

Observed benefits other than energy saving:

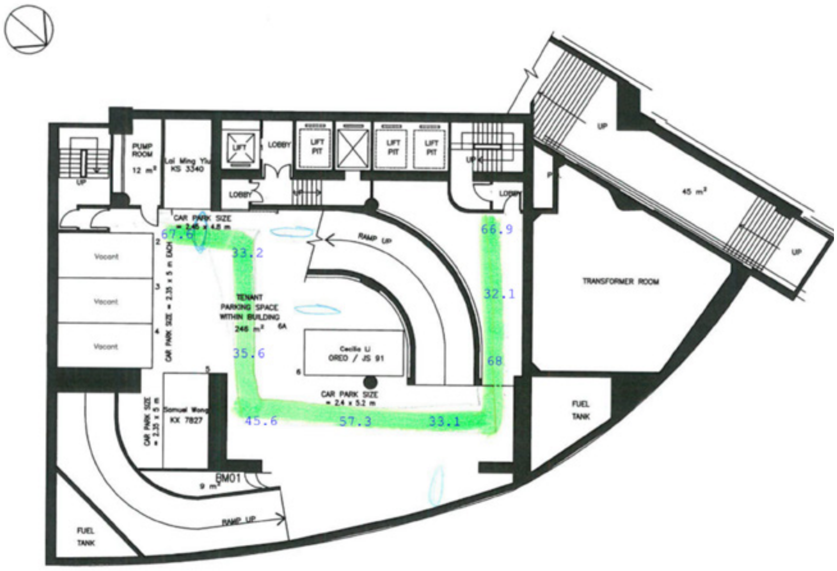
- Prolong the lifetime of the LED tube, therefore save money.
- Reduce the temperature of carpark, therefore better indoor environment for carpark user.

General observations of the retrofitting project:

- New carpark lighting system retrofit have not affected the users.
- Standard retrofitting initiatives with proven technologies and straight forward.
- Retrofit requires shut down of lighting system temporarily at a very short period of time. Minimal disturbance to tenants.
- Overall a well justified project with good outcomes with tangible and non-tangible benefits.

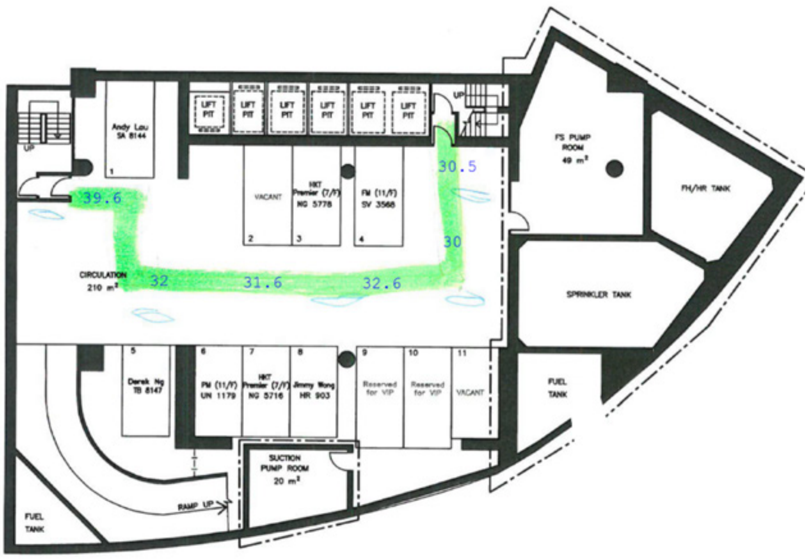
East Exchange Tower Basement 1 Plan

(Lighting lux measurement)
Unit: Lux



East Exchange Tower Basement 2 Plan

(Lighting lux measurement)
Unit: Lux



Cost		Saving	
Total cost:	HKD 45,000	Total savings/year:	24,800 kWh
		Payback:	1.8 years

CASE 3

Information of Building

Building owner:

PCCW-HKT Telephone Limited

Building name:

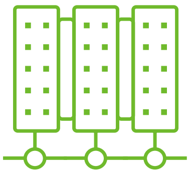
Yuen Chau Kok Exchange

Description of the building:

- A 9-storey building with offices, datacentres, telephone exchange areas and a canteen
- IT loads are served by Uninterruptible Power Supply (UPS) System

Information of Retrofitting Project

Retrofitted system involved:

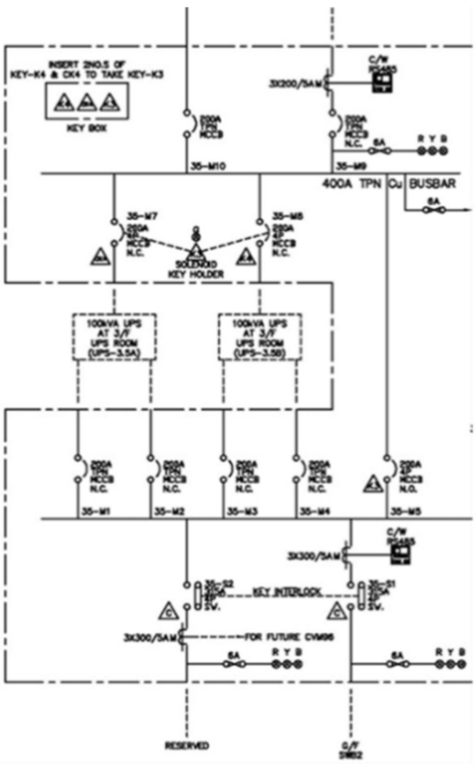


Retrofitted initiatives:

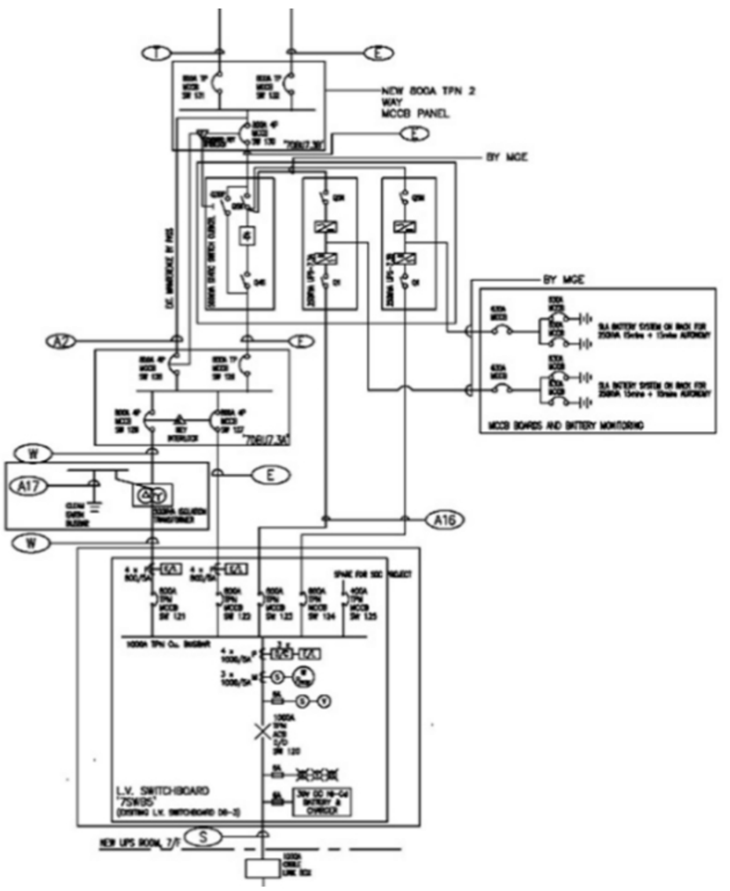
- Replace the obsoleted UPS systems in smaller rating (UPS 7.3A&B, 7.4A&B, 3.5A&B, 3.6A&B) by new UPS systems in larger rating (UPS 7.3A&B, 7.4A&B) with high conversion efficiency.
- Remove isolation transformers.

Schematic Diagram showing the old UPS system

Old UPS3.5A & B



Old UPS7.3A & B



04 CASE STUDIES | **CASE 3** | **PCCW-HKT Telephone Limited**
• Yuen Chau Kok Exchange

Observed benefits other than energy saving:

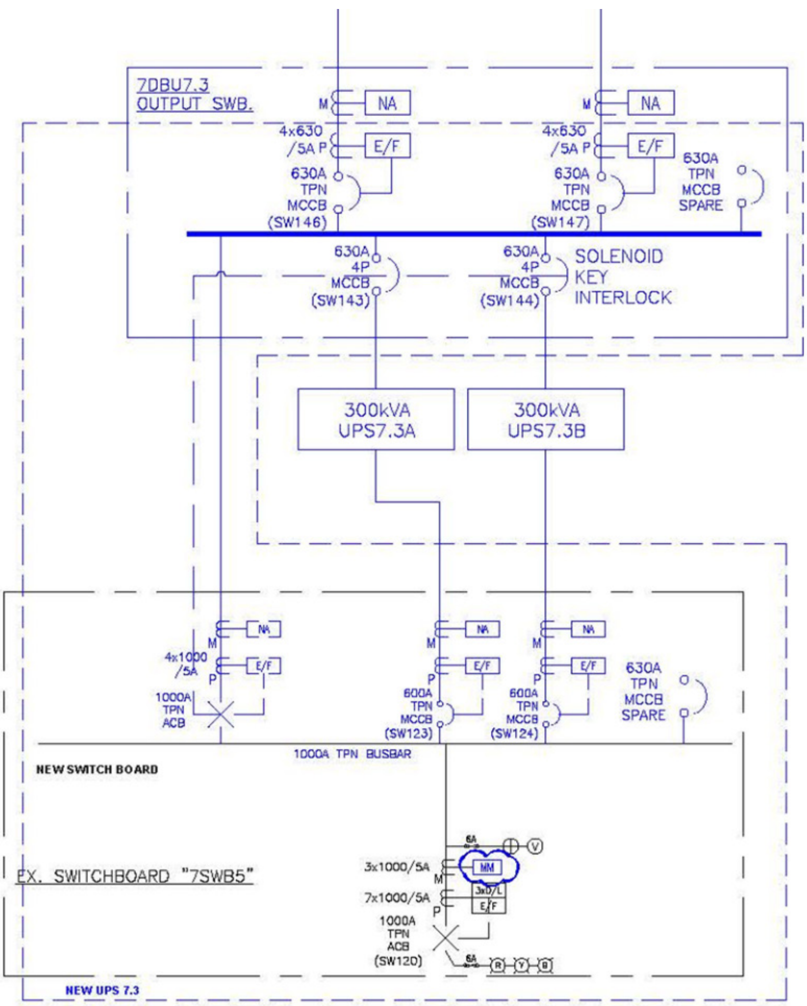
- Improve the reliability of the uninterruptible power supply for mission critical equipment.
- Reduce the maintenance cost.

General observations of the retrofitting project:

- UPS system retrofit has not affected the users.
- Standard retrofitting initiatives with proven technologies and straight forward.
- Retrofit requires diversion of IT loads. Some disturbance to tenants but manageable.
- Overall a well justified project with good outcomes with tangible and non-tangible benefits.

Schematic Diagram showing the new UPS system

New Consolidated UPS7.3A & B



Cost		Saving		Subsidy/ Funding	
Total cost:	HKD 3,564,000	Total savings/year:	HKD 1,100,000	The project is supported by:	CLP Eco Building Fund
Cost breakdown:	UPS c/w all necessities HKD 2,244,000 Backup Batteries HKD 1,320,000	Savings/year breakdown:	HKD 850,000 - electricity consumption cost saving due to improved UPS conversion efficiency HKD 250,000 - Saving in maintenance cost		
		Payback:	2 years		

CASE 4

Information of Building

Building owner:

Hongkong Land Limited

Building name:

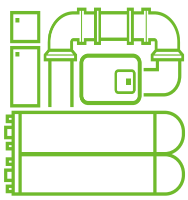
Chater House

Description of the building:

- Chater House is at the hub of Hongkong Land's portfolio in Central, with telecommunications, electrical and mechanical features designed for the specific needs of investment banking and financial services
- One of the four iconic buildings under LANDMARK, representing the epitome of top-tier luxury shopping and lifestyle experiences

Information of Retrofitting Project

Retrofitted system involved:



Retrofitted initiatives:

- **Centralised chilled water plant:**

  Replace 5 of the existing 12 air-cooled chillers into 3 water-cooled chillers. The water-cooled chillers were installed and connected with the remaining air-cooled chillers. Cooling towers were installed on the roof for heat rejection. A variable flow, decoupled chilled water system is adopted.

- **Chilled water plant control:**

  Converting from manual operation to automatic plant operation, a new BMS system is installed with energy optimisation strategies for better control and equipment monitoring, including the upfeed pumps, condensing water pumps, cooling towers, make-up tank, condensing water tank and water-cool chillers. The air-cooled chillers and new water-cooled chillers work seamlessly to meet the building cooling load in an energy efficient manner.

Observed benefits other than energy saving:

- Reduced operator resources in plant operations with adoption of automatic chiller plant operation.
- Larger overall cooling capacity (5 existing 300Ton ACC replaced with 3 new 750Ton WCC).
- New chillers and chilled water pipes now housed indoor are better protected and less prone to outdoor damages.
- Lower noise level since outdoor air-cooled chillers are commonly known to produce higher noise levels via chiller condenser fans.
- Less vibration.
- Enhanced reliability of chilled water supply with the presence of both water-cooled chillers and air-cooled chillers.
- Longer service life of water-cooled centrifugal chillers than air-cooled screw chillers.

General observations of the retrofitting project:

- Space utilisation is the key since extra space is needed to install cooling towers and condensing water pumps for water cooled systems.
- Plan for upfeeding water to make up the water loss during operation of cooling towers.
- Equipment delivery is another critical challenge. Unlike air cooled chillers which are mostly modular design, larger capacity water cooled chillers tend to have a long bundle of evaporator and condenser.
- Energy saving is significant.

Name of the consultant and contractor	Cost		Saving	
Consultant: **WSP (Hong Kong) Ltd.** Contractor: **The Jardine Engineering Corp., Ltd.**	Total cost:	Around **HKD 23 million** (2010)	Savings/year breakdown:	**>45%** total energy consumption saving **>3.35 MWh** saving per year Saving in parts replacement and service cost of air-cooled chillers and saving in manpower resources in plant operation **>HKD 2 million**
	Cost breakdown:	Mechanical and Electrical work over **HKD 13 million** Chiller Supply over **HKD 10 million**	Payback:	**(HKD 23 million – HKD 2 million) / HKD 4.36 million = 4.82 years**

CASE 5

Information of Building

Building owner:

Hongkong Land Limited

Building name:

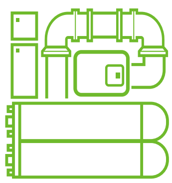
Exchange Square

Description of the building:

- Grade A Commercial Buildings for a prestigious, globally oriented, 24-hour business complex
- 52 levels for One Exchange Square and 51 levels for Two Exchange Square comprising of offices, retail, and F&B outlets
- Fully air-conditioned with direct sea water-cooled central chilled water system with primary and secondary chilled water pumping system
- Air handling unit (AHU) and Fan-coil units (FCU) for offices, retail, and F&B outlets with pre-treated fresh air

Information of Retrofitting Project

Retrofitted systems involved:



Retrofitted initiatives:

- **Centralised chilled water plant:**

  Two 3,000Tons existing sea water-cooled chillers were replaced by two new 1000Tons and one 2000Tons direct sea water-cooled chillers. New primary pumps were also replaced for new chillers. For Chiller-1A and 1B, two new primary pumps are installed for chilled water and two new heating water pumps were installed for heating water system. For Chiller-2, two new primary pumps were installed. At the discharge side of each chiller, constant flow control valve was installed for automatic flow rate control of chilled water passing through each chiller. A decoupling chilled water system was arranged for the central chiller plant. It consists of constant water flow through each chiller evaporator and variable flow secondary water distribution system.

- **Chilled water plant control:**

  DDC control system is provided for fully automatic control, energy optimisation control, monitoring, supervision and data logging for chilled water plant operation. The building load requirement is predicted by the DDC control system based on the loading profile in the past years. The predicted building load is analysed to determine the optimum configuration of the chiller plant.

- **Implementation of JEDI (Jardine Engineering Digital Insight):**

  This further enables system fault detection, chiller optimisation and real-time energy dashboards.

Observed benefits other than energy saving:

- Lower noise level since the new chillers adapt multiple stage of compression which operate exceptionally quieter.
- Heat recovery at condenser side of chiller to eliminate additional heating equipment and reduce condensing water (seawater) provision.
- Diversity in chiller capacity and chiller types to cater for optimisation based on cooling loading.
- Enhanced building load prediction system with optimised control logic to allow the system to determine the most optimal combination of equipment to suit the predicted building demand.

General observations of the retrofitting project:

- Before the project, heating water was generated by the old chiller which can either operate in cooling mode or heating mode. We applied heat recovery operation in this project since the buildings require simultaneous cooling and heating, i.e. the base building cooling demand is high even in winter. This is the most critical consideration to adapt this energy saving operation.
- All chiller units are now being fitted with an electromagnetic clamp-on device installed on the exterior of condensing seawater pipes. This greatly hinders growth of microorganisms which adversely impact the heat transfer at the condensers.

<table>
<tr><th>Name of the consultant and contractor</th><th colspan="2">Cost</th><th colspan="2">Saving</th></tr>
<tr><td rowspan="2">Consultant:
J. Roger Preston Ltd.

Contractor:
The Jardine Engineering Corp., Ltd.</td><td>Total cost:</td><td>over HKD 60 million (2016)</td><td>Savings/ year breakdown:</td><td>>23% saving on annual water side energy consumption
>3.4 MWh saving per year compared to maintenance cost of aged chillers >HKD 6 million</td></tr>
<tr><td>Cost breakdown:</td><td>Mechanical and Electrical work over HKD 15 million
Chiller Supply over HKD 30 million
Major Equipment Supply over HKD 15 million</td><td>Payback:</td><td>(HKD 60 million – HKD 6 million) / HKD 4.9 million = 9.15 years</td></tr>
</table>

CASE 6

Information of Building

Building owner:

Hongkong Land Limited

Building name:

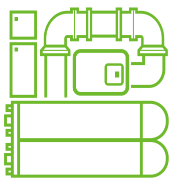
One & Two Exchange Square

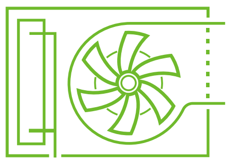
Description of the building:

- Grade A Commercial Buildings for a prestigious, globally oriented, 24-hour business complex
- 52 levels for One Exchange Square and 51 levels for Two Exchange Square comprising of offices, retail, and F&B outlets
- Fully air-conditioned with water-cooled central chilled water system and primary and secondary chilled water pumping system
- Air handling unit (AHU) and Fan-coil units (FCU) for offices, retail, and F&B outlets with pre-treated fresh air

Information of Retrofitting Project

Retrofitted systems involved:





Retrofitted initiatives:

- **EC Plug Fans:**

  Replace the existing AHUs with belt-driven centrifugal fans to EC Plug Fans. Apart from a more effective motor comparing with the old AC motor, EC Plug Fans also enhance system efficiency as it does not require belt and pulley for operation. With BMS control for the new AHU, if one of the EC Plug Fans malfunctions, the other EC Plug Fans can pick up the required flow or provide partial flow by maintaining a static pressure set point and preventing the single point failure of centrifugal fan motors, fan bearings, pulleys etc.

- **Energy Valve:**

  Replace the existing control valve in chilled water return pipe with Energy Valve. The Energy Valve consists of 'Delta-T Manager' Control - when cooling load is met and the chilled water delta-T is lower than the design value, the Energy Valve will further be closed to reduce water flow for achieving energy saving.

- **IEQ Monitoring:**

  Install the CO_2 sensors and PM sensors to monitor the indoor air quality. When the CO_2/PM level is too high in the environment, the fresh air supply can be increased. Alternatively, the fresh air supply can be reduced if the CO2/PM is constantly at low level.

Observed benefits other than energy saving:

- Reduced maintenance resources in operations, future retro-commissioning and water re-balancing when adding/removing AHUs.
- More information for AHU monitoring and reporting as both EC Plug Fans and Energy Valve provide high level interface for connecting to Building Management System (BMS).
- Provide resilience with multiple modular fans to replace single centrifugal fan in traditional AHUs.
- Provide better indoor air quality monitoring and control.

General observations of the retrofitting project:

- AHU retrofit requires suspension of AC supply to tenant. To avoid nuisance to tenants, the replacement of AHU was done in 60-hours during the weekend.
- Advanced work such as conduit and wiring works can be arranged weeks before actual replacement to shorten the AC suspension time.
- Some AHU rooms are located inside tenant area; comprehensive protection works are done with reference to tenant's comments. No complaints received.
- A few models of EC Plug Fan were selected to reduce the parts provision and storage.
- Overall a well justified project with good outcomes with tangible and non-tangible benefits.

Name of the consultant and contractor	Cost		Saving	
Consultant: J. Roger Preston Ltd. Contractor: The Jardine Engineering Corp., Ltd.	Total cost:	**HKD 25 million** for supply and installation of 130 nos. of EC Plug Fan AHU / PAU and energy valve only (2019)	Savings/year breakdown:	**HKD 1 million** (Average Energy Saving) **HKD 2.2 million** (Average Maintenance Cost Saving) *Note: More than 30% saving of water volume of some AHU / PAU obtained from position to flow control + dT Manager after applying the function of Energy Valve.*
			Payback:	**Around 7.8 years** (Around 5-15% direct saving in air side. The indirect saving in water side was achieved by lowering the demand after installation of energy valve)

CASE 7

Information of Building

Building owner:

Housing Authority

Building name:

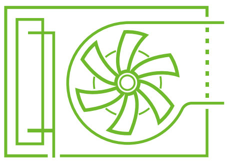
A wet market at Ying Tung Estate in Tung Chung

Description of the building:

- A wet market with a total floor area of 260 m2 for this experimental study
- An all-fresh-air air-conditioning system
- The cool exhaust air from the air-conditioned space cannot be reused, but exhausted through this IEC system
- Two air handling units (AHUs) were installed for the wet trade area and each one is responsible for half of the area
- Two rotating heat recovery wheel systems (HRW) are installed before each AHU to pre-cooling/pre-heating fresh air by recovering cold/heat from exhaust air in summer/winter

Information of Retrofitting Project

Retrofitted system involved:

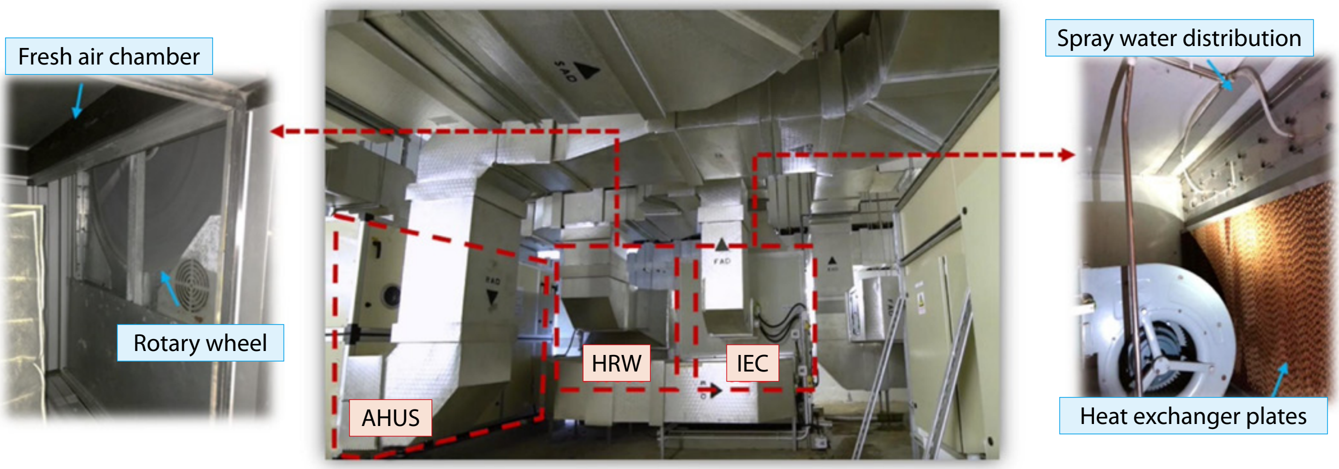


Retrofitted initiative:

- **HVAC primary fresh air system:**

  Two Regenerative Indirect Evaporative Coolers (RIEC) are designed and installed in parallel with the two existing heat recovery wheel (HRW) systems. The cool exhaust air from the indoor environment is introduced to the IEC secondary air channels. The fresh air is pre-cooled before it passes through the AHUs.

The view of plant room for central AC system



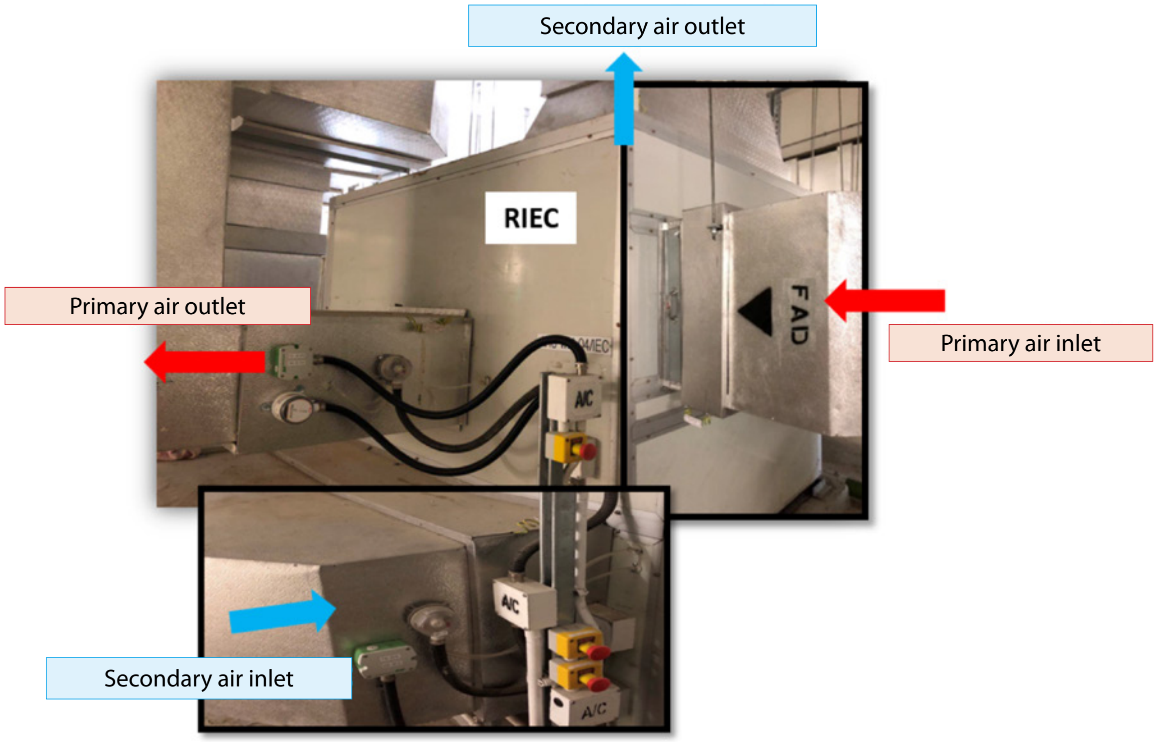
Observed benefits other than energy saving:

- Simple system.
- Less initial cost and operational cost.
- Shorter payback period.

General observations of the retrofitting project:

- During the renovation process, the existing HRW system could still work for fresh air pre-treating, so it will not affect the thermal comfort of people in the wet market.
- All refurbishment work is carried out in a proprietary plant room only, with no impact on other activities.
- RIECS can substitute the HRW and treat fresh air to the aimed setpoint and satisfy the thermal requirement with less energy consumption.

The duct arrangement of the packed RIEC system



Cost		Saving	
Total cost:	HKD 96,000	Total savings/year:	HKD 23,000
		Payback:	4.17 years

CASE 8

Information of Building

Building owner:

Swire Properties Limited

Building name:

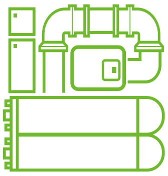
Cityplaza Mall

Description of the building:

- Cityplaza is the largest shopping mall on Hong Kong Island which operating since 1983, with approximately 1.11 million ft2 floor area managed by Cityplaza Management Office (CPMO) of Swire Properties Management Limited (SPML).
- Separate chiller plant serves the north and south wing of Cityplaza, with a central indirect seawater heat rejection system.

Information of Retrofitting Project

Retrofitted system involved:



Retrofitted initiative:

- **Modification of HVAC Chilled Water System:**

  Modified chilled water system from existing constant primary and variable secondary to variable primary system. Use of existing primary chilled water pump sets were suspended and new bypassing primary loop system completed in early Feb 2021. The related performances are continuously monitored by the Cloud-Based Smart Energy Management Platform (CBSEMP).

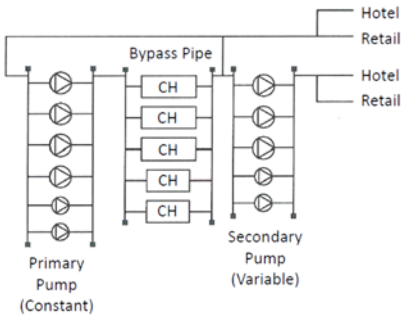
- **Cloud-Based Smart Energy Management Platform (CBSEMP):**

  A centralized cloud platform, namely the Cloud-Based Smart Energy Management Platform (CBSEMP) to collect, analyze, and visualize real-time energy and operation data. It enables real-time data collection, big data analytics based on artificial intelligence rule-based expert system and machine learning to identifies and alerts on energy saving opportunities and predictive maintenance.

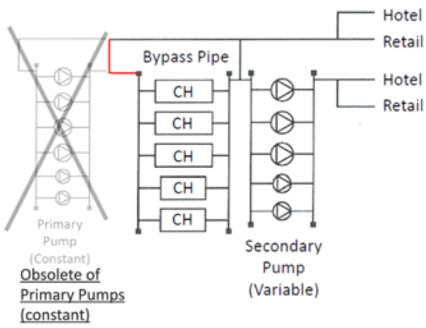
Schematic Diagram of Chilled Water System Before and After Modification

Schematic Diagram of Previous Chilled Water System

(Before modification)



(After modification)



Observed benefits other than energy saving:

Modification of HVAC Chilled Water System

Reduced maintenance resources in plant operations and future retro-commissioning and balancing

Cloud-Based Smart Energy Management Platform (CBSEMP)

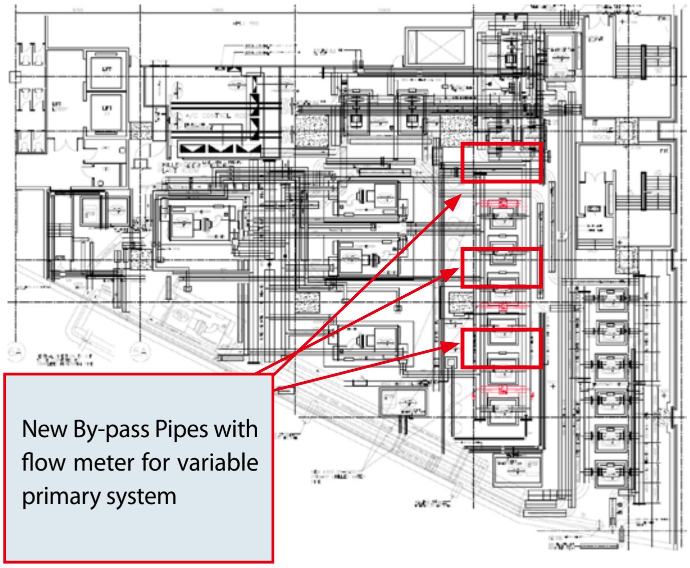
Providing real-time monitoring and analysis of energy and BMS operation data, identifying energy saving opportunities and maintenance insights through a customizable and flexible cloud platform.

- **Smart Diagnosis**
  AI Rule-Based Expert System identifies and alerts on energy saving opportunities and predictive maintenance
- **Dashboards**
  In-depth understanding of energy performance and associated energy cost performance. Breaking down to individual buildings
- **Automatic Reporting**
  Reporting for energy performance target tracking (for management and technical team) and operation performance tracking (for technical team)
- **Data Analysis**
  Enable your engineers to select any data to directly monitor and analyze online. Freely share charts created with others.
- **Alert and Monitoring**
  Let your engineers receive alert on their phone to follow up with identified opportunities. Monitor performance after rectification

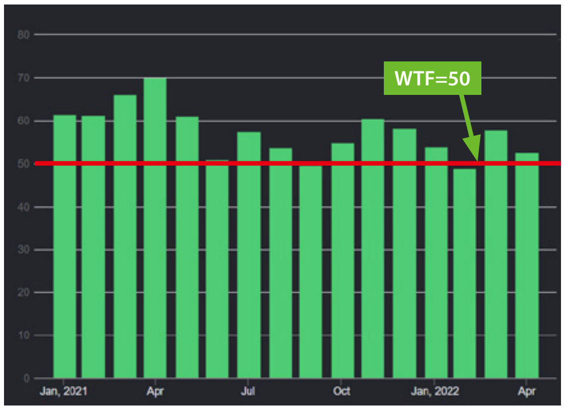
General observations of the retro-fitting project:

Night work for HVAC system retro-fit did not affect the tenants and systems.

Chiller Plant Plan After Modification



Cloud-Based Smart Energy Management Platform (CBSEMP) to continuously monitoring of WTF over the period



Cloud-Based Smart Energy Management Platform (CBSEMP)

Providing real-time monitoring and analysis of energy and BMS operation data across different portfolio types (office and retail) in different regions (Hong Kong and Chinese Mainland), identifying energy saving opportunities and maintenance insights through a customizable and flexible cloud platform.

Smart Diagnosis

AI Rule-Based Expert System identifies and alerts on energy saving opportunities and predictive maintenance needs

- Predictive Maintenance
- Increase Efficiency
- Energy Saving

Dashboards

In-depth understanding of energy performance and associated energy cost performance. Breaking down to individual buildings and systems.

- Performance Visualization

Automatic Reporting

Reporting for energy performance target tracking (for management and technical team) and operation performance tracking (for technical team)

- Performance and Target Tracking

Data Analysis

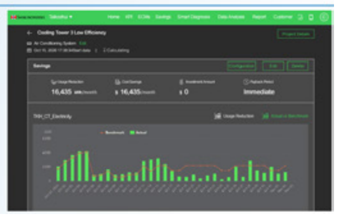
Enable your engineers to select any data to directly monitor and analyze online. Freely share charts created with others.

- Performance Analysis

Alert and Monitoring

Let your engineers receive alert on their phone to follow up with identified deficiencies. Monitor performance after rectification

- Optimize Human Resources



Cost		Saving	
Total cost:	Modification of HVAC Chilled Water System HKD 362,700 Cloud-Based Smart Energy Management Platform (CBSEMP) HKD 1,300,000	Total savings/ year:	Modification of HVAC Chilled Water System HKD 177,200 Cloud-Based Smart Energy Management Platform (CBSEMP) HKD 565,200
		Payback:	Modification of HVAC Chilled Water System 2.0 years Cloud-Based Smart Energy Management Platform (CBSEMP) 2.3 years

CASE 9

Information of Building

Building owner:

Swire Properties Limited

Building name:

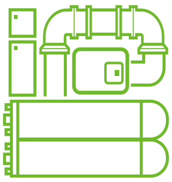
Devon House

Description of the building:

- A 29-storey Grade-A office building with 4 basements floors
- Served by 4 nos. of water-cooled chillers with VSD

Information of Retrofitting Project

Retrofitted system involved:



Retrofitted initiative:

- **Installation of automatic tube cleaning system (ATCS) for condenser of water-cooled chillers**

  Automatic cleaning system for the inner surface of condenser tubes of water-cooled chillers. One ATCS can serve two chillers at Devon House.

Observed benefits other than energy saving:

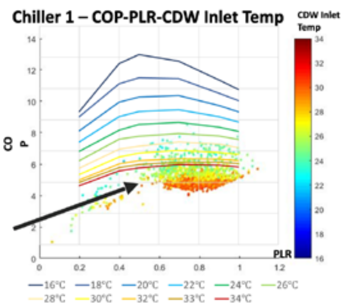
- Better efficiency operation of the condenser as well as overall efficiency of the chiller plant
- Reduce maintenance cost and manpower for periodic manual cleaning

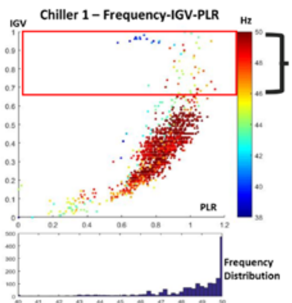
General observations of the retrofitting project:

- VSD Chiller (seawater-cooled) was unable to operate at designed condition
- Seems the operating pattern more like constant speed, as frequency was limited to 46-50Hz and IGV adjusted to match load
- Condenser refrigerant temperature is high (high approach temperature and condensing water inlet temperature, due to seawater quality)
- RIECS can substitute the HRW and treat fresh air to the aimed setpoint and satisfy the thermal requirement with less energy consumption.

Installation of automatic tube cleaning system (ATCS) for condenser of water-cooled chillers

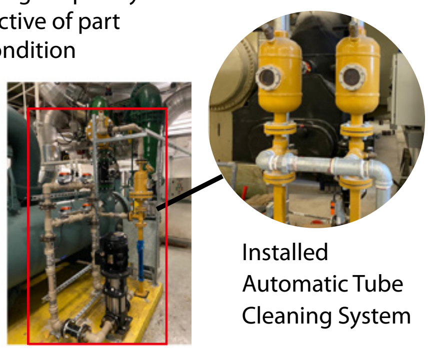
Operating performance lower than designed



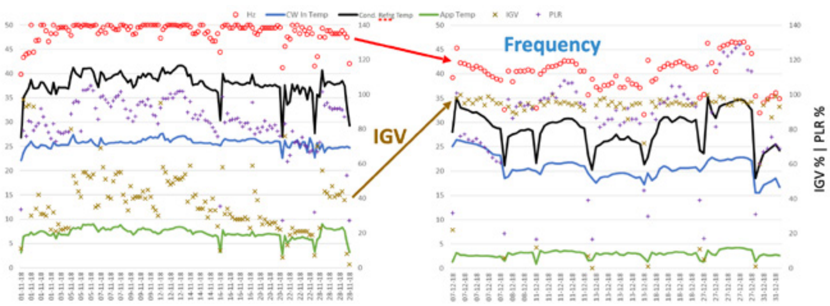


Operating frequency irrespective of part load condition

Findings: VSD Chiller (seawater cooled) was unable to operate at designed condition



Installed Automatic Tube Cleaning System



Chiller 1 – Before Cleaning and Adjustment of CDW Strategy

Chiller 1 – After Cleaning and Adjustment of CDW Strategy

- Monitoring of approach temperature to determine condensing tube cleaning
- Optimize condensing water loop to lower condensing water inlet temperature
- Frequency able to reduce, down to 35Hz, and fluctuate to match load while IGV remains at 100% opening

Cost		Saving	
Total cost:	HKD 520,000	Total savings/year:	HKD 220,000 (for 2 chillers)
		Payback:	2.4 years

04 CASE STUDIES

CASE 10

Information of Building

Building owner:

Swire Properties Limited

Building name:

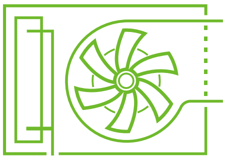
Two Pacific Place

Description of the building:

- A 27-storey Grade-A office building
- A central direct seawater-cooled system serving office, mall and hotels
- Each typical office floor is served by two air handling units (AHUs) with pre-treated fresh air

Information of Retrofitting Project

Retrofitted system involved:



Retrofitted initiative:

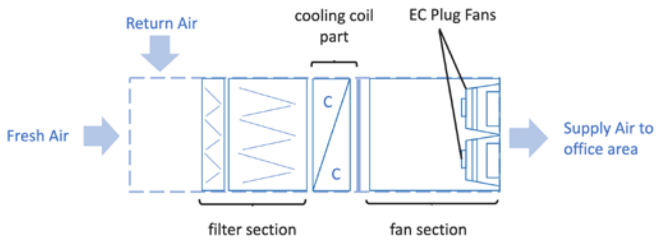
- **Replacement of Belt-Driven Fan by using Electrically Commutated (EC) Plug Fans Installation for Air Handling Units (AHUs)**

  Replace the existing AHU belt-driven fans with EC Motor Plug Fans, in order to provide higher motor efficiency with the use of brushless DC-operated motors and better part load efficiency by electronically controlled application of current to sustain optimal motor performance at the operating points.

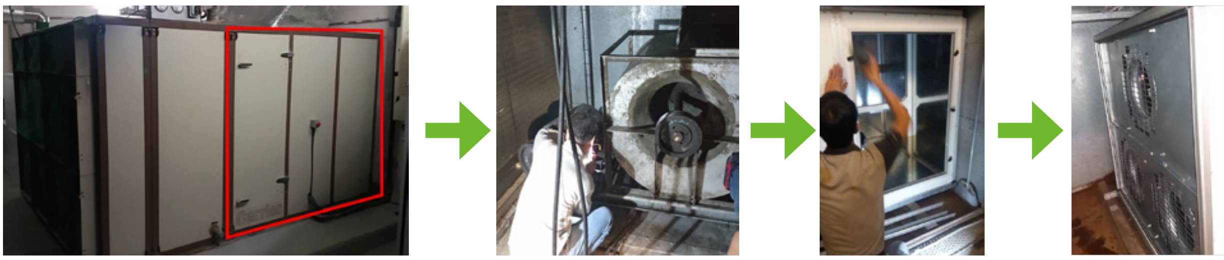
Replacement of Belt-Driven Fan by using Electrically Commutated (EC) Plug Fans Installation for Air Handling Units (AHUs)

Photos at typical AHU room

Indicative section of AHU equipped with EC Plug Fans



Plug Fan Installation



Observed benefits other than energy saving:

- Weekend work required to minimize the disturbance to building normal operation: Each fan replacement done over a single weekend
- Site spatial limitation and access to some whole floor tenant area for retro-fitting
- Existing fan section chamber panels cannot withstand high pressure: Extended site work required for modification of the whole fan section

Airside Electricity Consumption Comparison of Before and After Installation of EC Plug Fan

Cost		Saving	
Total cost:	HKD 6,400,000	Total savings/year:	Approx. HKD 600,000
		Payback:	11.0 years

CASE 11

Information of Building

Building owner:

Sunny Force Limited

Building name:

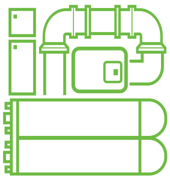
Hong Kong Pacific Centre

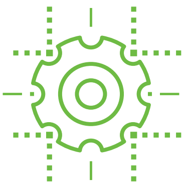
Description of the building:

- Grade A commercial complex with 16 floors of offices and 3 floors of arcade
- Fully air-conditioned with water-cooled central VSD chilled water system, differential pressure by-pass and VSD pumps & cooling tower fans
- Fan coil unit for offices and arcade with pre-treated fresh air supply
- Mainly medical services building

Information of Retrofitting Project

Retrofitted systems involved:





Retrofitted initiatives:

- Replaced 4 air-cooled chillers by 4 water cooled chillers with variable speed drive (VSD).
- All pumps are fitted with VSD to control the flowrate of the chilled water by differential temperature of chilled water supply and return header and override by pressure differential of the critical circuit point.
- All cooling tower fans are also fitted with VSD to control the approach temperature of condensing water.
- Installed a remote 24-hour monitoring system for condensing water quality.
- Installed electromagnetic water conditioner for condensing water.
- Installed a Central Control & Monitoring System (CCMS) for system monitoring and data logging.
- Installed a PV system of 12.8 kW.
- Conducted retro-commissioning (RCx) of ACMV system under HKGBC "ACT-Shop" programme between 2016 and 2017.
- Installed a chiller plant optimisation system for diagnosis of chiller plant.

Observed benefits other than energy saving:

- Reduced maintenance resources in chiller plant operations and future continuous RCx and balancing.
- More information for chiller plant monitoring and reporting.

General observations of the retrofitting project:

- HVAC system retrofit has not affected the tenants.
- Some advanced technologies, such as CCMS and remote condensing water monitoring system, can be led in a chiller plant retrofit project. This is value-added.

Chiller plant

PV system

Name of the consultant and contractor	Cost		Saving	
Consultant: ISPL Consulting Limited Contractor: Shun Hing E & M Engineering Ltd.	Total cost:	HKD 20 million	Total savings/year:	HKD 1,440,000
			Savings/year breakdown:	PV generated : HKD 45,000
			Payback:	6.98 years
Awards			**Subsidy/ Funding**	
Awards received by the project:	CLP GreenPlus Recognition Award 2016 • Silver Award EMSD Energy Saving Championship 2016 • Hanson Merit Award (Office Building) • Best Achievement in Energy Saving Award (Cross-Category) HKGBC Greed Building Award 2016 • Finalist (Existing Buildings Category: Completed Projects • Commercial Building)		The project is supported by:	CLP Renewable Energy Feed-in Tariff

CASE 12

Information of Building

Building owner:

World Empire Investment (CI) Limited

Building name:

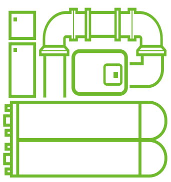
Avon Mall

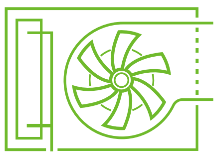
Description of the building:

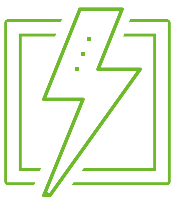
- Shopping Mall with 2 Storeys
- Fully air-conditioned with air-cooled central chilled water system, deferential pressure by-pass, constant speed pumps
- AHUs / PAUs for shopping mall common area
- Low Efficiency LED downlight in Atrium

Information of Retrofitting Project

Retrofitted systems involved:







Retrofitted initiatives:

HVAC – Chiller System (with BIM)

- Replace depreciated chillers to higher efficiency chillers and review new chiller combination.
- Newly install high static condenser fans in new chillers with Variable Speed Drive Control to increase the air circulation rate of condenser in different outdoor temperature conditions.
- Improve pump efficiency by converting constant speed pumps to variable speed pumps.
- Replace the zone valves to increase the reliability and accurately control the chilled water supply to designated area.
- Newly install Integrated Building Management System(iBMS) to enhance the system monitoring and optimise the chiller operation so as to maximise the overall system efficiency.

HVAC – Air Side

- Replace centrifugal fan in AHU by using EC Plug Fan to increase the efficiency.

Lighting

- Replace the high efficiency LED downlights in Atrium to improve the lumen but reduce the power density & overall electricity power supply.

Power Analyser

- Data collection and monitoring of power consumption of chiller system and tenancy area by installation of power analyser.

04 CASE STUDIES | CASE 12 | **World Empire Investment (CI) Limited**
• Avon Mall

Observed benefits other than energy saving:

- Increase reliability and life span of system and equipment.
- Enhance hardware to for future retro-commissioning and operation review.
- More information for data analysis to implement plant monitoring and reporting.
- Better human comfort in thermal, lighting and noise.
- Reduce frequency of working at heights for maintenance of lighting in Atrium.

General observations of the retrofitting project:

- HVAC system retrofit have not affected the tenants.
- Standard retrofitting initiatives with proven technologies and straight forward.
- Lightings for shopping mall are replaced during overnight with sufficient advanced notice and cordon-off the working area. No complaint from tenant is received.
- Training to operation staff can strengthen their understanding and familiarising the operation of new Integrated Building Management System (iBMS) and chiller systems.
- Overall retrofitting of air-conditioning and lighting systems gained the satisfaction from tenants and customers.

Photos indicating the implementation

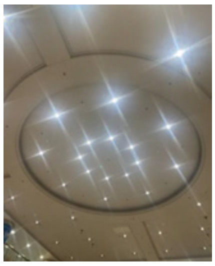
• Replace the zone valves for Chilled water control

• Use EC Plug Fan for AHU

• Convert constant speed pumps to variable speed pump

• Replace higher efficiency chiller plant

• Replace higher efficiency LED downlight



• Install central control and monitor system

• Replace high static condenser fans

• Chiller plant BIM model rendering

Cost		Saving	
Total cost:	HKD 5.6 million	Total savings/ year:	HKD 637,000
Cost breakdown:	1. Chilled Water System with CCMS: **HKD 5 million** 2. AHU with EC Plug Fan: **HKD 0.37 million** 3. High Efficiency LED Downlights: **HKD 0.25 million**	Savings/year breakdown:	• Chilled Water System with iBMS: **HKD 575,000 / 8.7 years** • AHU with EC Plug Fan: **HKD 42,000 / 8.8 years** • High Efficiency LED Downlight: **HKD 20,000 / 12.5 years**
		Payback:	~ 8.82 years
Award		**Subsidy/ Funding**	
CLP Smart Energy Award 2021 - Merit Certificate		The project is supported by:	CLP Eco Building Fund

CASE 13

Information of Building

Building owner:

Harvest Sun Limited

Building name:

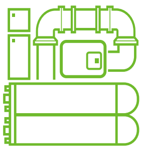
Olympian City 1

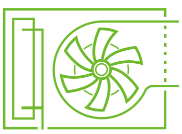
Description of the building:

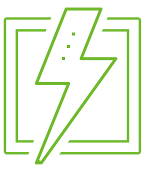
- Wholly Owned Shopping Arcade with parking space from G/F to 1/F
- Three floors shopping centre
- Fully water-cooled air-conditioned system
- BMS monitored A/C, Plumbing and Electrical System
- Grid-connected Photovoltaic System

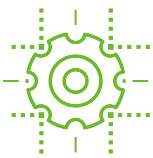
Information of Retrofitting Project

Retrofitted systems involved:









Retrofitted initiatives:

Chiller plant

- Replace depreciated air-cooled chillers to water-cooled and review new chiller combination.
- Newly install cooling tower fans with Variable Speed Drive Control to control the air flow rate to suit the operation condition.
- Improve chilled / condenser water pumps efficiency by converting constant speed pumps to variable speed pumps.
- Newly install Integrated Building Management System(iBMS) to enhance the system monitoring and optimise the chiller operation so as to maximise the overall system efficiency.
- Data collection and monitoring of power consumption of chiller system by installation of power analyser.

Electrically Commutated (EC) plug fans for AHU

- To provide the higher efficiency of motor as well as the cost and energy efficient.

Energy Valve

- Better control of water flow rate which matches the cooling load.
- More precise control with better control logic by controlling the flow rate instead of valve position only.

Photovoltaic system

- Total 178 pcs. of PV panels with 89 kWp.

Harvest Sun Limited
• Olympian City 1

Observed benefits other than energy saving:

Replacement of air-cooled chiller plant to fresh water-cooled chiller plant

- Increase reliability and life span of system and equipment.
- Enhance hardware to for future retro-commissioning and operation review.
- More information for data analysis to implement plant monitoring and reporting.

Electrically Commutated (EC) plug fans for AHU

- Fan speed reduced and less noise created.

Energy Valve

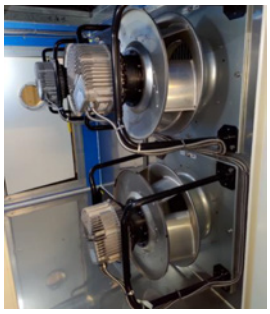
- Better balancing of chilled water flow. Can reduce excessive demand of chilled water and circulate surplus water to other more demanding AHUs/FCUs.
- Can check the actual flow rate of the AHU and whether or not the system chilled water flow is well balanced or not.

General observations of the retrofitting project:

- HVAC system retrofit have not affected the tenants.
- Standard retrofitting initiatives with proven technologies and straight forward.
- Training to operation staff can strengthen their understanding and familiarising the operation of new Integrated Building Management System (iBMS) and chiller systems.
- The flow & delta temperature control mode of the Energy Valve help in saving chilled water flow in individual AHU. By adopting the VSD feature of chilled water pump,more energy can be saved.
- Permanently measures and logs the energy usage of the application, the flow and the differential temperature across the coil. This creates full load transparency in the system.
- Electronic PI valves have a much lower pressure drop that mechanical PI valves and therefore require significantly lower differential pressures to achieve designed flow.

Water-cooled Chiller Plant

EC Fans in PAU/AHU



Energy Valve

PV System

Cost		Saving	
Total cost:	HKD 17,495,000 + HKD 1.89 million	Total savings/year:	HKD 2.17 million & PV: HKD 0.21 million
Cost breakdown:	• Chiller Plant : **HKD 17.4 million** • EC Fans (4 nos.) **HKD 74,000** • Energy valve (1 no.) **HKD 21,000** • PV system : **HKD 1.89 million**	Savings/year breakdown:	• Chiller Plant: **HKD 2.1million** • EC fan: **HKD 62,000** • Energy Valve: **HKD 9,000** • PV system generated power: **HKD 214,000**
		Payback:	• Chiller Plant: **8.3 years** • EC fans: **1.2 years** • Energy Valve: **2.3 years** • PV system :**9 years**
Subsidy/ Funding			
The project is supported by:		CLP Eco Building Fund CLP Renewable Energy Feed-in Tariff	

CASE 14

Information of Building

Building owner:

Best Profit Limited

Building name:

Olympian City 3

Description of the building:

- Wholly owned Shopping Arcade
- Two floors shopping centre
- Fully water-cooled air-conditioned system
- BMS monitored A/C & Electrical System

Information of Retrofitting Project

Retrofitted system involved:

Retrofitted initiatives:

- For unlocking the saving from the operation of A/C plant.
- A trial project for energy saving using machine learning and A.I. functions.
- Time-consuming manual processes: This included the manual switching on/off of chillers, and the setting of temperature based on experience and weather forecasts. Depending on the time of day, weather conditions and shopping mall traffic, the facility team would determine each time the number of chillers required for the day.
- Limited capacity to save energy: Facility team rarely had the opportunity to assess the system data and to put forth strategies for energy saving which is typically done through trial and error.
- Limited information: With mostly manual control, there was a lack of comprehensive information on chiller conditions, nor a sequencing that ran on an energy-conscious manner.

04 CASE STUDIES | CASE 14 | **Best Profit Limited • Olympian City 3**

Observed benefits other than energy saving:

- Early fault detection & early warning function.
- Comprehensive charting and data analysis for system performance.
- Auto staging (up/ down) based on weather condition and cooling load.
- Reduce carbon emissions as a result of improved energy efficiency.

General observations of the retrofitting project:

- Achieved an energy saving of more than 8% and reduced over 25 tonnes of carbon dioxide emissions from 2022 Apr to 2022 June.

BMS for chiller plant

Chiller plant optimisation monitoring and control system using smart/AI technologies

Name of consultant and contractor	Cost		Saving	
CLPe Solutions Limited	Total cost:	HKD 360,000	Total savings/year:	Average 9.2%, Annual Saving = total annual electricity cost * 9.2%
			Payback:	~ 5.8 years
Award			**Subsidy/ Funding**	
Award received by the project:	CLP Smart Energy Award 2020 • Smart Technology Excellence Award		The project is supported by:	CLP Eco Building Fund

CASE 15

Information of Building

Building owner:

Sino Estates Management Limited

Building name:

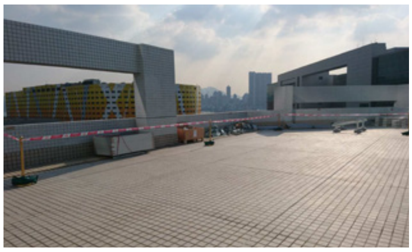
Skyline Tower

Description of the building:

- Grade A Commercial complex with 34 floors of offices, exhibition hall and kiosks at Ground floor, 8 floors of carpark
- Fully air-conditioned with water-cooled central chilled water system, deferential pressure by-pass, heat exchange, VSD and constant speed pumps
- Fan coil unit for offices and exhibition hall with fresh air supply
- Curtain Wall System in Office Tower
- 2 Generator sets for common area and tenant emergency supply
- T5 and LED light tube
- Green Roof on 9/F Carpark Block
- Renewable Energy System on 9/F Carpark Block and R/F Office Tower

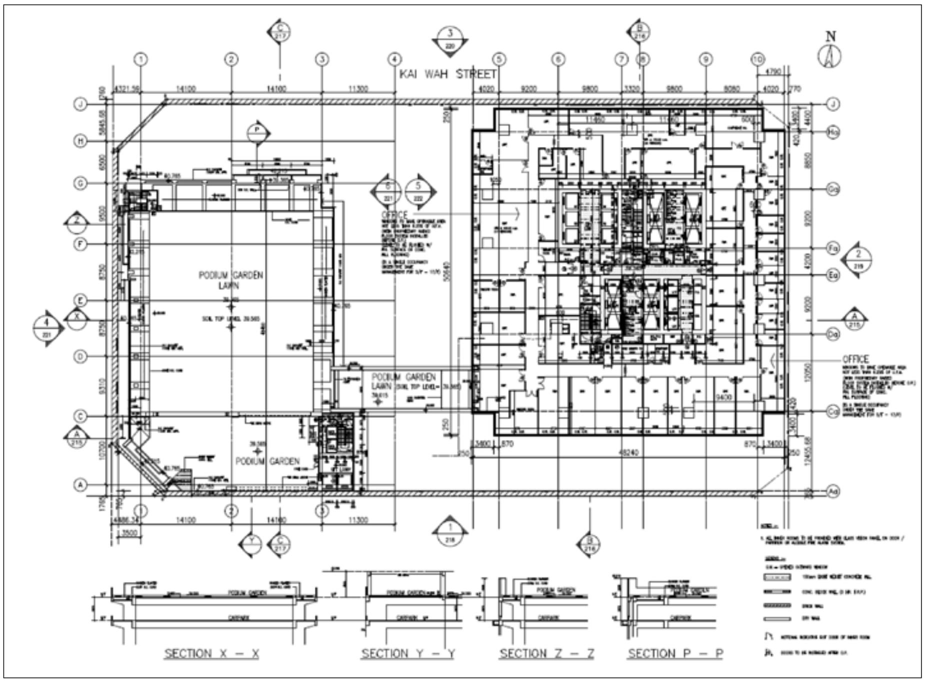
9/F Carpark Block and R/F Office Tower

9/F podium garden



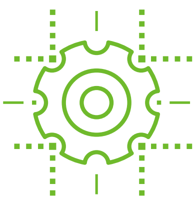
R/F Office Tower

Layout Plan for 9/F Carpark Block and R/F Office Tower



Information of Retrofitting Project

Retrofitted system involved:



Retrofitted initiatives:

Skyline Tower upholds sustainability to incorporate sustainability in all aspects of operations with a view to creating long-term value for the community. In 2018, we installed total 382 nos of solar panel at 9/F Carpark Block (92 nos) and R/F Office Tower (290 nos) with monitoring system to embrace low-carbon lifestyles. In 2020, we transformed the rooftop garden of 9/F Carpark Block into a 11,840 sq.ft. urban farm, namely Sky Farm, which providing a platform for staff, tenants and the wider community to experience the joy and benefits of urban farming while breathing new life into the Grade A commercial building. By turning the rooftop space into flourishing garden nestled amongst busy streets and skyscrapers, it also helps combat climate change and promotion of sustainability. Sky Farm opened for the general public and provided a public green place for stealing a little leisure from the rush of business. Various workshops (urban farm tours, dyeing workshop, etc.) were hosted to get our community involved and disseminate our Green responsibilities. With the Establishment of "Sky Farm" and missions of upholding corporate social responsibility and promoting sustainability, we wished to bring green inspiration to commercial building.

Sino Estates Management Limited
• Skyline Tower

Observed benefits other than energy saving:

Sky Farm with renewable energy established with a goal to make our community a better place to live and work. Aligning the Group's sustainability vision of "Creating Better Lifescapes", wishing we could build life together, where communities thrive in harmony and bring the community closer to nature. To ensure our business activities conducted within the wider context of our communities and the environment to create shared value for all our stakeholders, "Sky Farm" project was initiated in Year 2019. Hoping that Sky Farm can promote green life, enhance the wellness of our stakeholders, improve the wellbeing of community and foster a culture of innovation.

General observations of the retrofitting project:

To promote urban farming and work towards a greener future with our colleagues, tenant and the community, a green task force was formed and all of the staff including security guards, Customer Service Centre as well as cleaning staffs are included in the task force. All members are encouraged and welcome to raise their innovative ideas towards the Sky Farm, no matter trivial issue or substantial installation. They were invited to participate in every tiny parts of the project, and provide user-based feedback so as to make the Farm truly ready prior to the opening. Furthermore, it was understood that a majority of our employees do not have much knowledge toward urban farming, green-minded staff thus have been recruited as "Sky Farm Green Ambassadors" to spread the message to colleagues and tenants in workplaces. Shortlisted green ambassadors have joined the farming seminar taught by Smiley Planet, our farming advisor, in each Tuesday to learn green tips and farming knowledge, which raising awareness of green living and sowing the seeds for a green and caring environment for all. While Sky Farm produced radishes, staff will be participated in the harvest and having the opportunity to take home and share the harvest with their families.

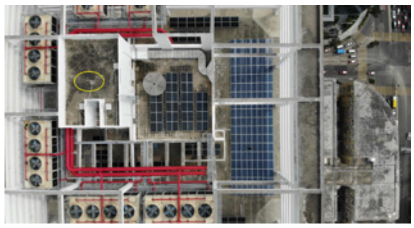
The project took a holistic, long-term approach and worked in partnership with stakeholders to create better environments together. In addition to promote green living and urban farm among the busy modern life, SkyFarm also serve the purpose of being a common rest place for the public, which was rarely exist in the business community.

9/F Sky Farm



R/F Office Tower





Cost		Saving	
Total cost:	HKD 3.1 million	Total savings/year:	~ 93,480 kWh/year
Cost breakdown:	• For Green Roof **HKD 0.7 million** • For renewable energy system **HKD 2.4 million**	Savings/year breakdown:	For renewable energy system
		Payback:	~ 5.81 years
Awards			
For 2021:	• **BEAM Plus EB V2.0 Comprehensive Scheme A** - Final Platinum • **Hong Kong Green Awards 2021** - Green Management Award (Service Provider - Large Corporation) - Gold • **HSBC Living Business SDGs Award 2021** – Silver Award • **HSBC Living Business ESG Award 2021** – Excellence • **Excellence in Facility Management Award 2021** - Innovative Technology Award • **Excellence in Facility Management Award 2020 (Office Building)** - Excellent • **20th Hong Kong Occupational Safety & Health Award** - Safety Performance Award • **The 8th Best Property Safety Management Award** – Safety Culture Award – Bronze Award • **IFMA Asia Pacific Awards of Excellence Environmental Stewardship Award** - Merit • **BOCHK Corporate Environmental Leadership Awards** - EcoChallenger • **Quality Lift Service Recognition Scheme** – Excellent • **Wastewi$e certificate – Excellence Level** • **CLP Smart Energy Award** – Merit • **Manpower Developer Award Scheme** • **Waste Electrical and Electronic Equipment Recycling Campaign** – Silver Award • **IAQ Certificate Scheme** – Excellence Class • **Hong Kong Work Happiness Scheme** – 5years+ • **Caring Company Logo**		
Subsidy/ Funding			
The project is supported by:	• **Landlord** • **CLP Renewable Energy Feed-in Tariff**		

CASE 16

Information of Building

Building owner:

Hyatt Regency Hong Kong, Shatin

Building name:

Hyatt Regency Hong Kong, Shatin

Description of the building:

- 5 Stars Hotel. A Refreshing Urban Resort in Hong Kong Located adjacent to the University MTR Station in Sha Tin
- Total 567 guest rooms & 9 treatment rooms
- L5-L12, 275rooms + 9 treatment rooms for Low Zone
- L13-L21, 207 rooms for Mid Zone
- L22-L26, 82 rooms for High Zone

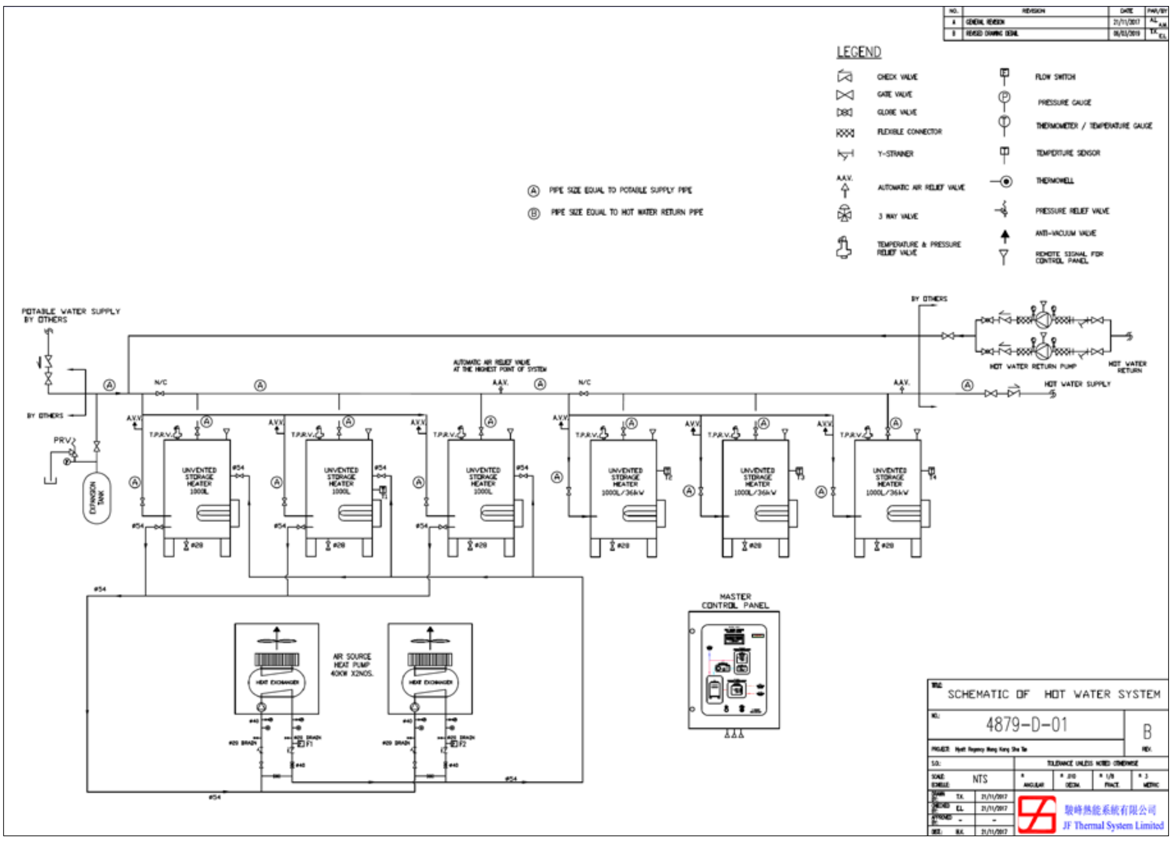
Information of Retrofitting Project

Retrofitted system involved:

Retrofitted initiatives:

- For high Zone hot water system, L22-L26, total 82 rooms.
- Replace original 24nos. of ~60kW Town Gas heaters (total energy output ~1440kW) by Heat Pump System.
- The heat pump system consists of 2nos. 40kW Air source heat pumps, 3nos. 1000L storage tanks and 3nos. 1000L/ 48kW storage heaters. (total output ~224kW), and with master control panel.

High Zone Heat Pump System



Hyatt Regency Hong Kong, Shatin

• Hyatt Regency Hong Kong, Shatin

Observed benefits other than energy saving:

- Smoother operation, Central monitoring and operation by master control panel.
- Reduced maintenance cost due to less equipment used.
- No CO_2 exhaust to environment on site.
- Stable and continuous hot water output.
- Better water balancing supply.

General observations of the retrofitting project:

- Heat pump system retrofitting work have not affected the hot water supplies.
- New system have been installed beside the existing, these would be changed over for replacing original gas heaters system at after system cleaning, self-tested, detail testes and trial running.

Original High Zone Gas Heaters

24 Nos. Town Gas Heaters

High Zone – Hot Water System after Retrofit

3nos. 1000L storage tanks and 3nos. 1000L, 48kW storage heaters

2nos. 40kW Air source heat pumps

1 no. master control panel

Name of consultant and contractor	Cost		Saving	
JF Thermal System Limited	Total cost:	HKD 1,081,500	Total savings/year:	HKD 250,000
	Cost breakdown:	Equipment: HKD 543,500 Material and Labour: HKD 538,000	Savings/year breakdown:	Heat Pump C.O.P. = 3.0~3.5
			Payback:	4.33 years

CASE 17

Information of Building

Building owner:

Newfoundworld Investment Holdings Limited

Building name:

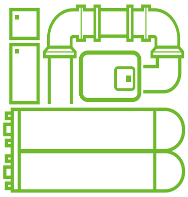
Citygate

Description of the building:

Citygate is a commercial complex in Tung Chung, comprising a premier outlet shopping mall, Citygate Outlets, together with a Grade-A office building, One Citygate. The total gross floor area of the development is approximate 62,800 sqm.

Information of Retrofitting Project

Retrofitted system involved:



Retrofitted initiatives:

HVAC Chiller Plant Upgrade - Chilled Water Side

- Adoption of "Platinum rated CIC Green Product" - Low GWP HFO chillers.
- Retro-commissioning approach.
- Constant Speed and Variable Speed chillers combination design for enhanced energy optimisation.

Newfoundworld Investment Holdings Limited
• Citygate

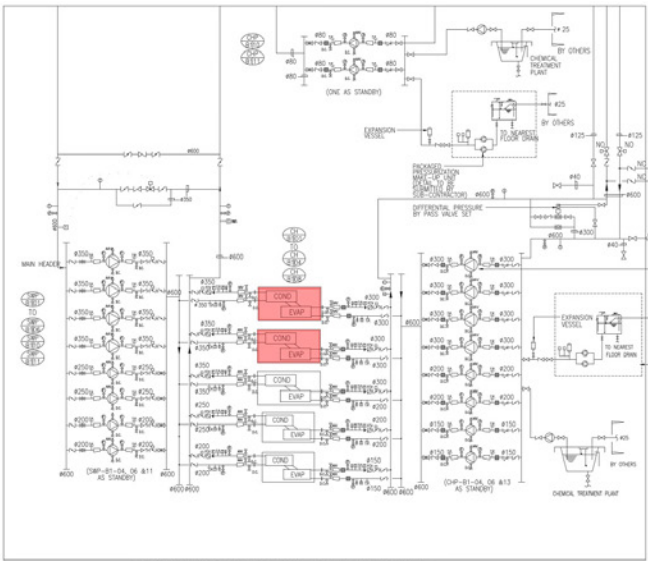
Observed benefits other than energy saving:

- Optimised the chillers operation by enhanced chiller plant design with Constant speed chiller and Variable speed chiller.
- Sustainability through adoption of Low GWP High energy efficiency HFO chillers.
- Reduced noise generation in the plant room by chillers with exceptionally low sound level.
- Reduced system downtime by chillers with superior reliability.

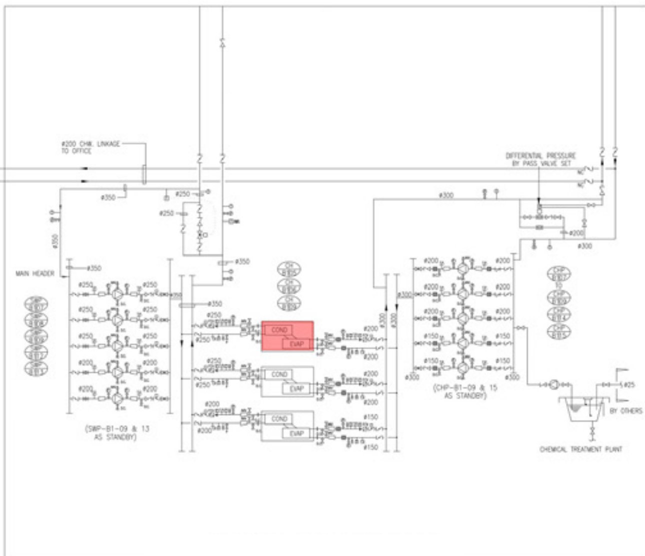
General observations of the retrofitting project:

- The tenants were not affected by the HVAC system retrofit.
- Disassembly of plant room equipment was minimised by well-planned project execution.
- Successful application was achieved by combination of constant speed and variable frequency drive chillers.
- A signature project which brings recognised rewards and excellent environmental benefits was accomplished.
- It is estimated nearly 20% of annual energy consumption is saved, equivalent to around 1,000,000 kWh per year.
- The payback is around 3 years for high efficiency chillers option.

Basement 1 Chiller Plant Room For Retail and Cinema



Basement 1 Chiller Plant Room for Office



<table>
<tr><th>Name of consultant and contractor</th><th colspan="2">Saving</th></tr>
<tr><td rowspan="2">Trane Service Hong Kong</td><td>Total savings/year:</td><td>HKD 1,062,100</td></tr>
<tr><td>Payback:</td><td>Around 3 years</td></tr>
<tr><th colspan="3">Award</th></tr>
<tr><td>Award received by the project:</td><td colspan="2">The Association of Energy Engineers Award 2019
• Final Platinum Rating - BEAM Plus Existing Building V2.0 (Comprehensive Scheme A)</td></tr>
</table>

CASE 18

Information of Building

Building owner:

Sun Hung Kai Properties Limited

Building name:

V city

Description of the building:

- 83 Tuen Mun Heung Sze Wui Road
- Owned by Sun Hung Kai Properties
- Managed by Kai Shing Management Services Limited
- GFA 300,000 s.f.
- Grand opening on 1 Aug 2013
- 215 parking spaces and 120+ shops

Information of Retrofitting Project

Retrofitted system involved:

Retrofitted initiatives:

- Chiller plant optimisation monitoring and control system using smart/AI technologies with required metering and sensing devices.
- Automated Chiller Optimisation using machine learning coupled with digit twin.

04 CASE STUDIES | **CASE 18** | **Sun Hung Kai Properties Limited**
• V city

Observed benefits other than energy saving:

- The sensor drift of temperature sensor is calibrated.
- The cloud based system enables a closer data monitoring on the chiller plant system from 15 mins to 30 seconds, and the system filters out invalid data.
- The performance of chiller can be compared between, and the priority of condenser tube could be decided.
- The efficiency of the cooling tower is monitored.
- A physical guided machine learning platform for suggesting more energy saving operation of the plant.

General observations of the retrofitting project:

- The project is a holistic consideration of the system that suggests the most energy efficient performance in the chiller plant system and provides some insight for maintenance works.

Name of consultant and contractor	Cost		Saving	
Contractor: **ATAL Building Services Engineering Ltd.**	Total cost:	**HKD 198,000**	Total savings/year:	**289,527 kW/year**
			Payback:	**Immediate** (with CLP Eco Building Fund)

Awards
Awards received by the project:

- **CLP Smart Energy Award (2019)** - Grand Award
- **Excellence in Facility Management Award (2020)** - Excellent
- **Hong Kong Green Awards (2020) - Green Management Award - Service Provider (Large Corporation)** - Silver
- **Sustained Performance 3 years +**
- **Hong Kong Awards for Environmental Excellence (2020)** - Property Management (Commercial & Industrial) Gold Award
- **CIBSE Building Performance Awards (2021)** - Merit
- **HKGSA (2021) Best Green Practice in Malls** - 1st Runner up
- **HKIH (2022) Shortlisted and to be announced in 18 Oct 2022**

CASE 19

Information of Building

Building owner:

Sun Hung Kai Properties Limited

Building name:

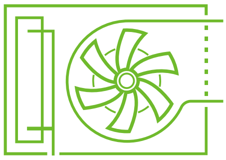
Sun Hung Kai Centre

Description of the building:

Sun Hung Kai Centre as one of the iconic building in Wanchai, with 53 floors. It also serves as the corporate headquarters of Sun Hung Kai Properties.

Information of Retrofitting Project

Retrofitted system involved:



Retrofitted initiative:

Replace air filters with lower MERV grading utilising the use of sonic technology, which can achieve the same or higher filtration efficiency with the original grading and enhance IAQ. Energy saving can also be attained through a reduction in pressure drop, hence on the fan power.

Existing filter of SHKC - 0.0701 kPa Pressure Drop

Aurabeat Energy Saving Sonic Air Filter - 0.0298 kPa Pressure Drop

04 CASE STUDIES | CASE 19 | **Sun Hung Kai Properties Limited**
• Sun Hung Kai Centre

Observed benefits other than energy saving:

- Enhanced PM Filtration Efficiency.

General observations of the retrofitting project:

- 1.17x increase in PM10 filtration efficiency.
- 8.68x increase in PM2.5 filtration efficiency.
- 1.65x increase in PM1 filtration efficiency.
- 57.5% reduction in pressure drop.
- 14.16% in fan power energy saving.

Measurement of Filter Efficiency of **existing electrostatic air filter:**

Particle size	Concentration before filtration	Concentration after filtration	Filtration efficiency
PM 1	4.0 μg/m³	3.3 μg/m³	17.5%
PM 2.5	4.0 μg/m³	3.8 μg/m³	5.0%
PM 10	7.1 μg/m³	4.8 μg/m³	32.4%

Measurement of Filter Efficiency of **Aurabeat Energy Saving Air Filter:**

Particle size	Concentration before filtration	Concentration after filtration	Filtration efficiency
PM 1	10.8 μg/m³	5.8 μg/m³	46.3%
PM 2.5	12.2 μg/m³	6.3 μg/m³	48.4%
PM 10	19.9 μg/m³	5.9 μg/m³	70.4%

Checkpoint Measurement **6 months** after installation.
Ventilation system **lowered Fan Power by 14.16%** while achieving **better filtration efficiency**

AHU fan power with electrostatic air filter	AHU fan power with acoustic-aided air filter	Fan power saving in AHU
2.33 kW	2.0 kW	14.16%

507,384 kWh Annual Electricity Saving

Sun Hung Kai Centre Installation Key Findings with 6 months running time:

14.16%	Reduction in Fan Power
57.5%	Reduction in Pressure Drop
1.65x	Increase in PM1 Filtration Efficiency
8.68x	Increase in PM2.5 Filtration Efficiency
1.17x	Increase in PM10 Filtration Efficiency

Cost		Saving	
Total cost:	HKD 18,000 per AHU	Total savings/year:	HKD 9,000 per AHU
		Savings/year breakdown:	HKD 660,000 per year (for 180 AHUs in total)
		Payback:	~ 2 years

CASE 20

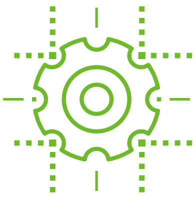
Information of Building

Description of the building:

South-west facing office unit at 25/F of Grade A office building in Central

Information of Retrofitting Project

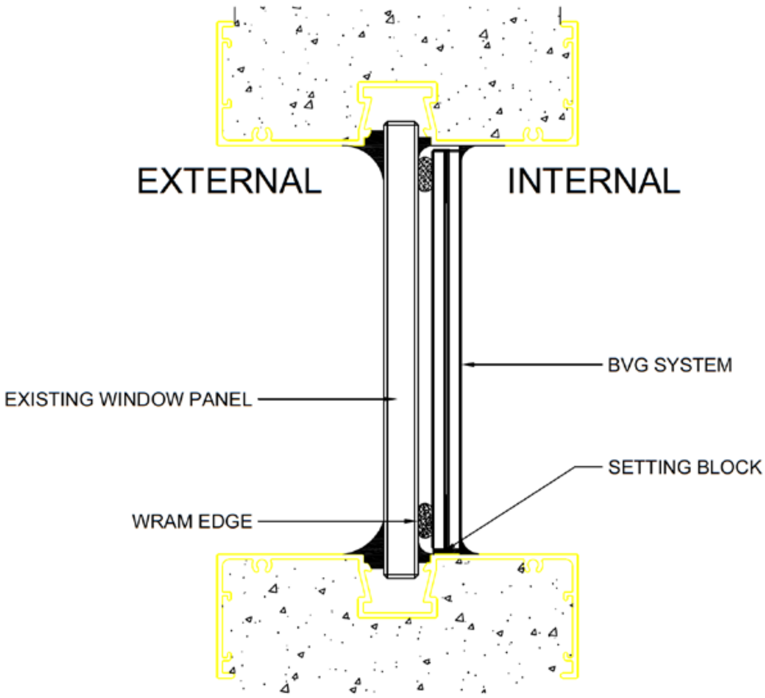
Retrofitted system involved:



Retrofitted initiatives:

- To improve solar shading performance of current curtainwall glass and hence cooling energy saving for the office unit.
- To improve thermal comfort of office unit occupants.
- To stabilise indoor air temperature in sunny and cloudy days.
- To validate solar shading and energy saving improvement for consideration of full scale retrofit for the whole building. Validation was done by HK Polytechnic University.

Typical Details for BVG



04 CASE STUDIES | **CASE 20**

Observed benefits other than energy saving:

- Improved thermal comfort.
- Improved sound reduction from 35 to 40dB (Rw).
- Reduced UV light transmittance to indoor to 5%.
- Reduced glass indoor reflectance from 47% to 35%.
- Eliminated condensation on glass at cold morning time.
- Stabilised solar heat flow to indoor.

General observations of the retrofitting project:

- The measured data indicates that, for both sunny day and cloudy day, the VIG retrofit can effectively stabilise the inside surface temperature of the window glass and significantly reduce the heat gain through windows.
- The risk of condensation on the insider surface of windows can be eliminated because of the VIG retrofit as the inside glass surface temperature is higher in winter.
- For VIG retrofit on this glass in the building, the energy-saving potential is 8.4% - 32.1% for different orientation.
- A higher cooling setpoint temperature for the indoor space is possible for additional energy saving without compromising the indoor thermal comfort. The potential saving is 25.2 kWh/m2 (floor area) when cooling set point is increased by 1°C.
- The OTTV is reduced by around 70% to 11 W/m2 level.
- Annual energy saving per window area HK$150.82/year.
- Reduce the carbon emission of 63.8 kg CO2-e/ m2 (window area).

Installation

Cost		Saving	
Total cost:	HKD 26,730	Total savings/year:	**HKD 2,443** (first year)
		Payback:	**8.25 years** for case office unit **4.58 years** for west facing office units
Award		**Subsidy/ Funding**	
Award received by the project:	CIC Green Product Certificate (Platinum) for vacuum glass	The project is supported by:	Building owner

CASE 21

Information of Building

Building owner:

Hang Lung Properties Limited

Building name:

GALA PLACE

Description of the building:

Located at the junction of Dundas Street and Nathan Road in Mong Kok, GALA PLACE houses a diverse array of merchants and attracts high footfall. In addition to the 4500-plus-square-foot Starbucks thematic store, and the new Foot Locker Power Store, which will span approximately 20,000 square feet, it also showcases an expertly curated portfolio of diversified services and products.

Information of Retrofitting Project

Retrofitted system involved:

Retrofitted initiatives:

With the technology of i2Cool passive radiative cooling, the cooler, called iPaint reflects most of the solar heat (>95% reflectivity) while effectively emitting thermal energy as mid-infrared (>95% emissivity) to the cold universe. Since the earth's atmosphere is transparent to the mid-infrared radiation, the heat emitted by the cooler can pass through the atmosphere and be absorbed by the cold outer space.

The coating method of iPaint is very similar to emulsion paint, leading to easy application and low cost. By coating the roof of the equipment room in GALA PLACE with iPaint, the effect of "electricity-free cooling" can be achieved without energy input or refrigerant, resulting in significant energy saving for air cooling.

Hang Lung Properties Limited
• GALA PLACE

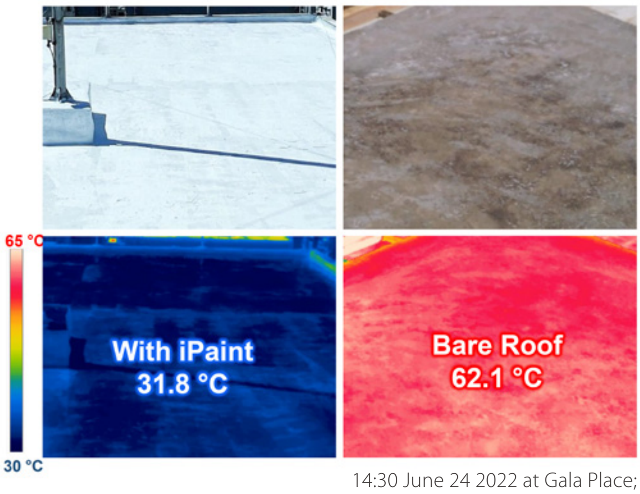
Observed benefits other than energy saving:

iPaint also offers the embellishment effect for the GALA PLACE rooftop, from a regular grey-coloured concrete surface to a brand new white-coloured area.

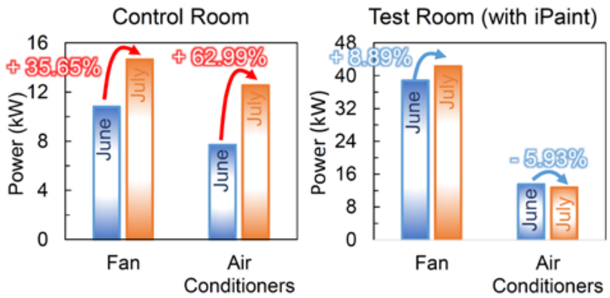
General observations of the retrofitting project:

The temperature of the bare roof measures 62.1°C of surface temperature via IR camera under the direct sunlight at noon; after applying iPaint, the temperature of the roof surface drops down to 31.8°C, without any energy input; With this electricity-free cooling effect, the cooling load and energy consumption of the HVAC system in the building can be reduced. Based on the measured data using power meter provided by the building owner, using 1 square meter of iPaint helps reduce approximately 0.39 kWh electricity consumption per hour for the building.

Gala Place with iPaint Schematic diagram of surface temperature



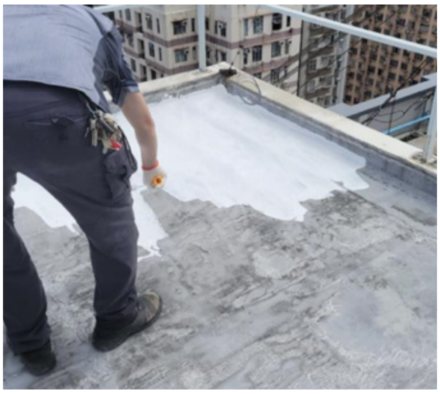
14:30 June 24 2022 at Gala Place;
Sunny Day with Ambient Temperature = 33°C



Item	Fan	ACs	Sum
June	38.8 kW	13.5 kW	52.3
July (*estimate**)	52.63 kW	22 kW	74.63
July (actual)	42.25 kW	12.7 kW	54.95
Saving	10.38 kW (-19.72%)	9.3 kW (-42.27%)	19.68 kW (- 26.80%)
kW/m2	- 0.2076	- 0.186	- 0.3936
2 months			585 kWh / m2

*Estimated based on the increasing rate (from June to July) in Control Room

Gala Place iPaint Implementation



Cost		Saving	
Total cost:	**HKD 180** / square meter	Total savings/year:	~ **HKD 2,340** / square meter
Cost breakdown:	**HKD 80** / square meter for material cost **HKD 100** / square meter for application cost	Payback:	**1 month**
Subsidy/ Funding			
The project is supported by:	HK Tech 300, City University of Hong Kong (CityU) Incubation, Hong Kong Science and Technology Park (HKSTP)		

ABBREVIATIONS

Abbreviation	Extension
AC	Alternating Current
AHU	Air Handling Unit
AI	Artificial Intelligent
BD	The Buildings Department
BEC	Building Energy Code
BEEO	Buildings Energy Efficiency Ordinance
BIPV	Building Integrated Photovoltaic
BMS	Building Management System
CAV	Constant Air Volume
CIC	Construction Industry Council
CLP Power	CLP Power Hong Kong Limited
CO	Carbon Monoxide
COP	Coefficient of Performance
CRAC	Computer Room Air Conditioning
CSR	Corporate Social Responsibility
DC	Direct Current
DCiE	Data Centre Infrastructure Efficiency
DDC	Direct Digital Control
EAC	Energy Audit Code
EC	Electronically Commutated
EERSB	Energy Efficiency Registration Scheme for Buildings
EMSD	The Electrical and Mechanical Services Department
EPD	The Environmental Protection Department
ESS	Energy Saving Sonic
FCU	Fan Coil Unit

Abbreviation	Extension
HK Electric	The Hongkong Electric Company, Limited
HKGBC	Hong Kong Green Building Council
HKSAR	Hong Kong Special Administrative Region
HVAC	Heating, Ventilation, and Air Conditioning
IAQ	Indoor Air Quality
IEA	The International Energy Agency
IEQ	Indoor Environmental Quality
IGBT	Insulated-gate Bipolar Transistor
IoT	Internet of Things
IPCC	The Intergovernmental Panel on Climate Change
ISPC	Industry Standards and Practices Committee
IT	Information Technology
LED	Light Emitting Diode
LiDAR	Light Detection and Ranging
OTTV	Overall Thermal Transfer Value
PAU	Pre-cooling Air Handling Unit
PM	Permanent Magnet
PUE	Power Usage Effectiveness
PV	Photovoltaic
RCx	Retro-commissioning
RH	Relative Humidity
UPS	Uninterrupted Power System
VAV	Variable Air Volume
VSD	Variable Speed Drive
VVVF	Variable Voltage Variable Frequency
WSD	Water Supplies Department

ACKNOWLEDGEMENTS

HKGBC Industry Standards and Practices Committee (ISPC)

Mr Donald CHOI, JP (HKGBC Director cum ISPC Chairman) - Chinachem Group
Ir Dr Anthony LO (HKGBC Director cum ISPC Vice Chairman) - CLP Power Hong Kong Limited
Dr Jack CHENG (HKGBC Director) - The Hong Kong University of Science and Technology
Ir Victor CHEUNG (HKGBC Director) - J. Roger Preston Limited
Mr Tony IP (HKGBC Director) - Tony Ip Green Architects Limited
Ir PAN Shu-jie (HKGBC Director) - CR Construction Company Limited
Sr Frankie SO (HKGBC Director) - LESK Solutions Co., Limited
Ms Eliza WONG (HKGBC Director) - Swire Properties Limited
Dr Raymond YAU (HKGBC Director) - Swire Properties Limited
Mr Andy YEUNG (HKGBC Director) - Hongkong Land (Property Management) Limited
Ms Yvonne IEONG (Founding Member Representative) - Y.I. & Associates Limited
Mr CHAN Hiu-hei - Ove Arup & Partners Hong Kong Limited
Mr Ivan CHIU - Gammon Construction Limited
Dr Benny CHOW - Aedas Limited
Mr Nicholas HO - The Hong Kong Institute of Architects
Mr Kevin LEE - SOCAM Development Limited
Mr LI Pui-chuen - Schneider Electric (Hong Kong) Limited
Ms LIN Yu - Allied Sustainability and Environmental Consultants Group Limited
Mr Alvin LO - CLPe Solutions Limited
Mr NIP Kam-cheong - Wheelock Properties (Hong Kong) Limited
Ms Samanta PONG - Shiu Wing Steel Limited

HKGBC Industry Standards and Practices Committee (ISPC) Advisors

Ms Kitty HO - Architectural Services Department
Mr Marsden KONG - Electrical & Mechanical Services Department
Ms Rachel LEUNG - Hong Kong Housing Authority
Mr Gary YIP - Water Supplies Department

HKGBC Retrofitting Expert Group

Ir Victor CHEUNG (Convenor) - J. Roger Preston Limited
Ir Antonio CHAN - REC Engineering Co. Limited
Ir Dr Cary CHAN - Hong Kong Green Building Council
Mr Dave CHAN - ATAL Building Services Engineering Limited
Ir Dr K.L. CHAN - The Jardine Engineering Corp., Limited
Ir Tony CHAN - CLP Power Hong Kong Limited
Ms Michelle CHEUNG - Building Services Operation and Maintenance Executives Society
Ir Chris TING - Building Services Operation and Maintenance Executives Society
Mr Andy YEUNG - Hongkong Land (Property Management) Limited

HKGBC Retrofitting Expert Group Advisors (Regulatory Perspectives)

Mr Leo CHENG - Electrical & Mechanical Services Department
Mr Osman LAU - Electrical & Mechanical Services Department

Case Study Contributors

Best Profit Limited
Hang Lung Properties Limited
Harvest Sun Limited
Hongkong Land Limited
Housing Authority
Hyatt Regency Hong Kong, Shatin
Newfoundworld Investment Holdings Limited
PCCW-HKT Telephone Limited
Sino Estates Management Limited
Sun Hung Kai Properties Limited
Sunny Force Limited
Swire Properties Limited
World Empire investment (CI) Limited

Image Credits

The Jardine Engineering Corp., Limited	6, 7 (middle), 9 (bottom), 10 (bottom)
ATAL Building Services Engineering Limited	8 (top and middle), 10 (top), 12 (middle), 13 (bottom), 17, 19, 21 (bottom)
iStock.com/ zhudifeng	11
Swire Properties Limited	12 (bottom), 13 (top), 21 (top)
The Hong Kong Polytechnic University	14 (top)
Hong Kong Telecommunications (HKT) Limited	18, 23 (bottom)
JF Thermal System Limited	26
South Star Glass Limited	27 (bottom)
i2Cool Limited	28 (top)
Shutterstock, Inc./ Lucas Eduardo Benetti	28 (middle)

HKGBC RETROFITTING GUIDEBOOK

HKGBC
香港綠色建築議會

The Hong Kong Green Building Council (HKGBC)

Contact Us

Phone +852 3994 8888

Email enquiry@hkgbc.org.hk

Address 1/F, Jockey Club Environmental Building,
77 Tat Chee Avenue, Kowloon Tong, Hong Kong

www.hkgbc.org.hk