Study on Optimization of Air-conditioning System

1. Introduction

Most of the existing buildings were designed and built at a time when energy saving was not a foremost consideration. Also, the building often get out of tune due to normal deterioration and drop in accuracy or sensitivity of equipment, addition, alterations and improvement works. This causes poor building services system control and wastes energy. In Hong Kong, building account for about 90% of our electricity consumption. Air-conditioning (A/C) system takes up a large proportion of electricity in building. There is a need of optimizing the A/C system in order to improve the situations and reduce the energy usage.

According to U.S. Department of Energy, retro-commissioning (RCx) is a systematic process for optimizing energy performance in existing buildings. RCx can identify operational improvements in existing building through data testing, professional analysis and assessment. It resumes the system efficiency back to the design standard as degraded and optimize the operating system efficiency of the central building service installation (CBSI) and keeps it as an ongoing process. In short, it can maximize the energy saving potential of the existing building and thus lower energy bills.

Retro-commissioning on A/C systems covers different components in the installation, including air-cooled/ water-cooled chiller, chilled water pump, cooling tower, condenser water pump, sea water pump, VRV system, split-type system, primary air unit (PAU), air handling unit (AHU) or other AC equipment. Some of them are addressed in the pilot study below.

2. Methodology

Retro-commissioning is generally divided into 4 work stages, which are (1) Planning, (2) Investigation, (3) Implementation and (4) On-going commissioning.

2.1. Stage 1 Planning

- Collect building documentation.
- Interview operation and maintenance (O&M) staff and building occupants to find out the building operational pattern, operational problems, etc.
- Perform building walk-through to observe the operational conditions and further discover the operational problems.
- Compare actual condition with design condition.
- Develop RCx plan.

2.2. Stage 2 Investigation

- Conduct site survey and measurement.
- Analyze data collected (e.g. system characteristics, performance data, operating conditions).
- Carry out equipment investigation test to screen and spot the parameters deviated from expected.
- Identify potential improvement and optimization opportunities.

2.3. Stage 3 Implementation

- Implement the selected energy saving opportunities.
- Measure and verify the effectiveness of the implemented items.
- Prepare a final report of the activity conducted and performance.
- Develop an ongoing commissioning plan
- Conduct training for O&M staff

2.4. Stage 4 On-going commissioning

- Ensure the building services system after RCx would be maintained at “high” energy performance

3. Pilot Study

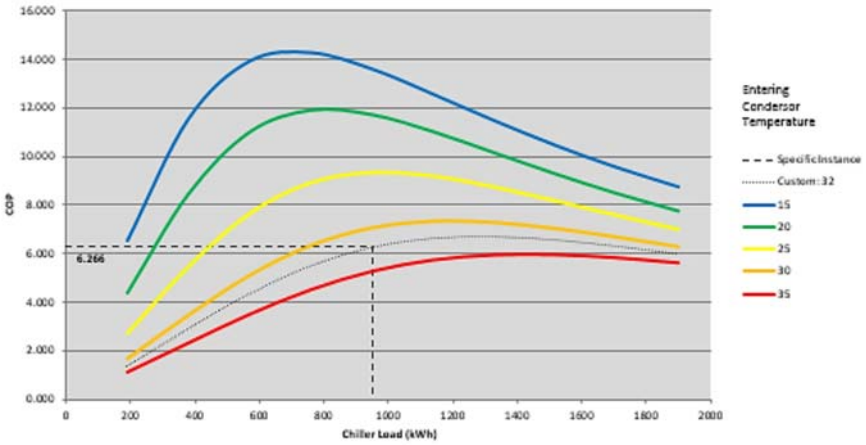
The value of retro-commissioning (RCx) is not demonstrated sufficiently by real examples to satisfy building owners and managers nowadays. Moreover, there is insufficient local technical guidelines about RCx. A pilot study is carried out at six existing government buildings to demonstrate the results and benefits of RCx and also the study result is used to fine tune the Technical Guidelines on RCx that is going to launch in 2017 officially.

RCx is carried out in government office, municipal service building, education service centre and departmental headquarter. These six buildings aged from about 10 to 30 years. Central control and monitoring system (CCMS) are provided. CCMS is the technology used in energy management of building. It can perform the real time display of the sensor reading, the alarm status, data logging and remote control the actuator. Central air-conditioning system are used in these buildings, including air-cooled chiller, water-cooled chiller and/or heat recovery chiller system. Variable refrigerant volume (VRV) and/or split type units are also used in individual rooms.

Some typical problems of A/C system are found at this pilot study and the potential of energy saving is estimated according to the preliminary findings.

<u>Chiller</u>

It is found that the Coefficient of Performance (COP) of some chiller is not optimized. The possible reason may be the change of user pattern, surrounding environment, retrofitting, etc. The COP is varied according different parameters including the cooling load and chilled water return temperature.



Further review on the performance of chiller with control strategy is recommended to achieve the optimal COP. The typical optimization strategies are listed below:

- Optimizing chiller sequence control.
- Optimizing of chilled water supply temperature.
- Optimizing chilled water pump speed.
- Replacing temperature sensor and flow meter.
- Increasing maintenance frequency

The preliminary estimated energy saving of optimization of chiller plant is up to around 5%.

<u>AHU/ PAU/ VAV Box</u>

It is found that air handling unit (AHU) or primary air unit (PAU) runs at full speed and variable air volume box opens the air damper at 100% at some buildings. The indoor air quality well achieves the ASHRAE Standard. The potential cause is that the design loading is greater than the actual loading of the venue due the change of usage pattern or other possible reasons. To balance the energy consumption and indoor air quality, it is recommended to reduce the air change per hour or fresh air intake by:

- Reducing belt ratio of the motor of AHU or PAU.
- Reprogramming Variable Frequency Device(VFD) to meet the new loading (If AHU or PAU is installed with VFD)

The preliminary estimated energy saving of optimizing AHU or PAU is up to around 1.5%.

For VAV box, it is recommended to optimize the VAV box by

- Reviewing the set-point of room temperature.

The preliminary estimated energy saving of optimizing VAV is up to around 0.5%.

<u>Control System on Operation Hour</u>

Some equipment is found that it is not in line with the operation hour of the venue. During non-operation hour, equipment is recommended to turn off to save energy. The equipment can be switched off automatically when the venue is at non-operation hour by:

- Installing or resetting the timers

The preliminary estimated energy saving of optimizing timer control is up to around 1.5%.

Some building may operate at both day time and night time. Usually, night mode requires a low cooling load demand. It is recommended to save more energy at night time by:

- Developing a night mode operation strategies

The preliminary estimated energy saving of developing night mode is up to around 1%.

4. Conclusion

Reviewing the air-conditioning system periodically is a method to identify the best potential energy savings for the A/C system of existing buildings. According to this preliminary findings in pilot study, optimization of air-conditioning system can achieve up to around 5% energy saving. It is recommended to transform the existing buildings into smarter energy efficient buildings and improve the energy performance by optimization.

However, energy saving potential of existing buildings is varied according to various conditions and optimizations, analysis or assessment is needed for the individual building in order to estimate and maximize the energy saving before optimization. Building owners should conduct RCx based on cost-benefit analysis.

A technical guidelines on retro-commissioning are going to be launched in 2017. It delineates effective and practical strategies in conducting RCx for different types of buildings. Experience and feedback obtained from the pilot study and RCx project would be consolidated to fine tune and enrich the technical guidelines.