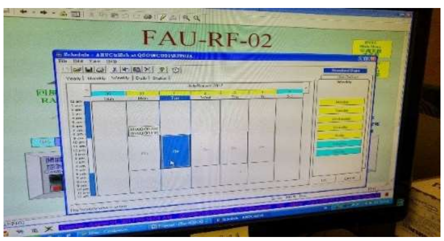
Technical Guidelines on Retro-commissioning



Supplementary Information

2018

EMSD

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Annex A

Information checklist for RCx service provider engagement procurement

Annex A – Information checklist for RCx service provider engagement procurement

In this Appendix, the aim is to provide an information checklist for the building owner. This allow information preparation in advanced for the RCx service provider engagement. In return the building owner can have a clearer understanding on what outcome deliveries to expect throughout the RCx exercise.

Information required from building owner

Drawings
Architecture layout drawings
M&E layout drawings*
M&E schematics drawings*
Documentation
Project requirement*
Construction record documents
M&E specification*
Operations and maintenance manuals*
HVAC equipment control sequence and setpoint*
Energy audit report
Past record of energy saving opportunity implementation
CCMS data point list
CCMS data point trend logged data
Past utility bills

All information provided should be the most up to date version. The building owner should keep record of any amendments to the building systems and operation requirement.

**To facilitate the process of RCx service provider engagement, building owner should provide sufficient information. At minimum, a description of the building (e.g total floor area, building height, number of storey, type of building, usage of building) and building systems (e.g. any provision of central air conditioning system, operation hour, electrical schematic drawing from these documents should be provided in the RCx service provider engagement tender agreement. This will allow RCx service provider to make sensible estimation on the pricing and able to make estimations on the potential energy saving opportunities. Further details maybe requested by the RCx service provider for more in-depth understanding of the system operation. A site walk through with the O&M staff should also be considered to collect necessary information that may be missing in the documentation.*

As RCx exercise is mainly related to building systems operation, any amendments done on the systems from the initial design should be mentioned during the procurement procedure. This will allow RCx service providers to take into considerations the adjustment on energy saving opportunities exploration.

Deliverables from RCx service provider

Deliverables
Review current building information and data
Develop RCx plan
Facilitates staff interviews, walkthrough and visual inspection
Carry out analysis on building performance and identify potential ESOs
Develop M&V plan
Prepare Investigation report
Prepare Implemantion report
Witness M&V
Develop RCx final report
Provide training to operation staff for on-going commissioning
Develop On-going commissioning report
Update building manual

Annex B

Technical Guidance Notes

Annex B – Technical Guidance Notes

Guidance notes in this section are not intended to be definitive or exhaustive. The RCx team is mainly responsible for finding energy saving opportunities to suit the building operation and requirement.

B1. Chilled water system (chiller, chilled water pump and condenser water pump)

B1.1 Understanding the system

B1.1.1 System description

A chilled water system distributes cooled water around the building. It consist of a series of components including chillers, pumps, heat rejection system, coils and valves that provide chilled water through a refrigeration cycle.

The main characteristic of a chilled water system is its capacity, a value that describe how much cooling the chiller can provide at maximum load, this value is also known as the total capacity of the chiller. Another important value is the coefficient of performance (COP), a ratio of the amount cooling generated per unit of electricity provided, which is an indicator of efficiency.

B1.1.2 Data reporting period

Ideally, whole year metered data would allow to determine ESOs effectively. However, if data collection during a whole year is not feasible, short-term measurements during maximum, minimum load and transition seasons are required. Generally, 1-2 weeks measurement is enough to understand the operational characteristics of the chiller. Consider a similar data collection period after the implementation of any ESO to assess its effectiveness. The recommended sample period of the data is up to 15 minutes.

B1.1.3 System schematics

The following figure is a schematic representation a chilled water system. It contains the chillers, pumps, valves, and loads. Additionally, flow meters (F) and temperature sensors (T) are included.

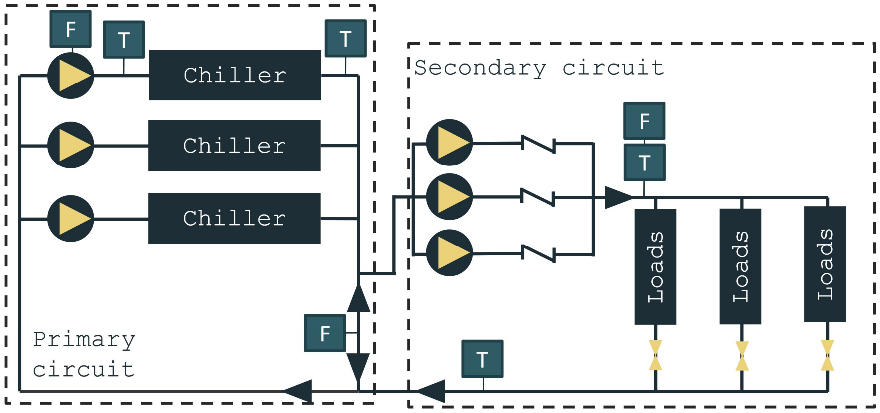

Fig. B.1.1.3 Chilled water plant block diagram

B1.1.4 Key measurements points

1. Chilled water flow, leaving and entering water temperatures,
2. Chillers and pump electricity consumption (excluding chilled water pumps for COP calculations),
3. Decoupler flow,
4. Secondary circuit flow, leaving an entering water temperatures,
5. Chillers water pressure (only for VFDs).

These measurement points provide critical information to determine potential energy savings opportunities. In general, temperature sensors shall be located at or near the chillers outlets in order to measure the actual temperature. A flow meter is recommended to be installed on each of the chillers, secondary circuit and in the decoupler pipe. Water flow meters can be an orifice plate, ultrasonic, etc. A water flow meter is also a reliable status indicator of chillers.

B1.2 Potential Energy Saving Opportunities

The following list of energy saving opportunities is not exhaustive but is intended to provide guidance on how to detect commonly found ESOs in chiller systems.

B1.2.1 Chiller sequencing optimisation

Consist of adjusting the sequence of operation of the chillers to achieve a higher system efficiency. A duty chiller is the first that activates when there is a demand for cooling, or cooling load. Standby chillers activate when the duty chiller reaches certain demand or when the chiller is unable to start due to a fault. Duty / standby designations interchange regularly to achieve a similar number of operating hours during the year or according to the efficiency of each chiller.

B1.2.1.1 Symptom

a. Pumps are continuously in full or very low loads.

B1.2.1.2 Results

a. One of the chillers is operating at full capacity while others are kept off or in a low COP zone
b. COP of the entire system is low.

B1.2.1.3 Analysis

a. Check flow, entering and supply temperature of the chilled water to determine the load;
b. Check manufacturer's performance curves to estimate the range of loads with highest COP.
c. If whole year data is not available, verify chillers' loads in several seasons;
d. Check load profiles or the variation of cooling demand during a 24 hour period during similar days across the year.
e. Check the actual chiller sequencing.
f. After computing cooling load of the building with the available data, create a load range breakdown table. See example 17 in Main Content Appendix A.

B1.2.1.4 Recommendations

a. Prepare a chiller operation table based on the building cooling load range. It consists of sequencing the chillers to maximise part-load operations by keeping them in the range of highest efficiency. It can be created by combining the building cooling load range breakdown with the chiller manufacturer's performance curves. See example 17 in Main Content Appendix A.

b. Generally, chillers should only be operating at full load for 1% to 2% of time throughout the year. In the opposite scenario, when low load is present during most part of the year it is likely that the chiller is oversized;
c. See Main Content Appendix A, example 1 and 2.

B1.2.2 Set-point optimisation

Consist of adjusting chiller temperature set points to achieve a higher system efficiency.

B1.2.2.1 Symptom

a. Cooling load is not fulfilled;
b. Continuous flow in the by-pass;
c. Chiller status do not match with changes in loads;
d. Cooling coils terminals fully opened or closed.

B1.2.2.2 Results

a. Low/high temperature difference (delta T);
b. High chilled water supply temperatures cause additional use of the pumps to compensate high temperatures with water flow;
c. Low chilled water supply temperatures provide an excess of supply which is only recirculated in the primary circuit.

B1.2.2.3 Analysis

a. Check chiller supply and return temperatures against the set point;
b. Check delta T and decoupler flow rate during high, low and transition season;
c. Compare building peak loads with design loads to determine if the system is under / oversized.

B1.2.2.4 Recommendations

a. Typical temperature is 7˚C and return of 12˚C with a temperature differential of 5˚C. Temperature reset should be considered based on external weather condition or building load.

b. Optimise water temperature to achieve maximum efficiency, consider pumps trade-off.
c. See Main Content Appendix A, example 3.

B1.2.3 Review variable speed driven pump pressure setting

When VSD pumps are installed in existing site with differential pressure as the control parameter. The differential pressure control setting can be reduced at part-load when the cooling demand reduced to help reduce pump energy consumption.

B1.2.3.1 Symptom

a. Pump differential setting is constant during part load operation.

B1.2.3.2 Results

a. Increase pumps energy consumption.

B1.2.3.3 Analysis

a. Check the differential pressure set point.
b. Reduce the set point during part load condition.
c. Check the air temperature of the downstream equipment at critical path.

B1.2.3.4 Recommendations

a. Before actual implementation, user can make trials to reduce the differential pressure step by step to ensure the downstream air temperature still satisfy the set point.

B1.2.4 Chiller plant inspection

Chillers are typically the largest single energy-consuming item in commercial buildings. Hence, inspection is key to determine potential ESOs varying from oil changes to scheduling chiller replacement in the near future. It is worth mentioning that replacing chillers that have exceeded their expected operational life span, are not able to fulfill the cooling design requirements, or are no longer reliable; can result in a cost-effective ESO when potential energy savings and reduced maintenance costs are considered.

B1.2.4.1 Symptom

a. Chiller cannot meet and work on the design condition or factory setting;
b. Excessive noise and vibrations;
c. Corrosion and other visible deterioration signs.

B1.2.4.2 Results

a. Low COP in the system;
b. Slow reaction for cooling supply, especially in high demand second;
c. Electricity use of the chiller is higher compared to previous years without apparent explanation;
d. Electricity use of the chiller system does not drop as expected in low demand seasons.

B1.2.4.3 Analysis

a. Visually inspect for severe corrosion;
b. Verify with O&M staff is there has been a change in noise in the chiller plants;
c. Check maintenance logs to determine if chiller has been maintained over a long period of time;
d. Check the general status in the oil systems, including the sump pump chamber. Look for traces of metal accumulation in the oil that would indicate faults and wearing.
e. Check supply temperature and compare it with set point;
f. Check delta T in chiller.

B1.2.4.4 Recommendations

a. If delta T is low as compared to the design delta T of the chiller in the O&M manual, consider scheduling maintenance or replacement. The latter option is only relevant if equipment is old (+20 years) and has been under maintained. For further detail on recommended HVAC equipment lifespan, please refer to ASHRAE equipment life expectancy chart.

b. If mechanical problems such as metal wearing, chiller surge or internal fouling are detected from the analysis, prepare a plan for addressing the issue.
c. For M&V requirements, install meters before and after the chiller ESO implementation to estimate changes in efficiencies.
d. See Main Content Appendix A, example 4.

B2. Water balancing

B2.1 Understanding the system

B2.1.1 System description

A chilled water system circulates chilled water from chillers to the conditioned areas in the building. In one side, the chiller water loop is connected to the evaporator in the chiller and on the other side, the water loop feeds air handling or fan coil units throughout the building. The function of a chilled water loop is to fulfill the cooling needs of the building, also known as cooling load and it is typically measured in kilowatts (kW). In ideal conditions, the supply and demand of cooling are in equilibrium.

B2.1.2 Data reporting period

It is recommended to collect relevant data for the whole year in order to determine ESOs effectively. However, if data collection during a whole year is not feasible, short-term measurements during maximum, minimum load and transition seasons is required. The recommended sample period of the data is up to 15 minutes.

B2.1.3 System schematics

Refer to figure B.1.1.3 in the previous section.

B2.1.4 Key measurements points

1. Chiller water flow, leaving and entering water temperatures.
2. Secondary circuit chilled water flow, leaving and return water temperature.
3. Primary and secondary pumps' speed.
4. Chiller water pressure in primary and secondary loops (only for VFDs).
5. Decoupler flow.

B2.2 Potential energy saving opportunities

The following list of energy saving opportunities is not exhaustive but is intended to provide guidance on how to detect commonly found ESOs in chiller systems.

B2.2.1 Control upgrade

Primary and secondary circuits circulate chilled water using pumps. A control upgrade should improve energy efficiency operation by eliminating excess in the use of pumps providing a similar cooling to the demanded by the building.

B2.2.1.1 Symptom

a. Number of chillers running do not correspond to the changes in load of the building.

B2.2.1.2 Results

a. Excessive use of primary pumps;
b. Potential rapid temperature fluctuation causing early wear on equipment.

B2.2.1.3 Analysis

a. Determine the current sequencing by doing an operational check;
b. Compute load on site using flow, supply and return water temperature and compare it with the calculated load in the control system, report any inconsistencies;
c. Use 15 minutes supply water temperature readings to detect temperature hunting.

B2.2.1.4 Recommendations

a. Make sure that sensors used to calculate loads in the control system are properly calibrated;
b. Verify that the existing control strategy avoids rapid temperature fluctuation by providing an adequate temperature range.
c. See Main Content Appendix A, example 5.

B3. Heat rejection system

B3.1 Understanding the system

B3.1.1 System description

In water-cooled systems, the cooling tower is responsible for releasing heat contained in the refrigerant into the atmosphere. Water containing heat from the condenser is sent to the cooling tower where the heat is then removed.

Towers can be either wet or dry but both use a fan to circulate air through the tower. It is common that more than one cooling tower is installed in the building (known as cells), and they are usually located on the roof.

On the other hand, air-cooled systems transfer heat contained in the refrigerant directly to the air. Air-cooled systems are typically found in small to medium size buildings, as they tend to take less space, however they are also less efficient as compared to water-cooled systems.

B3.1.2 Data reporting period

Ideally, whole year metered data would allow to determine ESOs effectively. However, if data collection during a whole year is not feasible, short-term measurements during maximum, minimum load and transition seasons are required.

There is not specifications for data collection intervals for air-cooled systems, however, outdoor air temperatures, leaving and return condenser water temperatures and fan power (or speed) should be recorded at a minimum of one reading per hour.

For the case of cooling towers, it is recommended a minimum of twelve readings per hour for entering wet bulb and entering dry bulb temperature and a minimum of one reading per hour regarding the water flow rate and fan power input. Refer to ISO 16345:2014 Water cooling towers – Testing and rating of thermal performance for further details.

B3.1.3 System schematics

The following diagram represents a wet cooling tower. Main elements are the fan, water nozzles, screens, basins, and pump. Valves for controlling the quantity and quality of the water are represented as well as make-up water and bleed-off lines.

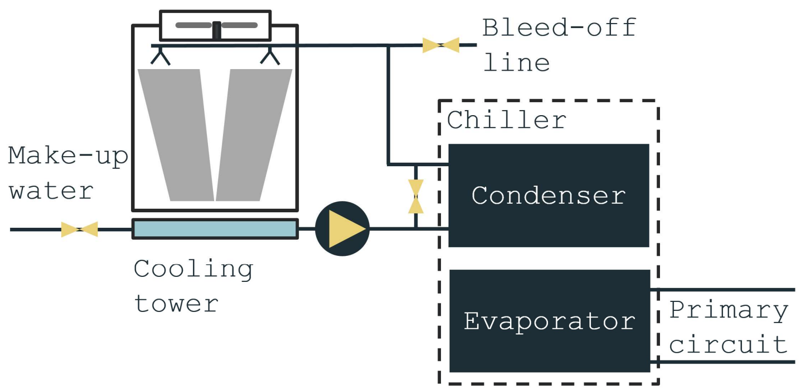

Fig. B.3.1.3 Heat rejection block diagram for water-cooled systems.

B3.1.4 Key measurements points

1. VSD fan speed (water and air cooled);
2. condensing water leaving and entering temperature (water and air cooled);
3. cooling tower power meter (water cooled);
4. water sampling for biological and chemical tests (water cooled);
5. Outdoor air wet bulb temperature (water and air cooled).

In addition to the listed points, noise inspection and visual inspections are critical for determining ESOs.

B3.2 Potential Energy Saving Opportunities

The following list of energy saving opportunities is not exhaustive but is intended to provide guidance on how to detect commonly found ESOs in chiller systems.

B3.2.1 Control optimization (water cooled)

Adjust control strategy including sequencing and VSD in fans to maximise efficiency.

B3.2.1.1 Symptom

a. High approach temperature, or difference between the water to the condenser and the wet-bulb temperature.

B3.2.1.2 Results

a. Water temperature to the condenser is not being cooled down as expected leading to a reduction of the efficiency of the chiller as it receives warmer water.

B3.2.1.3 Analysis

a. Check water leaving and wet bulb temperature to calculate approach temperature in various seasons of the year.

B3.2.1.4 Recommendations

a. Typical entering temperatures to the cooling towers are about 32 ˚C and leaving temperatures about 27 ˚C but it will vary on each case;
b. Optimise the operation of the cells in the cooling tower to achieve an approach temperature between 2 to 8˚C, depending on the tower size. The optimal approach temperature is when it is close to the design approach temperature as listed in the manufacturer's specification. Also, adjust the fans operation on each of the cells to achieve this target. It will increase efficiency of the chiller specially during periods with low wet-bulb temperature;
c. Consider modulating condenser water pump speed to maintain condensing water temperature difference according to the building loads and outdoor conditions;
d. See Main Content Appendix A, example 6

B3.2.2 Maintenance plan (water and air cooled)

Whereas air cooled systems are generally more resilient to outdoor conditions; cooling towers, especially wet ones, are vulnerable to external conditions and must be maintained regularly. Also due to the constant water losses, it is important to monitor the natural accumulation of minerals in the screen and water basin.

For a detailed water-cooled description, refer to EMSD Code of Practice for Fresh Water Cooling Towers CoP.

B3.2.2.1 Symptom

a. The cooling tower failing to provide cooled water to the condenser or (water-cooled systems);
b. Water entering to the condenser as cold as compared to previous years even with similar entering and wet bulb temperatures (water and air-cooled systems).

B3.2.2.2 Results

a. Lack of maintenance on a cooling tower leads to a decline of the overall capacity of the heat rejection system, which causes a rise on the cooling water temperature. Hence the air-conditioning chiller will decline in efficiency and capacity.

B3.2.2.3 Analysis

a. Check the current maintenance plan, if any (water and air-cooled systems);
b. Walkthrough the cooling towers to detect excess noise, vibration, signs of corrosion and other types of deterioration (water-cooled systems);
c. Check the status of the nozzles and report the ones that are clogged (water-cooled systems);
d. Check the status of the screens, including potential accumulation of minerals or debris (water-cooled systems);
e. Check the status of the water basin (water-cooled systems);;
f. Obtain samples of water to determine if its composition is acceptable (water-cooled systems);
g. Use infrared cameras to detect high temperatures in fans (water and air-cooled systems);
h. Check the status of the condenser including the tube, fins, and fans, look for debris blocking airflow (air-cooled systems).
i. Make sure the outdoor temperature conditions are within the design capabilities of the heat rejection system (water and air-cooled systems).

B3.2.2.4 Recommendations

a. Clean surfaces in the condenser, including tube and fins (air-cooled systems).
b. Remove debris that can block airflow. Check that all fans are working. (water and air-cooled systems).
c. Compute approach temperature and compare it to the design approach temperature (water-cooled systems).

B4. Airside system (VAV)

B4.1 Understanding the system

B4.1.1 System description

The airside system is responsible for collecting the heat from the building and transferring it to the chilled water system through coils. Air is pumped through the coils to the conditioned areas.

B4.1.2 Data reporting period

If data collection during a whole year is not feasible, short-term measurements in weekdays/weekends are required, especially during peak cooling load seasons.

B4.1.3 System schematics

A wide number of air system configurations exist. The diagram below shows one example of Variable Air Volume system.

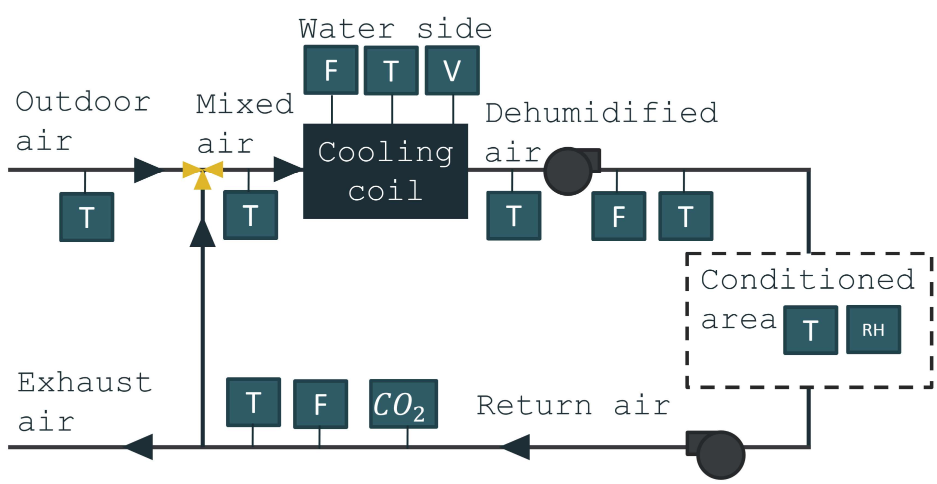

Fig. B.4.1.3 Air side system block diagram

C4.1.4 Relevant areas

1. Airflow;
2. Air temperature in various points including supply and return;

3. CO2 concentration from conditioned areas;
4. Cooling coils water temperature, flow and valve position;
5. In some VAVs, air pressure in ducts is relevant.

B4.2 Potential Energy Saving Opportunities

The following list of energy saving opportunities is not exhaustive but is intended to provide guidance on how to detect commonly found ESOs in chiller systems.

B4.2.1 Review indoor air temperature setpoint

Temperature set point in conditioned areas is a major driver of cooling energy consumption in a building. A thermostat is the first point of interaction between a building user and an air conditioning system; however, a set point that may seem adequate for one person or facility manager in reality could impact negatively on a majority of users and the energy consumption of the system. Careful analysis is required when defining a set point especially in large conditioned areas.

B4.2.1.1 Symptom

a. Space is too cold or too hot and the temperature set-point is not responding to air temperature re-sets;
b. Air ventilation excess in some areas (air drafts).

B4.2.1.2 Results

a. Complaints from users due to internal drafts and uneven cooling.

B4.2.1.3 Analysis

a. Check air temperature on conditioned areas and compare it against the thermostat set point;
b. Verify the activity of the cooling coils to detect cases of simultaneous heating/cooling;
c. Verify the status of air diffusers and air dampers in the VAV;
d. Check the status of the valves in the cooling coils.

B4.2.1.4 Recommendations

a. Verify room temperatures achieve set-points by plotting trended data;
b. Analyse the status of the valves focused on cases where valves are always on/off;
c. Adjust set points in the building to minimise simultaneous heating/cooling;
d. See Appendix A, example 7.

B4.2.2 Demand Controlled ventilation

During summer period, the hot and humid fresh air will increase the overall cooling load. Therefore by controlling the amount of fresh air to suit the system requirement will help reduce the system cooling load and fan power.

B4.2.2.1 Symptom

a. The carbon dioxide concentration in return air duct is well below the threshold value (e.g. 1000ppm).
b. Fresh air amount to each AHU is constant.

B4.2.2.2 Results

a. Constant supply of fresh air exceeding demand need.
b. Energy wastage in fresh air fan power.
c. Increase cooling load demand on air handling units.

B4.2.2.3 Analysis

a. Check the carbon dioxide concentration level in return air duct and compare with threshold value.

B4.2.2.4 Recommendations

a. If the average carbon dioxide concentration is well below the threshold, building operator can consider reducing the fresh air amount by reducing the fresh air fan speed or using variable speed control.

B4.2.3 Air Handling Unit fan static pressure reset

In situation where variable speed driven AHU fan is installed, the duct static pressure is used as control parameter. The fan speed will modulate in order to maintain the constant static pressure in the ductwork.

During low cooling demand period, the static pressure setting for the fan speed modulation can considered to lower further in order to achieve some savings in distribution fan energy.

B4.2.3.1 Symptom

a. The air flow rate is still high at low cooling demand condition.
b. Duct static pressure set point is constant even during low load condition.

B4.2.3.2 Results

a. Oversupply of air flow during low cooling demand period.
b. Room is too cold during low demand period.
c. Energy wastage in AHU fan power.

B4.2.3.3 Recommendations

a. Before actual implementation, user can make trials to reduce the static pressure set point step by step to ensure the downstream air temperature still satisfy the set point.
b. See Main Content Appendix A, example 9.

B4.2.4 Consider preconditioning periods

Preconditioning periods is a strategy that consist of cooling the building before working hours especially after continuous days without cooling. This is a common situation in buildings where the system is off during the weekend or holiday periods.

B4.2.4.1 Symptom

a. Temperature in conditioned areas fail to meet the set-point temperature during the first hours on Monday.

B4.2.4.2 Results

a. The system works at full capacity to meet the demand.

B4.2.4.3 Analysis

a. Use a time series plot to detect the time required for the system to meet the demand;
b. Check air supply temperatures and flow in primary air handling units.

B4.2.4.4 Recommendations

a. Calculate a preconditioning period of primary air handling units;
b. See Main Content Appendix A, example 8.

B4.2.5 Test and balance equipment

Ensure that airflow sensors are calibrated and that air flow is balanced. Refer to ASHRAE standard 111-2008 – Measurement, Testing, Adjusting and Balancing of Building HVAC Systems for further reference.

B4.2.5.1 Symptom

a. Building users constantly complain about air drafts;
b. Other comfort complaints in other areas of the buildings;
c. Temperature range across chillers / chilled water rises with same capacities will be different;
d. Pressure differential across pumps / AHUs with same capacities will be different

B4.2.5.2 Results

a. A system with an unbalanced air distribution will fail to regulate internal air temperatures in the whole building.

B4.2.5.3 Analysis

a. Use anemometers to verify the airflow in ducts. Refer to ASHRAE standard 111-2008 – Measurement, Testing, Adjusting and Balancing of Building HVAC Systems for further guidance on types and calibration requirements.
b. Review air pressure set-point.
c. Review the critical path of airflow.

B4.2.5.4 Recommendations

a. Compare measurements with the values recorded by the control system. Report excess or shortfall of air, which should not be beyond +/-10%;
b. Repair/replace fault sensors;
c. See Main Content Appendix A, example 9.

B5. Lighting system and automatic control

B5.1 Understanding the system

B5.1.1 System description

Lighting system consist on two main categories of lights: normal and emergency. They are also known as tradable and non-tradable lighting. Normal lighting includes task and general lighting. Emergency lighting cover evacuation sings, ATM lighting, main entrances, lighting in emergency rooms, etc.

B5.1.2 Data reporting period

If variability is low, short-term electricity metering is enough to determine actual lighting demands during weekdays and weekend. Consider at least two weeks using half-hourly resolution. Typically, low variability profiles across different weeks are found in office buildings.

If lighting use profiles varies considerably, longer metering periods will be required.

B5.1.3 System schematics

N/A

B5.2 Potential Energy Saving Opportunities

The following list of energy saving opportunities is not exhaustive but is intended to provide guidance on how to detect commonly found ESOs in lighting systems.

B5.2.1 Adjust lighting to meet allowance and lighting levels

Whereas energy saving opportunities in emergency lighting are limited, normal lighting almost always have areas for performance improvement by comparing actual lighting levels and power to recommended values in guidelines.

B5.2.1.1 Symptom

a. Lighting levels are above recommended and/or;
b. Levels of lighting are adequate but above the power allowance;
c. Passenger / occupants usage pattern is not related with the lighting level and its usage pattern.

B5.2.1.2 Results

a. Energy wasted by excess of installed lighting;
b. Reduction of the operative life of the lights.

B5.2.1.3 Analysis

a. Calculate maximum interior lighting power installed determining tradable and non-tradable areas;
b. Calculate exterior lighting power installed determining tradable and non-tradable areas;
c. Measure interior lighting levels in large occupied areas using a lux meter;
d. Check interior daylight zone controls.

B5.2.1.4 Recommendations

a. Compare interior lighting power installed to maximum lighting power allowance as per EMSD Code of Practice for Energy Efficiency of Building Services Installation. Alternatively, use the CIBSE, CIE or IES reference. If installed lighting power is higher than allowed, consider replacement for more efficient fixtures;
b. Compare lighting levels to recommended values. If installed lighting levels are higher than recommended, consider a de-lamping plan;
c. For the case of office buildings, using task light can reduce energy use while preserving adequate levels of lighting.
d. If M&V is carried out, measurements pre and post ESO implementation are required;
e. See Main Content Appendix A, example 13.

B5.2.2 Occupancy sensors

In large buildings, occupancy sensors can reduce the energy used for lighting.

B5.2.2.1 Symptom

a. Normal lighting is left on during the night, weekends and holidays.

B5.2.2.2 Results

a. Energy wasted by operating lighting when is not needed;
b. Reduction of the operative life of the lights.

B5.2.2.3 Analysis

a. Locate interior lighting controls;
b. Install electricity sub-metering to lighting circuits in the main areas of the building during a recommended period.

B5.2.2.4 Recommendations

a. Install occupancy sensors in tradable areas for automatic on/off;
b. For the case of office buildings, using task light can reduce energy use while preserving adequate levels of lighting.
c. If M&V is carried out, measurements pre and post ESO implementation are required.

B5.2.3 Daylight zone controls

Lighting control in exterior areas as well as in occupied areas in large buildings can reduce energy use for artificial lighting by taking advantage of the natural light. When installed indoors, photocells can also integrate occupancy sensors for improved lighting efficiency.

B5.2.3.1 Symptom

a. Areas in the building next to large vertical windows or skylights keep lighting on during daytime with the aim of preventing building-user complaints during early morning or afternoon periods.

B5.2.3.2 Results

a. Energy wasted by operating lighting when is not needed;

b. Increased cooling loads from lighting;
c. Reduction of the operative life of the lights.

B5.2.3.3 Analysis

a. Determine if the building has areas with daylighting potential, use 2015 IECC or ASHARE Standard 90.1 2016 as reference;
b. Determine minimum lighting requirements of the areas, adhere to the referenced standard in the previous step;
c. Estimate potential savings from installing these sensors;
d. If daily use patters vary considerably, install electricity sub-metering to lighting circuits in the main areas of the building during a recommended period.

B5.2.3.4 Recommendations

a. Install daylighting sensors in areas with daylighting potentials;
b. Ensure to collect user feedback and adjust the sensibility of the sensors as required;
c. For the case of office buildings, using task light can reduce energy use while preserving adequate levels of lighting.
d. If M&V is carried out, measurements pre and post ESO implementation are required.

B6. Lift and Escalator

B6.1 Understanding the system

B6.1.1 System description

Means of vertical transportation vary installed in buildings vary widely, hence each system must be assessed individually.

B6.1.2 Data reporting period

If variability is low, short-term electricity metering is enough to determine actual vertical transport equipment demands during weekdays and weekend. Consider at least two weeks using half-hourly resolution during peak and off-peak seasons.

B6.1.3 System schematics

N/A

B6.2 Potential Energy Saving Opportunities

The following list of energy saving opportunities is not exhaustive but is intended to provide guidance on how to detect commonly found ESOs in vertical transport systems.

B6.2.1 Install metering devices

The installation of metering devices beyond energy codes can provide a better picture of how energy is used in lifts allowing a more accurate ESO estimation.

B6.2.1.1 Symptom

a. Energy used in lifts is unknown.
b. Energy usage pattern is not related with the travelling capacity pattern.

B6.2.1.2 Results

a. It is difficult to propose ESOs due to the lack of data.

B6.2.1.3 Analysis

a. Check testing and commissioning records of the actual lift or similar ones;
b. Check access to circuits for installation of meters.

B6.2.1.4 Recommendations

a. Collect voltage, current, total power factor, energy consumption, power and maximum demand readings for each bank of lift;
b. See EMSD – Code of Practice for Energy Efficiency of Building Services Installation 2015, section 8 – Energy Efficiency Requirement for Lift and Escalator Installation.

B6.2.2 Optimise lift operation

Especially during off-peak period, minimising the number of available lifts beyond codes as well as reducing lighting and cooling in active lifts will help to reduce energy use.

B6.2.2.1 Symptom

a. Lifts are switched on during low-peak period.

B6.2.2.2 Results

a. Energy wasted by running a number of unused lifts.

B6.2.2.3 Analysis

a. Collect voltage, current, total power factor, energy consumption, power and maximum demand readings for each bank of lift.

B6.2.2.4 Recommendations

a. Switch off light and ventilation during stand-by mode;
b. Switch off lift units beyond code requirements;
c. Use smart technologies to reduce the number of travel of lifts.

d. Optimise the counter balancing weight of lift when upward and downward travelling weight is significantly different.
e. Fitted in regenerative power of lifts into the power supply systems.
f. See EMSD – Code of Practice for Energy Efficiency of Building Services Installation 2015, section 8 – Energy Efficiency Requirement for Lift and Escalator Installation.

B7. Power quality

B7.1 Understanding the system

B7.1.1 System description

Electricity distribution loss cause overheating of conductors and devices, which affect the energy consumption of the building. Power quality is critical to minimise electricity distribution loss.

Reactive loads in the circuit, the ones originated by induction motors, consist on additional currents in the circuit that does not do productive work. The ration between the true and the apparent power is called power factor. For instance, a power factor (Pf) equals to 1, suggest that only resistive loads such incandescent lighting and electric heating present. If the power factor includes as correction factor is called total power factor.

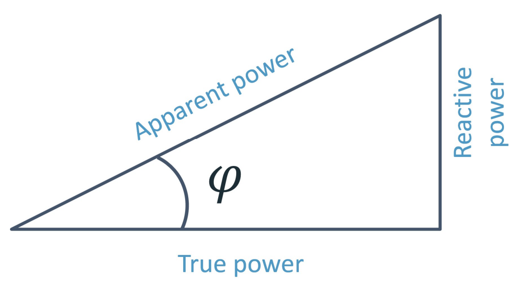

Fig. B.7.1.1 Power triangle

Total Power factor (cos phi) = phase angle between amps and volts. This angle can affect negatively true consumption and shall be minimised. True RMS meters measure voltage, amperage and phase angle.

B7.1.2 Data reporting period

Short-term electricity metering is generally enough to determine Total Power Factor (TPF) and Total Harmonic Distortion (THD).

B7.1.3 System schematics

N/A

B7.2 Potential Energy Saving Opportunities

The following list of energy saving opportunities is not exhaustive but is intended to provide guidance on how to detect commonly found ESOs in chiller systems.

B7.2.1 Measure TPF and THD

Harmonics are waveform distortions in current or voltages that exist in an ideally sinusoidal signal. Harmonics are caused by any non-linear loads in the network and have a negative impact on the quality of the electricity (current and voltage). Examples of non-linear loads include computers, copying machines, battery chargers, etc. On the other hand, linear loads examples include incandescent lighting and electric heating. Total Harmonic Distortion THD is a measure in percentage that represents the ratio between the true voltage of the harmonic frequencies and the fundamental frequency of the signal. THD provides an estimation of how much of the variation in voltage or current can be attributed to harmonics. The lower the THD the better the quality of the signal. For further reference on the maximum limit of THD, please refer to EMSD Code of Practice for Energy Efficiency of Building Services Installation. Section 7.6

In practice, THD is considered through the calculation of the TPF, which is defined as the ratio between true and apparent power. TPF is close to one when only linear loads are connected to the circuit and this value reduces as non-linear loads are added. The recommended lower limit for TPF is 0.85 , further reference can be found in EMSD Code of Practice for Energy Efficiency of Building Services Installation Section 7.6.

B7.2.1.1 Symptom

a. Excess of inductive loads create additional demand of electricity due to the additional resistance of the circuit.

B7.2.1.2 Results

a. Energy wasted due to cables and component overheating.

B7.2.1.3 Analysis

a. Calculate apparent and real power

B7.2.1.4 Recommendations

a. When metering electricity, the best practice is to always measure true RMS Watts, to be sure of including all possible power factor and harmonic influences. Simple wattmeter can be used only in circumstances when the technician is sure that loads are only resistive.
b. If TPF is less than minimum requirements, implement a correction plan;
c. If the percentage of THD is above the specified limits, implement a correction plan;
d. See Main Content Appendix A, example 12.

Annex C

Central Control & Monitoring System (CCMS) data sample

Annex C – Central Control & Monitoring System (CCMS) data sample

The following examples show different data format samples that can be exported from CCMS. In this example, two data points, AHU off coil temperature and air supply flow rate (l/s) for illustration. Some CCMS are able to configure different data format based on user specification. User should consult the CCMS service provider for further reference.

Sample 1

Date and time stamp

Data point variable value
- AHU off coil temp
- AHU airflow supply rate

Date and time	AHU 1 off coil temp (degC)	AHU 1 flow rate(l/s)
30/11/2016 00:00	15	987
30/11/2016 00:15	17	1244
30/11/2016 00:30	17	1806
30/11/2016 00:45	14	1760
30/11/2016 01:00	15	592
30/11/2016 01:15	14	1945
30/11/2016 01:30	16	1004
30/11/2016 01:45	14	1005
30/11/2016 02:00	17	1937
30/11/2016 02:15	17	1607
30/11/2016 02:30	15	835
30/11/2016 02:45	16	1372
30/11/2016 03:00	15	1937

In this data format, each row represent one data logging time interval, with the column representing different data points recorded value.

Sample 2

Date and time stamp

Data point variable value
- AHU off coil temp
- AHU airflow supply rate

Date and time	Reference	Value
30/11/2016 00:00	AHU 1 off coil temp (degC)	16
30/11/2016 00:00	AHU 1 flow rate(l/s)	590
30/11/2016 00:15	AHU 1 off coil temp (degC)	15
30/11/2016 00:15	AHU 1 flow rate(l/s)	1023
30/11/2016 00:30	AHU 1 off coil temp (degC)	15
30/11/2016 00:30	AHU 1 flow rate(l/s)	801
30/11/2016 00:45	AHU 1 off coil temp (degC)	15
30/11/2016 00:45	AHU 1 flow rate(l/s)	1103
30/11/2016 01:00	AHU 1 off coil temp (degC)	14
30/11/2016 01:00	AHU 1 flow rate(l/s)	1964
30/11/2016 01:15	AHU 1 off coil temp (degC)	17
30/11/2016 01:15	AHU 1 flow rate(l/s)	1195
30/11/2016 01:30	AHU 1 off coil temp (degC)	14
30/11/2016 01:30	AHU 1 flow rate(l/s)	1070
30/11/2016 01:45	AHU 1 off coil temp (degC)	14
30/11/2016 01:45	AHU 1 flow rate(l/s)	1303
30/11/2016 02:00	AHU 1 off coil temp (degC)	14
30/11/2016 02:00	AHU 1 flow rate(l/s)	781

In this data format, the data points value are listed together in rows (red line separation) for every data logging time interval. This type of data format is less common compare to sample 1 and 3.

Sample 3

Time

Date stamp

AHU 1 off coil temp (degC)									
Date	00:00	00:15	00:30	00:45	01:00	01:15	01:30	01:45	02:00
30/11/2016	16	15	15	15	14	17	14	14	14
01/12/2016	17	16	14	17	15	17	17	15	15
02/12/2016	15	14	16	15	17	17	16	15	16
03/12/2016	15	15	16	15	15	14	14	15	15
04/12/2016	14	17	16	17	14	15	15	14	16
05/12/2016	17	16	16	15	15	16	15	16	15
06/12/2016	15	15	14	16	14	14	17	17	15
07/12/2016	14	16	14	14	14	14	16	15	16
08/12/2016	15	14	16	16	15	15	14	14	17
09/12/2016	16	15	14	15	17	15	15	17	17

Time

Date stamp

AHU 1 airflow rate (l/s)									
Date	00:00	00:15	00:30	00:45	01:00	01:15	01:30	01:45	02:00
30/11/2016	590	1023	801	1103	1964	1195	1070	1303	781
01/12/2016	1477	1425	1436	1626	1689	1198	1144	1595	1992
02/12/2016	1417	908	1038	984	1997	1896	1313	1545	1773
03/12/2016	1604	1386	979	728	1269	1563	1042	1380	1472
04/12/2016	1002	1972	1350	1457	736	1312	1607	553	1674
05/12/2016	1661	627	1556	1299	1231	1760	893	1779	1918
06/12/2016	2000	1935	1379	855	1232	982	659	1806	724
07/12/2016	707	1946	744	841	707	657	1076	1652	795
08/12/2016	1880	1913	1291	1570	1000	1393	761	1970	861
09/12/2016	1439	1596	769	1310	1799	1438	644	1506	1334

In this data format, each row represent one day, where each column represent one data logging time interval recorded value. The column should read from left to right for the whole day trend.

The above examples are some data samples commonly encountered, there are other data format available from different CCMS service provider. User should consult the CCMS service provider for further explanation should there be any enquiries to understand the logged data.