
(First Edition, 2018)
Acknowledgement

The Guide on Specifications for Energy Performance Contracting (EPC) for Air-Conditioning System Maintenance Contract is an industry-driven effort and collaboration across the building and construction community. Singapore Green Building Council (SGBC) would like to extend our sincere appreciation to all the stakeholders for their support and contributions towards the development of this Guide.

Working Committee

Co-chair
Mr Lim Fatt Seng
Comfort Management Pte Ltd, also
SGBC Board Representative

Mr Toh Eng Shyan
Building and Construction Authority

Members
Mr Alfred Lim
CapitaLand Limited

Mr Anthony Goh
City Developments Limited

Mr Bey Jiann Ming
Ascendas-Singbridge Group

Mr Chua Thuang Kee
Daikin Air-conditioning (Singapore) Pte Ltd

Mr Daniel Ong
Jardine Engineering (Singapore) Pte Ltd

Mr Donovan Chua
Daikin Air-conditioning (Singapore) Pte Ltd

Mr Eddy Lau
Singapore Green Building Council

Mr Ho Chee Kit
C&W Services Singapore

Mr Jonathan Koh Shin Kae
Individual Capacity

Mr Liew Kwong Chin
TRANE Distribution Pte Ltd

Mr Lim Sin On
Keppel Land Real Estate Services Pte Ltd

Mr Mark Lim
Aircond Network Pte Ltd

Ms Ng Beow Suan
Squire Mech Pte Ltd

Mr Prasanth R
Comfort Management Pte Ltd

Mr Roslee Abdullah
TRANE Distribution Pte Ltd

Mr Sam Ringwaldt
Smardt Chillers Pte Ltd

Mr Sia Chen Wee
City Developments Limited

Mr Tan Boon Kuan
Carrier Singapore Pte Ltd

Mr Terence Tan
Johnson Controls (S) Pte Ltd

Mr Tony Ang
TRANE Distribution Pte Ltd

Mr Tony Choo
Ascendas-Singbridge Group

Ms Wenda Lew
Comfort Management Pte Ltd

Mr Yee Peng Huey
JTC Corporation

Mr Yeo Kong Nee
ENGIE Services Singapore

Secretariat
Mr Ang Boon Wee
Building and Construction Authority

Ms Chew Wenyi
Singapore Green Building Council
Contents

1. Introduction ........................................................................................................................................ 2

2. Key Considerations to be Included in an Energy Performance Contracting Air-Conditioning System Maintenance Contract .................................................................................................................. 3

2.1. Maintenance Contract Model ............................................................................................................ 3

2.2. Transitional Period ............................................................................................................................. 3

2.3. Key Performance Indicators (KPI) .................................................................................................... 4
   i. Guaranteed Air-Conditioning System Energy Efficiency Performance ............................................ 4
   ii. Penalty / Incentive Scheme ................................................................................................................ 4
   iii. Penalty / Incentive Settlement ........................................................................................................... 6
   iv. Heat Balance Computation ............................................................................................................. 6
   v. Guaranteed Water Efficiency ........................................................................................................... 7

2.4. Measurement and verification (M&V) System of Air-Conditioning System ................................. 7
   i. Possible M&V System Failures ........................................................................................................... 7
   ii. Penalty for Loss of Data ................................................................................................................... 8
   iii. Connecting to BCA’s Chiller Portal ................................................................................................. 8

Annex A – Sample of Recommended Maintenance Servicing Regime ................................................. ii
1. Introduction

Since 2013, SGBC has been working closely with the Building and Construction Authority (BCA) and industry stakeholders to build an industry ecosystem to support greening of our existing buildings. This latest SGBC Accreditation scheme for EPC for Air-conditioning Maintenance is the next step to ensure that the chiller plants that are commissioned and/or retrofitted to high efficiency standards can continue to perform at its optimum levels over its life cycle. It is critical for our industry to recognize and accredit a group of competent and professional EPC maintenance companies to help building owners and Facility Managers maintain their green buildings with confidence.

In order to build up this supply chain, building owners have to change the air-conditioning plant maintenance procurement model, to one which is outcome and performance based, vis a vis the traditional prescriptive and reactive maintenance model.

This guide serves as a reference document for both the building owners and the EPC Air-Conditioning System Maintenance service providers. It includes key considerations that are considered industry best practice in an Energy Performance Contracting (EPC) for Air-Conditioning System Maintenance contract. It is recommended that individual service buyers modify the recommended specifications accordingly to suit the project needs and requirements. A list of SGBC accredited EPC Air-Conditioning System Maintenance Firms who are experienced in performance-based contract modelling and servicing can as well be found on SGBC website: https://sgbc.online/certification-directory/services/. A recommended maintenance servicing regime (Annex A) is also included for reference.
2. **Key Considerations to be Included in an Energy Performance Contracting Air-Conditioning System Maintenance Contract**

This section highlights the various Maintenance Contract Models and the Key Performance Indicators for the EPC, together with the incentive/penalty computation and payment models.

This guide recommends for service buyer to engage service providers from SGBC list of accredited Energy Performance Contracting (EPC) Air-Conditioning System Maintenance firm.

### 2.1. Maintenance Contract Model

The service buyers shall clearly state whether the EPC Air-Conditioning System Maintenance Contract is adopted based on a **comprehensive or non-comprehensive** contracting model.

For non-comprehensive contracting model, the components which are not inclusive in the contract shall be clearly itemised and be quoted with a Schedule of Rate. While for the components which are included in the contract shall state clearly the scope and coverage.

### 2.2. Transitional Period

A transitional period is recommended to allow service provider to familiarise with the site before the actual performance obligation start. The frequency of the reporting and performance review meetings to discuss on the results shall be agreed between the service buyer and provider.

For service providers with existing building maintenance contract, the Service buyer shall provide the baseline efficiency and performance data for the service provider to plan for the
implementation and servicing program that best fit the site condition.

2.3. Key Performance Indicators (KPI)

The service buyer shall clearly state the Key Performance Indicators (KPI) that the service provider shall guarantee. *This guide recommends* for the following to be included in the contract.

i. Guaranteed Air-Conditioning System Energy Efficiency Performance

Service buyer shall determine the minimum efficiency to be achieved for both the Chilled Water Plant and/or Air Distribution System. It is recommended for service buyer to stipulate a yearly efficiency to be guaranteed, which can be represented as follows in the contract:

<table>
<thead>
<tr>
<th>Year</th>
<th>Chilled Water Plant Efficiency (kW/RT)</th>
<th>Air Distribution Efficiency (kW/RT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>2</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>3</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>4</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

ii. Penalty / Incentive Scheme

This section recommends the method to calculate the monetary settlement if the guaranteed air-conditioning system efficiency performance is not met. The service provider shall modify the formula whenever required to best fit their business models.

The service buyer shall consider incentivising the service provider if performance is better
than the contracted efficiency. Incentives can be based on a lump sum reward or on a co-sharing basis on the savings.

An example on the recommended calculation method is shown below.

**Work Example: Quarterly Measured Efficiency Calculation**

<table>
<thead>
<tr>
<th>Month</th>
<th>(a)</th>
<th>(b)</th>
<th>(c) *</th>
<th>(d)</th>
<th>(e)</th>
<th>(f)</th>
<th>(g)</th>
<th>(h)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heat Balance (HB) Requirement (%)</td>
<td>Actual % of Heat Balance sampled points that meet the ±5% tolerance</td>
<td>Difference between the required HB% and the Actual %</td>
<td>Trended Efficiency (kW/RT)</td>
<td>Actual Efficiency (kW/RT)</td>
<td>Trended Cooling Load (RTH)</td>
<td>Actual kWh (kWh)</td>
<td>Average Quarterly Measured Efficiency (kW/RT)</td>
</tr>
<tr>
<td>Jan-16</td>
<td>80</td>
<td>60.7</td>
<td>19.3</td>
<td>0.607</td>
<td>0.724</td>
<td>202,760</td>
<td>146,829</td>
<td>0.6123</td>
</tr>
<tr>
<td>Feb-16</td>
<td>80</td>
<td>79.7</td>
<td>0.3</td>
<td>0.553</td>
<td>0.555</td>
<td>195,006</td>
<td>108,162</td>
<td></td>
</tr>
<tr>
<td>Mar-16</td>
<td>80</td>
<td>83.3</td>
<td>-</td>
<td>0.565</td>
<td>0.565</td>
<td>241,156</td>
<td>136,253</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Quarterly Total</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>638,922</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>391,244</td>
</tr>
</tbody>
</table>

**Difference between the required HB% and the *Actual % = 80% - Actual % of sampled points that meet the ±5% tolerance**

**Actual Efficiency** = (100% + Variance) x Efficiency of the month

**Actual kWh** = Actual efficiency x Trended Cooling Load

**Average Quarterly Measured Efficiency** = Summation of 3 months Actual (kWh) / Summation of 3 months Trended Cooling Load (tonhr)

*Only percentage that is lower than the required 80% requirement will be taken into the calculation.*

Service providers may refer to Singapore Green Building Council (SGBC)-certified efficient Chillers. A list of SGBC certified products and solutions can found SGBC website: https://sgbc.online/certification-directory/products/
iii. **Penalty / Incentive Settlement**

With the measured efficiency calculated, the quarterly monetary settlement can be computed as follows:

\[
(Average \text{ Quarterly Measured Efficiency - Contracted Efficiency}) \times 3 \text{ months Cooling Load Hours (RTH)} \times \text{Average 3 months effective Electricity Tariff Rate}
\]

**Notes:**

(i) The minimum cooling load shall be determined by the service buyer and be communicated to the service provider before commencement of the contract.

(ii) Effective Tariff = Total 3 months electricity cost (S$) / Total 3 months electricity consumption (kWh)

(iii) Service buyer may amend the payment settlement period in accordance to commercial agreement. This guide recommends for a quarterly or six-monthly payment settlement with monthly performance reporting. Payments from the service provider can be recovered through progressive payments or offset based on the savings’ incentive.

(iv) All records shall be kept for a minimum period of 5 years. The extensiveness of the reports shall be determined by the service buyer in the contract.

iv. **Heat Balance Computation**

The computation of the percent heat balance shall be within ± 5% for 80% of the sampled points over the trended hours. The heat balance is represented by the following equation:

\[
q_{\text{condenser}} = q_{\text{evaporator}} + W_{\text{input}}, \text{ where;}
\]

- \(q_{\text{condenser}}\) = Heat Rejected
- \(q_{\text{evaporator}}\) = Cooling Load
- \(W_{\text{input}}\) = Measured Electrical Power Input to Compressor

\[
\text{Percent Heat Balance} = \frac{(q_{\text{evaporator}} + W_{\text{input}}) - q_{\text{condenser}}}{q_{\text{condenser}}} \times 100\%
\]

*Computed heat balance shall be within ± 5%
v.  Guaranteed Water Efficiency

The service buyer shall stipulate a minimum of 7 or better Cycle of Concentration (CoC) at acceptable water quality as required under prevailing codes and regulations. The frequency of the testing and reporting shall be agreed between the service buyer and provider.

Service providers may refer to Singapore Green Building Council (SGBC)-certified cooling towers and cooling tower water treatment on the possible options to optimise COC. A list of SGBC certified products and solutions can found SGBC website: https://sgbc.online/certification-directory/products/

2.4. Measurement and verification (M&V) System of Air-Conditioning System

The accuracy of the Measurement and Verification (M&V) of the air-conditioning System shall comply to BCA’s Green Mark Scheme requirements. The accuracy of the data is of paramount importance for performance-based contracting hence this guide listed several possible failures and the penalty measure for loss of data.

i. Possible M&V System Failures

- Failure of consistency checks on flow, temperature, power between headers and individual equipment that will lead to inaccurate efficiency measurement.

- Failure of Energy Management System (EMS)’s calculation and/or recording instruments which will lead to inaccurate computation of the trended efficiency.

- Loss of data where information is destroyed by failures or neglect in data storage, transmission, or processing. This guide recommends that the service provider conducts a 7-day data loss test to verify that 99% of data is archived as recommended in SS591: 2013 upon taking over of the Chiller Plant.
ii. **Penalty for Loss of Data**

As a good industry practice, this guide recommends for the quarterly actual trended hours to log at least 95% of the data. If the EMS fails to perform to record at least 95% of data, the service buyer may by giving written notice to the service provider impose a penalty based on the following computation:

\[
\text{(Average 3 months trended hours / 3 months chiller operating hours) x 100 = K\%}
\]

If K% ≥ 95% - No penalty
If K% < 95% - penalty will be imposed

**Penalty in SGD($) :**

\[
(95\% - K\%) \times 3 \text{ months} \times \text{EMS Maintenance price}\]

iii. **Connecting to BCA’s Chiller Portal**

BCA initiates the Chiller Portal to facilitate Green Mark recertification and legislative audit and to provide rudimentary remote monitoring features. Buildings which have a valid Green Mark certificate or are in the process of getting certified are eligible to use the portal at no cost.

Service provider who owns a proprietary remote monitoring system can arrange for a single integration connection to BCA’s Chiller Portal to get the building’s data on board the portal. Connection is straight-forward via a REST data interface, and technical documentation including installation protocol is available from BCA.

The benefits to the service provider and its client are that this will streamline re-certification and, at BCA’s discretion, obviate legislative audit if the chiller plants are performing satisfactorily.

---

1 Maintenance price is based on the submitted Maintenance price (After Maintenance Period) in the tender for the respective year.
Annex A –
Sample of Recommended Maintenance Servicing Regime
Annex A – Sample of Recommended Maintenance Servicing Regime

The equipment to be included in the Air-Conditioning System Maintenance contract is at the discretion of the service buyer. The service provider shall with due diligence integrate the recommended maintenance servicing regime with the manufacturer’s maintenance manual. The suggested servicing regimes may include Chiller Maintenance, Cooling Tower Maintenance, Pumps Maintenance, Expansion Tank Maintenance and Electrical & Controls Equipment Maintenance. The following information shall be included in the contract for the service providers:

- List and Quantity of Equipment
- Equipment Description and Technical Information
- Location of Equipment
- Operating Hours
- Breakdown Response

The service shall also take into consideration of the Health and Safety aspect and should only deploy qualified and trained servicing personnel. A suggested maintenance regime is as follows:

**CHILLER MAINTENANCE**

i. Monthly Maintenance

- Check and monitor operation. Record operating pressure, temperature and operating amperes. Report defects if any.
- Check compressor oil level.
Annex A – Sample of Recommended Maintenance Servicing Regime

- Inspect for symptoms of refrigerant leakage.
- Noise and vibration. Inspect vibration isolators and to report defects if any.
- Inspect cable termination. To tighten if necessary.
- Inspect condenser fans, if applicable
- Review operation log sheets.

ii. Quarterly Maintenance

- Measure and review compressor motor windings' insulation resistance.
- Inspect machine base and body. To touch up if necessary.

iii. Yearly Maintenance

- Safety control checks.
- Condenser tubes cleaning.
- Evaporator tubes cleaning, if necessary.
- Oil and oil filter replacement.
- Measure and review compressor motor windings' insulation resistance
- Inspect all electrical panel and chiller sensors.
- Replace compressor oil and acidic check.
- Replace filter drier cores.
- Conduct pressure test and top up refrigerant, if necessary.
- Inspect machine base and body. To touch up if necessary.

**COOLING TOWER MAINTENANCE**

i. Monthly Maintenance

- Inspect fan and pulley drives.
▪ V-belt tension adjustment.
▪ Lubricate bearings.
▪ Inspect vibration isolators for defects. To recommend replacement when necessary.
▪ Check and clean in-fill, basin and sump.
▪ Visually inspect for any physical defect, general cleanliness, organic fouling and presence of physical debris.
▪ Collect water sample for Standard plate count (monthly) and Legionella bacteria count by approved laboratories (quarterly).

ii. Quarterly Maintenance
▪ Thorough cleaning, disinfection and manual desludging of cooling towers
▪ Inspect motor starters and termination. To tighten when necessary.
▪ Measure and review compressor motor windings' insulation resistance.

**PUMPS MAINTENANCE**

i. Monthly Maintenance
▪ Inspect pump’s physical condition and valve positioning.
▪ To inspect pump’s glands, gasket, coupling, bearings, phase rotation and vibration.
▪ Lubricate bearings.
▪ Check pump operation and bleed air when necessary to prevent air lock.
▪ Check pressure gauges. To recommend replacement when necessary.
▪ Inspect vibration isolators for defects. To recommend replacement when necessary.
ii. Quarterly Maintenance
   - Check and clean strainers.
   - Inspect motor starters and termination. To tighten when necessary.
   - Measure and review compressor motor windings' insulation resistance.

**EXPANSION TANK MAINTENANCE**

i. Monthly Maintenance
   - Inspect tank and test float assembly.

ii. Half-yearly Maintenance
   - Inspect tank and float assembly.

iii. Yearly Maintenance
    - Drain, clean and flush the tank. To touch up the rusting part with paints as necessary.

**ELECTRICAL PANEL**

i. Monthly Maintenance
   - Checking of Miniature Circuit Breaker which includes changing of faulty light indicating bulb(s).
   - Tighten wire and cable at cable connector.

**Energy Management System**

i. Monthly Maintenance
   - Checking of the data integrity and report any abnormality.
Annex A – Sample of Recommended Maintenance Servicing Regime

- Backup of historical data.
- Inspection of equipment on site:
  - Data acquisitions system
  - EMS server
  - Digital Start/Stop Point
  - Analog Point
- Inspection on the communication of the equipment’s to the EMS system on site:
  - Variable Speed Drive
  - Power meter
  - Temperature Sensor

ii. Yearly Maintenance

- Basic monitoring & control refresher training.
An initiative by: