Monitoring Based Commissioning (MBCx)
case study and sharing

Gary Hui (1), Peter Chan (2)
1. gary.hui@energenz.com
2. peterspchan@mgm.mo
(1) Energenz Consulting, Hong Kong.
(2) MGM China, Macau.

Abstract

Commissioning, retro-commissioning and recommissioning are all very important tasks that ensure a building is fine-tuned and optimized for its operations. Entering the big data era, monitoring-based commissioning (MBCx) offers the potential to maximise the yield of commissioning by higher penetration and efficiency, revolutionising project based commissioning works into operations for continuous improvement and issue identification.

This paper looks at how MBCx leverages the increasing power of technology to assure that building operators and managers have the insight of the building, making the invisible issue visible, and how it can equip building personnel with the intelligence to deal with frequently overlooked issues in operation or conventional project based commissioning works.

This paper not only shares MGM’s case how MBCx is used to target quality of service and energy efficiency as the primary tangible benefits, but also provides intangible benefits such as policing best practice, increasing building operators and managers’ skillset, identification of systemic failure and providing visibility of service contracts’ performance.

Keywords

MBCx; monitoring based commissioning; continuous commissioning; retro-commissioning; energy management.
1 Introduction

Since 2010, there has been a rise in a new service that pulls together many new technologies in order to help existing buildings be operated more efficiently. This service has been coined Monitoring Based Commissioning or MBCx.

Monitoring based commissioning (MBCx) is the process of integrating automated monitoring of the building system and retro-commissioning (RCx) approach. The objective of with the aim of providing substantial, persistent, energy savings (Mills and Mathew, 2012).

Due to a convergence of technologies and the rise of open protocols, we now have the ability to cost effectively tap into a building and analyse the buildings operations in great details. Those technologies can be summarised as:

- The rise of cloud computing allowing computing power to be increased
- The increased connectedness and low cost of the internet of things (IOT)
- Increased connectivity and speed –data can be input/output and flow seamlessly between systems
- Open protocol organisations such as project haystack allowing previously locked systems to be analysed on a common platform

This paper looks into the difference between MBCx and other conventional methods of commissioning, its approach and application and case sharing.

2 MBCx background

2.1 Commissioning and the conventional approach

2.1.1 Building commissioning following construction
Commissioning comes from the naval engineering term, it is the standard practice of taking a new ship for a test run to ensure that it is fit. Testing and commissioning is often mentioned together however each carries its own purpose with testing focusing on functional requirement and commissioning focusing on performance requirement, one often refers commissioning to fine-tuning.

In conventional Building Commissioning (Cx), it is often carried out during construction before occupancy of the building. Sometimes this process extends to operation due to delays in construction. In most cases, commissioning is conducted with an assumed mode of operation without consideration of real operational loads. This is common during construction phase when business operation, occupancy and real user requirement are absent.

While this proven approach is properly the best option during construction, it is however an issue that the building performance can be far from the theoretical optimised level due to the lack of real operational load, requirement and feedback. Many development projects would conclude at this stage, leaving the building and its
system functional, with performance enchantment opportunities to be realised in operation.

2.1.2 Building Re-Commissioning (RCx)
Due to the nature of building commissioning following construction, some buildings are left with operational or performance issues during operation, as these issues were not visible, persistently occurring or start to surface after the construction phase as buildings reach its full function and capacity.

A decision to conduct RCx is often triggered by the surfacing of operational problems, whether due to commissioning not being properly conducted after building construction, commissioning limited by lack of operational feedback or change of building requirements (Green California, Department of General Service, 2016).

2.1.3 Building Retro-Commissioning (EBCx)
As a result of the accumulation of operational changes, reoccurring problems, staff turnover and management inefficiency, a building’s performance would naturally deteriorate under a status quo operation.

The aim of EBCx is to find and fix issues of various kinds, so as to improve a building’s operations and maintenance (O&M) process to bring the overall building performance back to the theoretical optimal level (Green California, Department of General Service, 2016).

2.1.4 Monitoring-Based Commissioning (MBCx)
In essence, MBCx is the practice of EBCx with the addition of technologies enabled monitoring and analytic technique to conduct commissioning continuous. By doing this, the building performance can be maintained close to a theoretical optimal level persistently. Figure 1 shows an illusive nature of different commissioning process against building performance over time.

Figure 1 – Different commissioning approach and performance over time
2.2 The MBCx approach

2.2.1 The MBCx model
With the evolution of technologies, a standard modern building will consist of thousands of sensors (Temperature, Humidity, Pressure, Flow, etc.), streaming data to the Building Management System (BMS). These data are used to monitor the building and determine the control required to service the building according to user requirement in the form of Setpoints and Sequence of Operations (SOO). This creates the inflow and storage of massive set of building metric data over time, if these data are correctly analysed and transformed into knowledge and actionable information, it can be used to rectify building issues and improve building performance.

The power of MBCx anchors firstly on this continuous flow of big data, and then applying artificial intelligence, this speedy process and multiplication of near real time data would achieve a continuous function for the identification of building issues that would be often overlooked or invisible during the manual labour driven EBCx. The below table and figure shows the basic building block of a MBCx system.

<table>
<thead>
<tr>
<th>MBCx Block</th>
<th>Capabilities and Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Source</strong></td>
<td>- Multiple platform data analysis. It can handle multiple data sources, e.g. data from a dedicated chiller management and optimisation program, a BMS handling air side equipment and power management system (PMS).&lt;br&gt;- Key requirement – time series data</td>
</tr>
<tr>
<td><strong>Analytic Engine</strong></td>
<td>- Once extracted, data can be compared by the analytics engine using simple logic algorithms. i.e., if Chilled Water Supply Temperature (CHWST) deviates from its setpoint, it often indicates an issue with control overrides or component failure.&lt;br&gt;- Time series data analytics, i.e. this allows intermittent issues to be monitored and picked up as soon as they arise</td>
</tr>
<tr>
<td><strong>Investigation – Rectification</strong></td>
<td>When the MBCx system identifies an issue, it usually does not have the ability to investigate nor rectify the issue. At this stage, the EBCx investigation process would take over to rectify issues or to carry out any fine-tuning</td>
</tr>
</tbody>
</table>

![Figure 2 – Basic building blocks of a MBCx](image-url)
With digital systems being a standard provision of modern building, data can be easily extracted from these systems to be compared and analysed.

The MBCx is not a system that would improve building performance once deployed and it relies on the conventional EBCx process to deliver end results. In fact, one can consider MBCx as a pivot tool that enables EBCx to be carried out in a more efficient way through the use of data trending massive processing power and the automated process which enables it to commission continuously.

2.2.2 MBCx vs BMS
Many facility managers may have raised the question of whether the BMS can perform the same function. The quick answer is no at this moment of time and it is due to the functional nature of BMS. The following table compares a BMS against an MBCx system:

**Table 2 - Comparison of BMS and MBCx**

<table>
<thead>
<tr>
<th>System</th>
<th>BMS</th>
<th>MBCx</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purpose</strong></td>
<td>Monitoring, Control and Automation of equipment and components.</td>
<td>Monitoring, continuous analysis of data pattern of BMS to identify issues and problems via analysis of big data:</td>
</tr>
<tr>
<td></td>
<td>Identification of equipment critical failure.</td>
<td>BMS Setup</td>
</tr>
<tr>
<td></td>
<td><em>Designed to carry out building function and automation.</em></td>
<td>Control setpoints</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Control logics / Automation problems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Identification of Equipment and components non-critical failure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carry out commissioning works</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Used as M&amp;V tool</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Work flow programme for issue identification, solution and ratification.</td>
</tr>
<tr>
<td></td>
<td></td>
<td><em>Designed to optimise building performance and identify complex issues with mechanical plants.</em></td>
</tr>
<tr>
<td><strong>Dealing with Exceptions</strong></td>
<td>Basic level of alarms and alerts design to reduce system downtime</td>
<td>Data analysis to identify cross variables conditioning issues, often overlooked by basic alarms and alerts. Designed to reduce system / culture inefficiencies.</td>
</tr>
<tr>
<td><strong>Interface</strong></td>
<td>Optimised for control and operation of building.</td>
<td>Optimised for data representation, issue identification and investigation and problem solving.</td>
</tr>
<tr>
<td><strong>Data and Communication</strong></td>
<td>The communication protocol is opened, however data is often structured and stored in a vendor proprietary manner. This disables common understanding and processing of data even if communicate is possible.</td>
<td>Use of open communication protocol and data mapping and adapting techniques to transform proprietary data into open source structure for processing or further communication.</td>
</tr>
<tr>
<td><strong>Flexibility</strong></td>
<td>Coded and programmed by BMS contractor. Cannot integrate to other system unless opened source. Changes after deployment would require works from the BMS vendor. Proprietary protocols.</td>
<td>Opened source programming, designed for flexibility and cross platform of different BMS or system provider. Analytics programming is done by user of MBCx specialist. Changes are flexible after deployment. Haystack opened source protocols.</td>
</tr>
</tbody>
</table>
2.3 The pros and cons of MBCx

2.3.1 Technical perspective

When compared with conventional EBCx or RCx, the use of MBCx usually might not necessarily yield a better output, the main demarcation is explained below.

Data availability determines effectiveness – Whether automated flowing digital data are available can be a key constraint of MBCx. For example, if only a small and insignificant data sample is available due to the lack of sensors or key indicators, the power of MBCx will be limited. The conventional commissioning approach would still be possible with acquisition of data via manual data-logging techniques.

Sample size and continuous data flow enables higher yield – This is a major advantage of MBCx. MBCx will not replace EBCx. The practice of MBCx can pivot the efficiency and effectiveness of commissioning, speeding up surveys and enlarging its boundaries and scope. Due to the use of time-series big data, the coverage of the commissioning can be much larger than conventional commissioning approach with greater efficiency in terms of processing time. The continuous sampling nature would allow intermittent issues to be identified while conventional commissioning might otherwise overlook.

Issue rectification – To realise the benefit of MBCx, the manual process of EBCx will need to be followed in fixing or tuning of the identified issue. MBCx is a tool that accelerates and expands conventional commissioning approaches but does not necessarily replaces human analysis and intervention especially post-issue identification.

2.3.2 The invisible issues and MBCx outcomes

The gem of MBCx is in its ability in breadth and depth in issue identification. As issues occur over time in different scenarios or under various conditions, with tracking and proper categorisation and statistical analysis of issues, MBCx can be empowered in causation modelling of issues to a certain degree. Figure 3 shows the breadth and depth in issue identify in MBCx.

2.3.3 Outcomes of MBCx

Looking beyond the technical benefits of MBCx, the potentially larger coverage using big data and the persistency inflow of data, MBCx can enable the following managerial and business in Figure 4.
Figure 3 – “Invisible Issues” that MBCx can identify

- **Energy saving** – Resolving operational issues in a real time and consistent manner, leading to cost savings.
- **Improve service quality and operational issues** – Through continuous monitoring and issue rectification, service level will be improved. For example, operator usually overrides default setpoints to resolve thermal comfort complaints, but seldom remembering to reset the setpoint. With MBCx, the issues with thermal comforts can be identified and resolved, avoiding manual overrides. With continuous inflow of data, KPI of thermal comfort criteria such as setpoint deviation hours and manual override occurrence can easily be defined for feedback.
- **Identify invisible issue & FM empowerment** – The coverage and continuous sampling nature would allow greater quantities and intermittent issues to be
identified. This also empowers facilities management with greater understanding of the system, their usage and behaviour leading to the betterment of FM.

- **Improve skillset and police best practice** – The consistency and persistency of MBCx are great guardians of best practice working against human errors. It can be imagined as a butler always there pointing out the issues relating to human practice.

- **Improve service contract, equipment maintenance and lifecycle** – Identifying equipment obvious and non-obvious failure, monitoring responsiveness of service contactors and prioritising their actions can act as a policing action on service contacts. By preventing unnecessary running or cycling of equipment, and lowering their frequency and interval of failures, it can enable condition based maintenance, extending equipment life and saving resource.

### 3 Application of MBCx

#### 3.1 Deployment of MBCx

**3.1.1 Data availability**
The initial task in the deployment of MBCx is to understand the data availability across various systems and to carry out a gap analysis against the objectives of MBCx reporting against the data available. Such an exercise would identify the sensors or points that need to be installed for full functionality of MBCx. Where a significant data gap is identified, one might need an entire upgrade of the BMS system before the application of MBCx.

**3.1.2 Data extraction and automation**
Data extraction can be a challenging task. This is because each and every system that stores or provides the data source can be propriety. There are various techniques to capture data from different sources. One can wait until the data is stored within the data source’s system then extracts such information from a centralised location. The benefit of this is a single path of extraction. However not all system would collect, process then store all data at a centralised location, such as PLC based system. For these system where data could not be stored at a central location, the data will need to be intercepted in the communication channel and replicated for MBCx use. Once the data extraction method is defined, the process of automation is usually simple, using automation process in place for the system or OS of the data source.

**3.1.3 Data mapping**
This task is about selecting and mapping the dataset required for the MBCx. For example, all chiller plant performance-related data might be considered as critical and that data on safety such as fire alarm (e.g. function related) might be considered less critical in the MBCx.

Data definition in an MBCx is often comprehensive to enable greater data analytics and visualisation. Data is arranged with tree-like relation from component, equipment to system. Metadata and tagging is set on each data point to define the nature of the data,
for example, a CO2 sensor in an AHU would have the following tagging: ahu, return, air, sensor, CO2. Such tagging enables the user or analytics code to quickly filter and associate data point mapping from the sensor, to the equipment and system of the HVAC design.

3.1.4 Analytics definition

Once the data is transferred on to the MBCx platform, analytics can be carried out. The analytics is often pre-defined by the MBCx deployment team and it is critical that the team possess knowledge in the design, operational of the building services system and sufficient knowledge in electrical and mechanical engineering. Such is often a partnership of the facility management team (expert onsite, operations and their system) and an external MBCx consultant (expert in MBCx and mechanical engineering).

The analytic definition can be considered as the brain of the MBCx system. If the analytics are well written it can enable massive issue identification at a scale unseen in manually based commissioning. If written poorly, it can generate large numbers of false-positive alerts, or alerts that generate no additional knowledge or function on top of the already provided alarms and alerts by the data source’s system, such as the BMS.

For example, the chilled water supply temperature on a supply header should match the chiller water temperature setpoint. If this is not case, raising an alert can be useful and offering additional diagnosis would enable actionable outcome. Such as checking chiller/decoupler bypass status, supply temperature of individual chiller, chiller setpoints, etc. By elimination, MBCx will can reduce the efforts in manual diagnosis for a quicker and more efficient rectification.

Analytics coding is about understanding the design, equipment and system on site and imagining all potential issues and scenarios that can go wrong. Using “rules” to check data behaviour in terms of identifying these issues and suggesting a potential reification solution Two examples are shown below in Table 3.

Table 3 - Examples of rules for identification of issues

<table>
<thead>
<tr>
<th>Examples</th>
<th>Identification of Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Equipment Short Cycling</td>
<td>If power status of an equipment goes from ON to OFF or OFF to ON for more than twice within a fix period (say 30 minutes), then raise alert on equipment as it appears to be short cycling</td>
</tr>
<tr>
<td>2. Chiller Control Issues</td>
<td>If delta T is converging (say below 1.5 Deg C) or diverging (say more than 10 Deg C) for more than a fix period (say 15 minutes), then raise alert as the chilled water production is not responding to the load. The low delta T indicates an energy efficiency issue which is often overlooked while the high delta T indicates a thermal comfort issue which is often rectified as the issue is easily picked up</td>
</tr>
</tbody>
</table>

3.1.5 Analytics categorisation and quantification

To enable causation modelling of issues identified, it is a good practice to structure the analytics into their system and issue type by category. By doing this, patterns might start to emerge regarding issues that are occurring on site. These issues could be caused by gaps in human resource, design, process, service or equipment supplier.

The prioritisation of issues should be considered when structuring analytics and their
“rules”, for a fan running, the energy wastage can be easily estimated. An error of an air side sensor on a PAU will have a more significant impact than that on an AHU or VAV. With this kind of quantification and comparison of magnitude, it allows facility management to resource their rectification programme efficiently.

3.1.6 Workflow and reports

As mentioned previously, MBCx relies on a manual process for rectification of issues and this often relies on a good workflow and reports to achieve the intended outcomes. This part of the MBCx is highly dependent on the facility management’s own process and might be incorporated into the already in place work order system. Below is a list of questions that often help setup the workflow and reports.

<table>
<thead>
<tr>
<th>Category</th>
<th>Questions</th>
</tr>
</thead>
</table>
| Workflow | • What is the interval in reporting issues?  
• Who should get the issues report? Will this be one person or multiple parties depending on the issue’s nature?  
• What kind of details should be included in this report?  
• How are issues prioritised?  
• How does the reported issue get tracked until full rectification?  
• How is false-positive get dealt with, reported and tracked? |
| Reporting | • What kind of reported is needed and what is their interval?  
• What is the purpose of each report and what information is needed?  
• How do we report the progress of MBCx and overall commissioning performance?  
• How do we look into causation of issues? |

Only with proper workflows and reporting techniques can the full potential of MBCx be realised. MBCx is an automated system yet not an automated process and it will need to be tailored to each site and organisation, with the aim to incorporate the MBCx into the existing facility management practice or process to keep actions implemented, tracked and reported.

4 Case study

4.1 The site

MGM Macau is an integrated gaming resort in the Macau Special Administrative Region. It is 35-storey high and has a gross built area of 211,545m², comprised of 28,976 m² of casino facilities, 468 guest rooms, 99 suites and 14 villas. In addition, there is a spa, laundry, six restaurants, a staff dining area, a commissary kitchen and kitchens serving the banquet, in room dining as well as casino pits and catering.

In order to better identify design and operating issues, MGM Macau has introduced MBCx to its operations in 2016. Through the MBCx process and a network-based platform that automatically monitors the operations of the BMS and the Power Management System (PMS) in real time, empowering FM is to pinpoint and routinely optimized the HVAC system which less manual process and resource than before. During the MBCx cycle, the analytical rules are continuously refined as the HVAC
system changes. This has resulted in significant improvement in the energy efficiency, thermal comfort and ease of maintenance of the plants. See Figure 5 for a screenshot of the platform for identification of issues.

![Figure 5 - Screenshot of “Issues” at MGM identified by MBCx](image)

4.2 Scope and boundary

The main goal of the MBCx platform involves monitoring the performance of the BMS to enhance the ongoing energy efficiency of the building HVAC system. The platform helps identify energy efficient and operating issues in real-time which provides the needed information for the FM Team to respond in a timely manner. Implementation of the MBCx platform includes the initial system configuration/rule refinement phase with a subsequent ongoing analytical phase that focus on issue rectification and introduction of more advanced analytical rules (e.g. complex chiller plant staging rules) through regular monthly meetings. The building HVAC system includes both airside and water side equipment, namely the:

- Chillers
- Pumps
- Cooling Towers
- Air Handling Units (AHU)
- Variable Air Volume Units (VAV)
- Primary Air Units (PAU)
- Fresh / Exhaust Air Fans (FAF / EAF)
- Make-up Air Unit and Kitchen Exhaust Air Fans (MAF, KEAF)

4.3 Methodology and approach

The analytical rules of the MBCx platform are written based on the principle “To reduce energy consumption through improvements in energy efficiency and operating effectiveness of the HVAC system while maintaining guest comfort.” These rules are regularly reviewed and refined by the FM Team for better respond to operating abnormalities or efficiency issues on plant operations in real time. Issues range from high level control logic problems to individual sensor drifts. The MBCx platform captures these faults automatically and sends regular reports and alarms with descriptions of the faults and recommendations on how to rectify the problem. Issue notifications take the form of instant emails, daily reports, and weekly/monthly issue
summary reports. This results in improvements on the energy efficiency, thermal comfort and drives preventive maintenance of the plants.

4.4 Outcomes and sharing

During the inception of the MBCx platform at the start of the year, the MBCx Platform has initially identified over 16,000 individual issues. However, after further investigation and rule refinement, we have eliminated a significant portion of the issues due to false alarms and incorrect set points. The resulting 1,600 issues consist mainly of problems with missing data, overridden sensors, and low operating efficiency (e.g. low COP, high flow low delta T, etc.). One example is shown below:

**Chiller chilled water supply and return temperature differential too low**

In addition to the issues identified on the airside of the plant, the MBCx platform has uncovered issues on the waterside of the plant, one of the most significantly ones as the chiller plant low delta T. During the set-up phase of the ruleset, the Energenz and the FM Team have worked out a low limit to the differential temperature (delta T) of the chilled water supply and return to ensure a certain level of heat exchange take place. Through the MBCx platform, a number of instances of low delta T for several chillers have been identified intermittently (Figure 6). These instances are relatively short and rather hard to spot are usually caused by over-provision or underutilisation of chilled water. By understanding when low delta T happen, it allowed us to look into enhancing control of pumps and CCV, to precisely control the total quantity of chilled water and their flow distribution across each air side equipment.

**Figure 6 - Identification of instance of low plant delta T**

One of the key strengths of the MBCx platform is the ability to constantly monitor particular issues automatically regardless of their complexity, durations, and quantity. KPIs can be easily defined forming performance feedback. With the persistent effort in investigating and rectifying these issues, the number of identified issues has reduced (from 1600) and the visibility of these issues had motivated and empowered MGM’s FM team carrying out commissioning continuous. Our aim is to in tackle and reduce these issues to an absolute minimum (Figure 7).
4.5 Challenges and lessons learnt

MBCx is a powerful platform that provides the visibility needed to effective and efficient operations of the HVAC system. Nonetheless, there are several challenges that need to be overcome during its implementation:

- A new dedicated team/person from FM will be required for oversee and drive this MBCx process from both technical and management perspective. The team leader will need to be vigilant on driving the process on rectifying the identified issues.
- Persistent effort is needed to review and refine analytical rules. For the HVAC system to run on the best possible efficiency, continuous effort will be needed to ensure that the analytical rules on the MBCx platform are configured correctly. The MBCx is not a plug-and-play system and requires fine-tuning itself.
- Team members from different levels of the will need to participate actively for MBCx to be effective. This includes buy-ins from senior management, staff training, and alertness/responsiveness of operating staff. The MBCx is a new process that requires new procedures, process, drivers and responsibility on the FM and these will need to be defined clearing aligning the MBCx process.
- Liaison with the IT department – IT department may have security concerns with data and connection security. Close working relationship with the IT department will be required in order for the MBCx system and process to be IT compliance. It is important that the IT department is engagement early in the project to define requirement and working protocols.

5 Summary

As the use of MBCx in Asia-Pacific is picking up traction, much of its implementation detail is still unknown to most users. The aim of this paper is to elaborate on the details of MBCx and share with the industry this knowledge.

MBCx can be more efficient and effective when applied appropriately. It requires the site to possess data source that is needed for analytics, usually in the form of BMS data, as MBCx is an issue identification tool which relies on conventional commissioning techniques to rectify issue. It is also a process driven tool that requires management workflow and report to realise its full potential in facility management.
Data acquisition and mapping from the originating data source can be challenging depending of the “openness” of those systems. The analytic coding will rely on a good understanding of the site, design and operational of its system. The aim of the issue identification is to achieve massive coverage which minimising false-positive. Issues identification can also be enhanced by sifting through different possible causes of the issues, making ratification more efficient.

If applied successfully, an MBCx system should include the automated MBCx analytic platform and the management workflow. With workflows and reports that is well integrated to the facility management process, the whole continuous commissioning concept can be well adopted to reach its full potential.

With massive coverage and continuous data flow, MBCx can potentially bring and keep a building at its optimal level. The benefits are beyond energy and engineering. The consistency in pinpointing issues can police best practice, improve skillset and culture. It can act as a performance feedback loop of human resource, service and equipment providers. Looking at history patterns of issues, one can even work out the root cause of issues and attempt to address that to prevent future issues from recurring.

**Key points about MBCx:**

1. With massive coverage and continuous data, its issue identification function can be very powerful
2. It goes beyond energy and engineering benefits.
3. It requires good site design and operational understanding
4. MBCx can pivot efficiency and effectiveness of human investigation and rectification effort, but do not replaces it.
5. MBCx relies on workflow and reports to realise it full potential

**6 Acknowledgments**

The authors of this paper would like to express their gratitude to towards their team at Energzenz and MGM China, for their contribution in the application of MBCx at MGM, and to develop a new mentality and culture of continuous commissioning for the betterment of facility management and business operations.

We would also like to express gratitude to the senior executives of our company for the vote of confident in bringing and applying MBCx, a new concept Asia, to one a complex building challenging requirement.

At last, we wish our friend and colleague, Gilbert Lennox King (Director of Energzenz), whom developed the idea of writing this paper all the best for his relocation to the UK.
7 References