Building Management System

Part 1

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Introduction

Smart Buildings is a hot topic today in India. The Government of India has announced an ambitious plan of developing a hundred Smart Cities in the country over the next few years. It is obvious that Smart Cities will have many smart buildings. The term 'smart' refers to a host of technology-enabled and technology-driven features like internet connectivity and enabled services, integrated security system, building automation, mechanical system integration, access card system, lighting controls, smoke detection and fire-fighting system, etc. Building Management Systems (BMS) contribute significantly towards making a building smart. In this classroom series we are going to understand the concept and capability of BMS. Real-life application examples help us understand and appreciate the capabilities and usefulness of BMS. Let us start with a real-life example.

Scenario: Smart Building in Los Angeles, California, USA

8:00 PM

On a given day after office hours, the system starts preparing itself for the next day to be able to make the necessary schedules. First it accesses the internet and checks weather forecast for the next day. The meteorology office publishes real-time weather data on the internet. After retrieving this information, the system checks the 'time-of-use' electricity tariff for next day on an hourly basis. Electricity service providers in the USA provide a real-time power utility tariff data forecast to enable the users plan their work the next day, leveraging the incentivized tariff offered by the utility service providers.

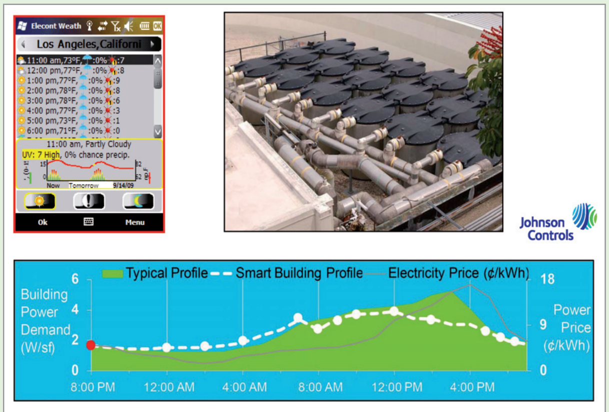

Figure 1: Likely demand scenario for next 24 hours

With the weather forecast and tariff forecast, the system runs a 'likely demand scenario' of the building for the next 24 hours by simulating the building cooling demand profile and the likely energy consumption during that time (*Figure 1*). Then it evaluates the lower energy tariff hours and figures out how to leverage this tariff saving opportunity. This building has a thermal storage cooling system. The control system now figures out the schedule for running the thermal storage and the amount of ice storage generation that it needs to build just then, during the night hours. The chillers are switched to thermal storage mode now.

02:00 AM

At the optimal time, the building mass is pre-cooled to the lower end of the comfort zone. This will facilitate adjusting the set-points throughout daytime the next day (*Figure 2*).

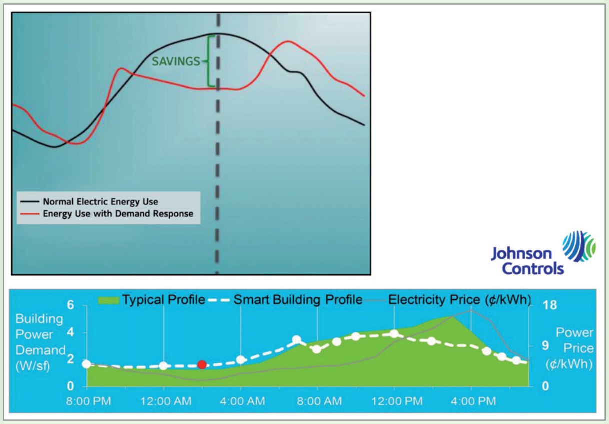

Figure 2: Energy saving with demand response

04:00 AM

In the early morning, the on-board diagnostic system detects the possibility of a valve failure on one of the chillers *(Figure 3)*. It automatically runs a diagnostics and concludes the failure of the valve. The system calculates real-time prices associated with replacing the valve, generates a work order and notifies the facility manager on his smart phone.

About the Author

K. Raghavan is a mechanical engineer with specialisation in air conditioning and refrigeration. He has a wide experience of 27 years in HVACR field. He was a technical committee member of BEE Labelling Standard for Room AC, Inverter AC and India Chiller Standards. He is a member of ASHRAE. In his current function at Johnson Controls, he focuses on sustainability solutions.

Figure 3: Predicting value failure

07:00 AM

The chiller technician arrives at the plant. He has already got the notification of work order and the exact valve model that requires a replacement (*Figure 4*). He straightaway locates the particular chiller and the defective valve and gets on with his work. He fixes it.

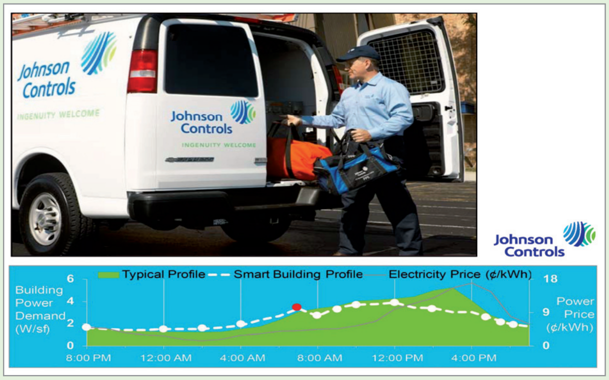

Figure 4: Chiller technician arrives with replacement valve

The system builds enough thermal storage, as per the estimation, to meet the peak building load demand anticipated in the afternoon.

08:00 AM

The employees working in the building start arriving. Quite a few of them plug their electric or hybrid vehicles into the charging station. The vehicles will be charged at a pre-programmed time, when the tariff charges are lower (*Figure 5*). The vehicle charging fees are automatically factored in their pay-roll system.

The employees occupy their work stations and cabins. The lights come on automatically, as they use their access card to enter the office facility. The AC system turns on. The users have the option of adjusting the required space temperature.

09:00 AM

A conference room, booked the previous day for about 15 employees, gets ready to host a meeting. The lights, the projector, AC system, etc. turn-on just in time for the meeting

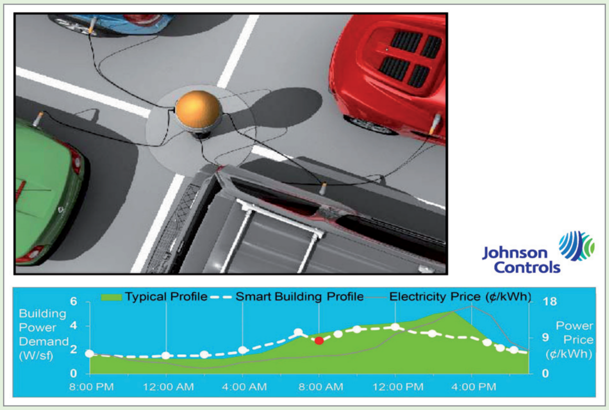

Figure 5: Vehicles plugged into charging station

(*Figure 6*). User-adjustable thermostat and CO_2 sensors provide the necessary controls – to maintain comfort conditions – just in case there are more or less people than planned.

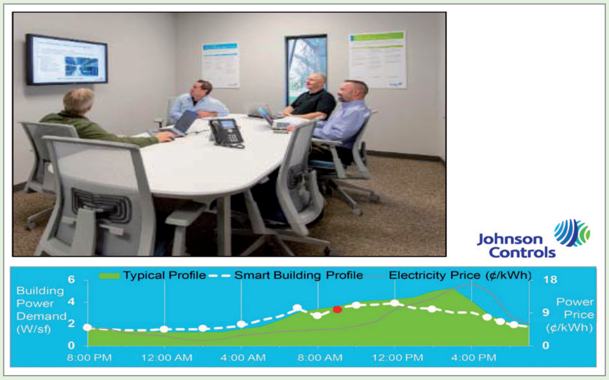

Figure 6: Conference room is ready for use

10:00 AM

The CFO of the company is having a meeting with the Business Analyst and their conversation turns to their carbon footprint and carbon management strategies. The Enterprise dashboard of the BMS gives access to the carbon emission data for most recent quarter and the costs associated with emission reduction (*Figure 7*).

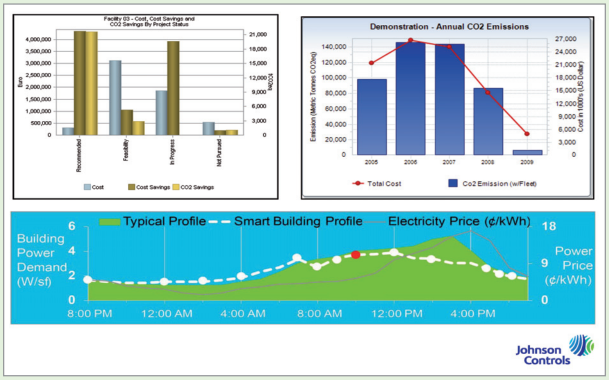

Figure 7: Enterprise dashboard of BMS displays emission data

12:00 Noon

The lower power tariff schedule declared by the electricity service provider starts. This triggers automated demand-reduction for the building (*Figure 8*). BMS now takes the following actions:

(a) Brings-in thermal storage cooling and puts the chillers into hibernation,

(b) Increases the chilled water set point,

(c) Dims the lighting in common areas by 20%,

(d) Sends report to utility/facility management team on the actions taken by it and the estimated impact (results) from these actions.

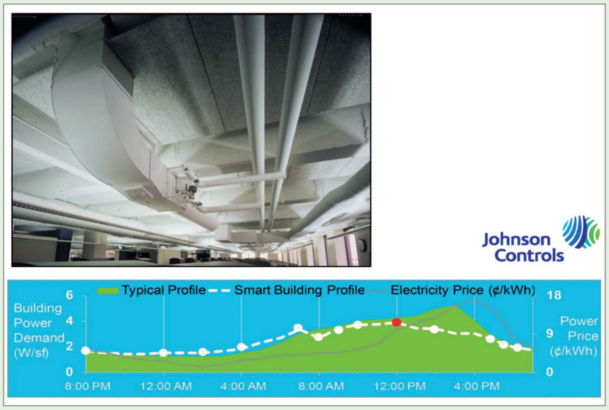

Figure 8: Automated demand reduction is triggered

BMS also sends notification to a (pre-determined) select set of employees about the increased set point temperature to keep them informed and to avoid unnecessary calls to the facility team.

2:00 PM

BMS is still in demand reduction mode. Now it leverages the IT system integration and takes following actions (*Figure 9*):

(a) It sends system alert messages to all employees via e-mail or text message, requesting them to unplug their laptops from electric power and to run on battery power from 2:00 – 4:00 PM.

(b) For employees using desktops, the PC power management software agent automatically reduces desktop power consumption.

Figure 9: BMS leverages IT system integration

(c) Computing load is reduced for non-production servers and non-critical tasks are deferred.

5:00 PM

Regular office hours end and employees start to leave. As they swipe their card to check out of office, the system automatically turns-off the lights and powers-off their computers or puts them in stand-by mode, as per instructions (*Figure 10*).

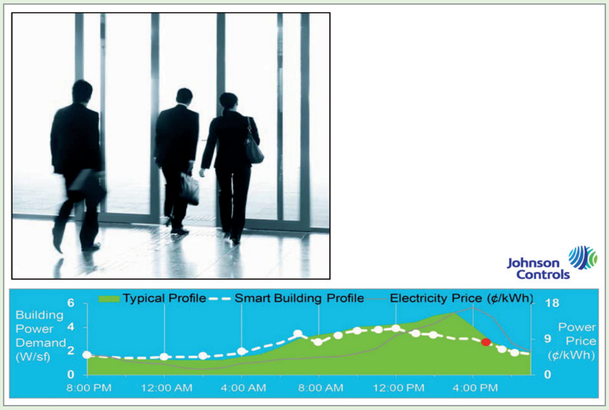

Figure 10: Employees start leaving at end of regular office hours

When employees arrive at car parking stations, their vehicles have been charged and are ready for getting back home.

6:00PM

A few employees have still not left and BMS is in 'occupancy' mode now. The workstations have individualized control provisions, allowing employees to indicate to the system that they are still in office. BMS now optimizes the lighting and HVAC, still allowing the employees to set these at their preference level (*Figure 11*).

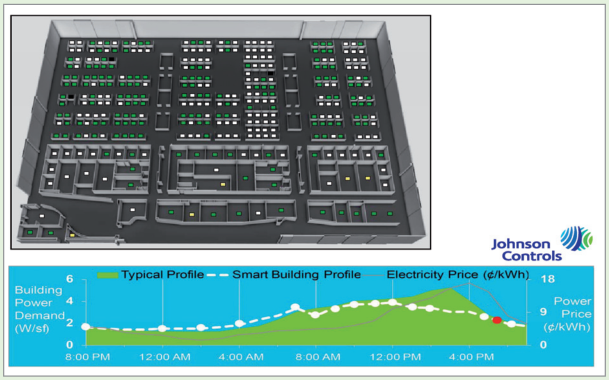

Figure 11: BMS optimizes lighting and HVAC

The BMS also tracks and keeps record of the occupancy trend over time, enabling the concerned department to optimize office layout and workspace design.

7:00PM

End of work-day now. BMS now controls the lighting and

HVAC to follow the janitorial staff throughout the building. The video surveillance system counts the occupants remaining after office hours and adjusts the temperature set point and lighting (*Figure 12*).

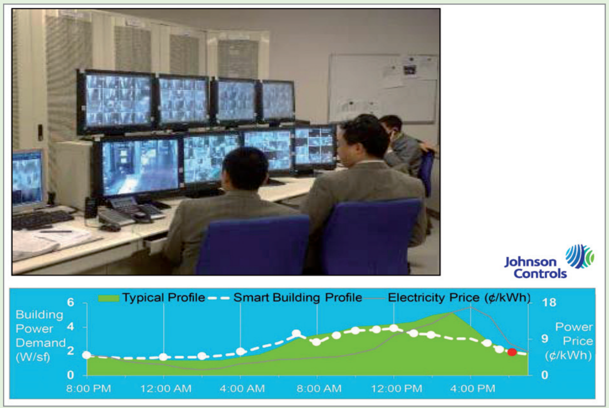

Figure 12: BMS controls lighting and HVAC

Recap

Let us pause here for a few moments and try to recapture in our mind what tasks the system in this scenario is able to do on its own like planning, execution, monitoring, controlling, reporting, etc.

The system described here and many BMS systems in India integrate HVAC automation, video surveillance, access card systems, fire-fighting, public announcements, etc. and are referred as IBMS (Integrated BMS). For this classroom series, we will restrict our discussions to HVAC-related portions of IBMS.

For the same office building, let us now look at the automated actions and responses from the HVAC system, under the monitoring and control of BMS. For the sake of easy understanding of the beginners, this is presented in a simplified manner. In subsequent chapters we will go into more details of different aspects of HVAC system control.

The office which is being discussed uses Air Handling Units (AHUs) on different floors with an extensive ducting layout and Variable Air Volume (VAV) boxes for zone control (*Figure 13*). The VAV boxes are of pressure-independent type and are selected to deliver specific quantity of air flow to the zone. Each box has a temperature sensor-cum-controller, with an adjustable dial for temperature setting, for the user to set the required temperature (*Figure 14*). Many zones also use multiple LCD-type temperature sensors of 'networking type' (not shown in the figure), which enable maintaining a comfortable zone temperature by adopting design strategies like temperature polling, temperature averaging etc.

The controller in the VAV box deploys advanced PI algorithms and adaptive control logic to maintain the set temperature within narrow tolerances. On nearing the set point, the VAV controller-actuator drives the primary air valve of the VAV box towards close or open position, over a range of approximately 10% to 100% as required, to maintain space conditions. There are many hundreds of VAVs used in the office. When many of these start to throttle down to different percentages of the close position, the static pressure of the duct increases.

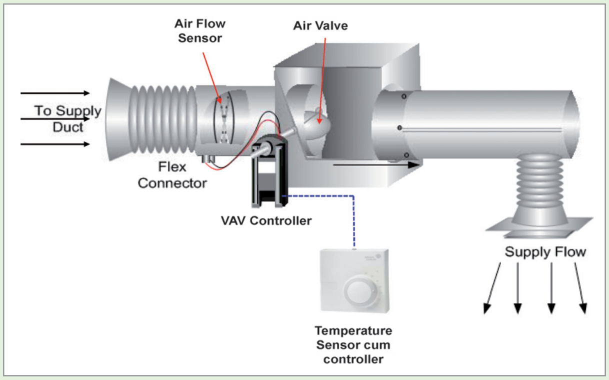

Figure 14: Temperature sensor-cum-controller to maintain space temperature

The action shifts to the AHU now *(Figure15)*. A static pressure sensor installed in the duct senses the rise in static pressure due to many of the VAVs throttling the air flow in the ducting network. On the input from static pressure sensor, BMS suitably reduces the speed of AHU blower motor driven by a VFD, to maintain a set static pressure range in the ducting network.

Figure 13: VAV box

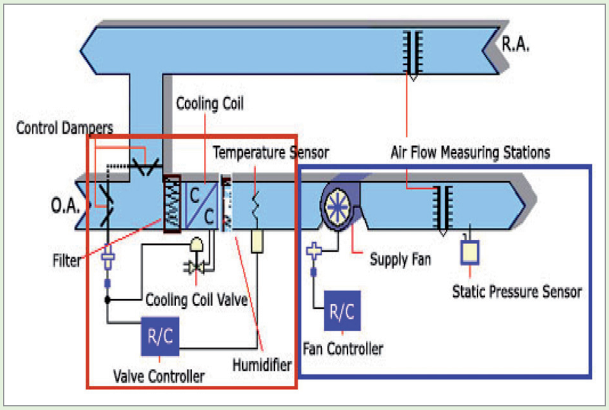

Figure 15: Chilled water modulating valve regulates water flow to AHU

The AHU coil is selected to deliver a specific cooling capacity at a given air flow rate and chilled water inlet and outlet temperature conditions. As the AHU air flow rate is reduced now, the heat transfer rate across the AHU chilled water coil reduces and the outlet water temperature starts dropping. For optimal system performance, ΔT is better maintained at design ΔT level. A chilled water modulating valve is regulating the water flow to the AHU *(Figure 15)*. When ΔT across AHU drops, the modulating valve is further driven towards the close position to maintain optimal ΔT.

When the VAVs started throttling air flow, the duct static pressure increases. Similarly, with AHU chilled water modulating valves throttling the flow, the chilled water line pressure increases and a differential pressure switch installed in the chilled water line is activated to reduce the speed of the VFD-driven chilled water pump (*Figure 16*). With the reduced speed of chilled water pump, the chilled water flow across the chiller reduces and the heat transfer rate in the evaporator decreases.

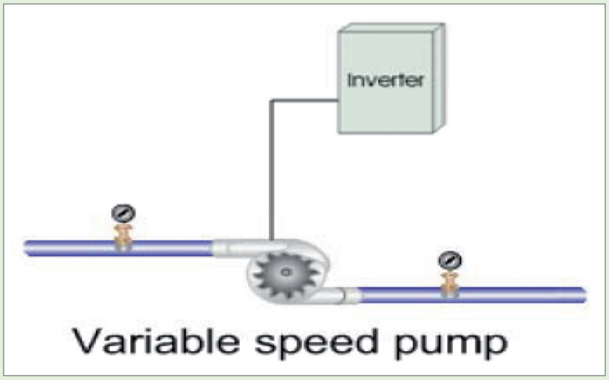

Figure 16: VFD-driven chilled water pump

This leads to reduced ΔT across the evaporator in the chiller (*Figure 17*); sensing it, the compressor capacity regulation mechanism is triggered to balance and match the chiller capacity to the load demand. This cascading effect ends with regulating the cooling tower fan motor speed *(Figure 18)*.

Many variable parameters are being monitored and controlled by BMS, including building a history of system behavior pattern and a lot of data storage for analytical purpose. BMS has many additional features like energy dashboard and central plant automation, which helped the facility team in the above example.

While reading these live case scenarios, many questions

Figure 17: Compressor capacity regulation matches chiller capacity to load

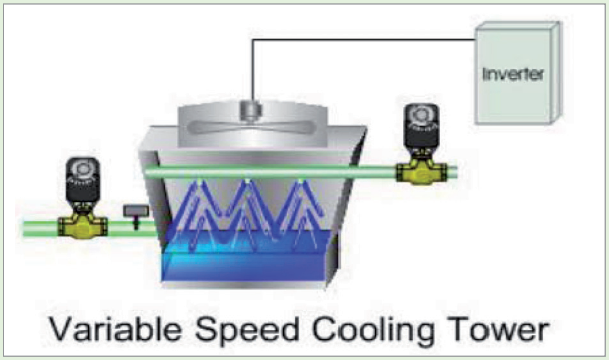

Figure 18: VFD-driven cooling tower fan

may be coming to your mind: BMS consists of what elements? How are the different system parameters monitored? How does the communication occur? Where is the data processed? How is the command system structured? How are the reports generated? And many more.

All these questions will be answered in this classroom series, as we move forward and learn the BMS architecture, sensors, control electronics, control protocols, network cabling, energy saving concepts, a brief on HVAC design logics, chiller controls, intelligent airside controls and user interface.

(Contd. in the next issue)

Index to advertisers