WHITE PAPER

How to Create Actionable Outcomes with Data Analytics in Connected Buildings

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iGR

12400 W. Hwy 71

Suite 350 PMB 341

Austin TX 78738

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EXECUTIVE **SUMMARY**

In-building wireless (IBW) networks can not only be used to support voice/data communications among people, but they are also an ideal platform on which to base an Internet of Things (IoT) solution which feeds actionable data into a building automation and control system. These systems can then be used to support and improve the environmental management of the commercial building, which includes delivering quantifiable benefits in terms of lower operating costs and compliance with sustainability requirements.

A building automation and control system (BACS) can be seen as one piece of a larger solution which the U.S. Department of Energy (DOE) often refers to as energy management information systems (EMIS). These systems can take all the data generated by building sensors, utility bills, etc., and feed it into a machine learning and artificial intelligence (ML/AI) solution that help facilities managers and/or building owners/managers make even greater strides toward optimizing building operations and net zero goals while also improving tenant comfort.

The building managers and owners are also able to gain more analytical data on the performance of the various systems and then make changes to further improve tenant comfort, energy efficiency and operating costs. And, depending on what types of sensors and software are installed, some systems can count people, both tenants and guests, those entering and leaving the building or other areas, which can be useful to environmental controls and emergency services.

Sustainability and energy conservation are obviously very important considerations for any commercial building. Many new buildings today are built obtain a high Leadership in Energy and Environmental Design (LEED) score while many existing buildings are being retrofitted to support net zero goals.

EXECUTIVE **SUMMARY**

The U.S. Green Business Council, which maintains LEED, has found that **every dollar saved in operating expenses can increase property value by ten dollars**. So, not only do sustainability improvements lower costs, but they also improve revenue which is valuable to building owners/managers and commercial real estate (CRE) investors.

Unfortunately, energy efficiency upgrades can mean that radio signals will transmit poorly through, and inside, the building. This is especially true of buildings with good LEED scores – low-e glass does an especially good job of blocking radio signals. Wi-Fi and cellular signals are also blocked by steel and since most commercial buildings use steel in the construction, the walls and fabric of the building will block signals coming from outside the building and signals moving between rooms or floors inside the building.

Note that an IBW does not have to be cellular OR Wi-Fi - due to the many needs for coverage and capacity inside a building and the need to support different devices and applications, buildings usually take a technology-agnostic approach to deploying IBW. It is common to have both Wi-Fi and cellular systems installed in a building. Note that cellular integration with the Wi-Fi network is possible to provide multi-carrier access inside the building.

When a building owner or tenant is selecting an IBW solution provider, it is therefore important to look for a vendor that is technology-agnostic, can provide complete range of solutions (cellular, Wi-Fi, and wired) and has experience working in new buildings with high LEED scores. With IBW, one size does not fit all needs – networks need to be designed to make the most of the building layout and construction, and to fit the specific needs of the users and applications. Similarly, the network design should maximize the benefits of the building and ensure that the targets for coverage and capacity are met.

ENERGY SAVINGS:

THE LOW-HANGING FRUIT

Some of the main benefits of smart building system are energy savings. This is important because according to the DOE, commercial buildings account for approximately 40 percent of all U.S. energy use and 76 percent of all electricity use.

Energy intensity and efficiency

In September 2022, the U.S. Energy Information Administration (EIA) released the preliminary results of its 2018 Commercial Buildings Energy Consumption Survey (CBECS). One key finding is that total floorspace in commercial buildings has increased relative to the 2012 CBECS, but consumption per square foot (energy intensity) has decreased, which means that efficiency has likely increased.

For example, the CBECS 2018 data shows a 12 percent decrease in energy intensity since 2012, from 80,000 British thermal units (Btu) per square foot to 70,600 Btu per square foot. Between 2012 and 2018, electricity intensity decreased 14 percent, and natural gas intensity decreased 11 percent. The CBECS report stated that these decreases in energy intensity were driven by improvements in building operations, materials, and design, as well as heating, cooling, and lighting technologies.

Regulations

Many U.S. cities, counties and states have implemented legislation and regulations that require buildings to benchmark and disclose their energy use. For example, California and Washington state both mandate commercial building benchmarking, as have many of the major cities in the U.S. including Atlanta, Austin, Chicago, Denver, New York City, Pittsburg, Salt Lake City, and more. Sustainability, green energy, net zero are all a part of these efforts and there are more than 750 policies that incentivize LEED, as one example, across all levels of U.S. government.

According to the Environmental Protection Agency (EPA) and its Energy Star program, studies have shown that just benchmarking consistently is likely to lead to a 6 to 9 percent reduction in consumption, which, if energy costs held steady, would absolutely result in cost savings. In the current era when energy costs are rising, the nominal savings are potentially even greater.

Potential savings on energy costs

With respect to spending on energy, the CBECS data shows that commercial buildings spent $142 billion on energy in 2018, averaging $1.47 per square foot. Food sales and food service buildings spent more than $5.00 per square foot, and vacant and warehouse and storage buildings spent less than $0.75 per square foot.

So, operational savings of a few cents per square foot per month in energy costs can justify the capital investment necessary to not only deploy the IBW system, but the energy management and/or building automation solutions, as well.

Note that there are operational savings over and above the individual component savings due to the ability to optimize across all building systems. By standardizing monitoring and controls in the entire building and then providing real-time visibility into and automation of those systems, savings can be realized by managing the entire building as a whole and not as a series of separate entities or building zones.

Key Benefits

In a presentation via the DOE's Better Buildings program, UC Davis described the installation of a centralized HVAC management system that interconnected previously unconnected HVAC systems across more than 120 small buildings on its campus. There were two main problems with the existing system: no remote visibility into the disparate HVAC systems and no ability to remotely turn those systems on/off based on building occupancy.

In short, UC Davis connected the various systems together thus enabling remote HVAC scheduling, the creation of an occupancy-based schedule and actionable information that the facilities maintenance team could use to remotely troubleshoot problems. With these measures in place, UC Davis realized:

- 35 percent decrease in HVAC equipment runtime
- 900 MWh in annual energy savings
- $70,000 per year in annual energy cost savings (at 7.5 cents per kWh)
- Total invesment in the system was $200,000.

These savings writ large are beneficial to investors in commercial real estate. For example, in the Journal of Corporate Real Estate cited a U.S. study that found that for buildings with environmental certifications can command an average rental premium of four to five percent and a sales premium of 25 to 26 percent.

This finding is consistent with what the Green Building Council has found with respect to LEED buildings which can:

- Command rents as much as 10 percent above market value and lease rates as much as 20 percent above average
- 30 to 40 percent savings on energy and water above comparable, non-LEED buildings
- Every dollar saved in operating expenses increases property value by $10.

HOW TO CREATE OUTCOMES **WITH BUILDING DATA**

A 2020 Berkeley Lab whitepaper refers to BACS as a key component of what it terms an energy management and information system (EMIS). Other components can include utility bills, weather stations, etc. – basically anything that produces data relevant to the building's operations and/or energy consumption. There are several steps required to realize benefits and cost savings from commercial building data and automation systems (BAS)

1. Providing reliable connectivity using both wired and wireless networks in and around the building
2. Inventorying the buildings operational assets
3. Standardizing data used in the building systems, including naming of devices and controls, so that data from multiple disparate systems can be fed into one ML/AI function
4. Feeding data generated by these systems into a data warehouse which is then accessed by ML/AI to generate monthly data analytics, fault detection and diagnostics and automated systems optimization.

THE POWER OF **IOT**

The Internet of Things (IOT) has an important role to playing building automation systems. Simply, IOT is a network of interconnected devices that sense and communicate data in multiple directions, which can then be actioned and analyzed as a whole.

The IoT is already being used for a wide variety of applications in many industries, including:

- Monitoring of outdoor environments or natural occurrences, including temperature, water and soil quality, forest fires, landslides, and earthquakes
- Monitoring of manmade infrastructure, such as roads, bridges and buildings
- Monitoring and management of manufacturing processes and inventory
- Monitoring and management of energy resources in households, enterprises, buildings and communities using the Smart Grid
- Automation and monitoring of homes in Smart Homes and buildings.

The Building Automation Systems need inputs from multiple sensors around the building (temperature, humidity, lighting, etc) and the ability to control the various systems – turn on or off lights, lock or unlock doors, change the temperature, open or close window blinds, etc. This is where IOT comes in – IOT sensors and controls feed into and action data from the BAS

PROVING RELIABLE IBW COMMUNICATIONS

There are two main reasons to use an in-building wireless (IBW) network to wirelessly connect devices such as sensors, controls, thermostats, management software, cameras, etc.:

- Flexibility: As requirements change wireless devices can be added, removed and/or moved with relative ease.
- Lower cost: Because wireless devices do not need wires, by definition, they are typically easier and less expensive to deploy.

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When a building owner or tenant is selecting an IBW solution provider, it is therefore important to look for a vendor that is technology-agnostic, can provide complete range of solutions (cellular, Wi-Fi, and wired) and has experience working in new buildings with high LEED scores. With IBW, one size does not fit all needs – networks need to be designed to make the most of the building layout and construction, and to fit the specific needs of the users and applications. Similarly, the network design should maximize the benefits of the building and ensure that the targets for coverage and capacity are met.

INVENTORYING THE BUILDING OPERATIONAL ASSETS AND DATA STANDARDIZATION

The next step is to provide a complete inventory of all building systems, sensors and controls. Once done, this inventory is used to build a complete 'map' of the building systems to ensure that everything is connected to the IBW and the BAS, if needed.

Data standardization is the next step – ensuring that all systems, sensors and controls are correctly named and tagged for the BAS. While this may sound simple, it is a critical step. For example, an air handler in one particular building was named by a tenant (not by the building manager) and then tenant subsequently changed multiple times – this resulted in no one in building management knowing what the air handler controls were called in the automation systems.

By standardizing naming and tagging in any of the systems in a consistent and logical manner, it is much easier to capture and evaluate data at both the building and portfolio level.

USING ML/AI TO IMPROVE PROCESSES

The US DOE, among others, advocate for feeding the data generated by these systems into a data warehouse which is then accessed by ML/AI to generate monthly data analytics, fault detection and diagnostics and automated systems optimization. The output of these processes can be used to:

- Lower building operating costs: as an example, detecting and/or preventing faults can reduce maintenance costs and improve equipment longevity.
- Reduce a building's energy use, carbon footprint while helping the building become compliant with various regulations.
- Improve building marketability, thus making it easier to acquire new tenants, charge lease rates that are higher than the local market's average, retain tenants by providing them a safe, sustainable working environment.

And, of course, building managers/owners and/or facility operations teams are integral to the decision/action loop since they will review the output of the EMIS and make other changes to the system to further improve tenant comfort, energy efficiency and operating cost.

Building automation and control has been around for decades. The inclusion of ML/AI, however, is a relatively new field with great potential, according to a September 2020 presentation by the Better Buildings program within the U.S. DOE. That presentation cited multiple capabilities associated with ML/AI, including:

- Load prediction: Using historical data to create a building energy consumption model for energy anomaly detection, control optimization, or savings estimation. Note that the energy consumption of systems and equipment connected to the electrical network would be relevant, as would occupant activity levels, behavior patterns, and comfort preferences. Moreover, the type of building is relevant – a refrigerated warehouse has different energy requirements than a dry goods store. Similarly, a building in which precise laboratory functions are carried out will have a different energy pattern than a factory building cars.

- Fault diagnostics: Leveraging historical data to implement pattern recognition and matching. Could help show where faults are likely to occur and thus aid proactive maintenance so that major failures / shutdowns are avoided.

- Automated data tagging: Tagging where the data is coming from inside/outside a building (e.g., HVAC, vents, windows, etc.) so that analysis via ML/AI generates better insights.

- Control optimization: Using occupancy sensors to determine when and what portions of the building are occupied and for how long. That data can be used to optimize building systems operations. It could also incorporate smart security systems that can control ingress/egress, track the number of people in the building (ideal for emergency services) and their location (with the caveat that the data are anonymized), monitor the building particularly key areas (parking garages/lots, doors, bays, etc.).

SUMMARY

According to the DOE, commercial buildings account for approximately 40 percent of all U.S. energy use and 76 percent of all electricity use. The recently published CBECS data shows that U.S. commercial buildings spent $142 billion on energy in 2018, averaging $1.47 per square foot.

With energy costs rising, even saving a few cents per square foot can help with the operational budget – while as other studies have shown – help make the building itself comply with sustainability regulations, more attractive to tenants and thus to investors.

An in-building wireless network is an ideal platform to support the building automation, control and energy management systems discussed in the paper.

This is for two simple reasons: flexibility of where IoT sensors are placed and the comparatively lower cost of installation and maintenance. Working with an IBW vendor that has experience with LEED and other sustainability initiatives can greatly improve the short- and long-term success of both the IBW system and the applications layered atop it.

About iGR

iGR is a market strategy consultancy focused on the wireless and mobile communications and digital infrastructure industries. Founded in 2000 by Iain Gillott, one of the industry's leading analysts, iGR researches and analyzes the impact new wireless, mobile and digital infrastructure technologies will have on industries, the competitive landscape and on a company's strategic business plan.

A more complete profile of the company can be found at http://www.iGR-inc.com/.

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