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Issue 24

INNOVATIONS AND INTEGRATIONS IN BUILDING AUTOMATION

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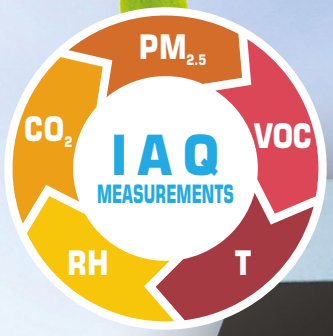

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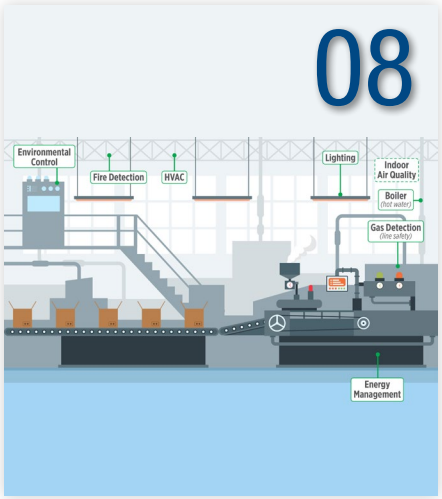

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BACnet International

Corporate Membership Benefits

Corporate membership in BACnet International provides unique and valuable benefits to manufacturers and service providers in the controls, building automation and energy management industries. Its information and communication services make it easy to keep up with the growth and evolution in the industry and with BACnet technology. BACnet International membership enhances a supplier's credibility with potential customers and partners while providing a variety of opportunities for exposure and promotion. Corporate membership also gives manufacturers access to deep discounts on product testing, BTL Certification and a variety of third party development tools.

Discounts on Tools, Testing and Certification

- 50% discount on hourly BTL testing rate for Platinum, Gold and Silver Corporate Members when using the BTL Lab
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- License to use BACnet International developed test-related tools
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- Corporate Update newsletters keeps your team up to date on important developments related to the BACnet standard, including proposed changes, new releases and corrections. This also alerts your team to the availability of marketing and promotion opportunities.
- Cornerstones monthly newsletter provides your team with timely information on new BACnet case studies, the latest products from member companies, educational resources, and highlights of global events.
- BACnet International's Journal of Building Automation provides more in-depth articles on BACnet technical issues, application examples and industry insights. The Journal provides your team with additional marketing and promotional opportunities through authorship and advertising.

Marketing & Promotion Opportunities

- Display of company logo on the BACnet International website, newsletters and tradeshow marketing materials
- License to use the BACnet International "Member of" logo on corporate website and marketing materials
- Opportunity to author and present BACnet content through print, electronic, in person and social media
- Discounts on advertising in the BACnet International Journal of Building Automation
- Trade show representation, participation, and conference presentation opportunities

BACnet Community Engagement

- Help the industry continue to move toward interoperable products based on BACnet, the global standard for building automation.
- Network with manufacturers, suppliers, users, consultants, and students by participating in annual events, trade shows and committees.
- Support the work of BACnet International in maintaining the global BTL Product Certification Program through the BACnet Testing Laboratories (BTL) and contributing educational materials to The BACnet Institute.
- Enjoy the "halo effect" gained from industry recognition and credibility gained from being a BACnet International Corporate Member.
- Get recognized by authoring articles, and volunteering for committees or Board of Directors

For more information:

Contact Membership and Education Manager David Nardone at david@bacnetinternational.org.

Letter from the President

What is BACnet?

Dear Reader,

Have you ever noticed how one “big idea” dominates conversations in the technology sphere for a while, only to be edged aside by the next “big idea”? Today’s “big idea”, of course, is AI (or artificial intelligence, for people who have been living in a cave for the last year). If you listen to technology podcasts or access a wide array of news outlets, you would think AI is the only important thing going on. But this all feels kind of familiar, doesn’t it? I remember seeing the same thing around IoT not that long ago, and Big Data before that in a never-ending series of new technology trends. Now, to be fair, all these trends are important and they do impact our industry, but they are not the only things going on. They may not even be the ideas you need to focus on today. So, this issue of the Journal of Building Automation, by BACnet International, is not centered on AI. Instead, we’re going to focus on a wide range of innovations and integrations in building automaton that could affect your work as soon as tomorrow.

Building automation is built on the ability to integrate a diverse set of devices with control systems. The broader the set of devices and systems that can be integrated, the more automation possibilities emerge. In this issue of the Journal, you can find articles that speak to this. Harpartap Parmar’s article on BACnet/SC and integration with IT is one example. Lisa Hickey’s article on integrating BAS with airflow measurement stations is another. A third example is Tim Skell’s article on fan array integration. Hopefully, all of these articles give you insights and ideas for furthering integration in your own projects and applications.

The increasing scale and scope of integration in the building automation industry is accelerating innovation in products, systems, and societal expectations of buildings. Mike Wilson’s article on regulatory compliance driving data center solutions touches on this. As does Ari Ruben’s article on the increasing attention paid to air quality resulting in creative and innovative opportunities. Perhaps the most compelling sign of innovation enabled by integration is presented by Troy Harvey in his article on the effort to create an autonomous building standard.

Safeguarding the progress our industry has made in open communications and system integration requires continuous effort to address cybersecurity issues. Hence, we’ve included Mike Osborne’s article on fast-tracking the next major advance in cybersecurity for BACnet and building automation through BACnet International’s new Cybersecurity Acceleration Program.

The need for extensive, cost-effective integration and the innovation it enables is the real story behind Mary Catherine Heard’s article highlighting the latest market research on BAS protocol utilization. Quoting data from a recent BSRIA market research study, the article outlines the continuing growth of BACnet’s already dominant market position.

The “big ideas” get plenty of attention in the popular press and industry information outlets. Our hope is that this issue of the Journal shines a spotlight on other relevant and exciting ideas that you can used more immediately and excite you about the possibilities for even more innovation and integrations in your own corner of the building automation industry.

Andy McMillan
President and Managing Director BACnet International
andym@bacnetinternational.org | www.bacnetinternational.org

ABOUT THE AUTHOR

Andy McMillan is President and Managing Director of BACnet International, where he works with users and suppliers to expand and enhance the BACnet community. Previously he served as President of a building automation and energy management business unit of Philips Lighting.

Understanding BACnet/SC for Easy IT integration

BACnet/SC introduces important aspects to implement cybersecurity standards and to easily integrate Building Automation networks into existing IT infrastructure. With BACnet/IP, the BMS installer only needed to request IP addresses from the IT department for the BACnet/IP devices at the installation site. BACnet/SC implements the robust concepts used for secure communications over the Internet by using Transport Layer Security (TLS). The BMS installer must be familiar with TLS communication concepts and be able explain their requirements to the IT folks for successful installation of the job site. There is also a difference between the communication architecture for BACnet/IP devices vs BACnet/SC devices. This article will attempt to familiarize the building automation installers with these concepts.

Basics of TLS (Certificates, Keys, and Certificate Authority)

TLS relies on the use of certificates and keys for data encryption, device authentication, and data integrity (i.e., no tampering). Keys occur in pairs (public/private key) and are used for encryption/decryption. A session key for communication may be generated after the initial key exchange for added security.

Certificates are used for authentication and encryption. The public key is part of the certificate, while the private key is secret to the device. The certificates are issued and managed by a central authority, commonly known as a Certificate Authority (CA). All devices must have certificates issued by the same CA to communicate. The device can get the certificate directly from the CA or send a Certificate Signing Request (CSR) to the CA to get the corresponding certificate.

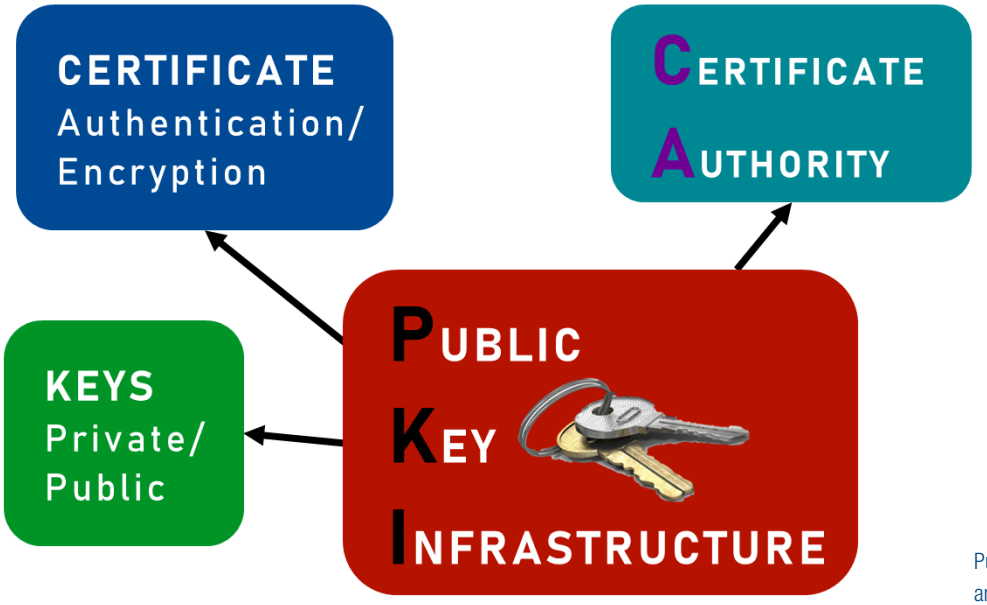
Getting an SSL certificate (SSL is an older version of TLS) installed for a website might be a familiar concept to some people. The CA in this case is a well-known company like Verisign, Comodo, GoDaddy, Let's Encrypt, etc., that is trusted by all devices and browsers to provide access to the website seamlessly over the public internet.

For a building automation system, getting a certificate from a public CA is not necessary and can be expensive given the large number of devices in a building. The IT department can implement their own infrastructure to generate these keys and certificates. The term PKI (Public Key Infrastructure) is used to define this setup. The building automation product vendors may also have specific software tools to implement the PKI, but the certificates and keys for all devices at a site, irrespective of their brand, must be generated from the same tool to ensure interoperability. The certificates on devices also expire and need to be renewed. The validity period must be noted to ensure that the devices continue to communicate seamlessly as part of the BACnet/SC network.

BACnet/IP vs BACnet/SC

BACnet/IP and BACnet/SC both operate over the IP layer. BACnet/IP uses unencrypted communication over the UDP port, while BACnet/SC is connection-based using TCP ports for encrypted communication. BACnet/IP uses broadcast messages for the discovery process and allows any BACnet/IP device to participate in the network. A BACnet/IP device may be a server providing data with the client device requesting the data. With the open BACnet/IP architecture, a new BACnet/IP client can be added which can discover the BACnet/IP server devices and send commands to control the points on the server device.

BACnet/SC adds additional security to the BMS network, and each device added to the network



Public Key Infrastructure to generate Keys and Certificates © Contemporary Controls

must be authorized. This authorization is controlled by the issuance of keys and certificates. If the device is not provided with the correct credentials, then all its messages will be ignored because a successful TCP connection will not be established in the first place. BACnet/SC with TCP connections also introduces the concept of "hub" and "node" devices. Nodes (or end devices) primarily communicate with each other via the hub using directed messages, and there are no broadcast messages. Direct node-to-node communication is supported as well. To provide redundancy, a primary hub and failover hub are used in the BACnet/SC network and must be configured on the BACnet/SC devices. The number of connections supported by the hub is another consideration to allow for future expansion of the BACnet/SC network.

There may be a requirement to integrate existing BACnet/IP and BACnet MS/TP devices in the building with newer BACnet/SC devices. This can be achieved with the use of a BACnet router supporting these datalink layers, but it is recommended to keep the BACnet/SC and BACnet/IP networks separate.

Harpartap Parmar
Director of Product Management | Contemporary Controls
hparmar@ccontrols.com | www.ccontrols.com

ABOUT THE AUTHOR

Harpartap Parmar is a Director of Product Management at Contemporary Controls, which designs and manufactures BACnet building controls and networking equipment. Parmar focuses on network security, IP routers and their application to Building Automation. He has over 22 years of experience at Contemporary Controls with range of networking, control, and communication products.

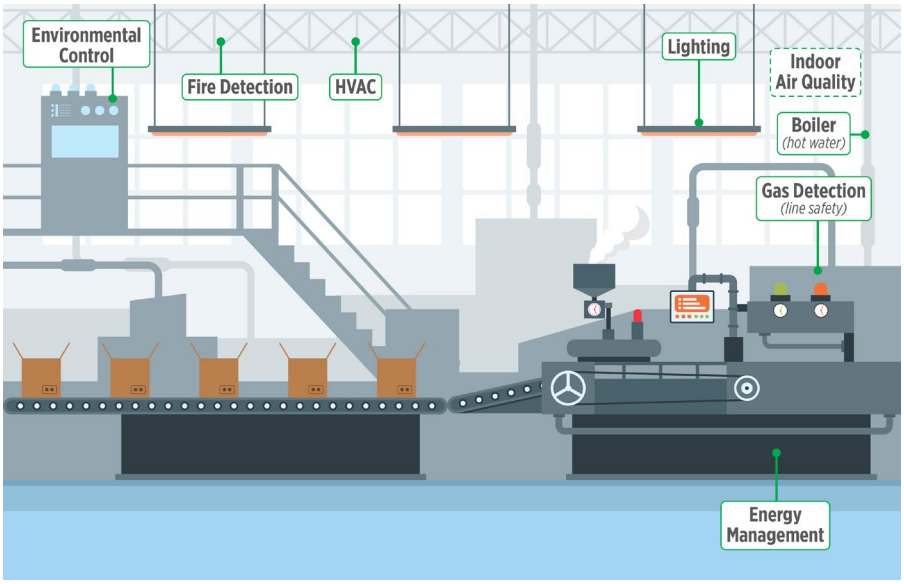
Unlocking the Power of BACnet in Industrial Automation

Introduction

The need for speed, efficiency, and flexibility keeps ratcheting up for industrial and manufacturing organizations around the world. Thanks to the convergence of the Internet of Things (IoT), digitization, and edge computing, what was once deemed futuristic is now a current reality.

Industrial connectivity is here and will continue to play an ever-increasing role as industrial automation grows and matures. Industrial and manufacturing organizations are at a critical juncture in the race to fully integrate building management with production to take operations to an even higher level.

As a result, forward-thinking companies are looking for ways to capitalize on technological advancements, smart devices, and the best-in-class open protocol, BACnet, to accelerate their transition to industrial automation.



BACnet-enabled automation solutions provide critical information needed to streamline processes and optimize production.

BACnet Basics

What is the BACnet protocol? BACnet, which is the acronym for Building Automation and Control Networks, is a popular and long-standing open communication protocol that was developed and is continuously managed by the BACnet Committee of the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE).

Originally developed in 1987, this innovative protocol was way ahead of its time in the 1980s and 1990s – a time when Wi-Fi as we know it did not yet exist and IoT-enabled building automation was still years into the future. As a worldwide standardized data communications protocol that is independent of specific technologies and suppliers with a deployment of more than 25 million devices, BACnet continues to revolutionize a wide variety of operations, including HVAC, lighting, and energy management.

Today, BACnet continues to be the de facto communications protocol to enable interoperability within the Building Management System (BMS)/Building Automation System (BAS). Thanks to the BACnet protocol in combination with BACnet-enabled solutions and devices, automation is made even more powerful by enabling communication between both operational systems – facility and production.

Why BACnet is Essential for Interoperability

Industrial and manufacturing plants consist of two kinds of operations: (1) the plant facility and (2) the production line. Both rely on automation to help ensure efficient and profitable operations.

But when they're not connected and are independent of each other, data can become siloed. As a result, it becomes very difficult to access and use captured data in a way that maximizes the effectiveness of both. Further, disconnected data and disparate devices do nothing but hinder productivity and lead to missed opportunities to maximize the benefits of automation.

BACnet, along with the newest generation of BACnet-integrated devices and technologies, changes this.

That's because the BACnet protocol provides the mechanism by which an interoperable system can exchange information, irrespective of the type and number of services it performs.

How BACnet Works in Industrial Automation

BACnet is particularly important to industrial and manufacturing organizations who've made a tremendous investment in technology to make production more efficient and reliable.

That's because, according to ASHRAE, the BACnet protocol is equally as effective whether it's used in building automation or industrial automation for mobile and Cloud-enabled devices, head-end computers, general-purpose direct digital controllers, or application-specific controllers.

BACnet-Supported Applications

Within the context of interoperability between facility and production, BACnet-enabled automation solutions provide critical information needed to streamline processes and optimize production.

Here are a few real-world examples of how the BACnet protocol supports a more connected system and helps keeps production rolling and workers safe.

Fire Alarm Panels: With building automation, when a connected device senses a dangerous smoke- or fire-related incident, the BMS alerts key personnel. With the integration of industrial automation, it also triggers a response within the production equipment. Response varies, of course, but in an especially hazardous situation, it can automatically shut down the line and sound an evacuation horn.

Protocol gateways, like the MSA FieldServer BACnet Gateway, can translate multiple protocols connected to a BACnet system.

Lighting: BMS lighting controls allow operators to monitor and manage usage based on such factors as time of day and occupancy. In an industrial setting, including production facilities, integrated lighting automation is especially important for alerting workers of unusual conditions or malfunctions, helping with workflow, and assisting in quality control.

HVAC: Temperature, humidity and air quality control are essential to both the comfort and function of industrial facilities and processes. In addition to boosting efficiency, industrial automation helps improve responsiveness. Take a frozen foods production plant, for example. Temperature control becomes less about personal comfort and more about product integrity, quality, and safety.

Environmental Control: Because smart factories can regulate all connected systems, they not only help improve product, they increase the quality of the indoor environment for both people and processing machines. This includes the ability to adjust temperature, ventilation, air flow, filtration, and more.

Energy Management: It's been said: What gets measured gets managed. This is especially true in industrial factories where energy usage is high – and costly. In fact, according to the U.S. Energy Information Administration (EIA), manufacturing accounts for 81% of industrial energy consumption. Thanks to automated energy management systems, however, manufacturers can better manage their usage, resulting in a more favorable impact on the plant, the planet, and the bottom line.

BACnet-enabled automation solutions provide critical information needed to streamline processes and optimize production.

BACnet … and Beyond

Despite the fact that BACnet is the most prevalent protocol standard for building automation, not all connected devices and sensors use it. That's where a protocol gateway that has the capability to translate dozens, if not hundreds, of different protocols – including BACnet – may be required.

The MSA FieldServer gateway, for example, speaks and converts more than 140 protocols to unlock valuable information from both building and industrial automation systems. The FieldServer BACnet IoT Gateway is a plug-and-play solution that quickly and easily integrates with BACnet Networks (BACnet/IP & BACnet MS/TP).

FieldServer's proven BACnet IoT Gateway also allows operators to interface with a wide variety of building and industrial automation systems for real-time, contextualized intelligence.

Protocol gateways, like the MSA FieldServer BACnet Gateway, can translate multiple protocols connected to a BACnet system.

Boost Data Transparency, Improve Production

The industrial automation market is still evolving. Where it will ultimately go is yet to be determined, however, proactive, safety-minded organizations are increasingly adopting BACnet-enabled solutions. These solutions allow industrial and manufacturing companies to integrate their two operational systems so they can make data-informed, real-time decisions about the facility, the production line, or both.

Those who understand the value of BACnet-enabled industrial automation will continue to accelerate adoption of BACnet-enabled devices and solutions to drive transformation.

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Richard Theron
Product Manager | MSA Safety
richard.theron@msasafety.com | www.msasafety.com

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ABOUT THE AUTHOR

Richard Theron is the Product Line Manager for FieldServer and Cloud at MSA Safety, where he works intimately with companies in the building automation, industrial automation, energy management and life safety markets to understand and build connectivity products and cloud solutions.

He is also a member of the BACnet International Marketing Committee.

How BACnet Secure Connect can help "Future-Proof" your Building

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Today's building owners are facing more and evolving cybersecurity threats. Building systems are becoming more complex and interconnected. In addition, the attack surface has become more significant due to an increase in remote work and the use of cloud applications. The IBM 2023 Cost of a Data Breach Report provides the following statistics:

1. The average cost of a data breach is $4.45M (up 15.3% from 2020).
2. Organizations that implemented effective security AI and Automation reduced breach data costs $1.76M compared to organizations that did not use AI and automation capabilities.
3. 51% of organizations plan to increase security investments due to a breach.
4. 82% of breaches involved data stored in the cloud – public, private, or multiple environments.

Implementing BACnet Secure Connect (BACnet/SC) can help mitigate cyber threats and aid in future-proofing a building. BACnet/SC is an advanced protocol used in building automation systems (BAS) to improve security and future-proof a building's automation infrastructure. It builds upon the BACnet protocol, which is widely used for controlling and monitoring building systems like HVAC, lighting, security, and more. The BACnet/SC protocol was adopted by the BACnet standard in 2019. BACnet/SC adds commonly accepted IT security features to the BACnet protocol, making it more resilient against cyber threats. This is accomplished by employing modern encryption and authentication mechanisms.

Following are some ways in which using BACnet/SC can help future-proof your building:

Cybersecurity Protection: BACnet/SC incorporates security measures to protect against unauthorized access, data tampering, and other cyber threats. This helps ensure the integrity and confidentiality of your building's automation and control systems. BACnet/SC provides the following benefits:

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1. Implements current IT standard state-of-the-art TLS 1.3 for communication security.
2. Establishes secure tunnels without needing Virtual Local Area Networks (VLANs) and/or Virtual Private Networks (VPNs).
3. Firewall friendly because BACnet/SC devices connect "outbound."

Implementing BACnet/SC is one step of an overall cybersecurity security strategy that should be integrated with a building owner's IT team.

Compliance with Regulatory Standards: By adopting BACnet/SC, the building automation system aligns with industry standards and best practices for cybersecurity. As cybersecurity regulations evolve, having a secure communication protocol like BACnet/SC can help a building remain compliant with current and future industry standards and regulations.

Compatibility: BACnet/SC is designed to be backward compatible with existing BACnet installations. This means building owners can gradually upgrade their building's systems without requiring a complete overhaul. BACnet/SC can be implemented in both on-premises installations and cloud installations.

Interoperability: BACnet Secure Connect maintains compatibility with the existing BACnet protocol, ensuring building owners can integrate new devices and systems from different manufacturers as technologies evolve. This interoperability reduces the risk of vendor lock-in and allows for flexibility in selecting the best-suited components for your building system.

Integration with IoT Devices: As the Internet of Things (IoT) continues to grow, having a secure communication protocol like BACnet/SC allows for the seamless integration of IoT devices into your building's automation and control systems.

Protection Against Advanced Threats: BACnet/SC employs advanced encryption and authentication mechanisms such as TLC 1.3 to protect against sophisticated cyber threats. This makes critical building systems more resilient against hacking and unauthorized access. BACnet/SC uses a Certificate process to authenticate devices and encrypt communication between the devices. The BACnet/SC standard requires the signing Certificate Authority to be controlled by the building owner/customer.

Long-Term Investment: A building owner protects their initial investment in a building automation system by investing in a secure and future-proof protocol. Implementing BACnet/SC is an investment in the long-term security and stability of a building's automation system. This can lead to cost savings in the future by reducing the risk of cyber incidents and minimizing the need for significant system overhauls. Choosing a well-established and widely adopted protocol like BACnet/SC ensures that building owners can access long-term support and updates. This helps ensure the longevity of a building's automation infrastructure as technology continues to evolve.

Remote Monitoring and Management: The secure nature of BACnet/SC enables remote monitoring and control of building systems. This is crucial for efficient building management and the ability to adapt to future demands, such as remote working arrangements or changes in occupancy patterns. BACnet/SC allows building owners to monitor and manage the building's systems remotely and securely. This is especially important when physical access is restricted, such as during a pandemic or other emergency.

Vendor Support and Updates: As the adoption of BACnet/SC grows, more vendors are likely to offer products and solutions that support this protocol. This ensures a broader range of options for building owners and operators. BACnet International is implementing a Cybersecurity Acceleration Program to assist manufacturers with interoperability and best practices.

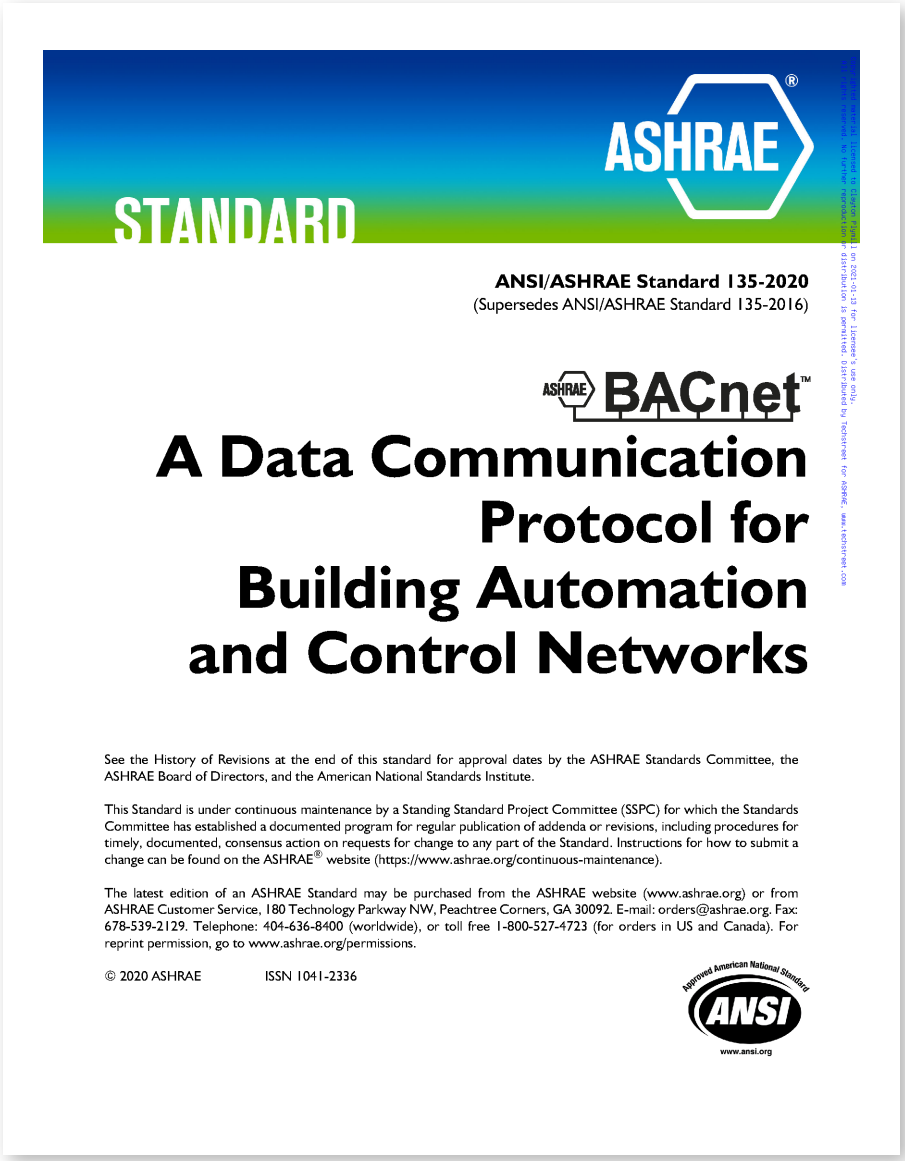
Scalability: BACnet/SC provides a secure foundation for growth. BACnet/SC is designed to be scalable, allowing a building's automation infrastructure to adapt to future needs. As the need to expand or upgrade the systems of a building, this protocol can seamlessly accommodate new devices and technologies.

Risk Mitigation: By adopting a secure communication protocol like BACnet/SC, you're proactively mitigating the risk of cyber incidents

that could potentially disrupt your building's operations or compromise sensitive information.

Using BACnet/SC can be crucial in future-proofing a building's automation and control systems. BACnet/SC can enhance security, scalability, interoperability, and sustainability. It provides a secure and scalable foundation that aligns with current and future cybersecurity needs, ensuring the longevity and resilience of your building's infrastructure. It's an investment in the resilience and efficiency of your building's infrastructure.

Acknowledgements:
"Cost of a Data Breach Report 2023", IBM Corporation, July 2023


STANDARD

ASHRAE®

ANSI/ASHRAE Standard 135-2020
(Supersedes ANSI/ASHRAE Standard 135-2016)

ASHRAE BACnet™

A Data Communication Protocol for Building Automation and Control Networks

See the History of Revisions at the end of this standard for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE® website (https://www.ashrae.org/continuous-maintenance).

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ABOUT THE AUTHOR

Ken Gilbert is a Regional Technical Consultant for Automated Logic. In this role, Ken performs the following functions:

- Support specifying consulting engineers with latest industry trends, writing specifications; system controls; developing sequences of operations, points lists, and flow diagrams; and Developing RFQs and RFPs
- Assisting ALC branches and factory-authorized dealers with presentations, responding to RFPs and RFQs, system demonstrations, and latest product developments

Ken brings significant industry experience to ALC, having served with The Trane Company and Honeywell International in various sales, engineering, and consultative roles. Ken graduated from the Georgia Institute of Technology with a Bachelor of Science in Industrial Management and recently completed his MBA from the University of Georgia. Ken is a LEED AP and is actively involved with ASHRAE and BACnet International. Ken, his family, and two dogs reside in the Atlanta area.

He is a member of the BACnet International Marketing Committee.

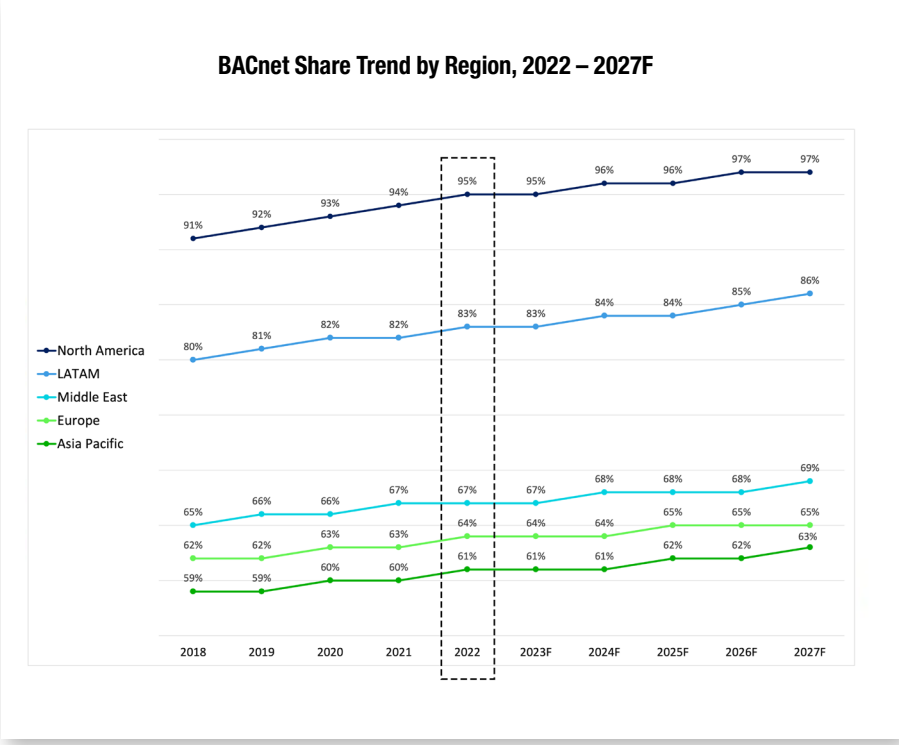
Automated Logic

Ken Gilbert, MBA, LEED AP
Regional Technical Consultant | Automated Logic Corporation
ken.gilbert@carrier.com | www.automatedlogic.com

BACnet Protocol Expands Dominant Market Share in Latest Market Research Report

BACnet International is pleased to release the latest BACnet Market Adoption Report, drawn from the BSRIA's Market Penetration of Communications Protocols 2018 – 2027 market research study. BSRIA is a premier provider of market intelligence in HVAC and Building Automation and Control (BACS). This study is a follow up to BSRIA's 2018 study of titled "Market Penetration of Communications Protocols". The BSRIA study draws on data from annual BACS market studies conducted by BSRIA since 2012 coupled with additional primary research. The most current BSRIA study was published in the first quarter of 2023.

The latest study concludes that since 2018, the BACnet protocol continues to remain the most widely specified protocol at a global level with 77% of projects specifying BACnet, up from 64% in 2018. The five-outlook projects continued market growth with a focus on cybersecurity and BACnet Secure Connect (BACnet/SC). By 2027, the BACnet protocol is predicted to have a 97% market share in North America, 86% in Latin America, 69% in the Middle East, 65% in Europe, 63% in Asia Pacific.



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This latest market research data reflects BACnet's central role in the industry as the integration platform for building automation that simultaneously achieves cost, performance, and climate impact objectives, said Andy McMillan, president of BACnet International. He continued, "The demands of that role drive continued BACnet evolution to address emerging performance and cybersecurity needs while maintaining multivendor interoperability." The BACnet Market Adoption Report was developed and initially released exclusively to Corporate Members to provide current and projected market share data in specific regions on the BACnet protocol and proprietary protocols. The report is now available to the public. In addition to testing and certification through BACnet Testing Laboratories and education through The BACnet Institute, BACnet International remains committed to facilitating the successful future use of the BACnet protocol worldwide through BACnet/SC and cybersecurity implementation programs like the Cybersecurity Acceleration Program.

Download the latest BACnet Adoption Report

ABOUT THE AUTHOR

Mary Catherine Heard joined BACnet International in 2022 bringing a decade of marketing experience that includes website management, email marketing, social media, copywriting, and graphic design. Prior to joining BACnet International, she worked in the auto industry and state government.

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Mary Catherine Heard
Communications Manager | BACnet International
marycatherine@bacnetinternational.org | www.bacnetinternational.org

CYBERSECURITY
ACCELERATION PROGRAM

BACnet International would like to invite you to the next phase of BACnet cybersecurity, the Cybersecurity Acceleration Program. Designed for manufacturers, the Cybersecurity Acceleration Program aims to reduce their cybersecurity implementation learning curve and align their product development with industry direction on interoperability and best practices.

The program includes reference implementation and source code components including:

- Certificate Authority (CA) server
- Certificate Signing Request (CSR) generation and validation tool
- Machine readable, interoperable certificate file format

Fast track your in-house technical knowledge and development with additional program features including:

- Cybersecurity implementation webinars
- Early tool release with full source code license
- Expert moderated developer's forum
- Manufacturer's cybersecurity guidelines document development
- Access to BRITE is also included in the Cybersecurity Acceleration Program.

BRITE provides a confidential, supplier-independent environment for remote interoperability testing of BACnet devices. The focus of BRITE is BACnet/SC product interoperability testing, and it utilizes BACnet/SC to achieve secure connections over the Internet. This allows cooperating suppliers to evaluate the interoperability of their BACnet devices without physical co-location.

Program Cost:

Corporate Members: $5,000 USD

Non-members: $10,600 USD (includes a Silver Membership to BACnet International)

The Cybersecurity Acceleration Program is FREE to all educational institutions.

After the program ends, the cost of program contents will increase to $6,500 USD for Corporate Members and $7,500 USD for non-members.

Scan for more information

For more information, please contact Dave Nardone at david@bacnetinternational.org.

BACnet International

New Cybersecurity Acceleration Program to Fast-track BACnet/SC Implementation

Cybersecurity continues to be a major concern in building automation industry resulting in more and more suppliers of these products adopting BACnet/SC as the backbone of security. Currently, there are nearly 100 BTL certified workstations and controllers available with BACnet/SC from dozens of suppliers.

BACnet/SC and your bank use the same underlying technologies to establish a secure connection. These secure connections are established by exchanging and validating certificates. This means every product intending to join a BACnet/SC network must contain valid certificates. These certificates are generated by the Certificate Authority for the BACnet/SC site. The Certificate Authority requires a unique file from the product called the Certificate Signing Request file. With this file, the Certificate Authority can generate the unique certificate files for the product.

Since a single Certificate Authority is used in a BACnet/SC system, each supplier must exchange files compatible with that Certificate Authority. The generation and processing of these compatible files will be a manual process that is time consuming and error prone.

The BACnet/SC Interoperability Acceleration Program helped suppliers jumpstart BACnet/SC product development. Similarly, the new Cybersecurity Acceleration Program will help suppliers efficiently generate, exchange, and manage these files significantly simplifying system integration.

The Cybersecurity Acceleration Program will provide a complete Certificate Authority reference implementation and a sister tool that can generate and validate Certificate Signing Request files and package them into an interoperable file format for the Certificate Authority. Additionally, all program participants will have access to cybersecurity implementation webinars and an interactive, peer-to-peer forum led by experts in BACnet and cybersecurity.

Participation in the program will help suppliers ensure their certificate management tools are interoperable with tools from other suppliers. This will keep integration costs down and maintain their reputation as a collaborative participant in multivendor environments. The program will also shorten the learning curve for manufacturers who do not have cybersecurity implementation experts on staff and help to ensure their products are ready for whatever comes next in building automation cybersecurity.

Access to BRITE is also included in the Cybersecurity Acceleration Program. BRITE provides a confidential, supplier-independent environment for remote interoperability testing of BACnet devices. The focus of BRITE is BACnet/SC product interoperability testing, and it utilizes BACnet/SC to achieve secure connections over the Internet. This allows cooperating suppliers to evaluate the interoperability of their BACnet devices without physical co-location. BRITE is built around a collection of cloud based BACnet/SC hubs along with interoperability support and diagnostic tools. Test sessions typically involve two suppliers and are arranged through BACnet International. Each session is private, only allowing access to the specific suppliers participating in that test session. BACnet/SC Interoperability Acceleration program participants are eligible for discounts and access to dedicated cloud hubs.

The Cybersecurity Acceleration Program is cost-effective, typically costing less than one week of an engineer's time. The program is 5,000 .00 USD for Corporate Members of BACnet International and 10,600.00 USD which includes a Silver Membership) for non-members. The cost of the Cybersecurity Acceleration Program will increase after the program ends. For more information, visit bacnetinternational.org/cybersecurity or email david@bacnetinternational.org.

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Michael Osborne
BACnet International | BTL Technical Advisor
mike@bacnetinternational.org | www.bacnetinternational.org

ABOUT THE AUTHOR

Michael Osborne has over 35 years' experience in various aspects of the high-tech industry. For the last 19 years, Michael has designed building automation products, managed technical projects, and supervised a team of talented developers. For most of his time in the building automation industry, Michael has also been involved in the BACnet community where he developed tests for the ASHRAE 135.1 Testing Standard and wrote proposals for the ASHRAE SSPC 135 Standard. From 2012 to 2021, Michael was the Secretary, Vice-Chair and finally Chair of the ASHRAE SSPC 135 Committee.

Trends in Building Automation and Smart Buildings

The global smart building automation market is seeing a paradigm shift in how technology is being put to work to improve not only energy efficiency, comfort, and safety of building occupants, but also to address aspects of property management, device and connectivity, asset management, visual representation of building control and performance, data security, reporting of building performance indicators, etc. to name a few.

The community associated with the smart building automation industry is frequently finding new ways to address the dynamic and fast-changing requirements of modern buildings. But they are often overwhelmed and challenged due to a wide variety of market requirements and a lengthy wish list from customers. The task becomes even harder with the frequent introduction of new products and services by the different brands, leaving the installers and system integrators clueless about which solution is apt for their project.

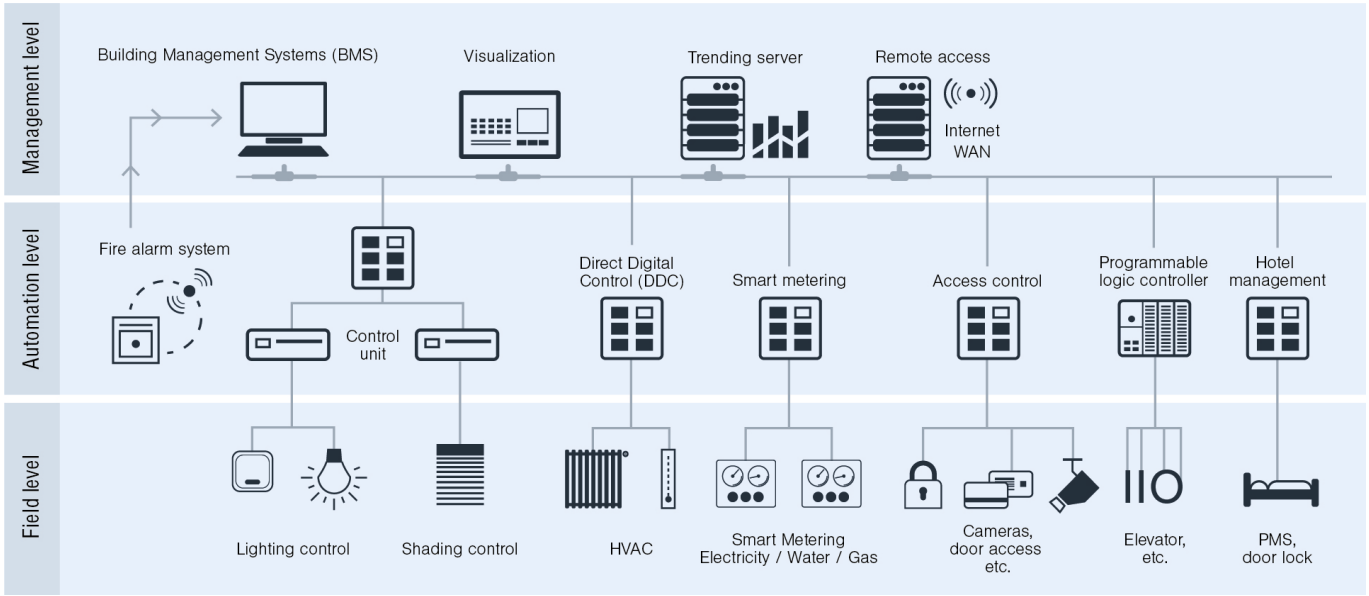
This is the exact situation where the power of standardisation comes in handy in solving the challenges of building automation market and making life easy for all stakeholders.

BACnet (Building Automation and Control Network) is addressing preciously such issues by providing a global data communications standard for building automation and control networks. It provides a vendor-independent networking solution to enable interoperability among equipment and control devices for a wide range of building automation applications. BACnet's unified data communications infrastructure for intelligent buildings is implemented over a huge installation base of buildings around the world, offering the flexible interoperability of thousands of products coming from multiple manufacturers of BACnet-compliant devices.

We are seeing the advent of software solutions managing complete building services occurring at a very rapid pace. The clients see a clear differentiation between the management side of the buildings and the implementation side of it. We are pleased to see the same trend in all major markets, where clients are not only thinking about hardware reliability and performance, but paying equal attention to how occupants interact with the building.

Modern building automation systems can broadly be segmented into three layers - the "field device level", the "automation level" and the "management level" at the top.

At the field device level, one needs to ensure a good synergy while choosing the relevant hardware components. BACnet provides a big basket of options with high-quality products covering wide application areas. But often it may be needed in a project to deal with systems which are more native in nature or unique in terms of their functions and used communication protocol.



Let's take an example of a hotel building to understand this better. We may cover a wide range of applications like lighting, HVAC, and access control based on the BACnet protocol, but a Property Management System (PMS), which is an integral part of a hotel project, is likely to use a proprietary nature of communication protocol. Because this PMS system contains important information about the guests and related services in the hotel, they have to be included as part of the holistic automation design approach.

The solution and services of our company solve such heterogeneous integration challenges in projects of diverse profiles.

If we turn our attention now on the automation level, one would agree that even more smart manoeuvring is needed to make sure the hard work done at the field device level is paid off and things are streamlined for the management level, which is the interface of the building. The real cross-integration of different systems happens at this level where products from different protocols and topologies tend to get interlinked to unleash the real benefits of automation. We can imagine this layer as a big kitchen with various types of ingredients ready to be used by the chef to create the customer's order.

The management level is about translating the technical features of hardware used at the field device level. The smart blending of different systems from the automation level, and the intuition and design philosophy of the specifiers/system integrators allows for a user-friendly, easy-to-maintain building management interface for the customer. This interface acts as a dashboard of the building automation system deployed so far. This is the layer where central monitoring and visualisation are deployed for the building. Such a system provides day-to-day operational information, device control schemes, building performance indicators, historical data, alarms management and notifications etc. as some of its key features.

Recently, significant development in the IoT space has influenced building automation projects significantly. IoT, for a long time, has been an undefinable term, but now such technologies have penetrated the conventional building automation market to a great extent. But it also brings questions and concerns on cybersecurity, data protection, sustainability and lack of standardization platforms to be a future-proof solution.

Initiatives like the Cybersecurity Acceleration Program, launched by BACnet International, will help stakeholders across the industry, especially manufacturers of BACnet devices, to increase confidence among customers.

Exploring the symbiosis – through higher-level networking and cooperation of local intelligence is what we are looking at these days to simplify our approach to the demands of our customers – be it connectivity, cybersecurity, or dealing with emerging new technology. That is how we reach new levels of possibilities, and at the same time, resource consumption optimization is raised to a new level.

Key building services offered by the BACnet ecosystem including lighting, HVAC, access control, security, alarm management, and energy management are merged at the management level we spoke of earlier in this article and at the same time, opening doors to welcome new platforms like IoT. This way, buildings are not only highly efficient, but also sustainable, upgradable and finally managed well throughout their lifecycle.

Another upcoming topic that must mention is Artificial Intelligence (AI) and how it may change the building automation landscape. Let's define it this way. (IoT + AI) * Cloud = future (with the assurance of standardization like BACnet). This means we shall see software and software-enabled services dominating the game. Because it will not only ease the life of building owners/operators by how the building is managed, but also bring in new possibilities to the installers in terms of offering value additions over the entire lifecycle of the building. Needless to mention, the backbone of using standardized devices using BACnet is the key to the sustainability of such a technology model which has the perfect mix of being future-proof and at the same time tried, tested, reliable and interoperable.

We see such trends catching up fast in the mid- and enterprise-level projects across all building types (e.g. commercial, hospitality, infrastructure, and industrial buildings). So, a mid-term vision will be just an extrapolation of the current practices in the building automation market. It is just a matter of time before today's trends become a mega trend and eventually a standard specification for all buildings.

Some of the positive trends of today, which shall propel our journey to the future of building automation, are a strong preference among customers globally to use devices that are open/interoperable and use global standards. They understand the importance of a solid foundation which BACnet provides via its wide gamut of products and solutions. We also see the widespread acceptability of headend software solutions to address a very wide variety of building automation applications. We at NETxAutomation are working towards it, being relevant and appropriate for our customer's needs. Remaining glued to BACnet standard and following its developments helps us fine-tune our offering.

Our knowledge base in the building automation space will continue to grow if we carefully listen to our customers and understand their perspectives. Being watchful of the developments happening around us, and adapting our strategy, be it in product development or system integration, shall take us closer to 100% customer satisfaction. Our openness to new ideas, mindset, regional habits and addressing them with suitable product developments and services shall make way for sustainability in this vast and technologically advanced field of smart building automation.

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Paul Furtak
CEO | NETxAutomation Software GmbH
office@netxautomation.com | www.netxautomation.com

NETx AUTOMATION

ABOUT THE AUTHOR

Paul Furtak is the CEO of NETxAutomation Software GmbH, one of the leading providers of innovative software for building automation. NETxAutomation develops and distributes software for building management and central building control, consisting of reliable server systems, shading controls, visualisations, and energy reporting systems.

Fan Array Integration

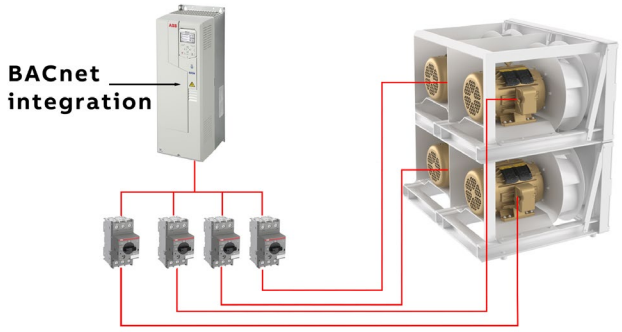


Figure 1: Single VFD fan array integration © Carrier

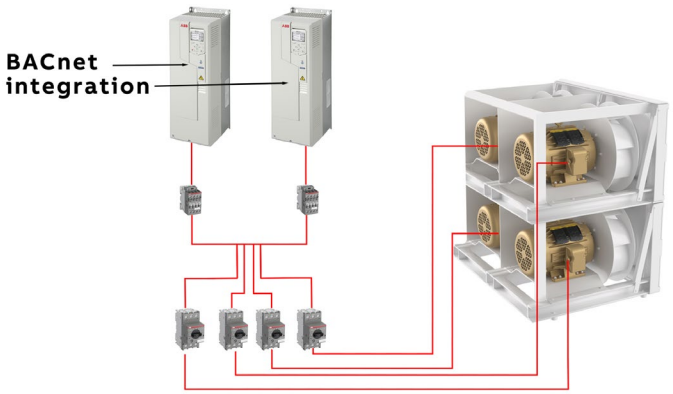


Figure 2: Redundant VFD fan array integration

Fan arrays are becoming more prevalent in HVACR applications, replacing traditional setups. Fan arrays have multiple small fans instead of one larger fan. The result? Improved redundancy, easier maintenance, and enhanced performance. But what about their integration over BACnet? Let's explore how fan arrays work and integrate into building management systems (BMS).

Before diving into integration, we first must understand the different fan array designs – as each design impacts how to integrate and what data is available. Fan arrays may be powered by one large variable frequency drive (VFD), one VFD per motor/fan, or by electronically commutated motors (ECMs). For example, a 2x2 array designed with 5 HP motors/fans, may be controlled by a single 20 HP VFD, (4) 5 HP VFDs, or (4) 5 HP ECMs.

The controls contractor's integration to the fan array will differ based on which of the (3) above designs are used. Let's look at some integration scenarios for each of those designs.

One large VFD, multiple small motors

VFDs designed for HVACR applications usually have BACnet MS/TP included as standard and they may offer BACnet/IP as an option. This one-large-VFD (Figure 1) is the easiest to integrate of the (3) fan array designs. Controls contractors have been integrating VFDs into the system for years, whether fan, pump, or cooling tower applications. The initial BACnet integration to a VFD in a fan array isn't very different from other applications, although some care must be taken such that the data is accurately presented on the operator workstation (OWS) graphics. A couple items to remember:

- Update the graphical image to show an array instead of a single fan – easy to miss this simple task when doing graphics work offsite and one is thinking about the single VFD
- Verify the text is accurate for all variables displayed on the graphics – we are dealing with "total" power and "total" amps instead of individual motor power/amps

A package, with one-large-VFD powering multiple small motors, will include some form of individual overload protection per motor, such as manual motor protectors (MMP). The most common integration "miss" with these array designs is to forget to monitor the MMP status. A single motor that becomes gradually overloaded in the array (i.e. bad bearing) is disconnected from the VFD by the MMP. These MMPs can come with an auxiliary contact for status which can be monitored by the local controller. Ideally, any open MMP would throw an alarm in the BMS and alert the facility personnel. Pro tip: Wiring the aux contacts in series back to a VFD's unused digital input and then monitoring that DI over BACnet – saves on wiring costs and a DI on the local controller. Consulting Engineers should take note to clearly document the need for aux contacts on the MMP and for the controls contractor to monitor their status.

There is a sub-set of the one-large-VFD solution, and that is a redundant VFD package. This package (Figure 2) has a primary VFD and a secondary/back-up VFD, thus removing the VFD component from being a single point-of-failure. If the primary VFD fails, the secondary VFD would then power the array. Redundant VFDs are popular for VAV (variable air volume) and for fan array designs that are designed to run above 60 Hz. The BACnet integration to a redundant package should result in both drives shown and their status/data properly identified on the OWS graphics. Depending on the application and owner's preference, the redundant drive package could be configured to either manually transfer to the back-up VFD, automatically transfer, or allow the BMS to control which drive is powering the array. While ideally these items would be clear in the sequence of operation and appropriate control wire pulled upfront, one beauty of BACnet is that it allows flexibility to have these types of controls changed quickly on the fly with minimal wiring changes.

One VFD per motor

From an integration viewpoint, the one-VFD-per-motor solution (Figure 3) has some similarities to the above, but there are a few key differences:

- Data pulled from the VFDs is for each fan/motor – thus both individual values/status for each VFD, along with the total values (i.e. power), should be available on the graphics
- There are no MMPs to monitor – traditional BACnet integration makes it easy to see the status of each VFD and verify proof-of-flow

Are you also responsible for implementing equipment safeties, such as a high static safety or smoke alarm? If so, make sure the safeties are wired back to all the VFDs. Due to the temptation of simplicity, one pitfall is to run the safeties into to the shared start/stop relay logic, which results in an open safety removing the start command from all the VFDs. While this does stop the VFDs (when the drive is in Auto mode), unfortunately the safeties are no longer in the circuit for Hand mode. Safeties must be functional in Auto and Hand mode.

ECMs

Over the past 10 years, ECMs have become another popular solution for fan arrays. The initial popularity was due to high efficiency, thus energy savings, of an ECM compared to a traditional AC induction motor. This healthy competition of

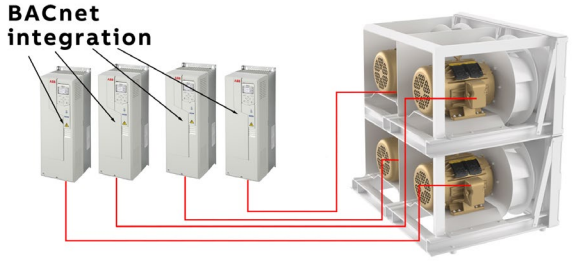


Figure 3: One VFD per motor fan array integration

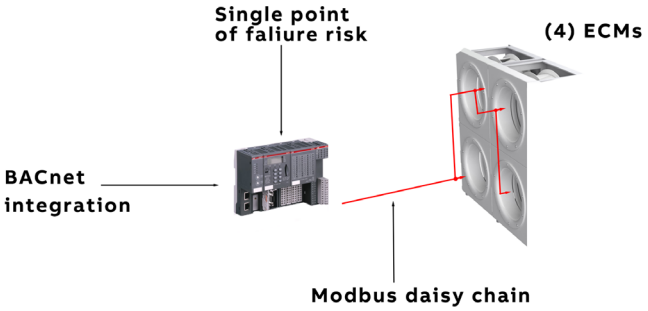


Figure 4: ECM fan array integration

motor technologies resulted in additional motors developed for fan arrays – ones like the VFD powered ferrite assisted synchronous reluctance motor, that are more efficient than an ECM. While ECMs are no longer the most efficient solution for fan arrays, some air handlers have standardized on them, and controls contractors should be prepared on how best to integrate them.

One may expect that ECMs have similar integration characteristics as the one-VFD-per-motor, but that's not typically the case. The control and integration with ECM based arrays are not as standardized. Only some ECMs include BACnet, with most (Figure 4) using Modbus to an intermediary controller or gateway. That controller then talks BACnet to the BMS. Even if the ECM has BACnet, there may still be an intermediary controller involved for general control or to offer Hand functionality that is expected on air handlers. ECMs themselves do not offer a Hand function and the intermediary controller/HMI can offer a Hand function via touchscreen. However, that controller/HMI does become a single point-of-failure risk, which can take an entire array offline, thus defeating the whole reason the Hand function was included. Hand mode is intended for when the controls fail.

The first step in integrating to ECMs is to determine if the integration is directly to the ECMs (and if so, what protocol) or if the integration point is the intermediary controller. Assuming the integration point is to the intermediary controller, now the controls contractor should determine which data points are offered from that controller and which to show on the OWS. Too often that intermediary device has a very limited object list. For example, an ECM may have 20 points of data available, but if the intermediary controller is only requesting (3) status/data points over Modbus from the ECM, then the BMS will only be able to read those (3) data points from the intermediary device. Consulting Engineers should communicate clear expectations for the fan array's intermediary controller and the controls contractor's responsible point list, otherwise the owner may have a very limited OWS graphics/data when it comes to an ECM fan array solution. Unlike when integrating directly to the device (VFD or ECM), it is much harder to adjust the points list after-the-fact with intermediary controllers.

Are you responsible for designing or implementing smoke control/evacuation controls? If so, care must be taken and possible early coordination with the authority having jurisdiction (AHJ) on what will be deemed acceptable functionality in Auto and Hand modes of operation. ECMs typically do not have specialized smoke control override logic so a limited variation of smoke control is handled via the intermediary controller. Critical fan array applications want to minimize single point-of-failure risks, which may result in a Hand mode design that is hardwired (switches and potentiometers). However, if that hardwired variation of Hand mode is implemented to provide the most reliable solution, then there is no specialized fire control logic available in Hand mode. These are considerations that hopefully occurred up front in the design and are not something being figured out during commissioning.

Summary

There is an incredible amount of useful data in HVACR devices. That data is just waiting to be extracted via BACnet and displayed and trended on the owner's OWS. For over 15 years controls contractors have been pulling that data via BACnet from single VFD applications. With fan arrays and their multiple motors, we have the added wrinkle of the possibility of multiple VFDs or multiple ECMs being involved. Someone familiar with a single VFD integration will typically quickly figure out the nuances of integrating to a multiple VFD fan array. Proper integration to an ECM based fan array is also possible but the available data may be limited if expectations were not communicated early on in the project.

Tim Skell
HVAC Application Engineering Manager | ABB Inc
tim.r.skell@us.abb.com | www.linkedin.com/in/tim-skell
https://new.abb.com/drives

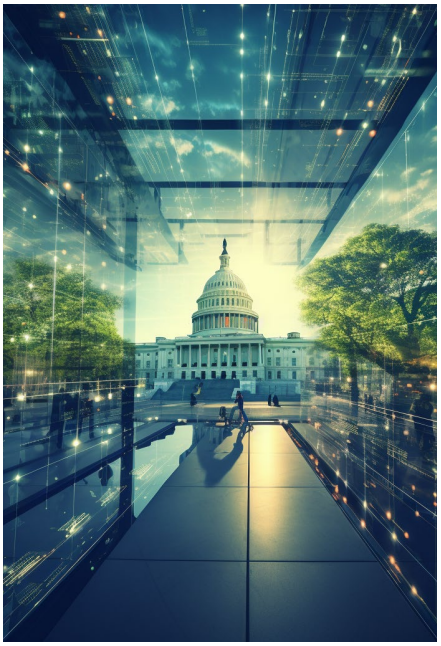
ABOUT THE AUTHOR

Tim Skell, Global HVACR Application Engineering Manager at ABB, has been working with variable frequency drives (VFDs) in the HVACR industry for over 20 years. He is also active in the BACnet community and has received a past BACnet International Member of the Year award.

Compliance as a Catalyst: Regulatory-Driven Sustainability in Data Centers

Climate change's stark reality and our interconnected world's ever-growing demands place enormous responsibility on data center operators' shoulders. Industry regulators, policymakers, clients, and investors are united in their call for environmentally friendly, energy-efficient operations. A Global Survey of I.T. and Data Center Managers 2022 by the Uptime Institute reveals that most operators anticipate mandatory carbon emissions reporting, yet many are unprepared to comply.

While data centers form the backbone of our connected world, they also significantly contribute to the world's carbon emissions. The U.S. Department of Energy highlights data centers as among the most energy-intensive structures, consuming up to 50 times more per square foot than a typical commercial building. Together, these centers are responsible for around 2% of total U.S. electricity consumption, with server energy usage projected to rise.



Who Moved My Cheese?

Global governmental regulators now enforce strict regulations and standards to address data centers' environmental impact. These measures aim to restrict energy use and carbon emissions, incentivize renewable energy adoption, and advocate for efficiency in data center operations.

For instance, the E.U. Energy Efficiency Directive (EED) has set ambitious goals for reducing energy usage, striving for a 32.5% decrease in primary energy consumption by 2030 compared to 2007. It also mandates a 30% improvement in energy efficiency in data centers within the same timeframe. Enforcement measures include compulsory energy audits for large energy consumers and labeling schemes for energy-intensive products.

California's Title 24 standards mirror the EED's rigorous energy-efficiency requirements for all new and existing structures, including data centers. From 2023 onwards, the updated Title 24 mandates a further reduction in the minimum Power Usage Effectiveness (PUE) requirement for data centers from 1.2 to 1.1.

The Data Centre Energy Efficiency Scheme (DCS) in Singapore and Australia's National Built Environment Rating System (NABERS) take an alternative approach by offering incentives for adopting energy-efficient technologies and practices. The SEC in the U.S. is contemplating new rules obligating publicly traded companies to disclose climate-related risks, encompassing those tied to data centers.

This surge in regulatory initiatives reflects the mounting global concerns regarding data centers' environmental footprint. Still, many operators struggle to meet these regulatory requirements, signifying an immediate need to prioritize sustainability.

Compliance necessitates operators to monitor various metrics such as Average Delta T, Cooling Efficiency, Energy Consumption, PUE, Total CO_2, Carbon Usage Effectiveness (CUE), Server Utilization, and Water Usage Effectiveness (WUE). With a clear understanding of these metrics, operators can demonstrate regulatory compliance while enhancing energy efficiency and reducing environmental impact.

Making Lemonade

Rather than viewing these regulatory actions as punitive measures, operators should consider them a call to action to future-proof their operations. The path to sustainability brings with it not only regulatory compliance but also improved operational efficiency, cost savings, strengthened corporate responsibility, and enhanced customer trust.

Operators must strategize how to align their data center designs and management with reduced energy use and emissions while handling the growing demand for their services. They can do this by focusing on PUE, CUE, WUE, and Server Utilization - all critical metrics for sustainability. Techniques for improvement include using energy-efficient servers, advanced cooling methodologies, power management software, regular monitoring and optimization, sourcing energy from renewable sources, and efficient workload management.

The transition towards sustainability requires a comprehensive, systematic approach from data center operators. They must establish clear sustainability targets and robust governance structures and foster a sustainability-centered culture within their organizations. Digital solutions and advanced analytics will provide real-time monitoring capabilities and insights to optimize operations.

Collaboration with governments, regulators, industry peers, and technology providers can expedite this transition. Operators can pool expertise and resources through such partnerships, share best practices, and spur energy efficiency and sustainability innovation.

Integrate and Automate

As data centers strive for sustainability and compliance with increasingly stringent regulations, integration and automation become invaluable tools. Integration brings together disparate systems – cooling, power, security, and information management – into a unified whole. This synergistic environment promotes efficient usage of resources and energy, directly contributing to the sustainable operations of the data centers. Moreover, automation within integrated systems helps maintain optimal energy utilization, dynamically adjusting the usage based on the data center's load and effectively minimizing wastage.

Automation is crucial in reducing human error, a significant cause of system inefficiencies and failures. Automated processes introduce consistency and precision that manual operations often lack. With routine tasks automated, human resources can shift focus towards strategic planning and decision-making tasks, such as future capacity planning or implementation of new technologies.

This redistribution of functions not only boosts operational efficiency but also aids in meeting sustainability goals.

Furthermore, automation enables a proactive approach to problem-solving. Constant monitoring systems can detect potential issues before they become critical, facilitating timely interventions. This predictive approach significantly reduces system downtime, promotes smooth operations, and indirectly contributes to energy savings. Additionally, the scalability afforded by integrated and automated systems means that data centers can adapt quickly and effectively to changes in demand, ensuring that energy use aligns closely with actual needs.

Finally, integration and automation greatly simplify regulatory compliance. From automatically generating reports on energy use or carbon emissions to ensuring adherence to set standards, these systems reduce the administrative burden of compliance. Accurate and timely reporting becomes less of a challenge and more of a routine, ensuring data centers stay on the right side of regulations. Thus, in their pursuit of sustainability and regulatory compliance, data centers find robust allies in integration and automation, reaping the benefits of efficiency, resource optimization, and proactive problem-solving these tools offer.

The Journey Ahead

Navigating the path towards sustainability, many forward-thinking data center operators have begun reevaluating their current practices and overhauling their infrastructures and operations. One emerging trend in this journey towards sustainability is the adoption of green technologies and designs in data center construction and management. This includes using energy-efficient hardware, implementing advanced cooling systems, and adopting techniques that maximize natural ventilation and minimize the need for artificial cooling. Some companies are also exploring the possibility of using renewable energy sources such as solar or wind power, either directly through on-site installations or indirectly through purchasing renewable energy certificates.

Another critical aspect of this transition is the increasing use of data and analytics in data center operations. By using advanced data analysis tools and techniques, operators can better understand their energy use patterns, identify inefficiencies, and implement targeted solutions. Machine learning and artificial intelligence are growing in this area, enabling operators to predict energy use trends, optimize cooling systems, and improve overall operational efficiency.

Training and education are also vital to this transition. As the field of data center operations evolves, operators and their staff need to stay up to date with the latest technologies, best practices, and regulatory requirements. This can be achieved through regular training sessions, seminars, and workshops and through collaboration with industry associations, research institutions, and technology providers.

The shift towards more sustainable data center operations also brings new challenges. For instance, implementing green technologies may involve high upfront costs, which can be a barrier for smaller operators. There is also the challenge of ensuring reliable service while making these changes, as any disruption to data center operations can have significant consequences for clients.

However, despite these challenges, the transition toward sustainability is a necessary and beneficial step for data center operators. It can help them comply with regulatory requirements and lead to significant cost savings in the long run, thanks to reduced energy use and improved operational efficiency. Moreover, it can enhance their reputation among clients and investors increasingly demanding sustainable operations.

In conclusion, regulatory pressures on data center operators to mitigate their environmental impact pose both a challenge and an opportunity. By responding to these regulations and investing in sustainable operations, operators can ensure compliance while improving operational efficiency, reducing costs, enhancing their corporate image, and gaining customers' and investors' trust. With the world's growing emphasis on sustainability, such steps are not merely beneficial; they are indispensable.

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Nlyte Software

Michael R. Wilson
Director of Marketing | Nlyte Software
Mike.R.Wilson@carrier.com | www.linkedin.com/in/mrwilson
www.nlyte.com

Referenced Legislation

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Australia's National Built Environment Rating System (NABERS) – https://www.nabers.gov.au/about/what-nabers

Additional Educational Resources

ASHRAE Standard 90.4-2002 Energy Standard for Data Centers – https://www.ashrae.org/technical-resources/bookstore/supplemental-files/ansi-ashrae-standard-90-4-energy-standard-for-data-centers
Consulting-Specifying Engineer eBook: Data Centers Summer Edition 2023 – https://bt.e-ditionsbyfry.com/publication/?m=34013&i=796584&p=1&ver=html1
Uptime Institute Global Data Center Survey Results 2022 – https://uptimeinstitute.com/resources/research-and-reports/uptime-institute-global-data-center-survey-results-2022

ABOUT THE AUTHOR

Michael is responsible for marketing strategy and execution to ensure that Nlyte retains its market leadership position for data centers globally. He orchestrates Nlyte's global market messaging, plans and executes SEO/SEM, administers lead generation, conducts product launches, and manages Nlyte's social media presence.

Michael has worked in the building automation and controls industry for nearly two decades and serves as a member of the board of directors of BACnet International, and its Marketing Committee chair.

Connect with Michael on LinkedIn: https://www.linkedin.com/in/mrwilson

On the Increasing Prominence of Indoor Air Quality as a Primary Driver of Trends and Opportunities in the Building Automation & Control Systems Sector

Abstract

Sophisticated owners and operators of commercial and institutional buildings have a clear and present understanding that Indoor Air Quality (IAQ) monitoring and remediation continues to increase in prominence as a primary driver of trends and opportunities in the Building Automation and Control Systems (BACS) sector. Demand drivers include, and are not limited to, emerging wellness protocols accelerated by the COVID-19 pandemic and In-Office versus Hybrid- Workplace decision vectors. In summary, IAQ impacts occupant satisfaction and workplace productivity. The main indoor air pollutants are Volatile Organic Compounds (VOCs), Particulate Matter (PM), and Carbon Dioxide (CO_2). Accepted data allows one to conclude that IoT sensor monitoring for these pollutants, along with improved measurement and control of ventilation rates can: a) reduce sick days by up to 35%, b) improve cognitive functioning and productivity by up to 11%, and c) yield energy savings of up to 21%. The market for these integrated sensor solutions in the US was estimated at $500M in 2022. The forecast through 2027 expects high single-digit growth rates year over year. The author will present supporting data and relevant information in the body of this document to provide the reader with necessary insights.

What is IAQ?

Indoor Air Quality (IAQ) refers to the overall quality of ambient air inside buildings and built environments, such as: hospitals, nursing homes, day-care facilities, schools, offices, data centers, factories, hotels, malls, airports, government buildings, and residences. Measurable factors or parameters include, and may not be limited to, temperature, humidity, ventilation, and pollutants. These factors can either enable building occupants to receive or preclude them from the benefits of the intended use of their built environment. The main indoor air pollutants are Volatile Organic Compounds (VOCs), Particulate Matter (PM), and Carbon Dioxide (CO_2).[1] Alongside these common pollutants, other chemicals such as Carbon Monoxide, Radon, Sulphur Dioxide, and Nitrogen Dioxide can also contribute to poor indoor air quality and are often monitored.

CO_2 is one of the most effective indicators of air quality. Generally, we want CO_2 levels to stay below 800 Parts Per Million (PPM). If it is consistently higher, improved ventilation may help. For example, under the conditions of natural ventilation of a study published in 2021[2], the indoor CO_2 concentration ranging from 500PPM to 600PPM, an indoor $PM_{2.5}$ concentration was measured to be the same as outdoor $PM_{2.5}$ concentration. Figure 1 provides a summary of results, as per measured indoor environment parameters based on five concentration levels (AKA, design scenarios). The $PM_{2.5}$ concentration in each test was controlled within ±15% of the designed value. Curtains were always closed to block direct sunlight, and air temperatures of five design scenarios were kept at approximately 25 °C. The results show that CO_2 concentration started at approximately 600PPM and ended at 800–900PPM in each experiment. The illuminance on the desk was controlled at approximately 300 luminous flux per unit area (lux), and the A-weighting sound pressure was measured at 38–43 decibel level (dBA).

Particles are defined by their diameter3. Those with a diameter of 10 microns or less (PM_{10}) are inhalable into the lungs and can induce adverse health effects. Fine particulate matter is defined as particles that are 2.5 microns or less in diameter ($PM_{2.5}$). Particles such as dust mites, dander, and mold reduce the quality of the air, and need to be minimized, no more than 12 micrograms per cubic meter of air (μg/m³).[4 5] Regarding Relative Humidity (RH), at any given time it can be attributed to several factors, such as the design and construction of the building, type and quality of insulation, caulk-

Scenario ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	Temperature (°C)	RH (%)	Illuminance (lux)	Acoustic (dB)	Separate Measured	
						Low CO_2 (ppm)	High CO_2 (ppm)
10	10.6 (1.0)	24.9 (0.5)	44.6 (4.6.)	309 (23.5)	40.7 (3.7)	630 (86)	863 (123)
25	25.2 (1.4)	25.1 (0.6)	41.8 (5.2)	328 (34.5)	42.8 (3.7)	595 (38)	794 (58)
35	34.7 (1.8)	25.2 (0.5)	40.8 (3.4)	296 (25.0)	42.3 (5.3)	618 (40)	857 (98)
50	50.3 (1.6)	24.9 (0.5)	42.3 (3.3)	323 (26.3)	38.6 (3.1)	608 (102)	850 (41)
75	73.1 (2.2)	24.8 (0.7)	46.6 (6.1)	329 (24.0)	41.6 (3.3)	653 (76)	899 (56)

Figure 1: Measured indoor environment parameter at the center of the desk, per NIH study published in 2021 and titled "The Synergistic Effect of PM2.5 and CO_2 Concentrations on Occupant Satisfaction and Work Productivity in a Meeting Room."

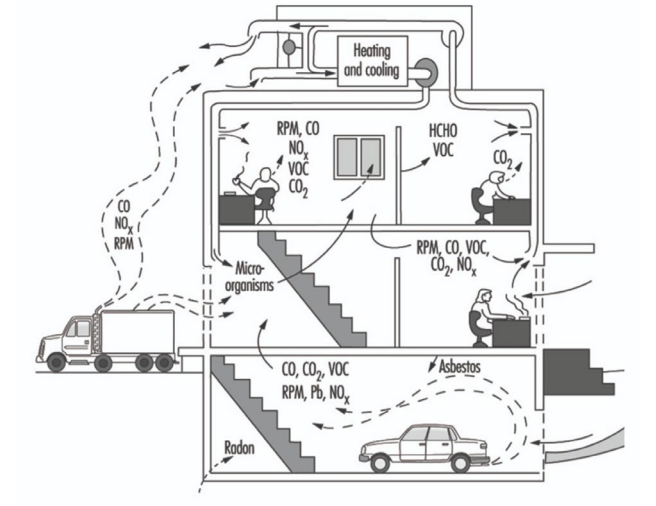

Figure 2: Diagram of building showing sources of indoor and outdoor pollutants.

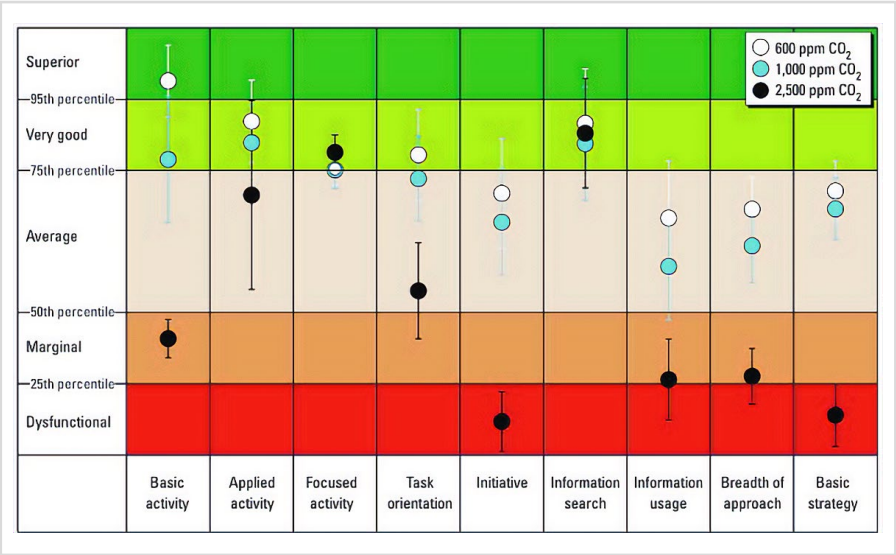

Figure 3: Impact of CO_2 on human decision-making performance. Error bars indicate one standard deviation.

ing, weatherstripping, and ventilation. RH should be kept between 40-60% to control mold growth and to promote overall wellness.[6] RH below 40% can cause discomfort and health problems associated with water loss in organs, especially the eyes and skin. This lower level of RH exposure can also reduce resistance to airborne pollution, respiratory infections, and allergies.

Volatile Organic Compounds (VOCs) are compounds that have a high vapor pressure and low water solubility. Examples include common industrial solvents, Trichloroethylene, Formaldehyde, Benzene, Toluene, Xylene, Styrene, Acetone, fuel oxygenates such as Methyl Tert- Butyl Ether (MTBE), and by-products produced by chlorination in water treatment, such as chloroform. The EPA[7] maximum guideline is 0.3 mg/m³.

Lighting levels, although not a direct indicator of air quality, have an impact on employee performance and wellbeing. According to a study published in 2019[8], lighting levels are the most important factor impacting employees after IAQ. For example, exposure to blue-enriched white light (17,000K) and white light (4000K) affect alertness and performance in an office setting during daytime work hours as well as cause evening fatigue.[9] By looking at trends over time, such as lighting unoccupied spaces, levels can also be used as a measurement to improve energy consumption.

In summary, the main sources of indoor air pollutants are VOCs, PM, and CO_2. Known data allows one to conclude that improvements in IoT sensor monitoring for elevated levels of CO_2 and of PM having average particle diameter of 2.5 microns ($PM_{2.5}$), along with improved measurement and control of ventilation rates can: a) reduce sick days by 35%, b) improve cognitive functioning[10] and productivity by up to 11%, and c) yield energy savings of up to 21%.[11]

The air quality in a building is a function of a series of variables which include: a) IAQ, b) design of the ventilation and air-conditioning system, c) conditions in which this system operates and is serviced, d) compartmentalization of the building, and e) presence of indoor sources of contaminants and their magnitude (See Figure 2). The most common IAQ failure modes are the result of inadequate ventilation, pollutants generated indoors, and pollutants coming from outside the building.[12] The causes of inadequate ventilation can include: a) an insufficient supply of fresh air due to a high level of recirculation of the air or a low volume of intake, b) incorrect placement and orientation in the building of intake points for outside air, and c) poor distribution and consequently incomplete mixing with the air of the workplace. The latter can produce stratification zones, unventilated zones, unforeseen pressure differences giving rise to unwanted air currents and continuous changes in the thermo-hygrometric characteristics noticeable as one moves about the building. Incorrect filtration of the air due to lack of maintenance or inadequate design of the filtering

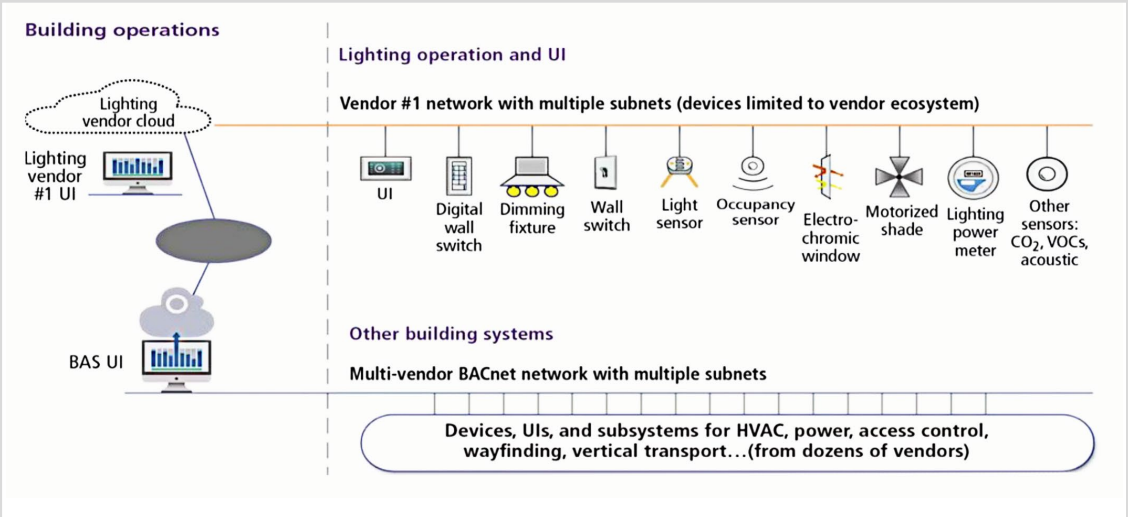

Figure 4: Typical BACS topology, where the IAQ sensor and other IoT sensors may have their own API, where the BAS utilizes BACnet to integrate multiple subnets over the network with a single control, monitoring, and alert interface to simplify the end-user scenario.

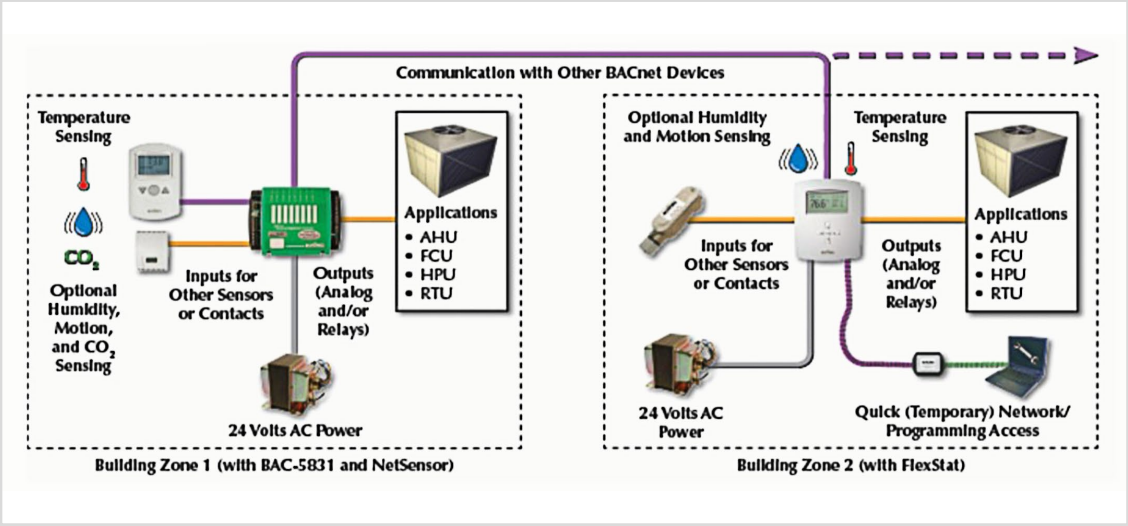

Figure 5: Example of an "all-in-one" BACS topology, where a controller and sensor in a single package provides a flexible solution to stand-alone control challenges or BACnet network challenges.

system, is a deficiency which is particularly serious where the outdoor air is of poor quality, or where there is a high level of recirculation within.

IAQ as Driver of Trends and Opportunities for BACS

Sophisticated owners and operators of commercial and institutional buildings have a clear and present understanding that IAQ monitoring, and remediation continues to increase in prominence as a primary driver of trends and opportunities in the Building Automation and Control Systems (BACS) sector. Demand drivers include and are not limited to emerging wellness protocols accelerated by the pandemic, and by In-Office vs. Hybrid-Workplace[13] decision vectors. Deployment of IoT sensors to continuously monitor CO_2 and VOC levels, humidity, air pressure, and other IAQ metrics delivers real-time IAQ data directly to your device.[14] These sensors enable tracking of trend data across all rooms, buildings, and sites, for highest situational awareness and building health. This approach to Integrated Facilities Management (IFM) can increase [15][16], and decrease expense. As a result, faster and more effective decision-making drives improvements in building efficiency, consumption of utilities, and in the wellbeing of all building occupants and visitors.

Figure 3 on the next page depicts percentile scoring on representative decision-making performance. The results segment decision-making performance per the following nine categories at the three CO_2 conditions[17] of: a) Basic Activity; b) Applied Activity; c) Focused Activity; d) Task Orientation; e) Initiative; f) Information Search; g) Information Usage; h) Breadth of Approach; and i) Basic Strategy. These categories are applied per percentile boundaries at five normative levels of performance: Superior, Very Good, Average, Marginal, and Dysfunctional. For example, Figure 3 shows that at 1,000 ppm CO_2 relative to 600 ppm, percentile ranks were moderately diminished. However, at 2,500 ppm CO_2, percentile ranks for five performance scales decreased to levels associated with marginal performance.

A recent survey reveals that 72% of office workers worldwide worry about the air quality comparisons across markets and facility types, including office buildings, hospitals, airports, schools, and hotels.[18] Of this total, 89% agree that the quality of air they breathe has a direct impact on their health and wellbeing, and 98% believe safe IAQ provides at least one health benefit: a) Better overall physical health (62%); b) Fewer allergies, less sneezing and coughing (60%); c) Less exposure to airborne contaminants (57%); d) Better overall mental health (53%); and e) Improved productivity and problem-solving (43%).

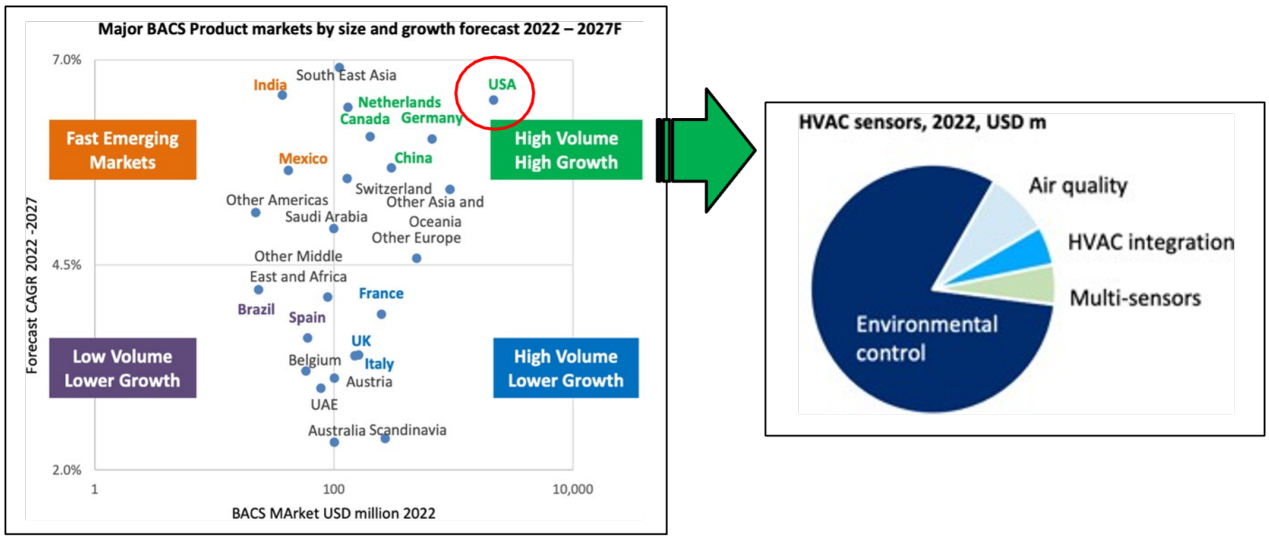

Figure 6: Multiple BACS markets show high volume high growth, with strong trend towards standalone control of HVAC, and an uptake of smart technologies in commercial buildings and other built environments.

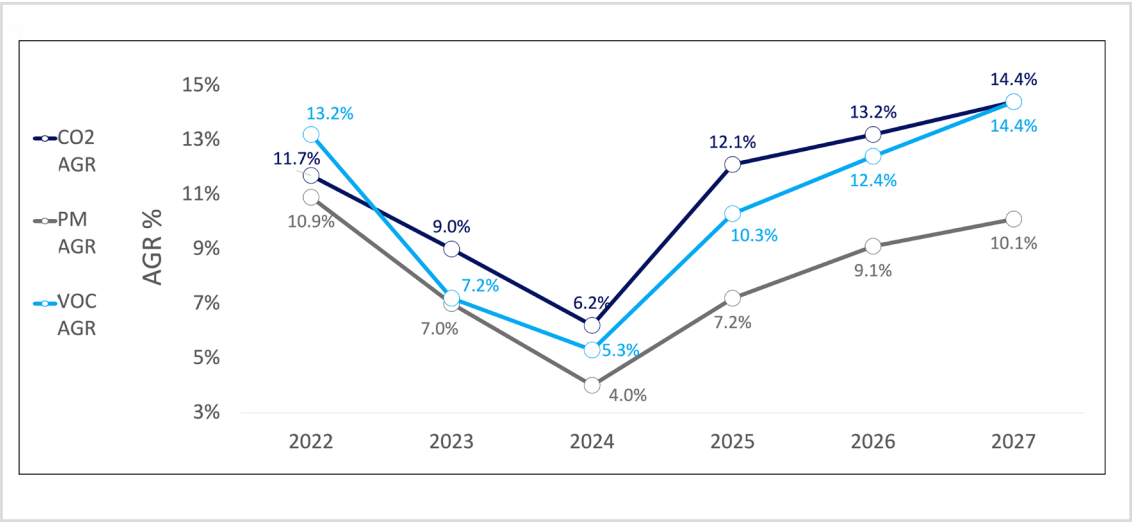

Figure 7: Sales of IAQ sensors for the 2022 – 2027 forecast period, value, AGR %.

IAQ Research Results in Offices, Classrooms, and Daycare Centers

The following studies were identified[19] that investigated linkages between ventilation rates and absence rates.

1. Studies performed in-**offices**:
   - Milton, D.K., P.M. Glencross, and M.D. Walters, Risk of sick leave associated with outdoor air supply rate, humidification, and occupant complaints. Indoor Air, 2000. 10(4): p. 212-21. https://dx.doi.org/10.1034/j.1600-0668.2000.010004212.x.
   - Mendell, M.J., et al., A longitudinal study of ventilation rates in California office buildings and self-reported occupant outcomes including respiratory illness absence. Building and Environment, 2015. 92: p. 292–304. https://dx.doi.org/10.1016/j.buildenv.2015.05.002.
   - Myatt, T.A., et al., A study of indoor carbon dioxide levels and sick leave among office workers. Environmental Health, 2002. 1(1): p. 3. https://dx.doi.org/10.1186/1476-069x-1-3.
2. Studies performed in-**elementary grade classrooms**:
   - Shendell, D.G., et al., Associations between classroom CO2 concentrations and student attendance in Washington and Idaho. Indoor Air, 2004. 14(5): p. 333-41. https://dx.doi.org/10.1111/j.1600-0668.2004.00251.x.
   - Mendell, M.J., et al., Association of classroom ventilation with reduced illness absence: a prospective study in California elementary schools. Indoor Air, 2013. 23(6): p. 515-528. https://dx.doi.org/10.1111/ina.12042.
   - Gaihre, S., et al., Classroom carbon dioxide concentration, school attendance, and educational attainment. J Sch Health, 2014. 84(9): p. 569-74. https://dx.doi.org/10.1111/josh.12183.
   - Haverinen-Shaughnessy, U., et al., An assessment of indoor environmental quality in schools and its association with health and performance. Building and Environment, 2015. https://dx.doi.org/10.1016/j.buildenv.2015.03.006.
3. Study in-**daycare centers**: This assessed ventilation and absence. Kolarik, B., et al., Ventilation in day care centers and sick leave among nursery children. Indoor Air, 2016. 26(2): p. 157-167. https://dx.doi.org/10.1111/ina.12202

Most of these studies tracked absences over a period of a full year or more, and one of these studies also monitored ventilation rates over the full period. Among the three studies in offices only one [1a] found a statistically significant increase in absence with lower ventilation rates. In this study, a 35% decrease in short term absence was associated with a doubling of ventilation rate from 25 to 50 cfm (12 to 24 L/s) per person, corresponding to a 1.4% decrease in absence per 1 cfm (0.47 L/s) per person increase in ventilation rate.

The two other studies in offices had high ventilation rates which might explain the lack of associations. In one study [1c], weekly mean worktime CO_2 concentrations were only 37 to 250 ppm above outdoor air CO_2 concentrations indicating very high ventilation rates. For reference, some ventilation standards recommend ventilation rates that maintain indoor CO_2 concentrations no more than about 700 ppm above the outdoor air CO_2 concentration. The second study reported very high ventilation rates, mostly between 34 and 90 cfm per occupant (16 and 42 L/s per occupant). If the association observed is causal, an economic analysis shows that the additional cost of delivering outdoor air to workers would be more than offset by the savings from reduced sick leave, particularly in the highly paid corporate environment studied.[20] At the time of this study there was assumed that 93.5 million full-time workers in the US were provided recommended ventilation rates, so the estimated lost productivity was determined to be $22.8 billion, and therefore $15.3 billion in net savings per year could be obtained.

Among the five studies from schools or daycare buildings, four found statistically significant decreases in absence rates with more ventilation or lower carbon dioxide concentrations. One study, which followed 162 classrooms for two years [2b], found a 1.6% decrease in absence for each 2 cfm (1 L/s) per person increase in ventilation rate. Because ventilation rates in most classrooms can be increased by at least several cfm (a few L/s) per person, the study indicates a potential to reduce absence by several percent.

A second classroom study [2a], reported a 1% to 2% relative decrease in the absence rate for each 100 ppm decrease in the difference between indoor and outdoor CO_2 concentrations. A third classroom study [2c] reported that absence increased by 0.4 days per year for each 100 ppm increase in time average indoor CO_2 concentration.

In the study of day care centers [3] there was a statistically significant 12% decrease in sick leave per each 1 h-1 increase in air exchange rate. There was also a 2% increase in sick leave per each 100 ppm increase in indoor CO_2 concentration, but the association was not statistically significant. Overall, the available research indicates that increased ventilation rates in

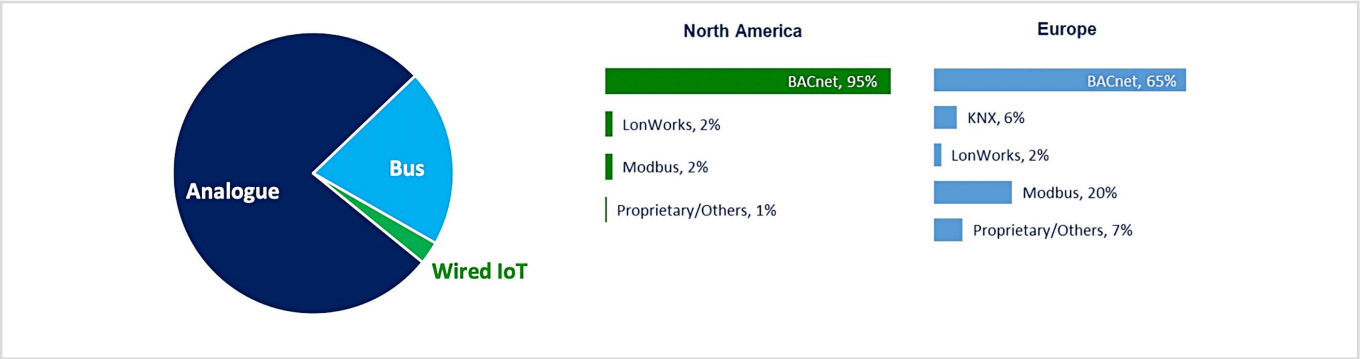

Figure 8: US wired sensors by protocol, share by value, in the 2022 forecast period.

classrooms are associated with reduced student absence. For elementary and middle school students, reduced student absence has been shown to be associated with higher grade point averages and higher scores in academic achievement tests.[21]

In offices, even very small decreases in absence rates from increases in ventilation rates would be financially significant.[22] In some school districts, income from government sources are linked to days of student attendance; thus, increased ventilation rates may increase school district income.

IAQ Integrations to BACS

How does one integrate a real-time IAQ data resident in the cloud within a BAS?

Figure 4 depicts a typical topology, where the BAS provides an Application Programming Interface (API) to integrate with a cloud-based building operations platform. Doing so creates a single-point cloud connection to the building, which is more secure, simpler, and cheaper to manage, providing great benefit to the building owner.[23] In general, the cloud has removed limitations imposed by on-site networking. Traditional integration of an IAQ sensor with a BAS would require a series of network links from the BAS to the IAQ sensor. IoT sensors for IAQ break the networking restrictions of this framework, as they connect to an off-site Cloud Core either directly, or through an intermediary gateway device. Traditional integration of an Input/Output (I/O) module with a BAS requires a series of network links from the BAS to the I/O module location. For wired networks, network cabling would need to be installed to ensure a contiguous network path that extends from the BAS to the I/O module. For example, RS-485 network wiring can be installed between a gateway device and a Modbus I/O module location.

Wireless I/O modules do not alter the fundamental requirement of on-site networking. For wireless I/O modules, a wireless network link (e.g., Zigbee) would simply replace a network cable as the wireless I/O module connects to a wireless gateway device. A conventional wired network from the wireless gateway device to the BAS would then complete the integration of the wireless I/O module. In either case, conventional on-site networking topology would be preserved.

There are many possible building automation solutions - from a single space to multiple zones in a building. For example, Figure 5 depicts an "all-in-one" BACS topology, where a controller and sensor in a single package provides a flexible solution to stand-alone control challenges or BACnet network challenges. Temperature sensing is standard with optional humidity and motion sensing. Flexible input and output configurations and built-in or custom programming ensures that a variety of HVAC application needs can be met.[24] IoT I/O modules break the networking restrictions of this framework. IoT I/O modules would connect to an off-site cloud core either directly or through an intermediary gateway device. From the cloud, connectivity to the BAS can be implemented at any point in the BAS network. For example, with an IoT thermostat installed in a remote part of a building or campus: a) The IoT thermostat would establish a WAN connection to the cloud for delivery of sensor data (e.g., Temperature, Humidity, CO_2, etc.) and for receipt of control commands (e.g., setpoint changes); and b) The cloud can then present a virtual I/O interface of the IoT thermostat to a centralized BAS at any part of the network in that building, or even in another building. This would obviate the need for potentially complex on-site networking using wired and/or wireless network links.

Market Statistics

The BACS market consists of revenues earned by entities providing services such as design and engineering, installation and commissioning, maintenance and support, monitoring and optimization, and consulting and training. The global BACS market is expected to grow from $81.30 billion in 2022 to $90.28 billion in 2023 at a Compound Annual Growth Rate (CAGR) of 11.06%. The building automation system market is expected to reach $141.34 billion in 2027 at a CAGR of 11.86%.[25] Figure 6 depicts how North America was the largest region in 2022 in the forecast period, and that Asia-Pacific is expected to be the fastest- growing region. A US field device study conducted in 2022 shows a $500m market for sensors – please refer to the right- side of Figure 6 above. The pandemic boosted sales of IAQ sensors – forecast is for high single- digit growth rates, as shown in Figure 7. Regarding Connectivity, Figure 8 shown that as of 2022 Analogue were estimated to occupy 75% of the market share, and BUS sensors were estimated to occupy 21% of the market share. IoT sensors are a small but growing segment, with wireless used when wired was not possible.

Conclusions

IAQ in a building is a function of a series of variables which include the quality of the outdoor air, the design of the ventilation and air-conditioning system, the conditions in which this system operates and is serviced, the compartmentalization of the building and the presence of indoor sources of contaminants and their magnitude. IAQ impacts occupant satisfaction and workplace productivity. The main sources of indoor air pollutants are VOCs, PM, and CO_2. Elevated levels of CO_2 and $PM_{2.5}$, along with improved measurement and control of ventilation rates can: a) Reduce sick days, b) Improve cognitive functioning and productivity, and c) Yield energy savings. The market for these integrated sensor solutions in the US was estimated at $500M in 2022. The forecast through 2027 is for high single-digit growth rates. The global BACS market is expected to grow from $81.30 billion in 2022 to reach $141.34 billion in 2027 at a CAGR of 11.86%. Sophisticated owners and operators of commercial and institutional buildings therefore have a clear and present understanding that IAQ monitoring, and remediation continues to increase in prominence as a primary driver of trends and opportunities in the BACS sector.

[1] https://www.infogrid.io/blog/how-to-improve-indoor-air-quality-in-the-workplace

[2] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8069632/#:~:text=Under%20the%20conditions%20of%20natural,the%20outdoor%20PM2.5% 20concentration.

[3] https://www.epa.gov/pm-pollution/particulate-matter-pm-basics

[4] https://www.epa.gov/pm-pollution/setting-and-reviewing-standards-control-particulate-matter-pm-pollution

[5] https://www.epa.gov/pm-pollution/setting-and-reviewing-standards-control-particulate-matter-pm-pollution

[6] https://www.epa.gov/mold/mold-course-chapter- 2#:~:text=Sometimes%2C%20humidity%20or%20dampness%20(water,as%20cockroaches)%20and%20dust%20mites. 7 https://tsi.com/microsites/ieq/resources/blog/may-2023/a-guide-on-volatile-organic-compounds-(vocs)/#:~:text=The%20U.S.%20Environmental%20Protection%20Agency,total%20VOCs%20in%20indoor%20air.

[8] https://view.com/sites/default/files/documents/workplace-wellness-study.pdf and https://www.bayes.city.ac.uk/ data/assets/pdf_file/0004/363217/lighting-work-performance-cass.pdf

[9] https://pubmed.ncbi.nlm.nih.gov/18815716/

[10] https://thecogfxstudy.com/study-3/findings-and-results/

[11] https://iaqscience.lbl.gov/human-performance-topics and https://www.workdesign.com/2020/01/higher-productivity-out-of-thin-air/#:~:text=According%20to%20the%20Environmental%20Protection,by%20up%20to%2011%20percent and https://www.hsph.harvard.edu/news/press-releases/green-office-environments-linked-with-higher-cognitive-function-scores/ and https://iaqscience.lbl.gov/ventilation-rates-and-absences-offices-and-schools

[12] https://www.iloencyclopaedia.org/part-vi-16255/indoor-air-quality/item/517-indoor-air-quality-introduction#AIR_fig2

[13] https://www.tridium.com/content/dam/tridium/en/documents/niagara-forum-2023/NF23-Plenary-BSRIA.pdf:

[14] https://buildequinox.com/files/iaq/milton_vent_sick_rates.pdf

[15] https://electricresults.com.au/bms

[16] https://www.nist.gov/system/files/documents/2021/10/29/38- Building%20Cyber%20Security%20%28BCS%29%20Status%20October%202021.pdf

[17] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3548274/table/t2/

[18] https://www.honeywell.com/us/en/press/2022/02/honeywell-survey-reveals-72-of-office-workers-worldwide-worry-about-air-quality-in- their-buildings

[19] https://iaqscience.lbl.gov/ventilation-rates-and-absences-offices-and-schools#_ENREF_8

[20] https://buildequinox.com/files/iaq/milton_vent_sick_rates.pdf

[21] https://iaqscience.lbl.gov/ventilation-rates-and-absences-offices-and-schools#_ENREF_9

[22] https://iaqscience.lbl.gov/human-performance-topics

[23] https://www.ledsmagazine.com/connected-ssl-controls/article/14209985/bacnet-provides-an-ideal-smart-building-backbone-magazine

[24] http://www.kmccontrols.com.hk/products/smallbuildingautomation.html

[25] https://www.researchandmarkets.com/reports/5820129/building-automation-system-global-market-report?utm_source=CI&utm_medium=PressRelease&utm_code=sq6g5j&utm_campaign=1861954+-+Global+Building+Automation+System+Market+Report+2023%3a+Increasing+Construction+Activities+Boosts+Growth&utm_exec=jamu273prd

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Ari Reubin
SVP of KMC Consulting, a division of KMC Controls | KMC Consulting
AReubin@kmccontrols.com | www.kmccontrols.com

© Baird

JJ Baird
Director of Strategic Partnerships at Airthings | Airthings
jj.baird@airthings.com | www.airthings.com/en

ABOUT THE AUTHOR

Ari Reubin serves as SVP of KMC Consulting, a division of KMC Controls. Ari has a proven track record in supporting business processes to solve for targeted outcomes. He has expertise in meta-data analytics, artificial intelligence, sensor arrays, business process improvement, change management, manufacturing, and university research to achieve capabilities that improve the sense of safety and well-being for people in all known built environments and workplaces.

JJ is passionate about helping the world breathe better. In his role at Airthings, he collaborates with the brightest minds of the most highly respected entities in government, institutional, and corporate workplace to integrate his patented IoT sensors with building management systems. Additionally, he has subject matter expertise to aggregate resulting data onto relative and predictive dashboard so that decision makers can maintain highest situational awareness.

Exploring Integration Opportunities with Airflow Measurement Stations

The increasing requirement for intelligent cities and energy-efficient facilities with enhanced security systems fuels the Building Automation Systems (BAS) industry. The global BAS market size was valued at USD 86.8 billion in 2022, and it is projected to reach USD 148.6 billion by 2027, growing at a compound annual growth rate (CAGR) of 11.4%.1

Thermal dispersion airflow measurement stations with BACnet communication protocols address the industry's need for data integration and operational transparency. Advanced BAS systems use extracted data for decision-making, trend analysis, interoperability, and issue resolution. The advantage of using a BACnet airflow sensor is that it allows for more actionable data with the option of using analog for the local controller.

TABLE F-2 BACnet Object List

ⓘ BACnet MS/TP, BACnet IP, and BACnet Ethernet specific network object table. All objects are conditionally available based on the connected sensors and transmitter type.

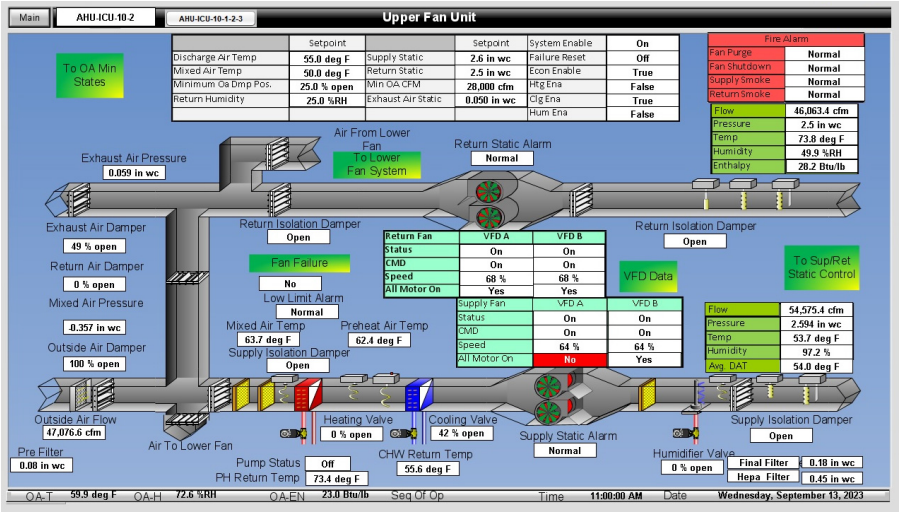
	Type, ID	Name	Product Line	Probe Type	Special Criteria	Units	Writeable Properties	Restrictions/Ranges
DEVICE	Device, 2	(Product Name)	All	All			Object Name	< 22 characters
							Description	< 22 characters
							Location	Populated from transmitter NAME
							Object Identifier	< 4,194,303
							APDU Timeout	< 65535
							Max Master	≤ 127
							Max Info Frames	≤ 255
ANALOG INPUTS	AI, 1	AMD[-1] Airflow	All	All		FPM, CFM [m/s, L/s]	COV Increment	> 0
							Out of Service	Set out-of-service to write present value
							Present Value	
							Units	FPM, CFM [m/s, L/s]
	AI, 2	AMD[-1] Temperature	All	All		°F [°C]	COV Increment	> 0
							Out of Service	Set out-of-service to write present value
							Present Value	
							Units	°F [°C]
	AI, 3	AMD Pressure	All	-B		iWG [Pa]	COV Increment	> 0
							Out of Service	Set out-of-service to write present value
							Present Value	
							Units	iWG [Pa]
	AI, 4	AMD Alarm Status	All	All			Out of Service	Set Out of Service to write present value
							Present Value	0=No Alarm, 1=High Alarm, 2= Low Alarm, 3=Both
	AI, 5	AMD Fan Alarm Status	Advantage IV	-F/An			Out of Service	Set Out of Service to write present value
							Present Value	0=No alarm, 1=Alarm
	AI, 11	AMD-2 Airflow	All	-P, -U, -T, -F	Dual location		COV Increment	> 0
							Out of Service	Set out-of-service to write present value
							Present Value	
							Units	FPM, CFM [m/s, L/s]
	AI, 12	AMD-2 Temperature	All	-P, -U, -T, -F	Dual location		COV Increment	> 0
							Out of Service	Set out-of-service to write present value
							Present Value	
							Units	°F [°C]

Integrating airflow data into the BAS provides the flexibility to control, monitor, and trend historical events for outside air, supply and return air, and exhaust systems. Thermal dispersion offers advantages over other technologies, such as inherent temperature measurement, multiple measurement points, and shorter distances from disturbances. System integrators can fully utilize airflow measurement station data with built-in BACnet digital communication protocols for monitoring and system control. There are also application-specific advantages, like the fan array, where you can individually measure the flow and control each fan independently. The system integrator uses industry software to execute all necessary field device setups, monitor, and control connected devices, reducing commissioning time and eliminating errors.

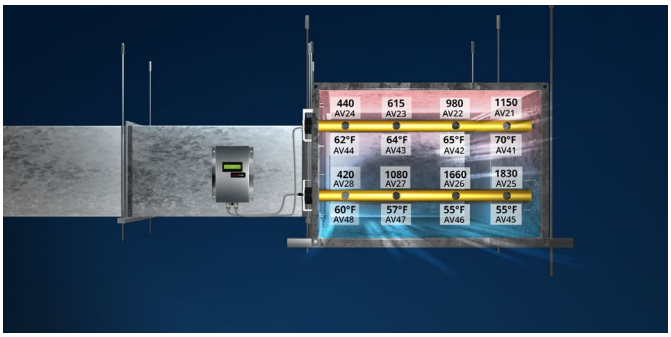
Facility managers and operators gain valuable equipment operation and performance insights without leaving their desks. Access to all device data enables timely fault detection and aids in diagnostics. The BTL-certified device "Protocol Implementation Conformance Statement," or "PICS," lists and describes the airflow measurement station functionality of the product: example shown above, Table F-2. PICs are available from BACnet International or the manufacturer's website. During the initial BAS setup, obtaining granular airflow information is possible with individual sensing node data points. Monitoring every node offers several advantages for efficiency, control, and optimization as the controller will compensate for airflow changes. For instance, if the airflow decreases, the fan will automatically increase to maintain the rate. This declining trend can lead to a continuous increase in fan speed over time, using more energy without understanding the reason for the decline. With individual sensor node data, you can evaluate the airflow profiles and trends of the decline, evaluate potential causes, and take action to resolve the problem. It could be anything from damage to a damper blade, rag in the damper on the sensor node, mechanical failure, dirty filters, fouling or heat exchangers, etc.

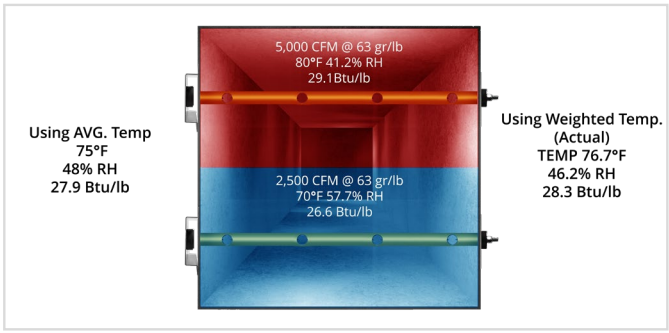
Integrators often use only average outputs to simplify information exchange, as shown in the image above: Example of Typical Average Outputs. However, more detail is valuable for operational efficiency, fault detection, energy usage, maintenance management, and problem-solving. You can have up to 16 sensor nodes, each with individual values. Within the PIC statement, each value noted for each sensor node: AV 21, AV 22, AV 23, AV 24, AV 25, AV 26, etc., provides real-time point temperature and airflow rate values. You can create a visual profile model of thermal and flow with the individual points. Since the system temperatures and flow rates are often changing, trends in performance can be recorded in more detail.

By setting up the system to request sensor node values via BACnet, you can monitor individual nodes and still control them by the average mea-



Example of Typical Average Outputs





sured value. The probe's sensor nodes provide an airflow and temperature measurement with NIST traceable calibration capable of communicating information with the BAS or Cloud monitoring system—multiple sensing points to produce more accurate velocity and temperature measurements. Adding optional humidity sensing provides control based on relative humidity, dew point, or enthalpy. Using this technology in converging airstreams or across energy-exchanging components can provide energy performance insight and act as an airside energy meter. The relative humidity and enthalpy can be more accurately calculated with multiple temperature and flow measuring points. The example image below could represent an outdoor air intake where the sun impacts the temperature in an upper hood. Alternatively, it could be a convergence of two airstreams or downstream of a split 2-stage cooling coil common in RTUs—having more data results in better control decisions for energy efficiency.

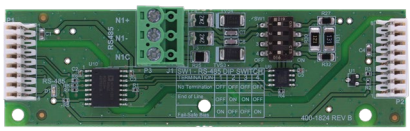
Using BACnet fosters a culture of data collection, leading to improved insight into buildings' airflow system operation. Analyzing data and system performance over time helps detect maintenance issues, schedule diagnostics, and identify faults, making buildings smarter.

Facility managers, service technicians, 3rd party data management, TAB, and Commissioning agents, to name a few, can use networked field devices to troubleshoot or adjust parameters. The system-level controllers can read airflow measurement device performance data to make HVAC equipment more efficient. A well-integrated BAS can analyze historical airflow data, identifying patterns that hint at potential issues. Proactive maintenance becomes a reality, preventing costly downtimes and enhancing system longevity. BAS integration via BACnet allows for customized airflow adjustments based on occupancy and improved scheduling. This dynamic control ensures occupant comfort while conserving energy. Standardized communication facilitates smoother data exchange between airflow measurement stations and the BAS. Integrating airflow device data enables enhanced operational insight and management.

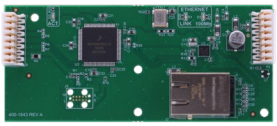
Digital communicating airflow measurement stations feature standard analog outputs and field configured 0-5/0-10 VDC or 4-20mA for flow, temperature, or alarm. Low flow alarms can be field set and enabled. Airflow measurement systems with optional BACnet MS/TP, BACnet Ethernet / IP network cards provide more flexibility, allowing local control via analog and a separate data channel for monitoring and trending, parameter changes, overrides, alarms, etc.

An app can display the sensor system's operation locally and provide additional information on settings, individual node values, and other diagnostic data.

Airflow Measurement Stations' seamless integration with BACnet presents opportunities to revolutionize how building environments are managed. Data from various airflow measurement stations can be provided through BACnet to many different platforms used to improve building operations. By navigating the challenges and leveraging the opportunities offered by this integration, we can create and manage indoor environments for a sustainable future.



BACnet® MS/TP



BACnet® Ethernet, BACnet® IP

Bluetooth® Interface App – Data at the Touch of Your Finger™

Reference

1 Building Automation System Market Trends & Growth Drivers | MarketsandMarkets

ABOUT THE AUTHOR

Darryl DeAngelis is the Director of Business Development for EBTRON, with over 30 years of experience in the HVAC industry. He holds a B.S. in Marine Engineering from the Massachusetts Maritime Academy and is a LEED AP. A 20-year ASHRAE member is active in ASHRAE technical and standard committees, including 11, 62.1, 90.1, 180, and 207. He is chair of TC 7.7 Testing and Balancing and a voting member 62.1 Ventilation subcommittee. Darryl is a participating voting member in ASTM and a member of ISIAQ and I2SL. Darryl holds four HVAC-related patents.

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Darryl DeAngelis
Director of Business Development | EBTRON
DarrylD@EBTRON.com | www.ebtron.com

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Establishing an Autonomous Building Industry Standard

Buildings are the most complex controlled infrastructure in the world, yet they still use outdated technology and building management systems that waste energy. Consequently, buildings account for more than **40% of the world's energy resource usage.**

The solution that the industry has developed to correct this is smart buildings. However, today's "smart buildings" are not actually smart; at best, they are just "connected." They are raw platforms that employ a patchwork of tools, such as simplistic relay logic, emulated thermostatics, "if-else" programming, and model-free PID control to hard-code static operation sequences. Depending on their size and complexity, buildings have anywhere from billions to quadrillions of potential states only one of which is optimal at any given moment. Therefore, the required number of programmed sequences to achieve optimal control of any building under all potential conditions provably exceeds the capacities and abilities of even the most skilled and experienced engineers with the largest budgets. In computer science, we call this kind of problem an intractable problem.

In recent years, cloud-based analytics-driven solutions have emerged to tune existing site-based procedural controls, but they have done nothing to address the larger intractable state space problem. Stuck using the same hard-coded simplistic operation sequences, building automation systems have not possessed the means to resolve the real-time dynamic control demands of the state space complexity required by real-world building systems, occupants, and the internal and external environment. Building controls therefore rarely find the right control path at the right time, let alone achieve operational optimality.

Autonomous Buildings are the Real Smart Buildings

The buildings industry presents the best opportunity for applying an autonomous platform because buildings are the largest controlled infrastructure in the world economy. They are also the most complex. A typical commercial building has thousands of sensors and hundreds of control points. When we add in complex dynamics like occupancy, weather, and equipment variance, a simple state analysis shows that the typical building has trillions of possible states. This is well beyond the complexity of other industries.

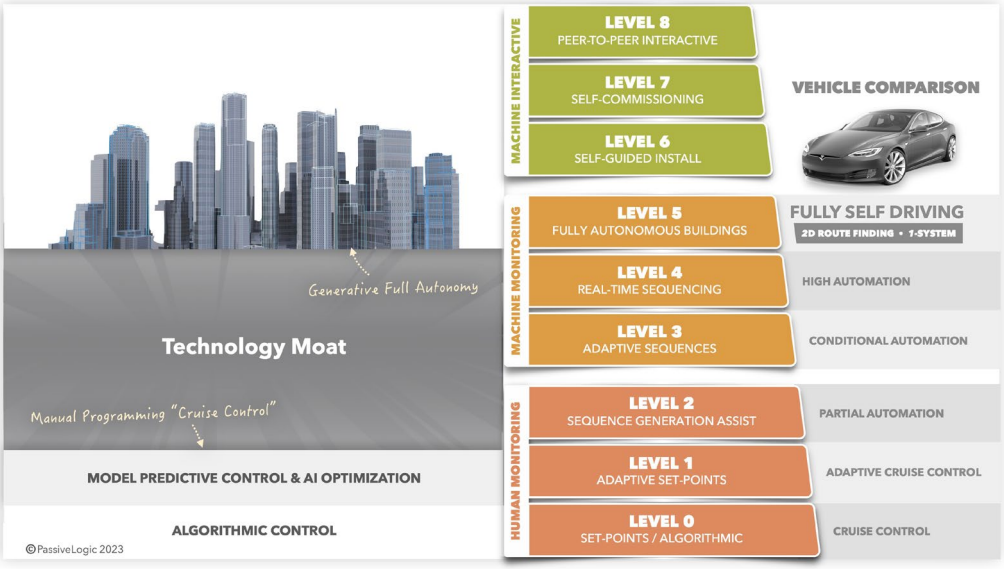
They also present a unique autonomy challenge as no two buildings are the same. Even when built by the same company and using the same materials, each building is in a different location and has fundamentally different orientations, topologies, and softwares. Whereas an autonomous car can use the same technology in every subsequent car, buildings each need to be individually designed and commissioned.

Fully autonomous buildings, however, develop their own control sequences in response to changing conditions. They're not based on static sequences, set-points, PID, or simple state machines. They understand their own underlying physics of operation and generate continuous control paths. They can introspect those same physics and provide deep insights or more importantly, analysis. This can be used to automate the commissioning and optimization of systems.

Fully autonomous building systems are aware of the future implications of their control decisions, enabling them to navigate around system "collisions" or energy "congestion" hours before it even occurs. This future-forward control is uniquely possible because autonomous buildings have accurate prediction horizons of many hours, or even days (in contrast to the mere seconds that vehicle systems have to work with).
Furthermore, autonomous buildings cooperate. Because buildings are the primary building-blocks of cities, you can't have smart cities without having truly smart buildings. Autonomous buildings will act as agents in energy networks, buying and selling energy futures using smart contracts, working with utilities and district systems, and ultimately building the backbone for future peer-to-peer grids.

The Levels of Autonomy

If we as an industry want wide-scale adoption of truly intelligent, autonomous buildings that are solving longstanding market problems, then we need to provide clarity for what autonomy means when communicating with our customers and the public.



The automation industry was conceived in the legacy of the First Industrial Revolution. The basic control loop, typified by the mercury switch thermostat, still lives on as an emblem of the ingenuity of this early 19th-century paradigm shift. In fact, the senior statesmen of our industry were all born out of this early era.

As our industry transitions beyond thermostatics to newer technologies like autonomous systems, AI, and distributed IoT, new terminology is required. As anyone operating in the space of "smarter" systems can attest, the building automation industry's lack of a clear lexicon is becoming a barrier to communication.

In the early 2000s, the automotive industry faced a similar communication challenge. The Society of Automotive Engineers (SAE) came together in 2014 to establish a common taxonomy and terminology for autonomous driving systems. This standard charted the course from conventional First Industrial Revolution vehicle technology to the future of fully autonomous vehicles with defined thresholds for each level of autonomy, from level 0 to level 5.

With clear definitions charting a technological path forward, the autonomous vehicles market has thrived with technological development, architectural evolution, customer identity, market investment, and cultural interest. It helped remove conflicting thoughts on what autonomous means and misleading claims about how autonomous the vehicles actually are.

I have a proposal. Let's apply the automotive industry's taxonomy to the buildings industry.

If we translate the six levels of autonomy from the SAE Autonomous Vehicles standard and add three more to reflect the different levels of autonomy possible in buildings, we can have our own autonomous building industry standard. The three additional levels are possible due to a key difference between buildings and vehicles: Every vehicle produced is essentially identical, whereas every building project is unique. We have the opportunity to automate the design, installation, and communications between autonomous buildings in smart grid networks. Our proposed taxonomy, including Levels 6–8 that go beyond the Autonomous Vehicles Standard, is defined below.

Level 0 – Set points/Thermostatics: Conventional set-point or proportional control. It is directly analogous to vehicle cruise control and the historical building industry approach.

Level 1 – Adaptive set-points: The system adaptively adjusts set points of otherwise static manual sequences, set-points, and/or PID control. This is directly analogous to an automobile's adaptive cruise control. For buildings, this is often done off-site, in the cloud, leaving the system error-prone and dependent on network connectivity.

Level 2 – Sequence generation assist: In addition to adaptive set points, the control system assists in generating the system sequences. The sequences are still static, though they may cover a larger state space than conventional control programming. This is analogous to driver-assist in the vehicle market.

Level 3 – Adaptive sequences: At this level, in addition to automated sequence generation, the system can adapt its control sequences during operation. The calculations to generate the adapted sequences are slow, meaning it is impractical to use this academic approach in real buildings. This is analogous to the SAE conditional automation level.

Level 4 – Real-time sequencing: The system no longer uses set-points or proportional reactive control. Instead, building control uses continuous paths. Sequences are generated in real-time, at the edge, addressing the problems of resiliency faced by cloud control solutions. This is analogous to the SAE high automation level.

Level 5 – Full autonomy: Buildings that self-optimize using adaptive real-time sequencing compare future outcomes of different control schemes are introspective about their own operation, automatically analyze the building's behavior, and continuously adapt to their environment. This level is analogous to fully autonomous vehicles.

Level 6 – Self-guided install: This level utilizes the underlying intelligence of Level 5 autonomy, and the introspection of its own physics and interconnectivity, to guide the installer through the installation process, assessing errors and providing installation guarantees based on the system design goals and/or engineering plans.

Level 7 – Self-commissioning: This level utilizes the automation system's own understanding of the building and mechanical system's physics to self-commission, validate the interconnectivity of equipment and zone-sensor interactions,

and automate point mapping. Level 7 autonomy enables system guarantees for architectural, engineering, or energy design intent.

Level 8 – Peer-to-peer interactive: This is the pinnacle of fully autonomous buildings. Buildings can act as real-time agents in smart city networks. Given a common interface and self-validating smart contracts, buildings can operate as free-market actors on behalf of their owners. These fully autonomous buildings enable real-time demand response, district energy systems, and peer-to-peer decentralized grids.

As we develop a language to discuss the future of our industry together, including the future of the control systems, and the buildings we interact with we will start to chart a course to designing buildings that are truly "smart."

Charting a Path to the Future

Today, the market is stuck at Level 0 and Level 1 solutions. We need a paradigm shift in the industry and to educate the market on how we control the built environment if we want autonomy as the future for all controlled systems.

The simple fact of the matter is this: The autonomous future cannot be achieved on the outdated foundation of current building control systems, much like how fully autonomous vehicles will never happen by tweaking cruise control.

This is where the smart buildings fall short, as they are all attempting to build upon the past foundation. Tackling the problem via this route eliminates the possibility of reaching any farther than Level 1 autonomy because the foundational models of the past 100 years are incapable of accurately modeling the extreme complexity of buildings. We can tack on bandaid solutions like a digital cloud or analytics platform to make small improvements, but ultimately it is not the most effective path for technological growth, nor one that can lead to full autonomy.

Enabling the future of truly autonomous buildings is only possible by establishing a new technology foundation based on deep digital twins a composable system model that fully describes the underlying physics of the elements of a controlled system, including portfolios, buildings, systems, equipment, components, media, materials, occupants, and environmental conditions.

Digital twins that form a structured data graph of all these system components enable full autonomy by providing the required building blocks to describe systems that can intuit their own control and operation. Unlike the past which has been defined by reactive control, the future will be defined by autonomy. This new deep digital twin foundation is required to unlock the road ahead towards full autonomy.

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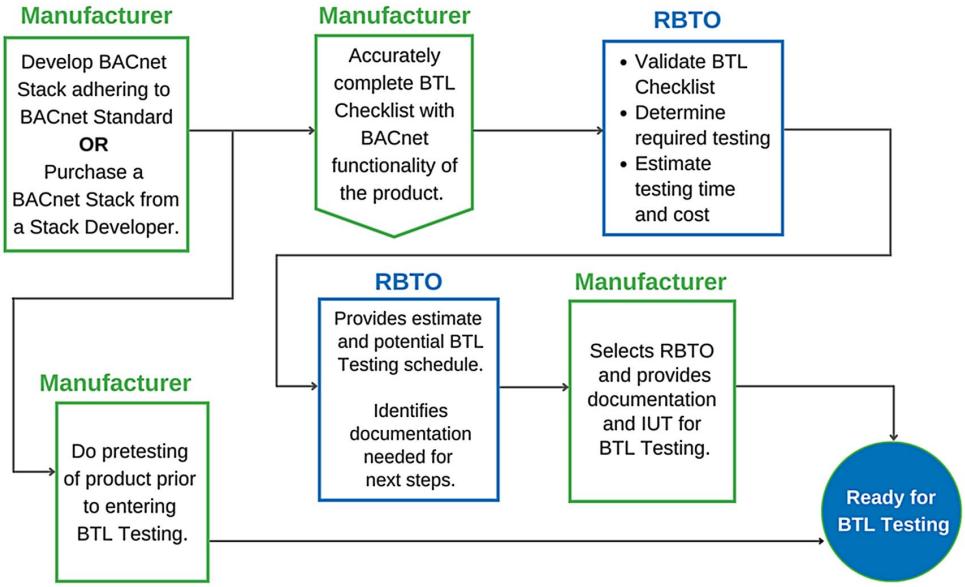
Troy Harvey
CEO and Founder | PassiveLogic
troy@passivelogic.com | www.PassiveLogic.com

ABOUT THE AUTHOR

Troy Harvey is the CEO and founder of PassiveLogic, the first platform for generative autonomy. As product architect, Troy has been the driving force behind the vision of the PassiveLogic platform since its inception, guiding the direction of each piece of the ecosystem through a systems-oriented approach. This includes the development of the Quantum digital twin standard – a physics-based ontology for next-generation control and AI that provides the foundation for autonomous systems. Troy is driven by a vision for a sustainable future, which stems from 20 years of experience enabling energy efficient buildings: an unmatched opportunity for lasting global impact.

The Benefits of Utilizing Pre-Testing Tools



Many manufacturers and end-users are aware of the numerous benefits the BACnet Testing Laboratories (BTL) Testing and Certification programs offers. Products that are BTL Certified provide users with the confidence that a product has passed the industry standard BACnet conformance tests conducted by a Recognized BACnet Testing Organization (RBTO). The advantages of BTL Certification can include lower integration cost, less integration risk, improved product quality and performance, and greater buyer confidence and opportunity to bid. Currently, there are over 1,300 BTL Listed products that have successfully completed testing and certification. These products can be found in the online BTL Listing Database: https://www.bacnetinternational.net/btl/

Before BACnet products can successfully complete BTL Certification and gain the right to use the BTL Mark, they have to pass compliance testing against the appropriate test package developed by the BTL Working Group. While getting a product tested is a worthwhile investment for manufacturers, time and cost are certainly factors that must be taken under consideration.

BTL Testing is designated for compliance rather than development. When development errors are discovered during testing, the process can be delayed, resulting in the device spending additional costly hours in the RBTOs lab. To potentially save time and money during testing, BTL strongly encourages manufacturers to take advantage of the wide-range of pre-testing tools that focus on the development of BACnet products. "It has been found that when the manufacturer performs pre-testing prior to submitting their device for BTL Testing, the issues that are found are limited, thus saving testing cost and expediting testing time," states Rich Ruel, Testing Services Manager for the BTL Lab. Additionally, the BTL Test Package, used by all RBTOs for BTL Testing, is available to developers for their own internal pre-testing.

"Besides saving time and money during conformance testing, manufacturers are required to extensively pre-test their products prior to submission to an RBTO. The RBTO is not a quality assurance lab. Products need to be ready for market when submitted," states Emily Hayes, BTL Manager.

A list of third-party pre-testing tools can be found at btl.org/pre-testing-tools. The types of pre-testing tools include Test Frameworks, BACnet Client Software, BACnet Protocol Analyzers, BACnet Device Simulators, General Tools, Reference BACnet Routers and Reference BACnet MS/TP Masters. These lists are provided as a convenience only. They represent a sampling of available resources and are not intended to be complete. No recommendation, endorsement or any form of warranty is implied or provided by BTL or BACnet International for any of the items in these lists.

For more information about pre-testing tools and additional testing resources, visit btl.org/testing-resources.

ABOUT THE AUTHOR

Mary Catherine Heard joined BACnet International in 2022 bringing a decade of marketing experience that includes website management, email marketing, social media, copywriting, and graphic design. Prior to joining BACnet International, she worked in the auto industry and state government.

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Mary Catherine Heard
Communications Manager | BACnet International
marycatherine@bacnetinternational.org | www.bacnetinternational.org

Riding the Time of Climate Change

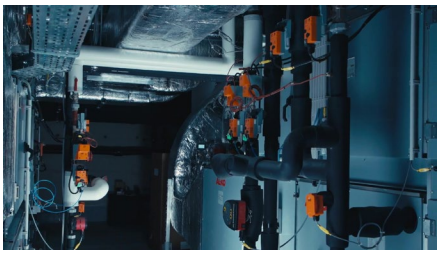
Sustainability and energy-efficient buildings are hot topics in modern architecture, and one of the latest marvels is the Floating Office in Rotterdam. The building consists of coupled blocks of concrete that float atop the Nieuwe Maas river and uses its waters for both cooling and heating. In addition, it has smart HVAC technology from Belimo to help create an optimal environment while using minimal energy. Together with the solar cells installed on the roof, this innovative set-up makes the building entirely self-sufficient.

Floating Office in Rotterdam (FOR) was designed and created by Powerhouse Company – an international architectural practice established in Copenhagen and Rotterdam – together with the real estate expert RED Company and consultants from Roodenburg Groep BV. The project aims to reflect the values of its tenant, the Global Center on Adaptation (GCA) – an organization that promotes environmentally friendly technologies and encourages a climate-centered approach in planning and investment phases. FOR received a lot of attention in the media when it was completed in September 2021, and was inaugurated by King Willem-Alexander of the Netherlands.

FOR is made entirely of wood and other recyclable materials and is designed so it can be completely dismantled for reuse. But it doesn't end there, the roof of the building is equipped with a total of 800 m^2 of solar panels and the rest of it is covered with sedum – a low-maintenance succulent species that acts as a sink for carbon dioxide and other greenhouse gasses. This green area also serves as a habitat for birds and insects, attracting pollinators and further decreasing the building's ecological footprint.

The base of the building consists of 15 connected floats that follow the rise and fall of the water level in the tidal estuary, which can change by as much as two meters during the day. FOR can be accessed via a boardwalk and its three stories provide a 3,607 m^2 of floor space that are home to GCA, a restaurant and a public pool area.

Plastic floor heating pipes are installed in the floats, serving as concrete core activation to force air to pass through the holes within the material and warm or cool the building with minimal energy loss. The heat and cold are extracted from the water in the river below, and heat pumps are used to transform water ranging from -7 to 55 °C to 12 °C for the chilled water pipes, and 35 °C for the central heating system. In addition, a combination of underfloor heating and change-over ceilings work as a delivery system to increase or decrease the room temperature.



HVAC systems account for a large portion of a building's energy consumption, which is why Powerhouse chose to work with Belimo – a company that is known to provide efficient solutions that require minimal power. By installing Belimo's valves and environmental sensors – which monitor the indoor temperature, relative humidity, and carbon dioxide levels – Powerhouse could ensure an optimal environment in both the office and restaurant areas. As the number of people in the different parts of FOR changes during the day, the air quality is continuously checked to ensure that each room receives just the right level of ventilation, further reducing power consumption without compromising comfort.

The sensors and valves are connected to BACnet, which makes it easy to collect the data and optimize the environment. Moreover, the 6-way pressure independent valves (EPIVs) effectively replace as many as four 2-way valves, ensuring that hot and cold water never mix. Its pressure release function can quickly react to, and compensate for, changes in pressure caused by differences in water temperature. Since sub-metering is now often a requirement in environmentally friendly buildings, a Belimo Energy Valve™ is installed in the chilled water and central heating pipes for any part of the building that uses up more than 5 percent of the total energy, making it possible to monitor different areas separately.

It is certainly not surprising that all the above-mentioned qualities have earned FOR a Building Research Establishment Environmental Assessment Method (BREEAM) 'Excellent' certification. BREEAM is a measure to assess the sustainability of projects, and factors in nine sustainability categories – management, health, energy, transport, water, materials, waste, land use and ecology, and pollution – highlighting how well thought out the FOR project is from start to finish.

BELIMO
technicalsupport@us.belimo.com
www.belimo.com

New Sedona Unitary Controller Adds Support for BACnet MS/TP

Contemporary Controls has expanded its BAScontrol Series of BACnet/IP Sedona Unitary Controllers with the addition of the 22-point BAScontrol22S, which supports BACnet client/server operation over BACnet/IP or BACnet MS/TP.

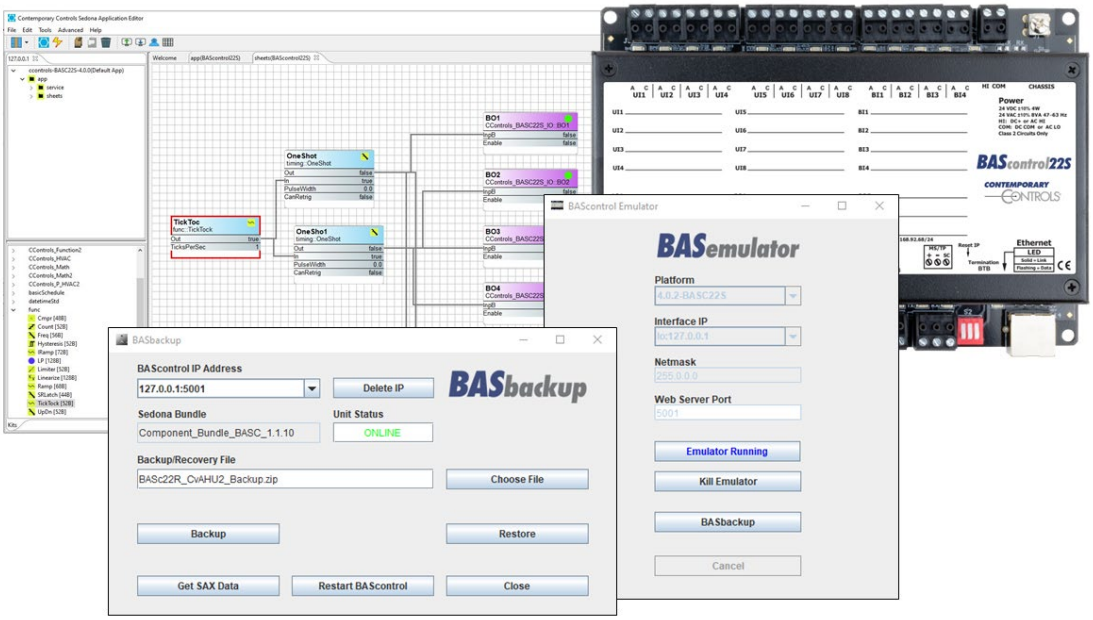
"While the trend is towards using IP-based networks, the BAScontrol22S offers flexibility at the job site in case there is no access to an IP-based network, and a twisted-pair network is the only option," said Harpartap Parmar, director of product management at Contemporary Controls. "Sedona function block programming and project archiving is still accomplished over the Ethernet port connected to a PC using the free BAScontrol Toolset while the controller communicates over BACnet MS/TP."

The BAScontrol22S retains the features found in all BAScontrol Series controllers, such as license-free operation and web page configuration over a 10/100 Mbps Ethernet. It complies with the B-ASC device profile with a convenient mix of 8 universal inputs, 4 binary inputs, 4 analog outputs, and 6 binary outputs. The unit has 48 web components which link Sedona wiresheet readable/writeable data to web pages, and 24 virtual points which link Sedona wiresheet readable/writeable data to a BACnet client. Its rugged metal enclosure, low device profile, and outdoor temperature operation of -40°C to +75°C make it ideal for indoor or outdoor applications. The unit is powered by 24VAC, commonly used in HVAC systems, or 24VDC.

The BAScontrol22S was built on firmware release 4.0.x with operational enhancements made to improve performance, develop more sophisticated Sedona components, increase application memory space, and to upgrade to BACnet release 15. In addition to the BACnet/IP Ethernet port, the BAScontrol22S has one non-isolated (2-wire) BACnet MS/TP serial port to provide BACnet client/server operation over BACnet/IP as well as BACnet MS/TP up to 115.2 kbps. Transmit and receive LEDs flash on MS/TP traffic.

BAScontrol22S 22-point unitary controller supports BACnet client/server operation over BACnet/IP or BACnet MS/TP. © Contemporary Controls

Contemporary Controls' BAScontrol Toolset is a free set of software tools for Windows PC that includes the Sedona Application Editor (SAE) which allows for Sedona programming, BASbackup which can save/restore and replicate the application and full configuration as a single project file, and BASemulator which will emulate full controller operation on a PC. The BAScontrol Toolset and a web browser are all that is needed to commission a BAScontrol controller.



The BAScontrol Toolset is a free set of software tools for Windows PC that includes the SAE, BASbackup project archiving tool, and a BASemulator which will emulate full controller operation on a PC. © Contemporary Controls

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hparmar@ccontrols.com
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BTL CERTIFICATION

Your Best Path to BACnet Interoperability

BACnet is the world's standard for interoperable building automation solutions, but it only works when products in a system are correctly implemented.

BTL Certification provides customers, end-users and building owners/operators with assurance that a product has successfully undergone industry-standard testing conducted by recognized, independent testing organizations.

It also provides users with confidence on product quality and interoperability in a multi-vendor environment, and can help **minimize costs and risks associated with system integration**.

For suppliers, BTL testing is a powerful methodology for **finding and eliminating implementation errors** before a product reaches the market.

Products that have successfully passed conformance testing are eligible for a BTL Certification and added to the BTL Listing. Only BTL Listed products may use the BTL Mark.

The BTL Mark is a mark of distinction and has come to represent a high level of quality and conformance. It is becoming commonplace for specifications to require a BTL Mark in order to be eligible to bid on a project.

To find out more about testing, or to view the list of tested products, visit **btl.org**.

There are over 1300 products in the BTL Listing of Tested Products Database.

BACnet Testing Laboratories
btl.org
info@bacnetinternational.org
+1-770-971-6003

THE BACnet INSTITUTE

Courses • Resources • Community

Sign-up for a FREE account with The BACnet Institute!

The BACnet Institute (TBI) is an online learning environment that serves as a central source for globally relevant information and education related to Building Automation System implementation. It offers a wide breadth of **FREE** resources in different languages and levels of expertise for key professionals within the buildings industry. These resources not only cover the basics of a BACnet-base system, but topics such as interoperability, devices, specifying, networking, and security. While registration to TBI is required, it is **FREE**. Sign up now at thebacnetinstitute.org.

OVER **160** ARTICLES & LECTURES

FREE CEUs & PDHs

OVER **10,000** REGISTERED USERS

BACnet International AHR education sessions are available on TBI!

New to the BACnet International Family

Member of BACnet International

BACnet International is the global organization that encourages the successful application of BACnet through interoperability testing, educational programs and promotional activities. BACnet International complements the work of other BACnet-related groups whose charters limit their commercial activities.

BACnet International Corporate membership includes a who's who list of top tier companies and industry professionals involved in the design, manufacture, installation, commissioning and maintenance of control and other equipment that use BACnet for communication.

We are proud to welcome the following new members to BACnet International.

New Silver Corporate Member

PECO CONTROL SYSTEMS

Astronics Peco, Inc.
Astronics Corporation serves the world's aerospace, defense, and other mission critical industries with proven, innovative technology solutions. We work side-by-side with customers, integrating our array of power, connectivity, lighting, structures, interiors, and test technologies to solve complex challenges.

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United States
astronics.com

CRESTRON

Crestron
Since 1972, Crestron has created innovative technologies that remove barriers to connection, collaboration, communication, comfort, and control many aspects professionally and personally. Engineered to be simple, reliable, secure, and easy to use, Crestron sets the standard for intelligent video conferencing, digital content distribution, smart home systems, as well as control and management technology.

15 Volvo Drive
Rockleigh, New Jersey 07647
United States
crestron.com

New Silver Corporate Member

PolarSoft®

PolarSoft
PolarSoft's products make use of the BACnet® communications standard. This standard, ISO 16484-5, also known as ANSI/ASHRAE 135-2020 and its subsequent addenda, represent over 30 years of effort and tens of thousands of hours of development by manufacturers, consulting engineers, building owners, facility managers, academic and government institutions. PolarSoft has been at the forefront of the development of this technology, and a significant force in both its design and adoption worldwide. PolarSoft's products represent the broadest range of third-party BACnet software products available anywhere.

368 44th St.
Pittsburgh, Pennsylvania, 15201
United States
polarsoft.com

Rheem®

Rheem Manufacturing
Founded in 1925, Rheem is the only manufacturer in the world that produces heating, cooling, water heating, pool/spa heating and commercial refrigeration products. Rheem is headquartered in Atlanta, and it has an international presence in 14 countries. The company's premium brands include Rheem, Raypak, Ruud, Eemax, Richmond and Splendid, as well as commercial refrigeration brands Russell, Witt, ColdZone and Kramer, which are part of the company's Heat Transfer Products Group (HTPG) division.

1100 Abernathy Rd NE #1700
Atlanta, GA 30328
United States
rheem.com

EXPAND YOUR BACnet KNOWLEDGE

THE BACnet INSTITUTE

Courses • Resources • Community

ACCREDITED IACET PROVIDER

TBI continues to grow. There are now over 6,000 registered users, and articles and presentations are continually being added to the Resources section, providing many materials to help you and your colleagues stay connected and engaged. A better-informed community brings positive change, so take a moment to expand your knowledge of BACnet as well as encourage others!

Popular BACnet International Trade Show Session Recordings

BACnet International has presented an Education Track at the past several AHR Expos. Most show sessions were recorded and have been uploaded onto TBI for you to experience either again or for the first time, including the four presented at the 2023 AHR Expo. Those sessions include "The Hitchhiker's Guide to BACnet," "BACnet 101," "BACnet-centric Guide Spec," and "Deploying BACnet Secure Connect."

Multi-Level and Multi-Lingual Materials in Resources

With over 160 articles and presentations focused primarily on BACnet, the TBI library offers a variety of topics, in different languages and expert levels. Among the top articles accessed are "An Introduction to BACnet," "Deploying and Maintaining BACnet Systems in Today's Networks," "LED Lighting – An Automation Armageddon," "Cybersecurity for BACnet BAS Webinar," and many more. Also check out the bi-lingual "Device Profile Families Facilitate Planning" article by Bernhard Isler. Check back often, since articles continue to be added.

Interactive Courses Fit into Your Schedule, and Offer FREE CEUs & PDHs!

There are three interactive courses available on TBI, and, as an IACET Accredited Provider, BACnet International offers FREE Continuing Education Units (CEUs) upon completion of each course. Professional Development Hours (PDHs) are also available upon completion. The three courses are:

- BACnet Basics - a comprehensive course that covers all the basics of BACnet. Don't know anything about BACnet or need a refresher? This is an excellent course to take.
- The Facility Manager's Guide to Building Automation Systems. You don't need to be a facility manager to take this course, in fact, this course is incredibly beneficial to anyone who works in the building automation industry.
- BACnet Device Profiles – introduces learners to the various BACnet device profiles and explains the role of each in the building automation. It also shows the learner how various profiles can be combined in a single device and explains the rules behind the combinations.

A Community Forum to Get Your BACnet Questions Answered

The BACnet Community Forum is an interactive environment that offers knowledge-sharing and provides an opportunity for users to submit BACnet-related questions to be answered by a panel of experts in the BACnet industry.

Participants in the forum can submit new discussions, reply to discussions, and receive updates of peer posts through email subscriptions. Answers to submitted questions are posted in the forum, which can then be searched by all registered users.

Past discussions submitted through the Cornell University BACnet-L email list server are also included.

Visit TBI!

If you haven't visited The BACnet Institute recently, you definitely should! AND, remind your colleagues to do so as well! To access all of these resources, or to sign up for a FREE account, visit thebacnetinstitute.org.

Sign-up for a FREE account today!

BACnet Testing Laboratories (BTL) Testing Updates

BTL Testing and BTL Test Package Information

A BTL Certification indicates that the BACnet Stack of the product has successfully passed rigorous industry standard testing and demonstrates that the device correctly implements all of the BACnet functionality it contains as governed by ASHRAE standard 135. The BTL Listing, the BTL Certificate of Conformance, and the right to use the BTL Mark are the three elements that indicate a product has passed the testing and achieved BTL Certification.

The BTL Working Group defines the BTL Test Plan and governs the testing. The BTL Test Package and BTL Testing Policies are published on the BTL website: btl.org/testing-documentation.

BTL Test Package 23.1

BTL Test Package 23.1 is the current test package. This test package includes testing up through Protocol Revision 23 of the BACnet standard (ANSI/ASHRAE 135-2020 plus addenda: cd).

Minimum Protocol Revision for BTL Testing

The current minimum BACnet Protocol_Revision for testing is PR_15. January 1, 2024, the minimum BACnet Protocol_Revision for testing becomes PR_16. This means that any new product to BTL Testing on January 1, 2024, or later must be at PR_16 or higher. Any products that are currently in testing on January 1 will continue testing at their current PR.

The minimum protocol revision does not pertain to any product that already has a BTL Certification or BTL Listing. However, if the product comes back to BTL Testing for a retest, the minimum protocol revision will apply.

ABOUT THE AUTHOR

Emily Hayes began work with BACnet International in 2014 as BTL-Coordinator, coordinating BTL Testing at the BTL Lab. In 2017, Emily took over leadership of the BTL Working Group as chair. Additionally, she led the transition from the BTL Listing Program to the BTL Certification Program. She became BTL Manager in January 2019. Emily maintains professional membership in the Project Management Institute (PMI), North Carolina Chapter of PMI (NCPMI), and Institute of Electrical and Electronics Engineers IEEE. Emily has a BEE from Auburn University and an MSEE from Duke University. She has maintained a Project Management Professional (PMP) Certification since 2010.

BACnet Secure Connect Resources Available:

The BACnet Secure Connect (BACnet/SC) Reference Stack was developed as part of BACnet International's first BACnet/SC Interoperability Acceleration Program. It is available to anyone in the BACnet Community for free. You can download it here: sourceforge.net/projects/bacnet-sc-reference-stack. The three educational BACnet/SC Webinars were recorded and uploaded to the BACnet International YouTube page and can be found here: youtube.com/c/BACnetInternational

The next phase of BACnet cybersecurity, Certificate Management:

The new Cybersecurity Acceleration Program will continue to reduce manufacturers cybersecurity implementation learning curve and align their product development with industry direction on interoperability and best practices.

The program includes reference implementation and source code components including:

- Certificate Authority (CA) server
- Certificate Signing Request (CSR) generation and validation tool
- Machine readable, interoperable certificate file format

The program will bolster in-house technical knowledge and development with:

- Cybersecurity implementation webinars
- Early tool release with full source code license
- Expert moderated developer's forum

Manufacturer's cybersecurity guidelines document development
Access to BRITE, BRITE provides a confidential, supplier-independent environment for remote interoperability testing of BACnet devices.

For additional information on BACnet Secure Connect resources, visit the BACnet International website at bacnetinternational.org/secureconnect

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Emily Hayes
BTL Manager, Certifications and Listings Manager and
BTL Working Group Chair | BACnet International
btl-manager@bacnetinternational.org | www.bacnetinternational.org

NEW BTL-LISTED PRODUCTS, September 2022 – February 2023

Manufacturer	Product Name	Model
75F	HyperStat	7X-HS-C2W-X
ABB	HVAC Drive	ACH180
	ASPECT-SUPERVISOR	ASPECT-SUPERVISOR, NEXUS-3-2128, NEXUS-3-264, ASP-ENT-2, ASP-ENT-96, ASP-ENT-256, ASP-ENT-12
Accuenergy (Canada) Inc.	AcuRev 2100 Series Multichannel Multifunction Power and Energy Meter	AcuRev 2110, AcuRev 2120
	Acuvim II Series Multifunction Power and Energy Meter	Acuvim II, Acuvim IIR, Acuvim IIE, Acuvim IIW, Acuvim IIBN, Acuvim IIX
Automated Logic Corporation	OptiFlex™ BACnet Building Controller	OFBBC OFBBC-NR
Badger Meter Inc	Flow Meter	Dynasonics TFX-5000 Flow (DQ)
Badger Meter Inc	Thermal Energy (BTU) Meter	Dynasonics TFX-5000 Energy (DR)
BELIMO	ZoneEase VAV	LMV-BAC-001, LMV-BAC-002, NMV-BAC-001, NMV-BAC-002
	Blue ID C4 Controller	C4 C-MX34m, C4 C-MX34
BEST Co.	SMART IoT	SMART-IoT
Chicago Faucet	CFC-COMBOX	116.101.AB.1X, 116.102.AB.1X, 116.103.AB.1X, 116.104.AB.1X, 116.111.AB.1X, 116.112.AB.1X, 116.113.AB.1X, 116.114.AB.1X, 116.121.AB.1X, 116.122.AB.1X, 116.123.AB.1X, 116.124.AB.1X
Computrols	Serial Connector	Serial Connector
Delta Controls	V4 Product Platform	eBMGR-2, eBCON-2, O3-DIN-CPU, O3-DIN-SRC, Red5-PLUS-ROOM, Red5-EDGE-ROOM, Red5-x-y where x is PLUS, EDGE, or FIELD
DEOS AG	OPENweb	DS-OWB
Distech Controls	ECY Series	ECY-303, ECY-303-M3, ECY-PTU-107, ECY-PTU-207, ECY-PTU-208, ECY-TU-203, ECY-S1000, ECY-S1000E, ECY-S1000-16, ECY-S1000E-16, ECY-S1000-48, ECY-S1000E-48, ECY-S1000-48-MS, ECY-S1000E-48-MS, ECY-VAV, ECY-VAV-POE
	ECLYPSE Building Intelligence Series	ECY-APEX-BI
DMS Digitale Mess- und Steuersysteme AG	OpenLS6000/BACnet-Service	OpenLS6000/BACnet-Service 1.2
EasyIO	EasyIO FW Controller	FW-VAV, FW-28, FW-14, FW-08, FW-08V

Manufacturer	Product Name	Model
Frimat	Frimat_BAVI	
Fr. Sauter AG	Smart Actuator	ASM115SAF232, AVM115SAF232, AKM115SAF232
	VAV Kompaktregler BACnet M	ASV205BF132E, ASV215BF132E, ASV215BF152E, ASV215BF152D
Fuji Electric	Low voltage AC drives	FRENIC-MEGA, FRENIC-Ace, FRENIC-VP
GD Midea Heating and Ventilating Equipment Co	KONG M0 series	MKG41-BTW23 (DDC M0) MKG42-BTW23 (WU Controller) MKG43-Y23P (Plant Controller) MKG43-Y23M (Mini Controller) MKG43-BTW23(1024) (Edge Controller S) MKG43-BTW23(2048) (Edge Controller M) MKG43-BTW23(10000) (Edge Controller L) MKG45-BTW23 (Space Controller) MDV8-GW3-IMMProII-M04G (IMMPRO II Controller)
Geberit	Geberit Gateway	F500
Grundfos	MIXIT	A
Honeywell International	Edge Control Series	ECGx1-x2x3x4 where x1 is 100, 200 or 500 x2 is C or P x3 is E or R x4 is number 0-9 or blank ECx1x2-x3x4x5 where x1 is C, D or E x2 is 100, 200 or 500 x3 is C or P x4 is E or R x5 is number 0-9 or blank
	Honeywell Smart Sensor	TR50-5N, TR50-5D, TR50-3N, TR50-3D, TR50-5N-B, TR50-5D-B, TR50-3N-B, TR50-3D-B, TR50-5N-BW, TR50-5D-BW, TR50-3N-BW, TR50-3D-BW
Honeywell	TB3 Series	TB3240x/U, TB3140x/U
Hysine Controls	BCU/BLC/ELV series programmable logic controller	BCU-x1 where x1 is 941, 630, 940, 860, 843, 1644, 1600, 16160, 1666, 8253, 8800, 8860, 8865, or 420 BLC-x2 where x2 is 1040, 1043, 1650, 1656, 1600, 621, 310, 54EH, 32EH, 32E, 24E, 2060E, or 621E BVC-442, BVC-442-P, BVC-SD, BVC-SD-P, BCX-x3 where x3 is H416, H616, H816, H1016, H1216, H620, H820, H1020, H1220, M416, M616, M816 or E466 MGP-x4 where x4 is 1102B, 1103B, 1104B, 1105B or 1106B BR-50, BR-10 ELV-x5 where x5 is 410P, 620P, 1050P, 1053P, 1550P, 1030P, 1032P, 1633P, M16A4, M16A6, or M16A8

Intesis (HMS Industrial Networks, SLU)	Intesis BACnet Server 700 Series	Modbus to BACnet IP & MSTP, KNX to BACnet IP & MSTP
Intesis	Intesis BACnet Client 700 Series	BACnet Client to Modbus Server, BACnet Client to ASCII Server, BACnet Client to KNX
	Intesis BACnet Server 700 Series AIR	Panasonic VRF Systems to BACnet IP & MSTP Hisense VRF Systems to BACnet IP & MSTP Hitachi VRF Systems to BACnet IP & MSTP Mitsubishi Electric to BACnet IP & MSTP Mitsubishi Heavy Industries VRF to BACnet IP & MSTP Midea VRF to BACnet IP & MSTP Samsung NASA VRF to BACnet IP & MSTP
	Intesis Air Conditioning Interface Series 2E	Universal Infrared AC to BACnet MSTP Daikin VRV to BACnet IP/MSTP Daikin VRV and Sky to BACnet MSTP Fujitsu RAC & VRF to BACnet MSTP Hitachi VRF systems to BACnet MSTP Mitsubishi Heavy Ind. FD & VRF to BACnet MSTP Mitsubishi Electric Domestic, Mr.SI.&CityM to BACnet MSTP Panasonic Etherea AC to BACnet MSTP
Johnson Controls	Advanced Application Field Equipment Controller (FAC), VAV Modular Assembly Controller (VMA)	MS-FAC4911-0 MS-VMA1930-0
Lennox International Inc.	Lennox CORE Unit Controller	106519
Price	Disio	Disio
Panasonic	PNS-P1000 series	PNS-P1000
	PNS-303 series	PNS-303, PNS-303-M3
	PNS-VAV series	PNS-VAV
	PNS-PTU/TU series	PNS-TU-203
Phoenix Contact GmbH und Co. KG	ILC 2050 BI	Article No. 2403160
	ILC 2050 BI-L	Article No. 2404671
Priva	Blue ID S10 Controller	S10
Quantum Automation	iCON-1400 Programmable DDC	iCON-1400PB
SE-Elektronic GmbH	BACnet Advanced Application Controller M-DDC	MTC FCU-01, MTC FCU-02, UltraSafe, MTC CB, MTC CB-HV, MTC CB-LI, MTC RES-01
Schneider Electric	Smart Field UC IP Controller	SF-UC-18A-E, SF-UC-24A-E
	SpaceLogic IP-IO Modules	IP-IO-DI10, IP-IO-UIO10, IP-IO-UIO5DO5DOFA4
	SpaceLogic MP Controller	MP-C-15A, MP-C-18A, MP-C-18B, MP-C-24A, MP-C-24A-M, MP-C-36A, MP-C-36A-M, MP-V-7A, MP-V-9A
	SpaceLogic RP Controller	RP-C-12A-F-24V, RP-C-12A-M-24V, RP-C-12B-F-24V, RP-C-12B-M-24V, RP-C-12C-F-24V, RP-C-16A-F-230V, RP-C-16A-M-24V, RP-C-16B-F-230V, RP-C-16B-F-24V, RP-C-16C-F-230V, RP-V-4A, RP-V-5A, RP-V-5C-M
	EcoStruxure Building Operation	ES, AS-B, AS-P, AS-P-NL, AS-P-NLS, AS-P-S, CS

Manufacturer	Product Name	Model
Siemens	APOGEE PXC7.A and PXC4.A Automation Station	PXC7.E400.A PXC7.E400.A, PXC4.E16.A
	Climatix	POL908.00, POL904.00
	Desigo BACnet Router	PXG3.M, PXG3.L
	KNX IoT to BACnet IP gateway	OCT200.KNBA
	Desigo Control Point	PXM30.E, PXM40.E, PXM50.E, PXG3.W100-1, PXG3.W200-1
	Desigo CC Workstation	Version 7.0
SungHan. Co	SmartBEN-BMI-BAC	SmartBEN-BMI-BAC-AWS, SmartBEN-BMI-BAC-OWS
TCS Basys Controls	Advanced Air Handler Unit	US5182
Trane	Tracer® EnsembleTM	Tracer® EnsembleTM
Toshiba Carrier	BN Interface	BMS-IFBN1281U-E, BMS-IFBN1281U-TR, BMS-IFBN1281U-UL, 40VCBB1-8FJEE
Veris Industries	Veris E71 Series Energy Meter	E71E3, E71E3A, E71E3X, E71E3AX
Wago	Touch Panel 600 Edge Controller	762-4301/8000-0002, 762-4302/8000-0002, 762-4303/8000-0002, 762-4304/8000-0002, 762-4305/8000-0002, 762-4306/8000-0002, 762-5303/8000-0002, 762-5304/8000-0002, 762-5305/8000-0002, 762-5306/8000-0002, 762-6301/8000-0002, 762-6302/8000-0002, 762-6303/8000-0002, 762-6304/8000-0002 752-8303/8000-0002
Yaskawa	JOHB-SMP3 BACnet/IP Option	JOHB-SMP3

BACnet International

Calendar of BACnet International Events

2024	Event	Location
January 22 – 24	AHR Expo	Chicago, IL

Journal of Building Automation 24

The Journal of Building Automation published by BACnet International is a global magazine for the building automation industry. Experts, practitioners and professionals show the way through articles, updates, developments, case studies, and news on the BACnet protocol as well as the wider building automation industry as a whole. Special attention is given to Corporate Members and activities of BACnet International.

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Hans Symanczik
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info@bacnetinternational.org

Advertising
TEMA Technologie Marketing AG
Phone: +49-241-88970-810 | Fax: +49-241-88970-999
E-mail: sistemich@tema.de

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