INTESA SANPAOLO
INNOVATION CENTER

INDUSTRY TRENDS REPORT
INFRASTRUCTURE AND CONSTRUCTION

BUILDING AND HOME AUTOMATION

FROST & SULLIVAN

CONTENTS

EXECUTIVE SUMMARY

Globally, buildings accounts for about one third of energy demand and emissions but Building and Home **Energy Management** solutions (BEMs/HEMs) offer part of the solution and are capable of reducing electricity consumption by over 50%. This potential is driving a global market that was valued at $6.8b in 2020 and is growing rapidly.

Internally, technology innovations are driving performance and decreasing costs and BEMs and HEMs are notably benefitting from the integration of a range of sensors which test parameters such as occupancy, temperature and humidity. In parallel, the widespread deployment of new Internet Protocol (IP) networks is enabling superior wireless BEMs and HEMs communication and control. This is particularly true in the energy-intensive HVAC segment where the application of the Internet of Things (IoT) is becoming a reality and remote monitoring capabilities are reshaping business models and prompting the roll out of subscription-based services to the benefit of vendors and customers.

Externally, the integration of BEMs and HEMs with increasingly smart power Transmission and Distribution (T&D) infrastructure is enabling the deployment of renewables. In particular, they serve to enhance the potential of Automated Demand Response Systems (ADRS) and to enable effective peak shaving. Moving forward, Artificial Intelligence-powered 100% holistic building optimization solutions will represent the next stage of the BEMs and HEMs market evolution with industry participants increasingly partnering to form an ecosystem that is capable of delivering the next generation of products and solutions.

AI is also shaping the **Building Automation** industry. A range of start-ups are, for example, allowing users to personalize their home experience through natural voice commands. More broadly, however, the industry is responding to the demands of the pandemic with ***air quality systems*** are a hot spot for growth, ***touch free operations*** rapidly gaining ground and ***people flow analytics*** playing a crucial role as building owners and operators seek ways to avoid congestion or crowding in public areas.

Home automation, in the context of the emerging smart home, is a real focus area for innovation. Concerns remain about interoperability, ownership and cybersecurity remain but technological advances are promising consumers "frictionless convenience" and supporting a market which will be valued at $263b globally by 2025.

Market leaders in the space will need to differentiate themselves by offering an effortless experience, supporting for example the integration of electric vehicles. They will also have to responsibly leverage data to be able to stack value propositions and provide fully customized and bundled end-user platforms. To achieve these aims, full system players are being complemented by new "point" solution providers which are specialized in areas such as robotic leak detection or water analytics.

Asset digitalization, for automation and/or energy management purposes, is enabling a radical shift in building maintenance practices with conventional reactive, planned or proactive approaches being replaced by proactive and increasingly prescriptive solutions. **Prescriptive Maintenance** is a step ahead of **Predictive Maintenance** in that it can advise on a building's optimal operational performance. Frost & Sullivan expects the global market for predictive maintenance in buildings to reach $2.8b in 2025.

This paper examines each of these areas in turn with a focus on the role of technologies in enabling the development of energy efficient, automated and well-maintained houses and offices. More broadly, it examines how increasingly connected and cognitive devices and systems are creating an ecosystem of solutions within and outside of residential and commercial buildings which serve to benefit both owners and occupiers.


ENERGY
MANAGEMENT

Globally, buildings accounts for about one third of energy demand and emissions

According to the International Energy Agency, energy consumption stemming from the buildings industry reached 130 Exajoule (EJ) in 2019, a jump of 20% compared to 2010 levels. The increased frequency of extreme weather conditions and the subsequent growing ownership and use of air conditioning (AC) systems are the major factors behind this trend. In 2019, emissions from the building industry reached 10 gigatons of carbon dioxide (Gt CO2) which corresponds to growth of more than 8% compared to 2010 levels.

Building and Home Energy Management solutions (BEMs/HEMs) offer the potential to reduce electricity consumption by over 50%

Inefficient processes and poor energy management result in commercial buildings wasting 30% of the energy that they consume. Advanced BEM solutions can provide savings of between 13% and 66% in terms of costs due to their detection, historical analysis, diagnostic and predictive capabilities.

In a 2018 Johnson Controls' Energy Efficiency Indicators study, out of 1,900 participating organizations in twenty different countries, 50% planned to build carbon-neutral buildings in the next 10 years. This augurs well for BEMs which will play a major role in realizing energy-efficient new and existing constructions over the course of the coming years.

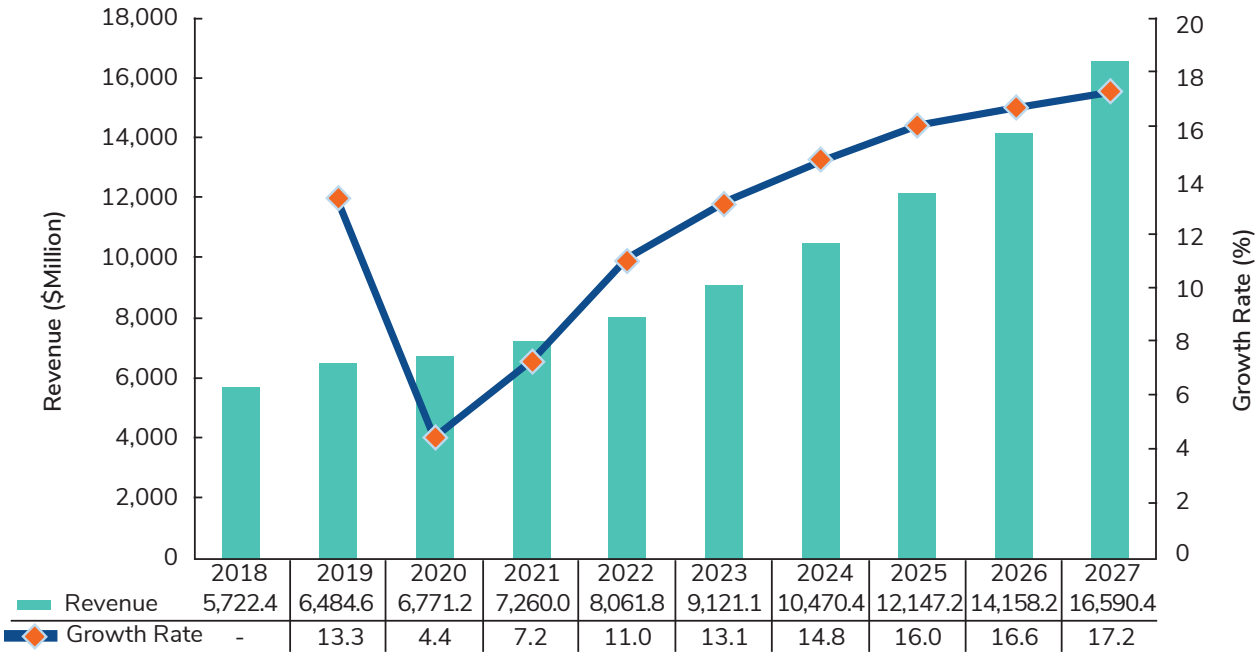
BEM typically refers to a computerized system that monitors, manages and optimizes commercial and industrial buildings' performance in areas such as heating, ventilation and air conditioning (HVAC) and lighting. It consists of **hardware** such as controllers and Internet of Things (IoT) gateways which send field-level data to the cloud by interfacing with the system's management layers and **software** which includes dashboard applications and cloud-based optimization.

HEM is defined as a technology platform that monitors, manages and optimizes residential buildings' performance in the same areas but increasingly extends to also take in solar photovoltaic (PV) and other integrated sources of renewable energy (RE). It encompasses **hardware** like hub devices, smart plugs and clamps as well as in-home displays which are incorporated into wireless mesh networks (which are also known as home area networks). Typically, HEM systems enable bi-directional communication between the end-user and his/her utility through a smart meter and are reliant on **software** such as dashboard application that are used to view home functions remotely through a desktop or a mobile device. This enables the management of energy consumption. Vendors do not usually sell the software separately as they bundle it with the hardware as a full package.

Source: Frost & Sullivan

Overall, Frost & Sullivan estimates that the market was valued at $6.8b in 2020 and will grow at a CAGR of 13.7% to $16.6b in 2027

BEMS AND HEMS MARKET REVENUE, GLOBAL, 2018-27



	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Revenue	5,722.4	6,484.6	6,771.2	7,260.0	8,061.8	9,121.1	10,470.4	12,147.2	14,158.2	16,590.4
Growth Rate	-	13.3	4.4	7.2	11.0	13.1	14.8	16.0	16.6	17.2

The sale of HEM and BEM solutions is set for continued expansion globally despite the short-term significant negative impact of COVID-19.

BEMs will play a crucial role in energy management in particular for large, complex and multi-occupancy buildings. In the commercial segment, increasing demand from owners and occupiers will stem from hotels, hospitals, schools, universities, malls and retails parks as well as from heavy industry.

Here, the market is expected to grow from $4.5b in 2020 to reach $9.0b in 2027.

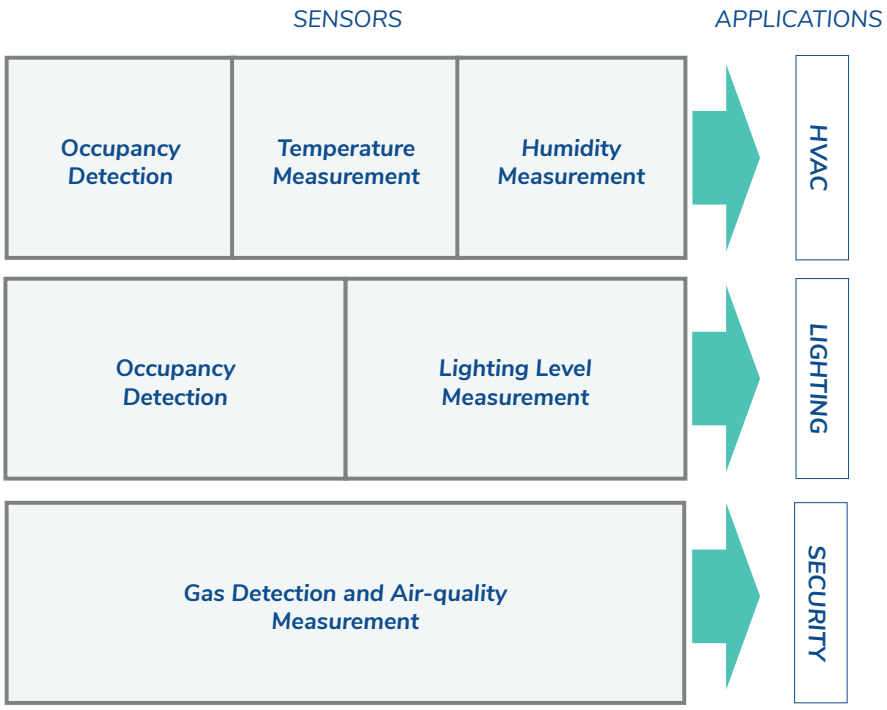
From a lower base, the rate of expansion will however be higher in the **HEMs** segment where revenues will exceed $7.5b in 2027 from $2.3b in 2020, a 18.8% CAGR.

In addition to demand side factors growth will also be underpinned by policy frameworks and specific legislation which incentivizes and rewards investments in energy efficiency. Building owners and occupiers are notably increasingly seeking recognition of their green credentials through the award of Leadership in Energy and Environmental Design (LEED), Building Research Establishment and Environmental Assessment Method (BREEAM) and Excellence in Design for Greater Efficiencies (EDGE) certification. These global programs are matched by local schemes such as the Energy Star (North America) and DGNB (Germany).

Internally, technology innovations are driving performance and decreasing costs

Source: Frost & Sullivan

BEMs and HEMs are notably benefitting from the integration of a range of sensors which test parameters such as occupancy, temperature and humidity



Occupancy sensors identify if a room is occupied or not while advanced occupancy sensors count the number of people in the area. Parameters that are used to measure their performance are their sensitivity and their resistance to "false triggering". Generally, there is a trade-off between the two which BEMs/HEMs developers need to manage.

Key occupancy sensor manufacturers are Johnson Controls, Leviton Manufacturing and Lutron Electronics (all US) with examples including Passive Infrared (PIR), Ultrasonic, Microwave, Acoustic and Dual-Tech solutions.

Temperature sensors measure the atmospheric temperature in the room and send the data to the BEMs' automation system. This then uses the inputs that it receives to optimize HVAC equipment conditions.

Key temperature sensor manufacturers are Honeywell (US), Siemens (Germany) and TE Connectivity (Switzerland) with examples including the commonly used thermocouple and resistive solutions (RTD temperature detectors).

Humidity sensors assess the humidity content in an indoor environment. Controllers use the data that they generate to manage HVAC working conditions, maintain the optimum level of humidity in a room and enhance the comfort of its occupants. Elevated humidity conditions can speed up mold formation and generate other unwanted complications in HVAC equipment. Data from humidity sensors allows BEMs to identify and alert the user about the need for maintenance.

Key occupancy sensors manufacturers are Sensirion (Switzerland), PCE Instruments (US) and Bosch (Germany) with examples including relative and absolute solutions. Indoor and human comfort applications typically use relative humidity sensors as they are based on simple mechanisms and are quite inexpensive.

In addition to occupancy, temperature and humidity, other sensors that are used in HEMs ad BEMs applications include **gas**, **lighting** and **air** sensors.

Source: Frost & Sullivan

Enlighted (US) for example has developed a patented solution for lighting systems

The company was founded in 2009 and has received over $80m in funding to become a vertically integrated BEMS suite developer which offers IoT and machine learning-based energy management tools focused on lighting.

Enlighted leverages 5G smart sensors and an app-based BEMS platform to ensure high quality performance in terms of energy savings achieved.

The company primarily provides its services to commercial clients and has installed its solution in about 200m square feet of buildings in the US.

Enlighted's patented sensors collect data 65 times per second to monitor environmental and occupancy changes and send the information to a building's control systems to adjust the lighting in real time and facilitate predictive maintenance.

Its BEMs suite is available in 3 configurations:

- **Enlighted One** is a simple wireless lighting control system that is quick and easy to install for quick turnaround of tasks
- **Enlighted Connected** has all the features of Enlighted One but also provides customizable networked lighting and building-wide control over lighting profiles. It offers significant flexibility by integrating its systems directly with a building's existing building management systems and/or demand response systems
- **Enlighted IoT** builds on Enlighted Connected to include advanced features which enable space planning, asset tracking and conference management

Enlighted's BEMs suite can achieve energy savings of up to 85% for lighting.

In parallel, the widespread deployment of new Internet Protocol (IP) networks is enabling superior wireless BEMs and HEMs communication and control

IP has multiple advantages over conventional BEMS networks that use cables to connect sensors, transducers, controllers and actuators. As a result, they now account for the majority of the solutions that are currently being deployed in the BEMS industry.

The pros of IP networks include:

Cost efficiency

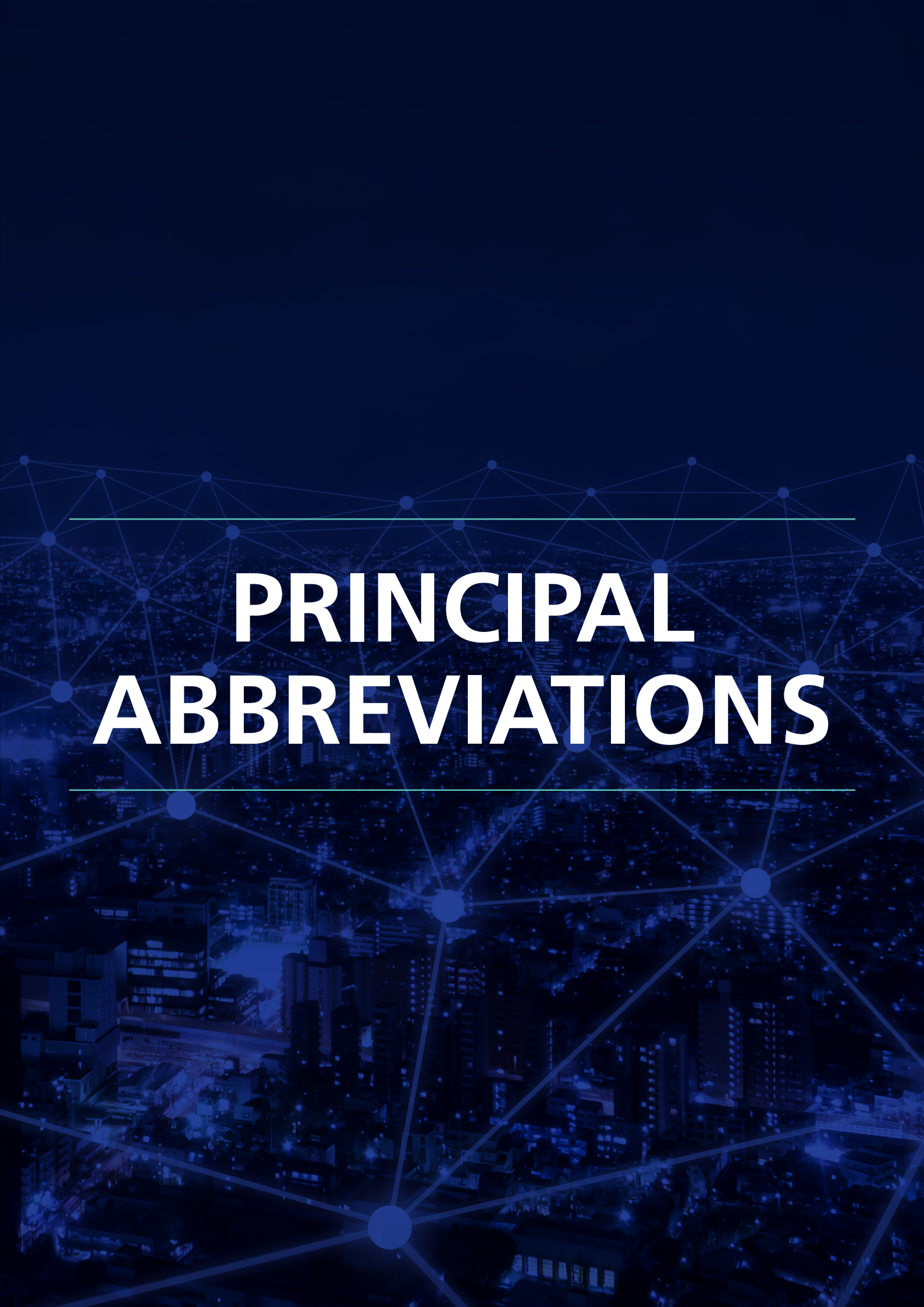
IP networks are almost omnipresent in commercial buildings to enable data sharing and provide internet access. Commonly used platforms can transmit up to 10 billion bits per second (Gbps). This high capacity allows IP networks to connect devices using compact and inexpensive infrastructure. To achieve the same bandwidth and quality, conventional BEMs networks would require many different types of expensive cables.

Centralization

Typically, BEMs require separate cables for every sensor as they each send a different signal. In IP-based systems, all data from is transported through the same network. This centralized approach favours the collection and consolidation of information and is a crucial advantage for the smooth working of BEMs controllers. Optimized HVAC operations are only possible when humidity, occupancy and temperature can all be measured together.

Personalized control

With IP networks, the use of common scripting languages such as XML allows users to monitor BEMS from devices such as smartphones and personal computers. These interfaces also facilitate the remote control of platforms enabling owners and occupiers to personalize HVAC and/or lighting settings across different rooms.



PRINCIPAL ABBREVIATIONS

AC	*Air Conditioning*
ACH	*Air Changes per Hour*
ADRS	*Automated Demand Response System*
AI	*Artificial Intelligence*
B	*Billion*
BA	*Building Automation*
BEM	*Building Energy Management*
BMS	*Building Management System*
BREEAM	*Building Research Establishment and Environmental Assessment Method*
CaaS	*Cooling-as-a-Service*
CADR	*Clean Air Delivery Rate*
CAGR	*Compound Average Growth Rate*
CO2	*Carbon Dioxide*
DR	*Demand Response*
EDGE	*Excellence in Design for Greater Efficiencies*
EJ	*Exajoule*
EU	*European Union*
FMCG	*Fast-Moving Consumer Goods*
Gbps	*Billion bits per second*
GT	*Gigaton*
HA	*Home Automation*
HaaS	*Heat-as-a-Service*
HEM	*Home Energy Management*
HVAC	*Heating, Ventilation and Air Conditioning*
HVACaaS	*HVAC-as-a-Service*
IAQ	*Indoor Air Quality*
IoT	*Internet of Things*
IP	*Internet Protocol*
LEED	*Leadership in Energy and Environmental Design*
LiDAR	*Light Detection and Ranging*
M	*Million*
ML	*Machine Learning*
OTA	*Over The Air*
PV	*Photovoltaic*
RE	*Renewable Energy*
T&D	*Transmission and Distribution*
US	*United States*
USD	*United States Dollar*

Source: Frost & Sullivan

ABOUT INTESA SANPAOLO INNOVATION CENTER:

Intesa Sanpaolo Innovation Center is the company of Intesa Sanpaolo Group dedicated to innovation: it explores and learns new business and research models and acts as a stimulus and engine for the new economy in Italy. The company invests in applied research projects and high potential start-ups, to foster the competitiveness of the Group and its customers and accelerate the development of the circular economy in Italy.

Based in the Turin skyscraper designed by Renzo Piano, with its national and international network of hubs and laboratories, the Innovation Center is an enabler of relations with other stakeholders of the innovation ecosystem - such as tech companies, start-ups, incubators, research centres and universities - and a promoter of new forms of entrepreneurship in accessing venture capital. Intesa Sanpaolo Innovation Center focuses mainly on circular economy, development of the most promising start-ups, venture capital investments of the management company Neva SGR and applied research

For further detail on Intesa Sanpaolo Innovation Center products and services, please contact businessdevelopment@intesasanpaoloinnovationcenter.com

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