CABA

INTELLIGENT BUILDINGS AND BIG DATA

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Intelligent Buildings and Big Data

There is a consensus in the industry, that the proliferation of intelligent devices and internet technologies has created an exponential increase in the volume, velocity, and variety of data. This phenomenon is commonly referred to as 'Big Data'. Current data management systems are not capable of processing this new influx of data, and as a result companies are forced to ignore the majority of the data available. The goal of this research is to examine new tools and resources that can help companies filter, analyze, and use Big Data collected from intelligent and integrated buildings. Leveraging Big Data will enable a better understanding of customer behaviors, competition, and market trends. Research on utilizing Big Data from building systems is crucial to staying competitive in this dynamic connected marketplace. A detailed Research Prospectus is available upon request.

This report was prepared for CABA by **Navigant Research**.

NAVIGANT RESEARCH

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SECTION 3

EXECUTIVE SUMMARY

3.1 ABOUT THIS REPORT

The Continental Automated Buildings Association (CABA) commissioned Navigant Research to study new tools and resources emerging in the market to help companies filter, analyze, and use Big Data collected from their intelligent and integrated buildings. Leveraging Big Data will enable a better understanding of customer behaviors, competition, and market trends. Research on utilizing Big Data from building systems is crucial to staying competitive in this dynamic connected marketplace.

Navigant Research and the Steering Committee first convened via a webinar in July 2014, and established a regular schedule of discussion and collaboration for the duration of the project. The findings presented in this report showcase the results of primary and secondary research including in-depth executive interviews and a broad stakeholder online survey.

The outcomes of this collaborative research project will provide a clear understanding of the opportunities and solutions of managing data derived from intelligent buildings. This research examined how data from intelligent buildings can be more efficiently filtered, analyzed, and ultimately used by all segments of the industry. This information will eventually lead to greater productivity, reliability, efficiency, and operational control of intelligent buildings.

3.2 SPONSORS

Navigant Research and CABA would like to acknowledge the CABA member sponsors listed below, and the respondents who helped make this research possible. We would also like to take this opportunity to thank the CABA member sponsors and CABA, as well as all those organizations that contributed their valuable time and information. In particular, we appreciate the trust and transparency shown by respondents willing to share confidential information. Without the help of all these organizations it would not have been possible to produce such an in-depth and detailed study. Ruby sponsors (EcoOpera Systems, Inc., Honeywell International, Inc., Jonson Controls Incorporated, Schneider Electric, Inc.) we provided the opportunity to present a case study in this report.

The final presentation was delivered by webinar in February 2015

3.3 ROLE OF THE STEERING COMMITTEE

The Steering Committee represents a cross-section of solution providers in the Intelligent Buildings marketplace. Representatives from each company joined Navigant Research and CABA on regular collaboration calls to ensure the research scope met the project objectives. The Steering Committee plays a vital role in outlining the research product in terms of defining the required content as well in collaboration on the research approach including the development of the interview scripts and survey guides.

3.4 ABOUT CABA

The Continental Automated Buildings Association (CABA) is an international not-for-profit industry association, founded in 1988, dedicated to the advancement of connected home and building technologies. The organization is supported by an international membership of over 300 organizations involved in the design, manufacture, installation and retailing of products relating to home automation and building automation. Public organizations, including utilities and government are also members. CABA's mandate includes providing its members with networking and market research opportunities. CABA also encourages the development of industry standards and protocols, and leads cross-industry initiatives.

Please visit http://www.caba.org for more information.

3.5 ABOUT NAVIGANT RESEARCH

Navigant Research is a market research and advisory group that provides in-depth analysis of global clean technology markets with a specific focus on the commercialization and market growth opportunities for emerging energy technologies. The team's research methodology combines supply-side industry analysis, end-user primary research and demand assessment, and deep examination of technology trends that impact the rapidly-evolving energy services and infrastructure sectors.

Our client base includes Fortune 1000 multinational technology and energy companies, government agencies, utilities, investors, industry associations, and clean technology pure plays. We provide these companies with market research reports, custom research engagements, and subscription-based research services.

Navigant Research is focused across four research programs: Smart Energy, Smart Transportation, Smart Utilities, and Smart Buildings. The Navigant Research analyst team comes from a diversity of industry backgrounds and leverages deep analytical skill sets in covering emerging technology and energy markets. Together, the team brings a wide range of capabilities to help clients build successful strategies in these sectors, from engineering and technology assessment, to corporate strategy development, to classic quantitative and qualitative market research methodologies. Research analysts are not only experts and thought leaders in their current areas of market coverage, but also bring a broad perspective from years of experience in related technology and energy businesses. This is further enriched by the expertise of Navigant Consulting's Energy Practice, with hundreds of professionals engaged in all aspects of the energy economy.

Please visit http://www.navigantresearch.com for more information.

3.6 INTRODUCTION

Big data is a topic of debate on the next frontier in business intelligence, and there is a growing interest in focusing the discussion on intelligent buildings. The reality, however, is that intelligent building solutions already represent an evolution in facilities and business operations management from the legacy systems that lead the landscape.

3.7 THE CHALLENGE OF BIG DATA IN INTELLIGENT BUILDINGS

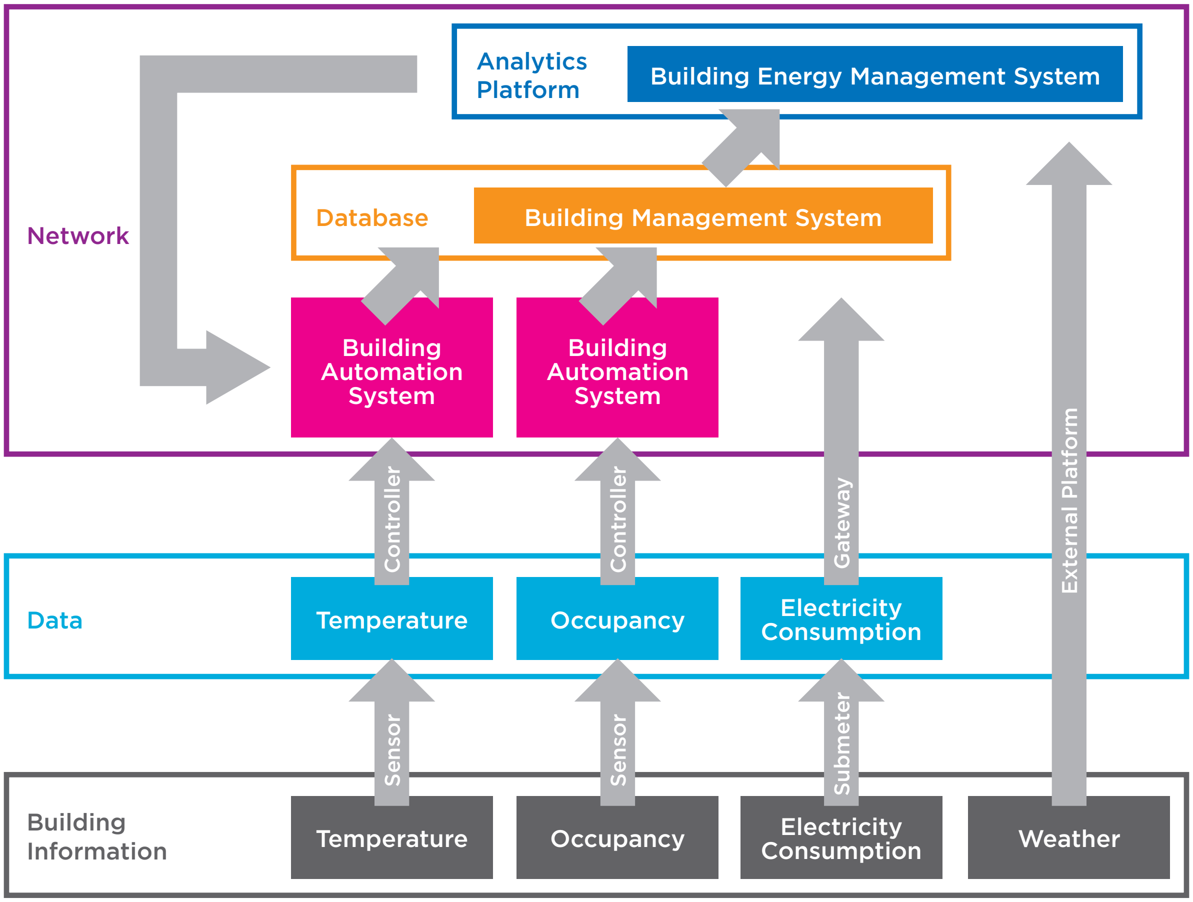
The challenge for big data solution providers is to help end-users understand the added benefits of big data and what differentiates these solutions in terms of business value to help accelerate the market from investment by innovators today and move toward early adoption in the medium term.

The term big data has become increasingly popular in recent years. Despite the hype, there is no single, cohesive definition. In general, the term refers to data that exceeds the capacity or capability of current or conventional methods and systems. In other words, the notion of "big" is relevant to the current standard of analysis. While there are various definitions depending on the industry in question, many seem to agree on the following characteristics that identify big data: volume, velocity, and variety.

3.7.1 Defining Big Data in Intelligent Buildings

Traditionally, building control has taken a top-down approach with integration between different systems, such as HVAC and lighting, occurring at a supervisory level. However, analytics solutions are beginning to shift the architecture of building systems to a more distributed platform with hybrid and predictive control based on multiple inputs and outputs from multiple systems. Current solutions focus mostly on energy management. However, building data analytics can also provide cost savings through optimized O&M as well as improved occupant comfort.

Figure 3-1 Generic Building Data Flow



(Source: Navigant Research)

On its own, big data, or any data for that matter, cannot actually solve any problem or do anything. It is only through the collection, integration, and use of the data in analysis that value can be provided, turning data into information and ultimately knowledge. Big data analytics can, therefore, be viewed as the tool that gives business value to large data sets.

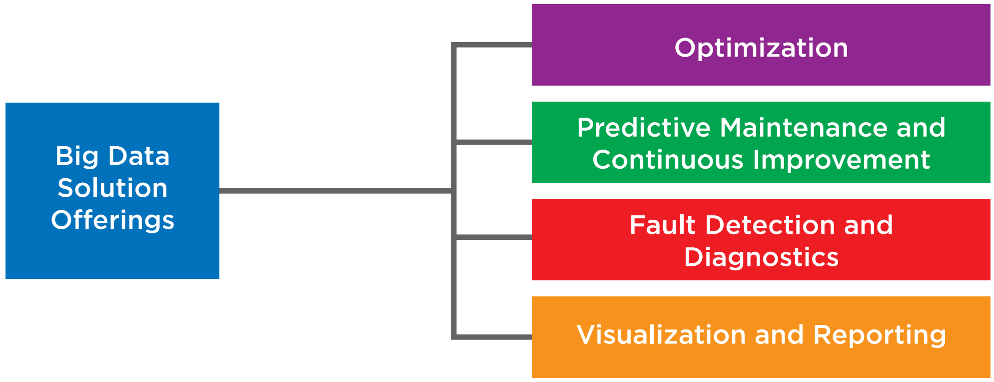
It is necessary to provide a clear definition of big data in the intelligent buildings context in order to support the market analysis and revenue forecasts, both critical deliverables for this research. Big data in intelligent buildings is, therefore, defined as:

> The next generation in business and operational intelligence derived from the analysis of data integrated across multiple streams or sources for the purposes of overall system understanding, performance, and optimization.

In addition, throughout this report, the term big data encompasses both the solution architecture and associated analytics. Big data analytics is an extension of the analytics that have brought new insight to key decision makers exploring opportunities for investment and operational management changes.

Furthermore, characterizing big data solutions for intelligent buildings by offering type helps provide a framework for assessing technology maturity, integration complexity, and the value proposition for different customer segments. There is a wide array of big data solutions in the market, but Figure 1.1 illustrates the four offering categories that are applicable to the intelligent buildings market.

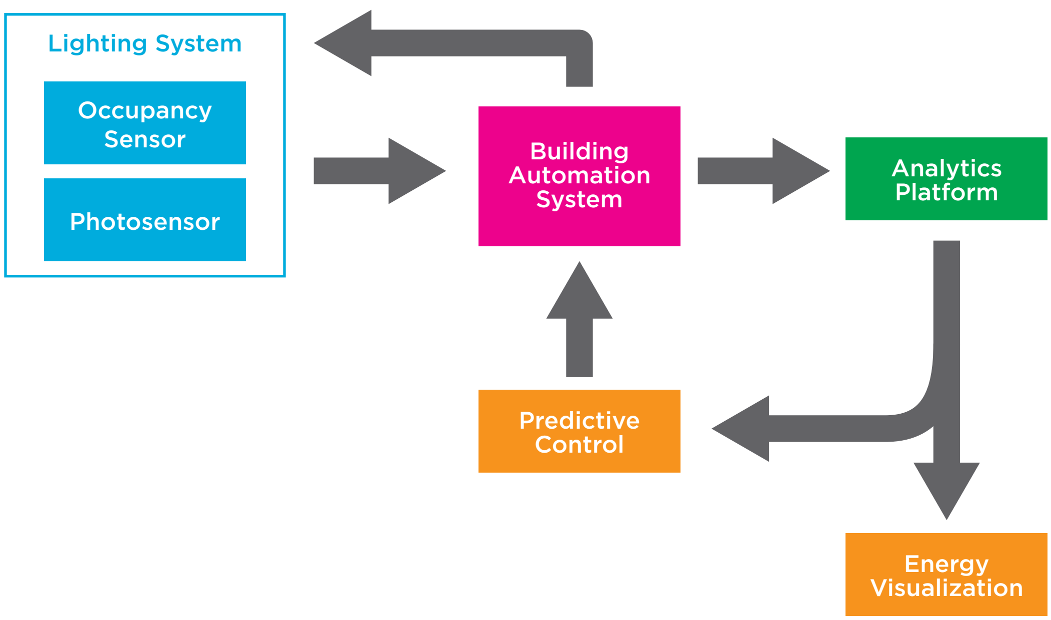
Figure 3-2 Big Data Solution Offerings for Intelligent Buildings



(Source: Navigant Research)

As an example, the deployment of the analytics process on a lighting control system similarly consists of capture, integration, analysis, and action. However, the data captured from the system would come from occupancy sensors and photosensors. Like in the HVAC deployment, this data is integrated through a BAS and then analyzed on an analytics platform.

Figure 3-3 Example Analytics Process for Lighting Applications



(Source: Navigant Research)

Lighting controls demonstrate the benefits that big data can provide to energy efficiency. However, there is a broader opportunity for big data in intelligent buildings that extends beyond energy into other operational benefits.

3.7.2 Business Case

Big data solutions change the paradigm for managing facilities, energy consumption, and business operations. Traditionally, building control has taken a top-down approach with the integration between different systems, such as heating, ventilation, and air conditioning (HVAC) and lighting, occurring at a supervisory level. However, big data analytics solutions are shifting the architecture of building systems to a more distributed platform with hybrid and predictive control based on multiple inputs and outputs from multiple systems. This new approach gives executives strategic decision-making support tools that offer holistic insight into enterprise-wide operations and building conditions.

The economic impact of big data solutions for intelligent buildings is the paramount concern of potential customers in the marketplace. Big data solutions in each of the four offering categories (detailed in Section 3.7) will only gain market penetration if the vendors can effectively communicate the financial savings or new revenue opportunities associated with the investment. Figure 6.7 summarizes the key benefits of each offering category as well as specific benefits for two key customer segments: enterprise/office and retail.

Figure 3-4 Customer Value Propositions for Big Data Solution Offerings

	Visualization and reporting	Fault Detection and Diagnosis	Predictive Maintenance and Continuous Improvement	Optimization
Key Benefits for the End User	• Economic metrics on efficiencies • Benchmarking • Customized data presentment	• OPEX savings • Prioritized fault management • Time-saving equipment management	• Capital planning • Efficient utilization of O&M human resources • Eliminate building drift	• Economic risk management • Sustainability / GHG improvements • Integrated energy and business strategies
Office / Enterprise	• Enhanced portfolio visibility for the C-suite	• Enhanced tenant comfort and retention	• Increased asset value of intelligent buildings	• CSR demonstration • Space utilization
Retail	• Comparative OPEX	• Customer comfort	• Reduced maintenance services costs	• Customer movement • Branding

(Source: Navigant Research)

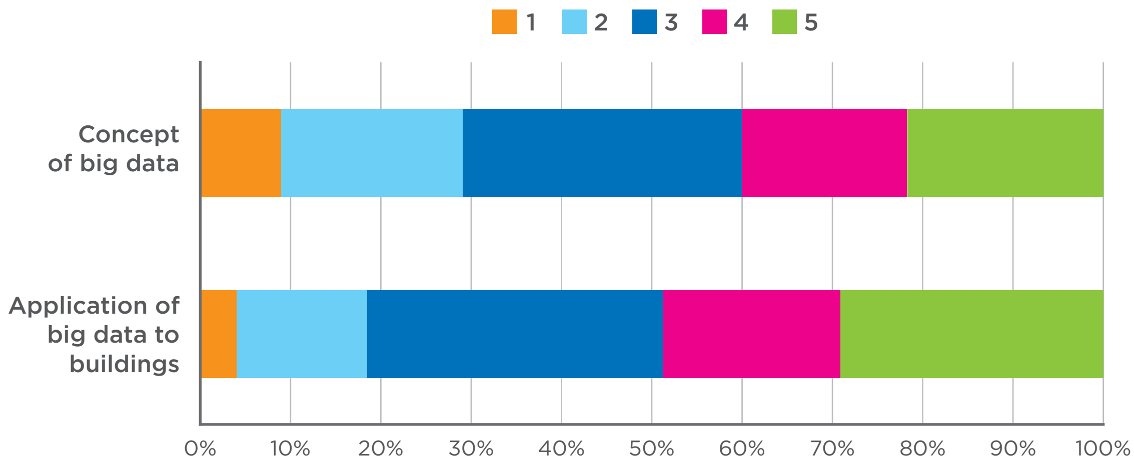
The economic benefits of big data begin with the savings associated with energy efficiency but expand to savings from streamlining O&M, more strategic capital planning, and space utilization. There is an overarching benefit of risk management inherent in big data as well. Big data solutions will help customers plan for facility improvements, monitor ROI of investments, and manage the environmental impact of their operations to hedge potential risks associated with regulatory compliance or corporate commitments.

3.7.3 Market Maturity

The market for big data in intelligent buildings is nascent. Research indicates that nearly all aspects of big data in intelligent buildings, from its definition to the description of its business value, differ depending on where one sits in the marketplace. This research suggests there is a chasm between the technology and end-user readiness for big data in the intelligent buildings context. Despite the need for market education and awareness, there are innovators investing in big data and demonstrating proof-of-concept in the field. Generally speaking, the near and midterm opportunity in North America centers on the retail and enterprise/office markets, in which the economics of investment are balanced by investment costs and end-users' maturity. It is worth noting that there are energy management solutions in the market that address the opportunities for energy and operational efficiencies in single offices, but in the big data context, when referring to the office or enterprise/office segment, Navigant Research is referring to the more complex management challenges associated with building portfolios.

The surveys and interviews conducted to inform this research provide valuable insight into the market maturity from both the supply and demand side of the equation. It is evident there is room for education to help promote the business value of big data in the intelligent buildings context, as illustrated in Chart 1.1.

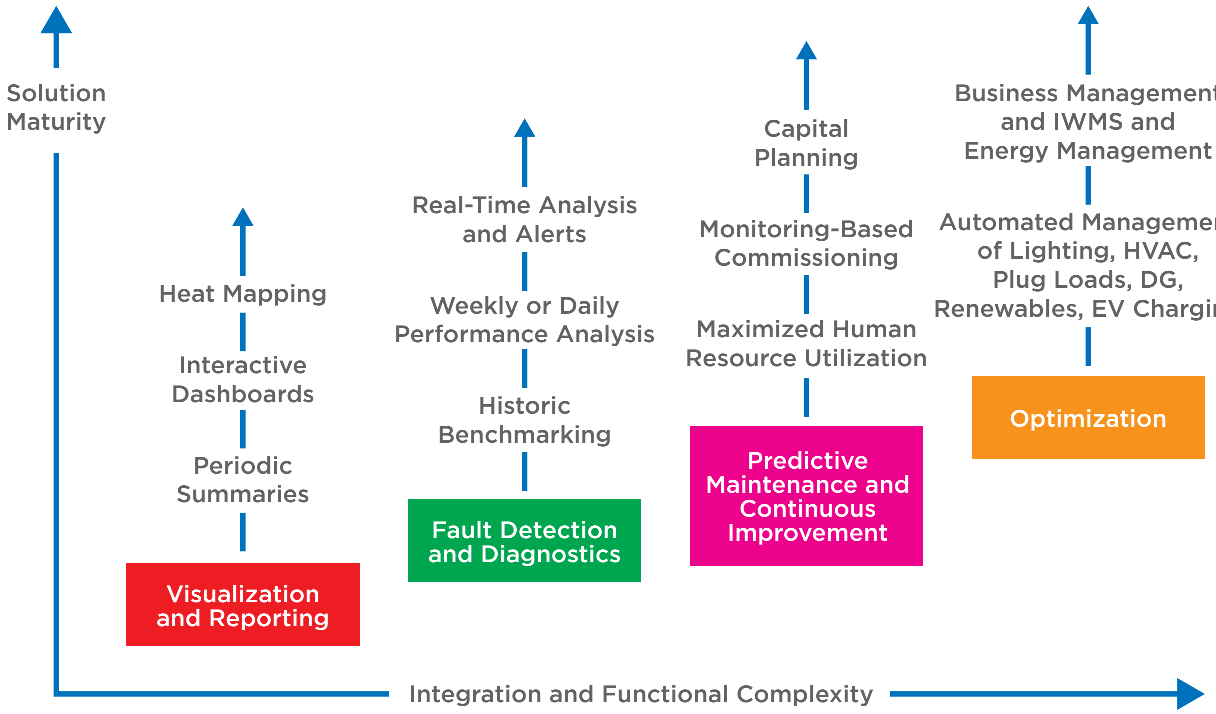
Chart 1.1 On a scale of 1 to 5, where 1 is not knowledgeable at all and 5 is extremely knowledgeable, how do you rate your knowledge about the concept of big data and the application of big data to buildings? (n=400)



(Source: Navigant Research)

Building owners and business executives are utilizing a mix of legacy tools and new intelligent building solutions that fall under each of the four offerings categories; however, new big data solution offerings can provide more holistic insight, which is unmatched by previous versions of the offerings. Figure 6.3 illustrates how solutions in each of the four offering categories fit into the roadmap toward big data. The important takeaway in reviewing the roadmap to big data is that these next-generation offerings provide the most sophisticated analytics to deliver insight and direct action for the greatest economic gain and strategic value from a portfolio or enterprise perspective.

Figure 3-5 Big Data Solutions and the Convergence of Facilities, Business, and Energy Management



(Source: Navigant Research)

3.7.3.1 The Big Data Reference

The CABA Building Data Reference provides a quantitative backbone for the market status of big data in buildings. It defines the level of component-based capturing of data rates, volume, and integration of current intelligent building solutions. By creating scenarios with varied primary building activity, building size, and level of integration, the reference creates a picture of the varying amount of building data in the existing building stock and what future data resources will look like. As a result, this report provides estimations of data size, volume, and velocity in retail and enterprise/office environments: the two key customer segments for big data in intelligent buildings.

3.8 RESEARCH APPROACH

This research is focused on how big data translates into the intelligent buildings context and whether these new solutions will help keep businesses competitive in the increasingly connected and dynamic marketplace. A combination of different types of primary research examined market perspectives on big data in order to project near and midterm opportunities in intelligent buildings. The findings present a new understanding of customer behaviors, competition, and market trends that will shape the adoption of big data solutions.

3.8.1 Methodology

The perceptions of big data in intelligent buildings presented in this report reflect the insight gained through the feedback of 34 interviews and 400 survey responses with a mix of technology and service providers and end-users. This primary research helped clarify how much data is needed and what kind of big data offerings can support the mission-critical requirements for building operations.

3.9 MAJOR FINDINGS

This research concludes that big data in intelligent buildings represents a pinnacle in energy and operational management. These solutions provide comprehensive and strategic decision-making support with automated systems' optimization through the integration of energy management and business intelligence tools.

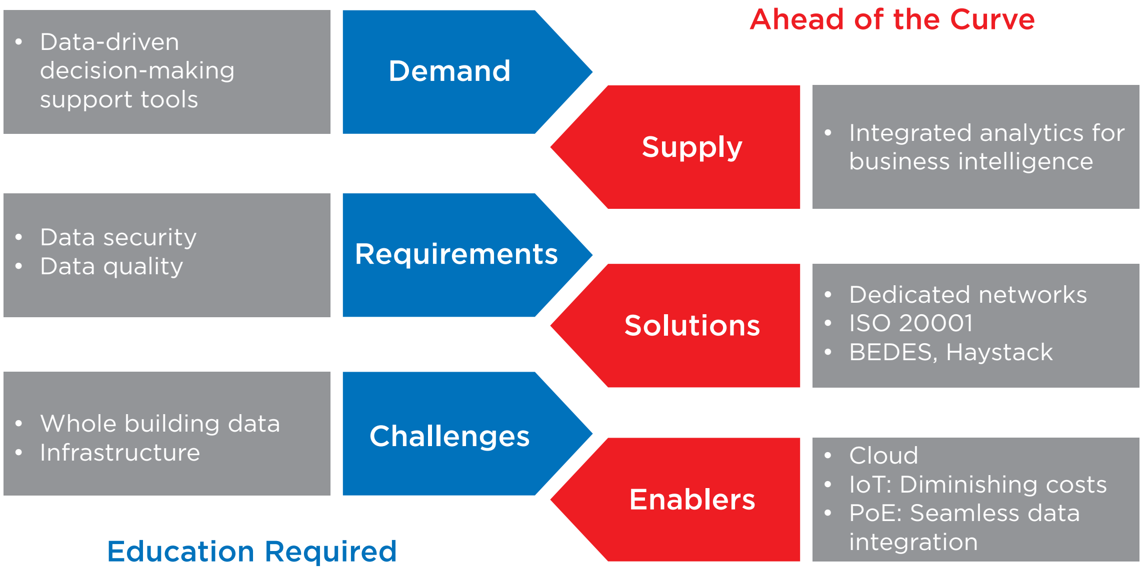
The following general conclusions reflect the perspectives shared between both the interviews and online survey:

- Customers prioritize investment on the economic impacts over all other benefits.
- The majority of decision makers in the intelligent buildings market do not know how to define big data or understand the potential benefits of these new solutions.
- Data security is a major concern for customers, and technology providers have an opportunity to demonstrate how standards and procedures can protect businesses investing in big data solutions.
- Those interested in big data require transparency in the ROI of building and operational improvements.
- There is a lot of low-hanging fruit in building and operational improvements – many customers can still benefit from periodic reporting and analytics on existing building systems, and, as a result, many customers are not ready to adopt fully integrated big data solutions.

The market for big data in intelligent buildings is, however, nascent, and there is a chasm between customers and solution providers. The majority of decision makers in the intelligent buildings market do not know how to define big data or understand the potential benefits of these new solutions. Indeed, many customers can still benefit from periodic reporting and analytics on existing building systems, both of which fall far short of a big data solution. Customers prioritize investments based on economic impacts, thus many are not ready to adopt fully integrated big data solutions. Transparency in the return on investment (ROI) of building and operational improvements is critical to drive adoption of big data in intelligent buildings.

The supply side of the market is ahead of the curve, while there is a substantial need for customer education before investment will significantly increase. Figure 1.2 summarizes the central demand-side dynamics and opportunities for supply-side response. Big data solution providers have an opportunity to address the key dynamics of their customers with sufficient education and demonstrations.

Figure 3-6 Market Dynamics for Big Data in Intelligent Buildings

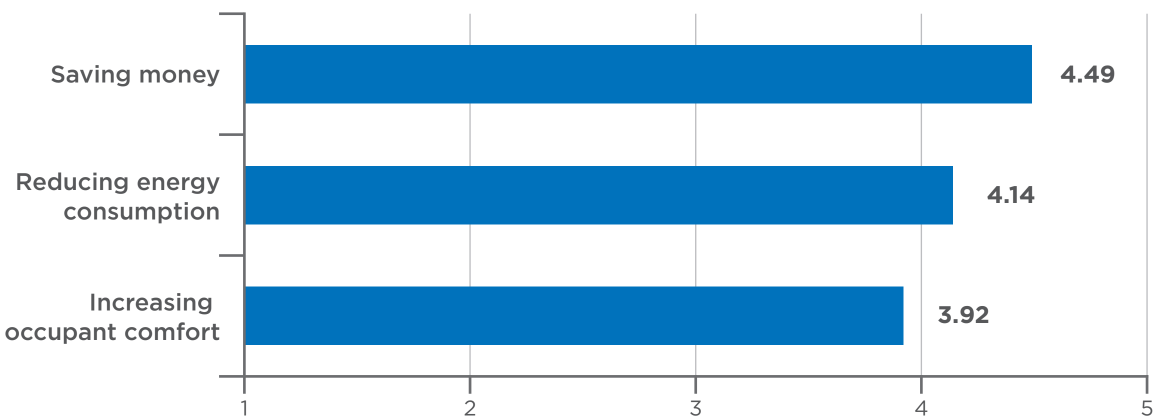


(Source: Navigant Research)

It is generally understood that C-suite executives demand new decision-making support tools to guide the biggest strategic decisions and that these tools must leverage an increasing depth and breadth of data. Big data analytics is well-positioned to bring unprecedented visibility and insight to executive decision makers.

Survey respondents, providing the perspective of end users, were primarily concerned with cost. When asked to rate different factors when making improvements to buildings, saving money was rated higher than reducing energy consumption or increasing occupant comfort.

Chart 5.2 On a scale of 1 to 5 where 1 is not important at all and 5 is extremely important, please rate how important the following factors are when making improvements to your building. (n=400)

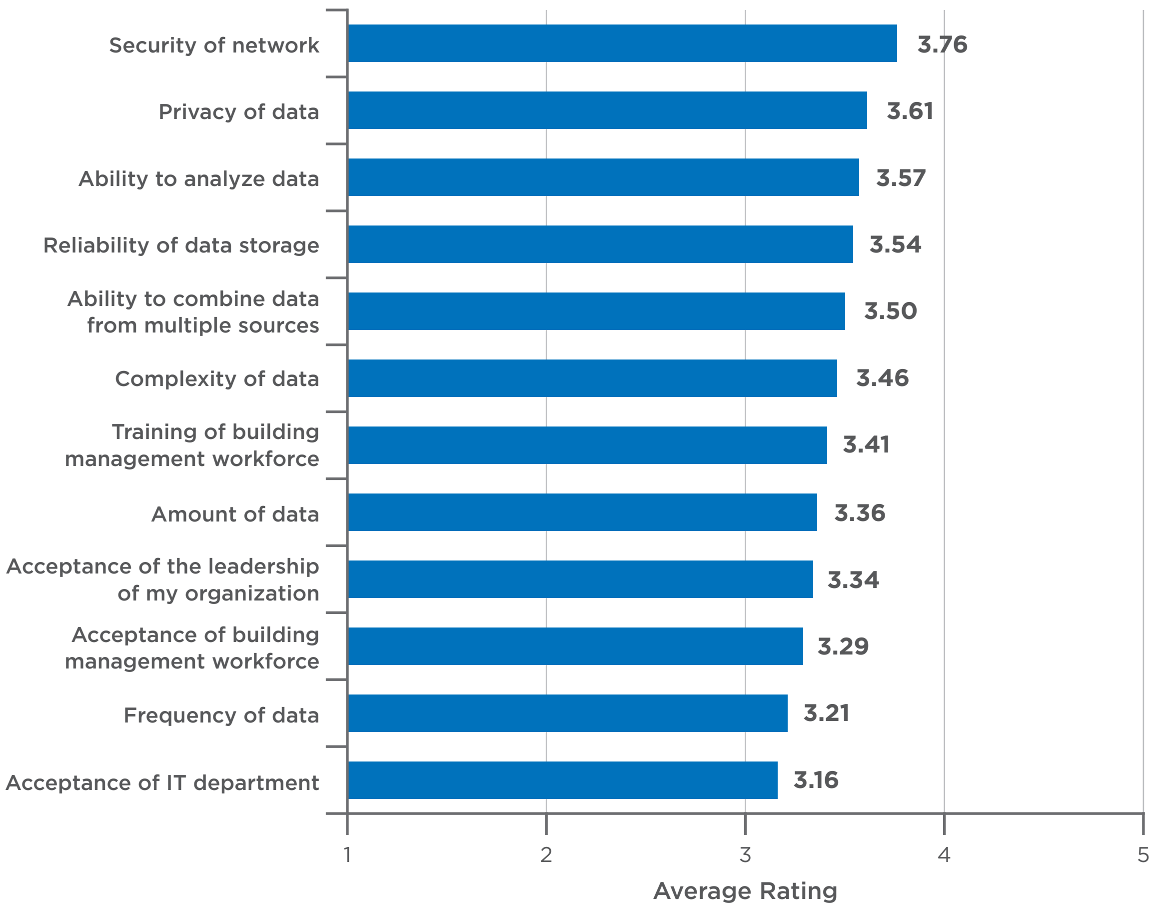


(Source: Navigant Research)

Additionally, respondents seemed unclear about big data. More than 20% of respondents indicated that they were unfamiliar with analytics. When asked to rate their level of knowledge about big data, 39.8% of respondents indicated a level of 1 or 2 out of 5. When asked to rate their level of knowledge about the application of big data to buildings, 48.8% of respondents indicated a level of 1 or 2 out of 5.

When asked to rate issues regarding data collection, security and privacy were rated the highest. Interestingly, respondents were least concerned with getting acceptance from the IT department. Getting acceptance from leadership and building management staff were also rated comparatively low, with fewer than half of respondents indicating that they were concerned or extremely concerned.

Chart 3.3 On a scale of 1 to 5, where 1 is not concerned at all and 5 is extremely concerned, how concerned are you about the following issues as it relates to data collected in your building? (n=400)

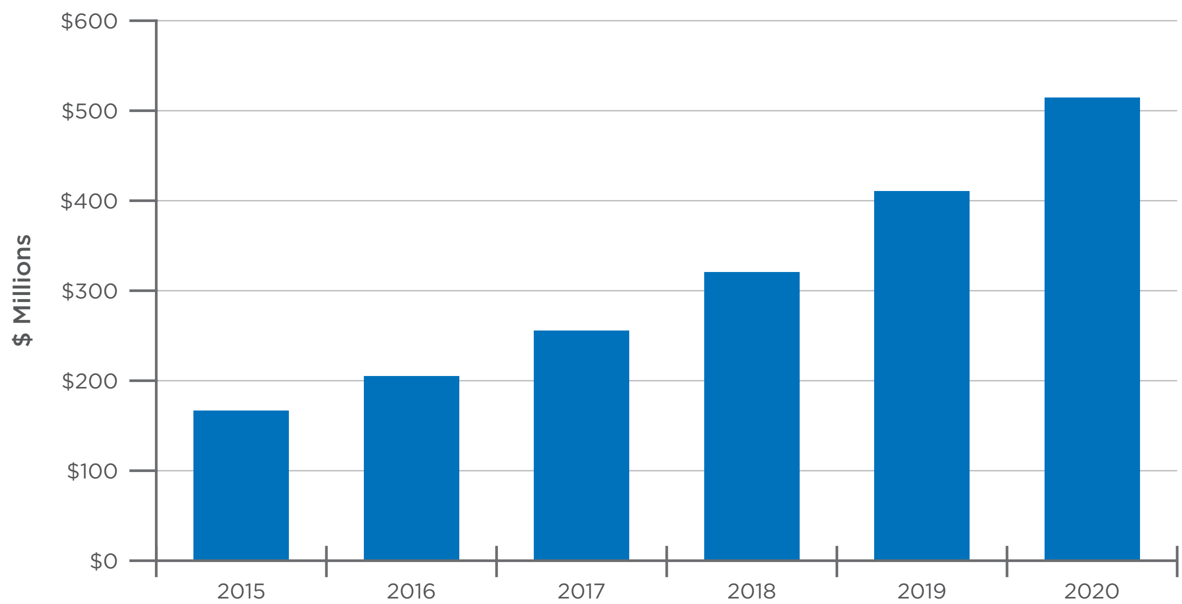


(Source: Navigant Research)

Again, the big data in intelligent buildings market currently in North America is in the beginning stages. Only innovative customers have adopted the solutions entering the market. There are robust signals of continued growth, and it is estimated that market revenue will increase to 2020 with a 24.5% compound annual growth rate (CAGR). Adoption will be supported by the economic benefits associated with the energy and operational efficiency generated by big data in intelligent buildings.

The revenue from big data in intelligent buildings in North America will reach $170.5 million by 2015 and grow to $511.7 million by 2020. The biggest share of the market is tied to the software, which represents more than 50% of the market in 2020. Chart 1.2 presents the topline forecast for big data in intelligent buildings. Greater detail on revenue for the software, services, and hardware system components and key customer segments, including retail and enterprise/office, are provided in Section 7 of this report.

Chart 1.2 Big Data in Intelligent Buildings Revenue, North America: 2015-2020



(Source: Navigant Research)

From both the survey and interviews, it is apparent that the stakeholders across the big data ecosystem have differing perspectives on what big data is and what it means for their business. This is a challenge for those wanting to sell products into this space. What is needed is a series of educational campaigns by vendors, alone or as a group, that focus on a few sets of intelligent building stakeholders. These campaigns would focus as follows:

- **Building and property managers**: Education on how analytics can aid automation, optimization, and operational performance.
- **Portfolio and property managers**: Define the cloud – this concept is amorphous by nature so it is important to define where, physically, data is being stored. Also, the benefits of onsite data processing versus cloud-based processing and analytics are needed for each solution offering.
- **All stakeholders**: Address the security and privacy concerns associated with building sensors.
- **All stakeholders**: Provide more case studies, reporting the CAPEX and OPEX of solutions, the role and investment needed for site energy or property managers, and a real-time view into cost savings. This last point underscores the natural variable performance of BASs. Buildings respond to occupants and the external environment; addressing how a complex (or expensive) system fares in normal and stressed times is beneficial.

3.10 OVERVIEW OF REPORT CONTENT

Sections 2 through 7 of this report provide greater detail on the market dynamics shaping the future for big data in intelligent buildings, including:

- The conceptual framework of building controls, the role of analytics, and how big data analytics changes the management paradigm
- Examples of the business value for big data in other industries and what these cases represent for the intelligent buildings market
- The role of big data in building automation and energy efficiency
- Details on the system infrastructure requirements for deploying big data solutions
- An overview of the process of big data systems integration
- Summary of the market barriers and customer perspectives on big data challenges
- Detailed findings from executive interviews (34) and online surveys (400)

3.11 CASE STUDIES

The following case studies highlight three innovative approaches to utilizing Big Data for energy and business optimization in healthcare and manufacturing. Honeywell, Eco Opera, and Schneider Electric have helped their clients realize the benefits of Big Data in the Intelligent Building framework.

At the Montefiore Medical Center in New York State, Honeywell deployed its Attune solution to achieve unprecedented real-time visibility into system performance that maximizes energy and operational efficiencies. In Vancouver, Eco Opera engaged the Coastal Health Authority and demonstrated the strategic benefits of comprehensive Energy Management Information System (EMIS) with the EcoCEO platform. In South Carolina, Schneider Electric generated proof of concept at home with its deployment of Building Analytics at its own manufacturing facilities that produces motor control centers (MCCs). These three case illustrate the cost savings that customers can realize through optimized operations via energy efficiency, streamlined O&M, and heightened executive oversight with sophisticated analytics running on Big Data.

3.11.1 Vancouver Coastal Health Authority Case Study – Eco Opera

Figure 3-8 Eco Opera Systems at Vancouver Coastal Health Authority

(Source: Eco Opera)

3.11.1.1 Key Highlights

- Showcases the benefits of the comprehensive Energy Management Information System (EMIS), EcoCEO, as a platform to optimize the building systems operation process

3.11.1.2 Features

- Building systems performance optimization achieved through combination of ongoing commissioning and a performance measurement and verification (M&V) process at the whole building and/or building systems and equipment level
- Generation of customized weekly and monthly building systems performance reports
  - Weekly reports utilized for systems performance validation and/or systems fault detection
  - Monthly reports offering detailed trend analysis and identification of systems operation efficiency improvement opportunity
- Facility maintenance group's continuous participation in this process is ensured through time-balanced commitment (five-minute review of the weekly reports and one-hour review of the monthly reports)

3.11.1.3 Project Overview

Vancouver Coastal Health Authority is a regional health authority serving more than 1 million people in British Columbia. An innovator in medical care provision, research, and instruction, the organization has also taken steps to maintain and develop facilities that emphasize occupant comfort and efficient operations.

Located in Sechelt, British Columbia, St. Mary's Hospital's expansion building is a 59,000 square foot healthcare facility that opened in 2012. This project was built to accommodate the expanding emergency and diagnostic imaging departments and new inpatient beds. The hospital expansion includes labor and delivery rooms, as well as an intensive care unit.

As a Leadership in Energy and Environmental Design (LEED) Certified Gold facility, it incorporates a range of sustainable technologies including a solar photovoltaic (PV) system, ground-source heat pump heating and cooling, numerous heat recovery loops, an envelope and glazing system, high efficiency lighting, and integral lighting controls. Through its sustainable design, this facility is North America's first carbon-neutral hospital.

CES Engineering Ltd. acted as the LEED Commissioning and M&V Authority for this project. Eco Opera Systems Inc., deployed EcoCEO on this site in response to the New Construction LEED M&V Credit requirements.

3.11.1.4 Facility Details

- Client: Vancouver Coastal Health Authority
- Address: 5544 Sunshine Coast Highway, Sechelt, British Columbia, Canada
- Building Occupants: 500 to 800
- SF of Building: 59,000 SF
- Building Type: Medical

3.11.1.5 EcoCEO Solution from Eco Opera Systems Inc.

The Eco Opera software solution is a comprehensive enterprise EMIS driven by the EcoCEO energy intelligence engine. EcoCEO supports energy management activities related to achieving continual improvements in facility energy, operational, and cost performance.

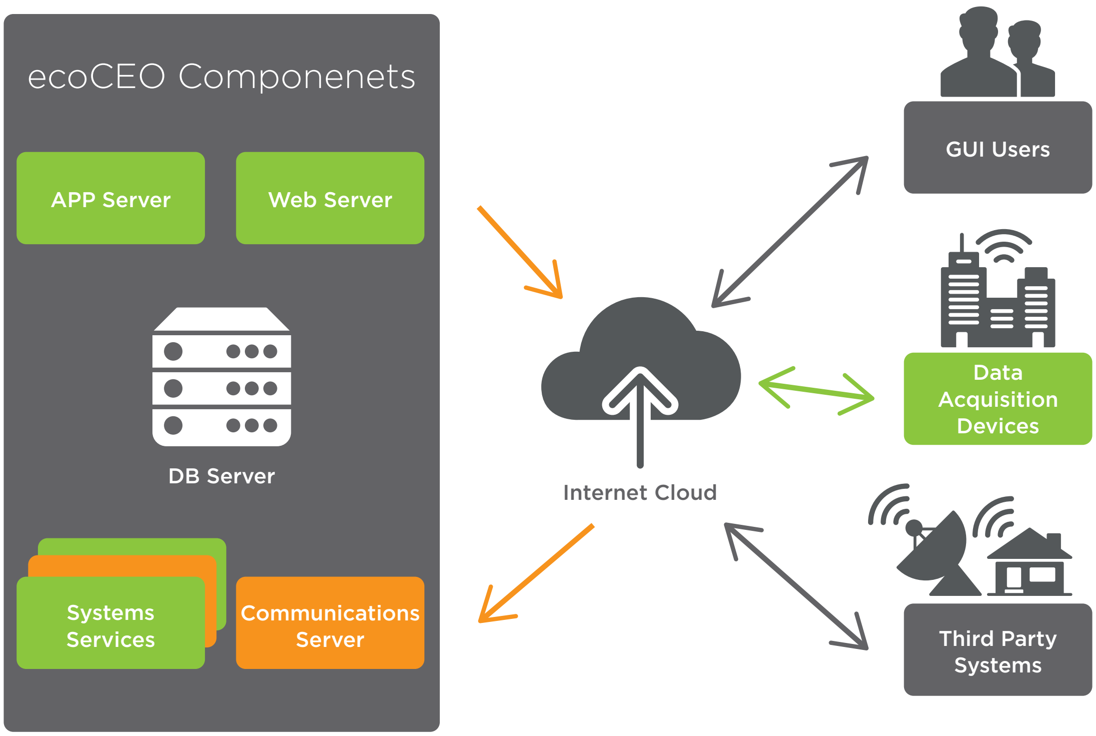
Developed as a fully configurable and scalable solution, EcoCEO allows for comprehensive energy monitoring, targeting and reporting (MT&R) and enhanced support for energy management, M&V, operations and maintenance (O&M), commissioning (Cx) and re-commissioning (RCx), and other custom processes through data acquisition and archiving, analysis, and reporting.

EcoCEO was developed based on industry guidelines and best practices, and produced through Canadian, European, and U.S. federal government research programs.

EcoCEO is offered as a Web-based software as a service (SaaS) or as a turnkey standalone system. The system provides unlimited scalability from standalone projects to worldwide building portfolios. Featuring full integration with BASs, EcoCEO functions as a central repository of facility data, a holistic analytical engine, and a user frontend.

The Eco Opera solutions architecture contains typical Web application server components (web, application, communication, and database servers), as seen in Figure 1.5.

Figure 3-9 EcoCEO Components



(Source: Eco Opera)

Eco Opera Systems currently utilize a number of specific products and modules in relation to continuous commissioning, fault detection, and M&V processes. The EcoCEO suite contains six different aspects: EcoOptimizer, EcoLEED M&V, EcoTrack, EcoQuest, EcoDas, and EcoKiosk. The St. Mary's Hospital project leveraged EcoDas, EcoTrack, EcoLEED M&V, and EcoOptimizer.

Figure 3-10 Eco Opera Systems

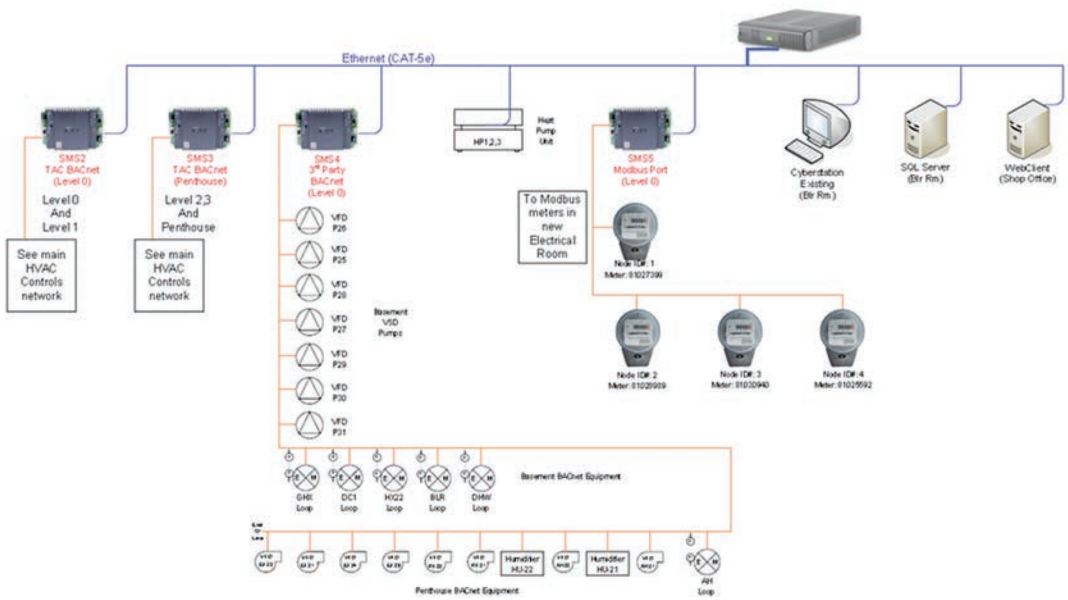
(Source: Eco Opera)

3.11.1.6 Project Stages

Utilizing Eco Opera's data acquisition system, EcoDAS, a centralized data acquisition system was created for St. Mary's Hospital to optimize performance. HVAC building management system (BMS) controls, third-party BACnet equipment devices, and Modbus electrical submetering were integrated into an Ethernet BACnet network. EcoDAS was then connected to a common Ethernet BACnet network.

EcoDAS was configured to collect a data sample of around 700 BMS data points from the building control system and 32 energy submeters on regular 3- to 5-minute intervals. The collected data was automatically uploaded to a cloud-based server for analysis and storage.

Figure 3-11 Eco Opera System Schematic



(Source: Eco Opera)

3.11.1.7 Whole Building Level Analysis (EcoTrack)

EcoTrack was deployed to monitor and track energy consumption and demand via a central electrical meter and central British thermal unit (Btu) meter that measured indirect gas energy from the existing boiler plant feeding this new expansion building.

EcoTrack also incorporated weather analysis for a specific reporting period. Outdoor air temperature sensor data, meteorological average weather file data, and weather station data were analyzed in relation to a number of heating degree days (HDDs) and cooling degree days (CDDs) in order to normalize the effect of external heating and cooling load for specific monitoring period (1 month).

EcoTrack monitored the extrapolated annual Energy Utilization Index (EUI) (kWh/m^2), energy consumption (kWh), and peak demand (kW) for a selected reporting period. Actual, baseline, and national averages were compared for the specified period of time.

Overall, St. Mary's Hospital performs about 55% better by consumption than the national average hospital (Actual EUI 278 kWh/m^2 versus the national average EUI 439 kWh/m^2).

EcoTrack incorporated other performance monitoring features like heat map analysis and time-of-day demand profile to identify average hourly electrical and gas demand for 7 weekdays in a specific reporting period. Consequently, every Tuesday was determined as a critical day in a week, and average daily electrical demand was consistently above 200 kW between 8:00 a.m. and 9:00 p.m.

Chart 3.12 Hourly Electrical Demand Heat Map of Reporting Period

	SUN	MON	TUE	WED	THU	FRI	SAT	Hourly Avg
Midnight	137	159	160	155	137	142	145	148
1:00 AM	134	145	156	146	131	136	140	141
2:00 AM	131	139	143	140	134	129	138	136
3:00 AM	129	131	131	137	134	131	137	133
4:00 AM	125	127	134	138	133	128	140	132
5:00 AM	130	125	138	140	135	132	137	134
6:00 AM	129	132	142	141	133	131	137	135
7:00 AM	130	137	166	154	149	141	143	146
8:00 AM	151	175	192	171	165	154	151	166
9:00 AM	169	183	187	175	168	155	164	172
10:00 AM	165	181	190	176	172	166	162	173
11:00 AM	162	184	191	177	168	169	161	173
Noon	165	186	192	178	172	169	162	175
1:00 PM	168	189	193	179	175	173	168	178
2:00 PM	176	195	195	147	164	174	170	174
3:00 PM	176	194	196	47	123	175	173	155
4:00 PM	184	197	192	182	177	177	178	184
5:00 PM	187	198	194	182	178	179	180	185
6:00 PM	190	195	194	183	181	181	179	186
7:00 PM	191	199	195	187	179	180	180	187
8:00 PM	187	192	195	182	180	182	183	186
9:00 PM	184	192	194	176	169	169	174	180
10:00 PM	173	178	173	162	159	160	162	167
11:00 PM	165	173	163	152	147	150	150	157
Daily Avg	159.89	171.16	175.26	158.49	156.79	157.60	159.00	

(Source: Eco Opera)

3.11.1.8 Systems Level Analysis (EcoLEED M&V and EcoOptimizer)

EcoLEED M&V was deployed to monitor and track energy consumption breakdowns for major energy categories as per the LEED energy model. Lighting, fans, pumps, space heating, space cooling, and plug load energies were monitored for a specified reporting period.

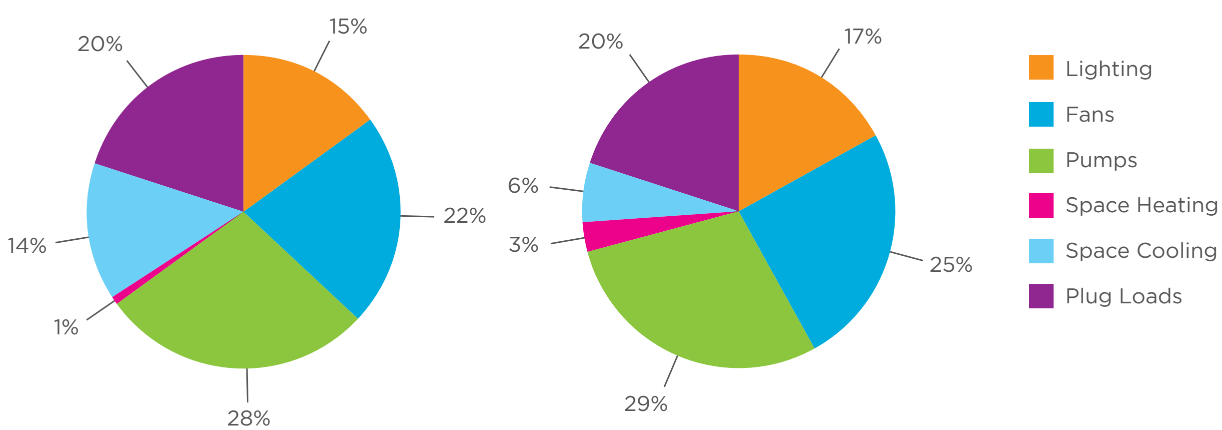
Chart 3.13 Energy Use in St. Mary's Hospital

The electriciy is utilized by the following energy use categories:

	Reporting Period					Year to Date				
	Max Demand (kW)	Min Demand (kW)	Average Demand (kW)	Total (kWh)	Percent Total	Max Demand (kW)	Min Demand (kW)	Average Demand (kW)	Total (kWh)	Percent Total
Lighting	32.2	16.9	24.3	18,089	15%	36.3	13.3	25.0	141,075	16%
Fans	49.3	25.3	35.7	26.596	22%	61.0	23.1	38.1	214,917	25%
Pumps	56.3	10.6	45.2	33,670	28%	61.0	1.2	44.7	252,186	29%
Space Heating	18.2	0.0	1.2	917	1%	31.2	0.0	4.4	24,569	3%
Space Cooling	61.2	1.3	23.4	17,420	14%	61.2	0.7	8.9	49,914	6%
Plug Loads	58.7	0.0	32.8	24,441	20%	76.9	0.0	30.8	173,646	20%

(Source: Eco Opera)

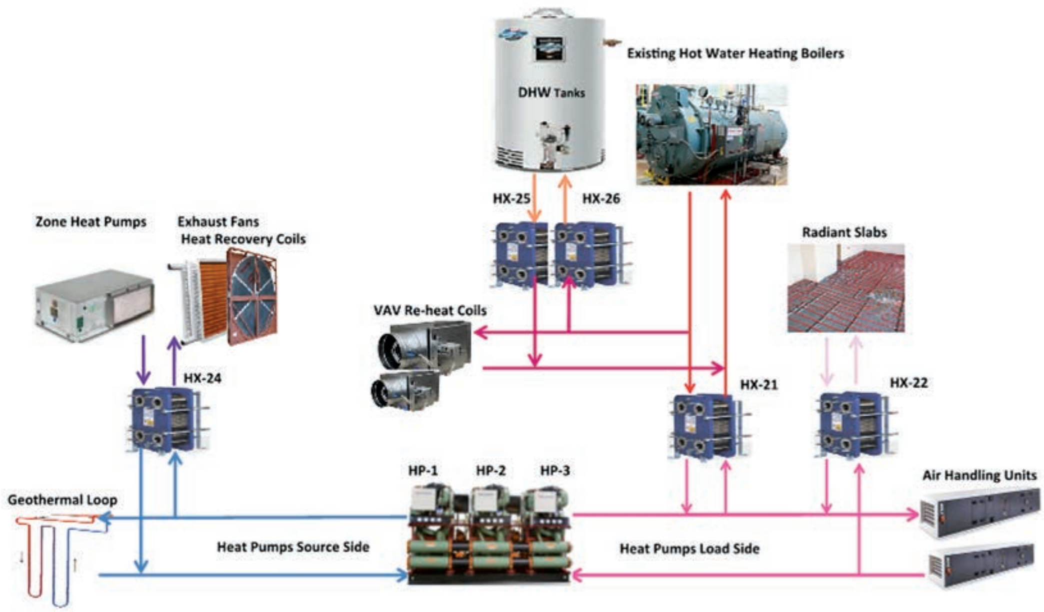
Figure 3-14 Relative Energy Load for St. Mary's Hospital



(Source: Eco Opera)

In St. Mary's Hospital, EcoOptimizer was deployed to monitor and track energy consumption and performance characteristics at the system and/or equipment level. The expansion building has an extensive hydronic system, as depicted in Figure 1.11.

Figure 3-15 St. Mary's Hospital Hydronic System Diagram



(Source: Eco Opera)

Due to the interconnected nature of the hydronic systems for this facility it is possible to maintain zone temperatures while multiple pieces of heating and cooling equipment operate simultaneously in heating and cooling mode. The EcoOptimizer tracks the performance of each heating and cooling plant and other energy sources and identifies opportunities for improvements and energy waste reductions.

EcoOptimizer measures the granular performance of every sub-system, including: heat pump load and source loop, zone heat pump water loop and heat recovery loop, radiant slab loop, air handling unit (AHU) system economizer, outdoor air flows and over ventilation, VAV box operation, and airflow demand ventilation.

3.11.1.9 Key Achievements

- » Developed measurable key performance indicators for quantifying optimum performances of individual building systems, heating and cooling plants, and the whole building
- » Facility operators are empowered with the knowledge of what it takes to operate the building systems efficiently
- » Building systems' performance monitoring is included in the regular operations and maintenance (O&M) business practice
- » Optimum performance is maintained persistently

3.11.1.10 Performance Optimization Opportunities

While St. Mary's Hospital performs about 55% better by consumption than the national average hospital, ongoing analysis of the systems operation parameters identified the following opportunities for improvements and/or systems faults:

- » Occasional simultaneous heating and cooling in the AHU system
- » Unnecessary boiler system interaction with central heat pump loop system
- » Central heat pump systems frequent cycling between heating and cooling modes of operation
- » Suboptimum heat recovery

- » Suboptimum solar panel performance
- » Potential over ventilation
- » Suboptimum AHU supply air temperature control
- » Night set back control loop is not incorporated

Implementation of the above noted operational adjustments could result in an additional 15% in energy consumption reductions.

3.11.2 Seneca Manufacturing Facility – Schneider Electric

Figure 3-16 Schneider Electric's Seneca Manufacturing Facility

(Source: Schneider Electric)

3.11.2.1 Key Highlights

- » Showcases Schneider Electric's Building Analytics service to diagnose system inefficiencies, save energy, and cut costs in the Seneca, South Carolina manufacturing facility

3.11.2.2 Features

- » Building Analytics service automatically analyzed the plant's data on performance, comfort levels, and energy and maintenance every 5 minutes
- » Building managers can access pre-designed daily diagnostic reports to pinpoint building system irregularities, avoidable costs, building comfort impacts, and more
- » A complete ROI is typically achieved within 18 months using the Building Analytics service

3.11.2.3 Project Overview

The city of Seneca occupies 7.1 square miles in the foothills of the Blue Ridge Mountains in the northwest corner of South Carolina. The 2010 census recorded a population of 8,102 for Seneca, and the National Register of Historic Places lists a number of the city's residential and commercial properties.

Seneca is also home to one of Schneider Electric's manufacturing facilities. This particular plant manufactures motor control centers (MCCs), which are used in applications ranging from equipment for production lines and oil rigs to equipment used in wastewater treatment plants.

The manufacturing facility operates multiple shifts throughout the week and on weekends. Thus, controlling the cost to heat, cool, and light a large, open facility with high ceilings while also maintaining desired comfort levels year-round can present a variety of challenges. For example, average temperatures in Seneca range from wintertime lows in the 30s to summertime highs in the 90s.

Implementing Schneider Electric's Building Analytics managed service offered the Seneca plant new ways to quickly address maintenance, comfort, and energy issues for its HVAC system.

3.11.2.4 Facility Details

- Client: Schneider Electric
- Location: 1990 Sandifer Boulevard, Seneca, South Carolina 29678
- SF of Building: 280,000 SF
- Building Type: Manufacturing facility

3.11.2.5 Building Analytics Service from Schneider Electric

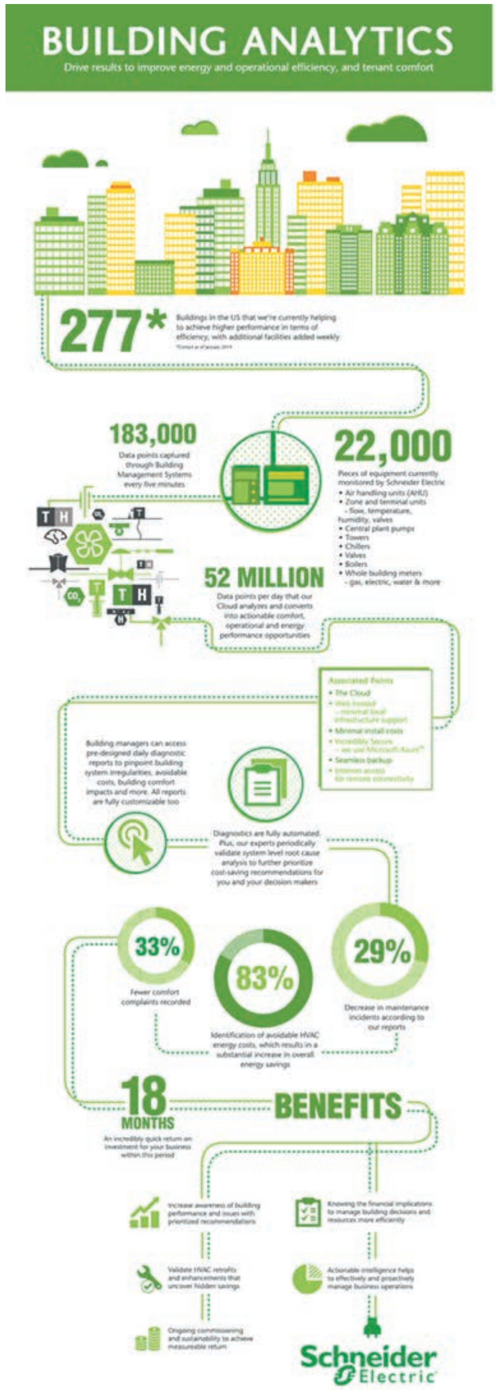
Building Analytics helps to reduce facility operating costs over time and achieve results by targeting maintenance efforts. This is achieved through four key steps: identification, expert review, execution, and validation.

Through identification, stakeholders can access automated diagnostic results for instant visibility into the most costly issues for their facility and can direct maintenance resources accordingly. An engineering analyst aggregates diagnostic results, tracks progress, and consults with stakeholders on harder to solve problems. Internal team members or external vendors are then directed to address mechanical issues and cost savings opportunities. The data generated by the Building Analytics service then determines if problems were effectively resolved or require further attention.

Building Analytics can reduce the cost of facility operations primarily in utility cost savings, maintenance efficiency, and operational improvements. For example, the service has achieved savings up to US$286,000 from fault detection in a ventilation system at a research laboratory. Another project at a community center saw a 23% ROI from commissioning rooftop units to reduce operational costs.

In the case of the Seneca plant, Building Analytics resulted in US$9,000 in energy savings from heating and cooling improvements, a 29% decrease in maintenance incidents, a 33% decrease in comfort incidents, and customized root cause reports generated to facilitate troubleshooting and planning.

Figure 3-17 Building Analytics Design Features



(Source: Schneider Electric)

3.11.2.6 Project Stages

Using its own Building Analytics service, Schneider Electric began to send information from the Seneca plant's building systems directly to the company's cloud-based data storage. Building Analytics then diagnosed building performance, identified equipment and system faults, and located areas for improvement for sequence of operation and energy use at the Seneca plant.

Instead of relying primarily on monthly checkups to track performance, comfort levels, and energy and maintenance data, Building Analytics automatically analyzed the plant's data every five minutes. Guided by the Schneider Electric team of building engineers and analysts, the facilities staff discovered that the Building Analytics service was able to diagnose and troubleshoot HVAC equipment issues that were previously undetected.

For example, some compressors were short cycling, causing premature compressor failure and unnecessary wear and tear on contactors due to small deadbands (i.e., intervals where no action occurred). Additionally, some units wasted energy due to setpoints that did not take building occupancy into consideration when determining heating and cooling needs.

Building Analytics not only evaluated the system's performance, comfort levels, and energy and maintenance data, but also prioritized areas for improvement and validated repairs to optimize building performance. Built on scalable software architecture and leveraging fault detection and diagnostics as well as other advanced diagnostics, Building Analytics ranked recommendations to achieve the most effective remedies and energy savings for the Seneca plant.

Customized reports provided insight into avoidable costs, trend analysis, and prioritization of energy maintenance and comfort issues along with recommended actions. Those reports pinpointed which systems and equipment had irregularities and then prioritized them based on energy cost, severity, and comfort impact.

> As of October 2014, Schneider Electric had certified five manufacturing facilities in the U.S. Department of Energy's (DOE's) Superior Energy Performance program.
>
> The Seneca, South Carolina plant received a Platinum level designation by improving its energy performance by more than 15%.
>
> Schneider's Smyrna, Tennessee facility also received a Platinum rating, and three plants earning Silver ratings – located in Lincoln, Nebraska; Lexington, Kentucky; and Cedar Rapids, Iowa – with an improved energy performance of more than 5%.

With the Building Analytics service, those responsible for building and equipment performance at the Seneca plant have both local and remote access to detailed information about the plant's systems operations. Moreover, staff can now be more proactive in optimizing the building's systems and energy consumption.

3.11.2.7 Key Achievements

- The Schneider Electric plant realized an 83% decrease in avoidable energy costs related to HVAC operations
- $9,000 in energy savings from heating/cooling improvements
- 29% reduction in maintenance incidents
- 33% decrease in comfort incidents
- Customized root cause reports for ease of troubleshooting and planning
- The Building Analytics service paid for itself during the first year by providing automated and sophisticated analysis combined with quarterly recommendations to eliminate energy waste

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