Project Synopsis

Current Situations and Trends In Buildings and Facility Operations

Research Supporting National Science Foundation Project:

"Educating Technicians for Building Automation and Sustainability"

National Science Foundation
Advanced Technological Education Program
Award #0802595

This material is based upon work supported by the National Science Foundation under Grant No. 0802595. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

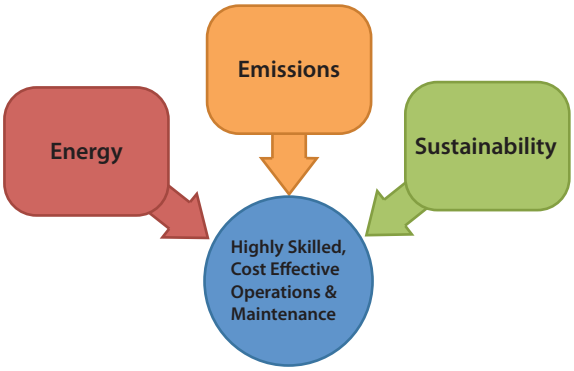
Current Situations and Trends in Buildings and Facility Operations

Executive Summary

Americans depend on commercial and institutional buildings including schools, offices, government buildings, retail stores, hotels, airports, and hospitals to provide safe and comfortable indoor environments. These buildings have a major impact on our economy and global competitiveness. They are also responsible for close to 20 percent of all energy usage and carbon dioxide (CO_2) emissions. Despite the importance of these buildings and their impact on the economy and environment, little attention is paid to appropriate training and professional development of technicians, operators, and facility managers responsible for proper operation of buildings. This project synopsis briefly describes relevant trends and influencing factors, as determined through *Current Situation and Trends in Buildings and Facility Operations,* the research report supporting the National Science Foundation Project "Educating Technicians for Building Automation and Sustainability".

The goal of the research was to document current trends by investigating the current condition of buildings and their operations and maintenance, with a primary focus on how technician training is impacted by global issues of energy, emissions, sustainability, market trends, legislation and regulation, technology and systems, people and processes, and the existing buildings portfolio. The research then summarizes the steps necessary for building automation technicians to have opportunities to obtain the skills required to operate high performance buildings today and in the future. This included the completion of a gap analysis, the development of a call to action, and identification of areas of future work and research.

This project synopsis summarizes the synthesized findings of the primary research (survey, interviews, and focus groups) and secondary research (literature review and observations of current practices), which was completed to assess the current situations and trends in building and facility operations literature. It also summarizes reports from government and trade associations on the topics of buildings, facility management, building operation, building control systems, and sustainability. The secondary research was used to inform the primary research. The primary research included an on-line survey, four focus groups, and 10 verbal interviews. The online survey was completed by 253 professionals, resulting in a 23 percent response rate. In total, the four focus groups included about 40 participants. The findings of both the primary and secondary research were synthesized to draw conclusions about the current gaps, form strategies to close the gaps, develop a call to action, and identify ideas for future research.



Issues Driving Workforce Needs

1.1 Current State of Buildings and Facility Operation

Today there are approximately five million existing commercial and institutional buildings in the United States, comprising 72 billion square feet. The buildings range from historic to newly constructed and from small to large, spanning all geographies and climate zones. Although new buildings follow increasingly stringent energy codes and offer improved energy efficiency, few existing buildings have been retrofitted to improve energy efficiency. Facility managers, technicians, building operators, and maintenance teams lead the daily effort to keep buildings operational, comfortable, productive, and efficient. Several major challenges confront this multidisciplinary profession and its practice.

Challenge 1 – Workforce Education and Training

Today there are few formal training programs available for technicians, operators, and facility managers. Many technicians enter this field with limited formal training and learn through on-the-job training (OJT) provided by traditional apprenticeship programs or military experience, as well as less formal training provided by senior technicians or chief engineers. The limited classroom training provided through apprenticeship programs is focused on system components and narrowly defined job skills. This historical apprenticeship model assumes that industrial job skills can be mostly learned on the job, without the need to rely on extensive classroom-based education. Formal job training for facility managers is often indirect, as few facility management educational degree and training programs exist. Combined with a lack of well-established industry standards for facility management, operations, and maintenance practices and processes, many entering the industry find themselves unprepared for the challenges ahead. The emergence of high performance green buildings complicates matters, as the skills required to understand the systems and practices to operate and continuously optimize these buildings cannot be achieved through traditional OJT methods. Community colleges may be best-suited to provide the in-depth education and training needed for future building operators, perhaps in partnership with traditional trade union and OJT training methods. This is because:

- Community colleges are structured to teach students seeking several different levels of education such as completion of one class, a certificate program, or associate's degree.
- Association or membership with a professional association or trade union is not a prerequisite for enrollment.
- Community colleges provide courses in math and science, which are the foundation for understanding building control systems as well as the ability to trouble-shoot and think critically about real-world operational challenges.
- Graduates of community colleges can be employed in either a union or non-union environment.

Challenge 2 – Separation of Design and Construction from Operation

In most organizations, the functions of design and construction are organizationally distinct from operations, and have separate budgets. The function of design and construction is typically outsourced to teams of architects and engineers, which greatly limits the input of building operators during the design and construction process. Limiting input from building operators during design prevents the exchange of information about what is truly necessary to maintain and operate a building, as the design and construction community has little understanding of these requirements. Construction processes, including value engineering and lack of proper commissioning, often leave the operations team with a building that operates significantly below the original design performance specification. As a result, building performance starts low and degrades over the life of the building.

"There is a lack of a holistic picture of the building because there is no continuity between the design of the building and the program it is being used for and the way it is being maintained."

– Quote from focus group participant

Challenge 3 – Stature of the Profession

The professions of building operator, technician, maintenance service provider, and facilities manager garner relatively low status in most organizations. Dominated by a traditionally blue-collar industrial ethos and, in many cases, segmented union structures, facilities management and building operation and maintenance teams are mostly invisible. Seen as largely peripheral to the core mission of the organization, they find themselves low in the organizational hierarchy. The results are declining budgets, limited staffing, low clout, and a sense of powerlessness among building operators and technicians to improve building performance, all the while facing outsourcing of facilities management and building operation jobs to property management and/or maintenance management service providers.

Challenge 4 - Interface
Facilities managers, technicians, operators, and maintenance teams often find themselves serving as the de-facto interface between owners, property managers, occupants, and tenants. Caught in the middle, they must balance the conflicting needs of comfort, convenience, energy efficiency, safety, and environmental sensitivity. As a result, energy efficiency and comfort often appear to be incompatible and mutually exclusive.

Challenge 5 - Mission and Purpose
Building operation groups tend to be focused on two tasks: satisfying tenants and making equipment work reliably. While these are important areas of focus, they do not easily extend to cover additional tasks such as optimization and energy efficiency.

1.2 Current Transition and Trends

The buildings industry is in the midst of a gradual transition toward high performance buildings. Programs such as LEED® from the U.S. Green Building Council and ENERGY STAR from the U.S. EPA are increasingly used for both new and existing buildings. U.S. government buildings are under executive and legislative mandates to dramatically improve efficiency and reduce greenhouse gas emissions. Private industry has followed suit, including corporate sustainability goals for both owned and leased space. This is all part of a global effort to reduce CO_2 emissions, of which buildings are a major contributor.

While most of the emphasis on sustainable and high performance buildings has been in new construction, existing buildings have the greatest environmental impact. Older buildings were often built using less stringent standards and operated at sub-par performance levels. Building operations have a major impact on the delivery of efficiency and sustainability goals. To achieve required levels of building efficiency, a transition is required in building operations.

Key focus areas of the transition include:

- **Re-defining the field:** The job descriptions of building operators include a wide range of functions. Some building operators are highly trained engineers, while others have a skill set similar to a custodian. Defining sustainable building operations as a profession and providing the appropriate pay and respect is a critical first step in this transition.
- **Proper training and certification:** Like any profession, proper training and certification is necessary. The development of training programs including curriculum, laboratories, testing standards, and proficiencies is required. If this field is to receive the needed respect and attention, professional certifications need to become an expectation.
- **Development of new tools and processes:** Improved tools and processes for building operations need to be more broadly deployed and effectively used. These include tools for evaluating and measuring building performance, scheduling maintenance, analyzing systems, and calculating return on investment (ROI). While most of these tools are commercially available today, they are rarely applied uniformly within facilities or properly integrated into well-documented processes.
- **Building performance:** Building performance must be clearly and practically defined by identifying best-in-class building systems and management processes. To determine what is possible and to define strategies to move towards net-zero building design and operation, best-in-class examples from buildings in the United States should be compared to best-in-class examples from buildings in Europe.
- **Ongoing performance measurement:**
  Finally, a system for ongoing performance measurement and management is needed. Rigorously defined performance criteria should include energy efficiency, carbon footprint, comfort, uptime, and tenant satisfaction.

1.3 Identifying the Gaps

In synthesizing the current state of buildings and facility operations with industry trends, several gaps emerged. The gaps can be classified within three broad categories: people, process, and technology. Ranking the three gap categories, the greatest needs are the people and process gaps. The technology gap presents the lesser need because:

- Many currently available technologies are present within buildings but underutilized, including building automation systems, energy benchmarking systems, and management tools such as computerized maintenance management systems (CMMS).
- To stay competitive, manufacturers and vendors must continue to develop and refine systems, equipment, and software products. As a result, the functionality and quantity of products on the market will only continue to increase. Manufacturers and vendors have a strong interest in marketing new products to stay in business and grow their customer base.

1.3.1 People Gaps

The people gap includes roles and building owner expectations, employment opportunities and career paths, education, and trade union roles and responsibilities.

Roles and building owner expectations:

The daily tasks and responsibilities of the high performance building technician and facility manager are not clearly defined. Additionally, technicians and facility managers often see their role as doing what is necessary to satisfy the tenant, even if it increases energy consumption. As a result, in most organizations meeting tenant needs is at odds with energy efficient equipment operation.

"The biggest gap that I see right now being in conservation and operation ... is really having the real talent to maintain all of these new energy efficient high technology buildings – that is our biggest problem."

– Quote from focus group participant

The Super Hero Theory: A belief, adopted by some managers, that a single technician has all of the expertise necessary to solve all operational challenges. A super hero technician can trouble-shoot and problem solve for all system types, and also possesses excellent customer relations and business skills and an ability to adapt quickly to change.

While some technicians fit the definition of the Super Hero Theory, it is an unreasonable expectation for most technicians because acquiring the skill set necessary to be a super hero technician requires many years of experience across multiple trades, as well as very strong analytical skills, the ability to communicate verbally with multiple stakeholder groups, and extensive troubleshooting and critical thinking skills. Additionally, the existence of the theory indirectly demonstrates that managers are not well informed about the complexity of mechanical, electrical, and other systems within buildings. Equating the expectations of the Super Hero Theory to a management role would be like expecting one person to have the skills and competencies necessary to fill the roles of a human resource manager, accountant, bookkeeper, and administrative assistant.

The existence of the Super Hero Theory suggests that it is necessary to educate managers and building owners about the complexity of building systems and technologies.

Employment opportunities and career paths:
Career paths are often not clearly defined and many people entering facility management and building technician roles do not enter the profession intentionally. Many people do not desire to enter the building operations and facility management fields because employment opportunities are seen as invisible and largely peripheral to the core mission of an organization, and/or work performed in the field is seen as undesirable.

Education:
Results of the research found that although about 75 percent of respondents had education from a college, university, or community college, only 12 percent of respondents pursued a course of study directly related to building operations or facility management. Few higher education degree and certificate programs exist to educate facility managers within the U.S. Although the International Facility Management Association (IFMA) Foundation helps community colleges and universities establish and accredit facility management degree programs, the number of students graduating from these programs is smaller than the number of professionals needed to fill future demands. Within current programs, the amount of time students spend in the field or doing lab work is often insufficient to prepare them for their careers.

Trade union roles and responsibilities:
Although trade unions provide many benefits to their members, the structure and roles of unions may reduce the opportunities members have to help meet the needs of high performance buildings. For example, the successful operation of a high performance building starts with building operator and technician involvement during the design and construction processes. However, many unions currently have tightly defined roles, constraining how union members can participate during design and construction processes. This decreases the opportunity for integration of the design, construction, and operations processes and reduces the potential to use a systems approach.

As the number of high performance buildings continues to increase, unions, like all other education and training providers, will need to offer training opportunities which include the skills necessary to operate and maintain high performance buildings.

> ***"We don't have time to really work on equipment like you should and that is where most of the bad conditions happen. Everybody does everything and so you are responding to the emergencies, cold calls, water leaks – room is too hot- lights are out – a number of things."***
>
> **– Quote from focus group participant**

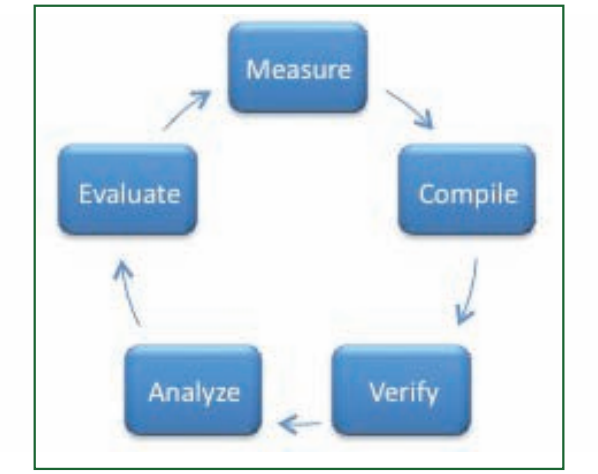
1.3.2 Process Gaps
The process gaps are centered on a lack of standardization of methods and best practices, including:

- Clearly defined energy management and sustainability goals.
- Benchmarking to track energy consumption and costs, including the use of meter data.
- Tracking methods for operations and maintenance cost analysis.
- Proactive maintenance management techniques.
- Clearly defined job roles and responsibilities.
- Integration between the design, construction, and operations processes during the design phase to eliminate lost project documentation, a lack of systems perspective, and building systems not working as intended.
- Well organized and accessible building system documentation.

The lack of clearly set goals and use of benchmarking tools is supported by the survey findings in that:

- Less than half of survey respondents use the Energy Use Index (EUI) or ENERGY STAR Portfolio Manager at their facilities.
- About one fourth of respondents were not aware of any set goals to reduce energy consumption.

A lack of standardization often requires facility managers and non-union technicians to be the "jack-of-all-trades" in order to complete the variety of activities required within their job descriptions.



The Continuous Benchmarking Process

1.3.3 Technology Gaps

Technology includes systems, equipment, and software. Although manufacturers and vendors often provide product education for engineers, construction contractors, and sometimes facility managers, technicians and operators must also be informed. Since technicians and operators do not make purchasing decisions, manufacturers and vendors do not generally reach out to educate them.

To understand how to further utilize existing software, technicians and facility managers must have an understanding of:

- High performance building systems
- Intelligent buildings
- Middleware and enterprise systems
- Effective use of metering and meter data
- How to communicate technical information with finance, procurement, and other non-technically minded professionals

> ***"A building operator may not talk the same language as the CFO because the CFO only sees in financials."***
>
> **– Quote from focus group participant**

High performance building systems include:

- Building envelope
- Mechanical, electrical, and building automation (controls) systems
- Lighting controls
- Wireless technologies
- Integrated systems
- Dashboards

Intelligent buildings are defined as buildings that use technology and processes to provide safe, comfortable, and productive indoor environments for the building occupants. Middleware and enterprise systems include open and integrated systems, which may also include business process software.

Sample Dashboard

Of all of the systems within buildings, controls were identified to have the largest skill gap when comparing current skill levels against skill levels required to operate high performance buildings.

It is important to understand that the technology gap is not a lack of systems and equipment to meet the design and construction needs of high performance buildings, but rather it is the ability to effectively use the technology and to optimize system performance. Closing the technology gap will require process improvements and increased educational opportunities for operators and technicians.

1.4 Vision: How to Close the Gaps

Meeting the goals set by building owners and managers for high performance buildings will involve further definition and elevation of the technician, operator, and facility manager. This will require identifying clear, measurable steps to close gaps and move building operations practices from reactive to proactive. Of the three gap categories defined, they should be prioritized as:

- People
- Process
- Technology

People are needed to fill the roles of high performance building managers and operators. In order for these roles to be filled, many people will need to be educated about the processes, methods, and technologies required to efficiently operate, manage, and transform existing buildings to high performance buildings. Without properly educated professionals, energy and greenhouse gas emissions reduction goals will not be met.

Many current industry challenges will need to be overcome in order to design, build, and operate a high performance building, such as:

- Proactive energy, operations, and maintenance management processes.
- Support from upper management to provide the proper training needed to complete systems-based maintenance.
- A properly skilled workforce.
- Educated owners and building managers who are willing to invest in staff training and process improvements.
- Respect for knowledgeable building operators and technicians.
- Incentives for building operators and technicians to operate buildings efficiently.
- Lifecycle cost considerations.
- Systems and equipment design documentation written and presented in a format that is understood by facility managers, building operators and engineers – not just engineers.

"If you want behavior modification to occur, you need to raise awareness and then [provide] the tools [necessary] to lead to long term action."

– Quote from focus group participant

1.4.1 Future Building Control Technicians

The findings of the research suggest that future building control technicians will need to have the following competencies to successfully operate high performance buildings:

- Systems thinker: Understand interactions between components including controls, HVAC, and lighting.
- Basic data analysis: Understand how to use data generated by a building automation system, including how to read trend logs and how to use the data for decision making.
- How to learn: How to think independently and critically to troubleshoot and solve problems.
- Effective verbal and written communication skills, including:
  - Ability to communicate with building managers about financial decisions impacting operations and maintenance.
  - Ability to communicate with building occupants, vendors, and service providers.

Future building control technicians will be challenged by:

- Overcoming the expectation associated with the Super Hero Theory.
- Continually increasing pace of new, computer-based technologies.
- Learning how to communicate with managers, building occupants, and vendors.
- Approaching maintenance and operations tasks from a systems approach, as opposed to a component-based approach.
- Cultural challenges such as a belief that effective building operation is not important to high performance buildings and energy efficiency.

Overcoming these challenges to achieve the vision will require collaboration between community colleges, trade unions, product manufacturers and vendors, colleges and universities, professional associations, and many other groups. In order to foster collaboration, a national conference should be established to help share best practices and lessons learned.

1.5 Call to Action and Future Research

Achieving the vision defined by this research will require commitment of the following:

- Development of clearly focused degree programs for technicians that include:
  - Field experience through labs and/or apprenticeships, communication skills, and negotiation skills to influence occupant behavior change.
  - Strategies to develop economical, portable lab modules that can be widely disseminated for use at community colleges and other training programs. The lab modules must be able to be replicated (blue printed), support multiple technologies, and be developed with support from product vendors.
  - Case studies and problem-based learning scenarios to allow students to learn from facility managers and technicians currently in the field (dealing with "real life scenarios").
  - Programs structured to be accessible to students from a wide demographic, including dislocated workers, high school graduates, returning students, working professionals, and others seeking hands-on and applied training. The programs must also be structured to allow students to either earn associate degrees or certificates, or to just complete single courses.
- Identification of the roles of trade unions and professional associations, and partnerships with other community colleges, universities, and market-driven training providers.
  - Determine if and how mentoring opportunities can be created.
  - Decrease the time and resources necessary to successfully implement more training programs through the development of regional and / or national clearinghouses to disseminate curriculum and lab blueprints.
  - Determine if standards should be developed for accrediting community colleges with regard to training controls technicians, building operators, and maintainers. If so, determine the most appropriate development strategy.
  - Determine how to encourage people to seek careers as building control technicians by reaching out to high schools and others seeking hands-on work opportunities.
  - Educate owners to understand the value of hiring and training skilled technicians.

After owners understand the value of trained technicians, work with owners to develop paid apprenticeship programs for students.

1.5.1 Future Research

To achieve the call to action, the following future research is recommended:

- Compare existing training opportunities within the market with existing programs at other community colleges. This comparison should include clearly documented site visits to help share and disseminate teaching and lab development best practices for educating building control technicians.
- Interview/shadow experienced technicians to understand what skills are necessary to operate equipment efficiently and to prevent operating equipment in-hand, as well as to discover preferred learning methods and topics of interest.
- Compare technician certification programs available from NATE, RSES and others to determine which one(s) brings the most benefit to the field. Then, work with these organizations to promote these programs to students, as well as to new and seasoned professionals.
- Compare facility management certifications available from IFMA, BOMA, AFE and others to determine which one(s) brings the most benefit to the field. Then work with these organizations to promote these programs to students, as well as to new and seasoned professionals.
- Develop a framework for facility management and technician apprenticeships that can be used to help community colleges, four-year colleges, and employers to build partnering relationships.

- Develop well documented processes and guidance to deploy standards and tools and for evaluating and measuring building performance, scheduling maintenance, analyzing system performance, and calculating ROI. Various teaching methods including classroom, lab, and online should be developed to help disseminate standards and tools.
  - Determine if/how Six Sigma can be applied to develop proactive operations and maintenance standards.
  - Teaching resources should be standardized so as to be useful to multiple community college and training programs, and should include information packets, workbooks, and online materials.
  - Teaching methods must be structured for both student learning and train-the-trainer instruction.

1.6 Summary

Meeting the needs of technicians to operate and maintain high performance buildings is a large, multi-dimensional challenge. This study has classified the challenge as having three gaps: people, process, and technology. Although closing the gaps within all three classifications is important, the research suggests that the people and process gaps are the higher priority. Future research is needed to create more collaborative opportunities between community colleges, unions, professional associations, and industry members. This will help to define the criteria for developing cost-effective training modules that can be widely disseminated, and educate owners about the value of training and the need for standardized operations and maintenance practices.

"We cannot purchase efficiency; we can enable it through continual training, testing, certification and encouragement."

– Mark McGann,
National Association of Power Engineers (NAPE) National President (2010)

Prepared by Building Intelligence Group LLC
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