

# BOMI

Building Owners and Managers Institute



## AIR HANDLING, WATER TREATMENT & PLUMBING SYSTEMS

Through this course, you will learn about climate control for human comfort, the components of HVAC systems, and the basics of water treatment and plumbing systems. You will gain the skills and knowledge to perform common water tests, maintain air conditioning systems, maintain water services, and inspect portable fire extinguishers.

Upon successful completion of this course, learners will be able to:

- Replace and/or maintain complicated HVAC systems
- Outline procedures for water sample analysis, testing, and treatment
- Reference guidelines when installing and monitoring pipes and valves
- Maintain a reliable and effective fire protection system

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**Chapter 1: Human Comfort, Air Properties, and Heat**

- Overview, Learning Objectives, Introduction
- Human Comfort and the Built Environment
- The Physics of Heat
- Air Properties
- Humidity and Human Perception of Heat
- Thermal Loads on HVAC Systems
- Summary

**Chapter 2: Ductwork**

- Overview, Learning Objectives, Introduction
- Classifying Ductwork
- Types of Duct Layouts
- Materials Used to Construct Ductwork
- Duct Heat Gain and Loss
- Establishing Good Ventilation
- Dampers
- Noise Reduction
- Summary

**Chapter 3: Air-Handling Units, Fans, and Building Pressurization**

- Overview, Learning Objectives, Introduction
- Structure and Function of the Air-Handling System
- Fan Types
- Fan Capacity
- Fan Laws
- Fan and System Performance Curves
- Fan Motors
- Fan Performance and Air-Handling Unit Maintenance
- Building Pressurization
- Summary

**Chapter 4: Principles of Thermal Comfort Devices as They Relate to the AHU**

- Overview, Learning Objectives, Introduction
- Refrigerants
- Cooling Coil Mechanical Refrigeration
- Types of Cooling Systems
- Facts about Pressure and Temperature
- The Four Devices in Mechanical Refrigeration
- DX Systems
- All-Air Systems
- Air-Water Systems
- Heating Coil
- Classifications of Boilers
- Types of Heating Systems That Use Water
- Summary

**Chapter 5: Indoor Air Quality**

- Overview, Learning Objectives, Introduction
- Components of Good Indoor Air Quality
- Removing Solid and Liquid Particles
- Filter Selection
- Filter Installation and Maintenance
- Removing Gases and Vapors
- Removing Microbiological Contaminants
- Sick Building Syndrome and Building-Related Illness
- Summary

**Chapter 6: Water Systems and Basic Chemistry**

- Overview, Learning Objectives, Introduction
- Water
- Types of Cooling Systems
- Types of Heating Systems That Use Water
- Basic Chemistry Concepts
- Polar Nature of Water
- Impurities That React in Water
- Acids and Bases
- Sources of Impurities in Water
- Summary

**Chapter 7: Water Systems and Internal Treatment**

- Overview, Learning Objectives, Introduction
- Scale
- Corrosion
- Fouling or Sludge
- System Descriptions and Their Associated Problems
- Equipment for Feeding Chemicals
- Summary

**Chapter 8: Water Testing and Internal Treatment**

- Overview, Learning Objectives, Introduction
- Testing
- Pretreatment of Water
- Summary

**Chapter 9: Piping and Valves**

- Overview, Learning Objectives, Introduction
- Materials Used in Pipe Manufacturing
- Piping vs. Tubing
- Pipe Sizes
- Methods of Connecting Pipes and Tubes
- Pipe Fittings
- Pipe Hangers and Supports
- Pipe Expansion
- Water Hammer
- Steam Traps
- Valve Types
- Valve Control
- Summary

**Chapter 10: Plumbing Systems**

- Overview, Learning Objectives, Introduction
- Potable Water Service Distribution Systems
- Water Pressure
- Backflow
- Water Metering
- Domestic Hot Water Heaters
- Building Drainage Systems
- Septic Tanks
- Summary

**Chapter 11: Fire Protection Systems**

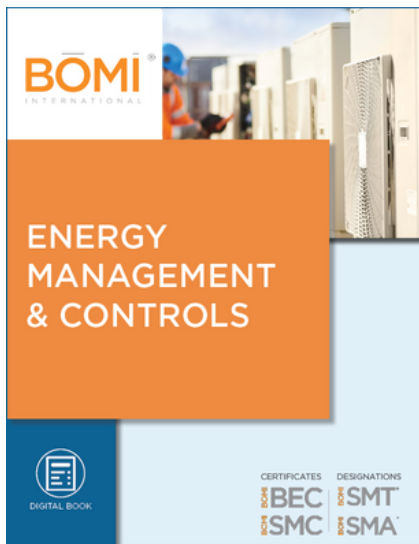
- Overview, Learning Objectives, Introduction
- Combustion
- Fire Classifications
- Portable Fire Extinguishers
- Fire Alarm Systems
- Automatic Sprinkler Systems
- Water Sources for Firefighting
- Other Fire Protection Systems
- Summary

**Chapter 12: Using the Psychrometric Chart**

- Overview, Learning Objectives, Introduction
- The Psychrometric Chart
- Applications of the Psychrometric Chart to Building Problems
- The Importance of Humidity
- Dehumidification
- Summary

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## ENERGY MANAGEMENT & CONTROLS

Understanding the essential maintenance and energy management aspects of building management is critical to running a cost-effective operation. From everyday preventive maintenance tasks to the challenge of developing and selling an energy plan, this course provides the skills to evaluate and optimize your current system, the know-how to integrate new components, and the ability to communicate your needs to management.

You will learn about the components, principles, adjustment, and maintenance of system controllers, auxiliary devices, and electronic, pneumatic, and computer control systems.

Upon successful completion of this course, learners will be able to:

- Apply an energy management plan to your building's systems
- Evaluate new systems with a concentration on retrofitting
- Describe traditional and alternative energy systems and their integration with other building systems
- Discuss how to use programmable logic controllers and other resources to optimize your system
- Develop, implement, and manage an innovative preventive maintenance program

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### **Chapter 1: Energy Management Overview**

- Overview, Learning Objectives, Introduction
- The Importance of Energy Management
- Managing Energy
- Energy Defined
- The Impact of Heat on Energy Use
- Energy Fundamentals
- Methods of Heat Transfer
- Improving Existing Mechanical Function
- Water Treatment and Analysis
- Factors Affecting Interior Building Conditions
- Summary

### **Chapter 2: Control System Basics**

- Overview, Learning Objectives, Introduction
- Elements of a Basic Control System
- Closed-Loop and Open-Loop Systems
- Pneumatic Control Systems
- Controllers
- Sensors
- Pilot Relay
- Proportional Relay
- Other Control Devices
- Air Compressor Maintenance
- Summary

### **Chapter 3: Heating Systems**

- Overview, Learning Objectives, Introduction
- Heating Systems Efficiencies
- EMOs for Heating Systems: Preventive Maintenance
- Additional Heating EMOs
- Service Water Heating
- Hot Water Heating and Storage
- Hot Water Distribution Methods
- Hot Water System Design
- Preventive Maintenance Measures
- Other EMOs
- Heat Recovery
- Uses of Recovered Heat
- Alternative Energy Systems
- Solar Energy Systems
- Geothermal Heat Pumps
- Summary

### **Chapter 4: Cooling Systems**

- Overview, Learning Objectives, Introduction
- Cooling System Efficiencies
- Control Valves
- Refrigerant Management
- Summary

### **Chapter 5: Air Handling Systems**

- Overview, Learning Objectives, Introduction
- Types of Air Handling Systems
- Air Handling System Configurations
- Preventive Maintenance Measures for Energy Management of Air Handling Equipment
- Indoor Air Quality Concerns
- Ventilation Control Applications
- Heating and Ventilation Control Applications
- Heating, Ventilation, and Humidity Control Applications
- Preheat Applications
- Types of Heat Recovery Systems
- Summary

### **Chapter 6: Energy Management Opportunities for HVAC Systems**

- Overview, Learning Objectives, Introduction
- Preventive Maintenance Measures for Energy Management of Heating Systems
- Other EMOs for Heating Systems
- Preventive Maintenance Measures for Energy Management of Cooling Systems
- Other EMOs for Cooling Systems
- Summary

### **Chapter 7: Ventilation Systems**

- Overview, Learning Objectives, Introduction
- Fan Modulation
- VAV Design
- VAV Equipment
- VAV Applications
- VAV Controls
- VAV System Arrangements
- Building Pressurization
- Pressurization Control Equipment
- Summary



**Chapter 8: Lighting Systems, Electrical Systems, and Retrofitting**

- Overview, Learning Objectives, Introduction
- Benefits of Lighting Management
- Primary Lighting System Types
- Preventive Maintenance Measures for Energy Management
- Other Energy Management Opportunities for Lighting Systems
- Electrical Systems
- Components of Electrical Power Distribution Systems
- Electric Power Rate Schedules
- Energy Management Opportunities for Electrical Systems
- Summary

**Chapter 9: Establishing Standard Operating Procedures**

- Overview, Learning Objectives, Introduction
- Energy Savings through SOP Programs
- Heating and Cooling Guidelines
- Refrigeration Equipment Guidelines
- Heating Equipment Guidelines
- Air Handling Equipment Guidelines
- Piping System Guidelines
- Ductwork Systems Guidelines
- Lighting System Guidelines
- Elevator and Escalator Guidelines
- Summary

**Chapter 10: Energy Management Control Systems, Computers, and Microprocessors**

- Overview, Learning Objectives, Introduction
- Benefits of an Energy Management Control System
- Types of Energy Management Control Systems
- Energy Management Controls System Applications
- Computers and Microprocessors in Control Systems
- Computer System Fundamentals
- Computer-Based Systems in Control Applications
- Types of Computer-Based Systems
- Direct Digital Control
- Training, Operation, and Maintenance
- Summary

**Chapter 11: Planning and Implementing an Energy Management Program**

- Overview, Learning Objectives, Introduction
- Understand Energy Intensity
- Commit to Energy Management
- Assess Energy Performance and Set Goals
- Capitalize on Opportunities to Improve Energy Performance
- Design with Energy Performance in Mind
- Buy Utilities at the Lowest Cost
- Maximize Utility Cost Recovery
- Recover Capital Costs from Tenants
- Recognize Results
- Summary

**Chapter 12: Calculating the Financial Value of an Energy Management Program**

- Overview, Learning Objectives, Introduction
- Additional Benefits of Good Energy Management
- Summary

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## HIGH-PERFORMANCE SUSTAINABILITY BUILDING INVESTMENTS

BOMI's High-Performance Sustainable Building Investments course delivers the strategies to envision, plan, and manage large-scale sustainable projects that maximize ROI.

Learners will gain an in-depth understanding of how to effectively impact efficiency challenges through cutting-edge approaches that positively affect an organization's financial, social, and environmental bottom line.

Upon successful completion of this course, learners will be able to:

- Identify and engage business stakeholders by demonstrating the value of investments from a 3BL approach
- Illustrate how social and environmental returns enhance economic returns for a more substantial overall investment
- Illustrate the value of high-performance projects through operational-focused and asset-focused industry benchmarks and tools
- Implement project delivery using a whole-building approach by bundling retrofit projects that maximize potential benefits
- Leverage financing resources, including internal capital budgets, off-sheet financing, and utility and tax rebate programs, among others, to mitigate the overall costs of high performance projects

### **Chapter 1: The Value Proposition for High-Performance Investments**

- Introduction
- Defining Value through the Lens of a Sustainability Framework
- Balancing and Prioritizing the Triple Bottom Line
- Valuation for High Performance
- Aligning Valuation and the Business Case
- Investment Recommendations for Business Strategy Outcomes
- Creating the Business Case for High-Performance Investment
- Summary

### **Chapter 2: High-Performance Valuation Approaches**

- Introduction
- Tangible and Intangible Drivers for Valuation
- The Opportunity to Direct Prudent Investment for High Performance
- The Valuation Toolkit
- Evaluating Investors' Financial Calculation Criteria
- Integrating Lifecycle Analysis into Valuation and Bundling
- Valuation Approaches for High-Performance Buildings
- Translating the Impact of Common High-Performance Investments
- Summary

### **Chapter 3: Establishing a Baseline for High-Performance Investment**

- Introduction
- Benchmarking for High-Performance Investments
- Devices for Enabling Data Collection
- Rating Systems for Building and Business Performance
- Benchmarking beyond Energy
- Using Benchmarking to Establish Targets
- Conveying Value through Benchmarking
- Beyond Financial Targets
- Benchmark Disclosure
- Benchmarking for Business Investment Decisions
- Audit Contributions to Business Case Development
- Summary

**Chapter 4: Analyzing and Pursuing High-Performance Opportunities**

- Introduction
- Strategic Considerations for High-Performance Opportunities
- Analysis Aligned with Bidding and Procurement
- Bidding Process Approaches
- Industry Analytical Tools
- Risk and High-Performance Investment Decisions
- Triple Bottom Line Analysis
- High-Performance Investment Analysis Best Practices
- Summary

**Chapter 5: High-Performance Investments: Interiors and Internal Systems**

- Introduction
- Whole Building Design
- Internal Building Systems
- Advanced Lighting Overview
- Daylighting
- Indoor Environmental Quality
- O&M Strategies
- Procurement
- Occupant Engagement
- Summary

**Chapter 6: High-Performance Investments: Exterior and Building Systems**

- Introduction
- Building Envelope
- Advanced Building Control Systems
- Heating, Ventilating, and Air-Conditioning Systems
- On-Site Renewable Energy
- Landscape Management
- Transportation
- Summary

**Chapter 7: Financing Options and Modalities**

- Introduction
- Internal Funding Resources
- External Funding Resources
- Identifying and Mitigating Investment Barriers
- Opportunities for Using “Other People’s Money”
- Business Case Alignment for Funding
- Summary

**Chapter 8: Gaining Commitment for High-Performance Investments**

- Introduction
- Stakeholder Distinctions
- Engaging Stakeholders for Investment Commitment
- Gaining Commitment for High-Performance Investments
- Summary

**Chapter 9: Investment Validation: The Role of Measurement and Verification**

- Introduction
- Measurement and Verification Value for High-Performance Investments
- M&V Program as a Component of Project Delivery
- Value of the M&V Process
- M&V Plans
- M&V Project Management
- Performance Contracting and Energy Service Companies
- Sharing M&V Results
- Summary

**Chapter 10: Case Study: To Invest or Not to Invest**

- Introduction
- Case Study Challenge

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## HIGH-PERFORMANCE SUSTAINABILITY BUILDING PRACTICES

*High-Performance Sustainable Building Practices* identifies the critical no-cost and low-cost sustainable initiatives that every building professional can start implementing now. Throughout this course, you will learn how to effectively optimize and apply sustainable best practices, which cover every aspect of the built environment, to drive operational efficiencies for a high-performance building.

Upon successful completion of this course, learners will be able to:

- Implement benchmarking protocols and strategies to improve operational performance and reduce energy demand and use
- Explore sustainable opportunities to improve building operations in areas including energy, lighting, water use, building envelope, waste management, and other critical areas
- Build an effective sustainable operating plan with a focus on purchasing, green cleaning, indoor air quality, fundamentals for interior and exterior maintenance, and vendor management
- Engage stakeholders, including occupants, vendors, and owners and investors, to ensure adoption and full integration of high-performance initiatives

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### **Chapter 1: The Rationale for Sustainable Practices in the Built Environment**

- Introduction
- Commercial Real Estate's Contributions to High-Performance Workplaces and Sustainability
- The Value of Sustainable Practices
- Stakeholders and the Implementation of Sustainable Practices
- Building a Case for Sustainable Practices
- Sustainable Practices and High-Performance Trends
- Summary

### **Chapter 2: Benchmarking to Improve Energy Performance**

- Introduction
- Overview of Energy Benchmarking in Rating Systems
- Submetering to Improve Energy Performance
- Benchmarking Strategies to Improve Energy Performance
- Benchmarking Challenges
- Regulatory Influences for Energy-Efficient Operations
- Summary

### **Chapter 3: Sustainable Building Enclosures**

- Introduction
- Measuring the Performance of Building Enclosure Components
- Building Enclosure Operations and Maintenance: Best Practices
- Enclosure Performance Impacts
- Façade Initiatives
- Window Initiatives
- Roofing Initiatives
- Summary

### **Chapter 4: The Indoor Environmental Quality Directive**

- Introduction
- Sustainable Interior Initiatives
- Building and Interior Space Design
- Product Selection and Construction Practices for Environmental Health
- Protecting Building Interiors from Contamination
- Operational Practices for Environmental Health
- Global Guidelines and Standards to Support Sustainable Interiors
- Summary



### **Chapter 5: Monitoring and Optimizing Systems for High-Performance**

- Introduction
- Electric Energy Use Trends
- Data Sources for Building Energy Management
- Metering Energy Consumption
- Energy Measurement and Monitoring
- Energy Audits
- The Role of Commissioning in Energy Management
- Indoor Environmental Quality
- Systems Maintenance
- Summary

### **Chapter 6: High-Performance Lighting Systems**

- Introduction
- High-Performance Lighting: Application Areas, Sources, and Levels
- Lighting Retrofit Goals for High-Performance
- Steps in Performing a High-Performance Lighting Retrofit
- Lamp Replacement Plan as a Retrofit Option
- Daylighting
- Lighting Control Systems
- Return on Investment
- Retrofit Stakeholder Engagement and Training
- High-Performance Lighting Trends
- Summary

### **Chapter 7: Water Efficiency Practices for Existing Buildings**

- Introduction
- Water Distribution Systems
- Cooling Towers
- Distribution System Audits, Full-Scale Water Audits, and Leak Detection and Repair
- Water Efficiency Checklist for Facility Managers
- Summary

### **Chapter 8: Renewable Energy Sources**

- Introduction
- High-Performance Energy Management
- Types of Renewable Energy
- Solar Energy
- Wind Power
- Evaluating Renewable Energy Solutions
- Summary

### **Chapter 9: Operations and Maintenance in a High-Performance Environment**

- Introduction
- The Value of Green Cleaning
- Green Cleaning Practices and Products
- Green Cleaning Plans
- Integrated Pest Management
- Indoor Air Quality Sustainable Maintenance Practices
- Sustainable Exterior Maintenance
- Sustainable Practices for Construction Projects
- Corporate Sustainability Goals for Facilities Management
- Vendor Performance
- Training for High-Performance Success
- Summary

### **Chapter 10: Creating a Strategy for Sustainable Transportation Solutions**

- Introduction
- Measuring Your Carbon Footprint for Transportation
- Sustainable Transportation Resources
- Occupant and Employee Sustainable Transportation Use
- Sustainable Transportation and Parking
- Summary

### **Chapter 11: Tenant and Occupant Engagement Strategies for Sustainable Initiatives**

- Introduction
- Sustainability Drivers and Commitment Levels
- Aligning Building Stakeholder Sustainability Goals
- Tenant Communication Practices
- Low-Cost Methods for Communicating Sustainability Efforts
- Tenant Engagement Plans for Sustainability Initiatives
- Incentive Programs to Motivate Tenant Engagement in Sustainability
- Summary

### **Chapter 12: Sustainable Procurement of Durable and Consumable Products**

- Introduction
- Product Selection for Sustainable Building Interiors
- Sustainable Product Categorization
- Think Twice about Making the Purchase
- Using Ecolabels for Sustainable Products and Services
- Ecolabel Standards for Service Providers
- Creating a Sustainable Purchasing Policy
- Implementing Sustainable Purchasing
- Waste Management
- Summary

**Chapter 13: Financial Tools for Driving High-Performance Initiatives**

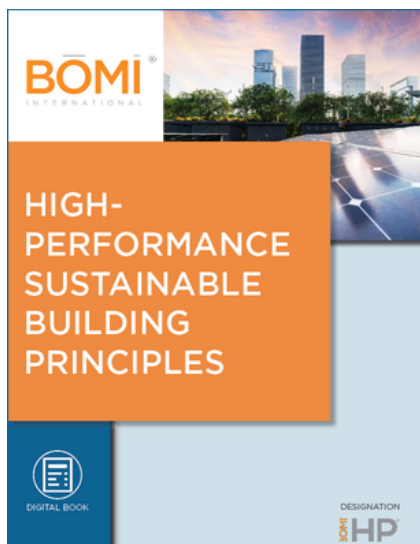
- Introduction
- Distinguishing between Capital and Operating Budgets
- Key Financial Metrics for Operating Expenditures
- Leveraging Operating Expenditures
- Leveraging Rebates, Incentives, and Credits
- Performance Contracting
- Summary

**Chapter 14: Action Plan for High-Performance Sustainable Building Practices**

- Chapter 1 Action Plan: Build Your Business Case
- Chapter 2 Action Plan: Highlight the Power of Benchmarking
- Chapter 3 Action Plan: Draft a Property Operations Report(POR)
- Chapter 4 Action Plan: Develop an IAQ Management Plan
- Chapter 5 Action Plan: Improve IEQ Assessments
- Chapter 6 Action Plan: Propose a High-Performance Lighting Solution
- Chapter 7 Action Plan: Explore Water Reduction Opportunities
- Chapter 8 Action Plan: Assess Feasibility for Renewable Energy Retrofits
- Chapter 9 Action Plan: Brainstorm Reporting Requirements for Vendor Contracts
- Chapter 10 Action Plan: Offer Incentives for Transportation Alternatives
- Chapter 11 Action Plan: Develop a Tenant Engagement Plan
- Chapter 12 Action Plan: Engage in Waste Management Initiatives
- Chapter 13 Action Plan: Budget with Strategy

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## HIGH-PERFORMANCE SUSTAINABILITY BUILDING PRINCIPLES

BOMI's *High-Performance Sustainable Building Principles* course provides a comprehensive overview of buildings and exposes learners to the critical components of the sustainable ecosystem. As an industry professional, you will gain insight on how to meet the imperative for sustainable building initiatives, stay abreast of new trends in greening, and effectively communicate the value of pursuing sustainable building initiatives.

Upon successful completion of this course, learners will be able to:

- Understand and tackle building performance issues that impact local environmental issues and global climate change
- Integrate high performance building standards and guidelines
- Identify and overcome the hurdles to achieving true high-performance
- Attain top-to-bottom organizational buy-in for sustainable building initiatives

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### **Chapter 1: The Evolution and Impact of Sustainability**

- Introduction
- The Definition of High-Performance and Sustainability
- The Evolution of Sustainability
- Sustainability's Impact on Society
- Why Sustainability Matters Now
- High-Performance and Sustainability Matter to Businesses
- High-Performance and Sustainability Matter to Commercial Real Estate
- Resistance to Sustainability Strategies
- Embracing High-Performance and Sustainability
- Summary

### **Chapter 2: High-Performance Buildings and Market Dynamics**

- Introduction
- What Defines a High-Performance Building?
- High-Performance Building Characteristics
- High-Performance Building Market Dynamics
- Key Interrelated High-Performance Market Drivers
- Technology Advances—Information and Communications Technology
- Policy and Disclosure Requirements
- Funding Opportunities for High Performance
- Social Factors
- High-Performance Building Certifications and Standards
- Summary

### **Chapter 3: High-Performance Building Energy Usage and Management**

- Introduction
- Natural Resources
- Energy Consumption in Buildings
- Energy Management
- The Increase of Electricity Energy Consumption
- The Origins and Evolution of the Electric Grid
- Wholesale Electricity Energy Sales
- The Decentralization and Consumerization of Power Systems
- The Economics of Electric Power
- Summary

#### **Chapter 4: Sustainable Benchmarking and Standards for Design**

- Introduction
- Benchmarking Fundamentals
- Sustainable Energy Benchmarking Tools
- Industry Trends and Energy Benchmarking Drivers
- Overview of Federal, State, and Local Benchmarking Requirements
- Overview of International Benchmarking Requirements
- Imperatives for Sustainable Design Standards
- High-Performance and Sustainability Standards for Design and Operations
- International Standards for Design
- US Policies and Sustainable Design Standards
- US Public and Private Organizations
- Summary

#### **Chapter 5: IEQ and Resource Management in High-Performance Buildings**

- Introduction
- Indoor Environmental Quality and Sustainability
- Sustainable Resource Management
- Summary

#### **Chapter 6: High-Performance Exterior Building Systems**

- Introduction
- High-Performance Building Envelopes
- Building Envelope Components and Purpose
- Common Building Envelope Elements
- Roofing Design for High-Performance Operations
- High-Performance Waterproofing of Building Facades, Roofs, and Interiors
- Strategies for Achieving High-Performance and Sustainable Goals
- Waterproofing Strategies
- Summary

#### **Chapter 7: High-Performance Internal Building Systems**

- Introduction
- Building System Contributions to High-Performance Operations
- Building Systems and Commissioning
- Benchmarking Metrics for High-Performance System Operations
- Energy Use for Lighting
- Electrical System Efficiency in High-Performance Buildings
- Electricity Efficiency Control Systems
- Integrated Building Management Systems
- Resolving Integrated System Comfort Issues
- Stakeholder Engagement
- Summary

### **Chapter 8: Water and Wastewater Systems in High-Performance Buildings**

- Introduction
- The Nature, Economics, and Regulation of Water
- Water Conservation for High-Performance Buildings
- Opportunities for High-Performance in Conventional Water Systems
- Efficiencies through Preventive Maintenance and Equipment Selection
- Opportunities for High-Performance in Alternative Water Systems
- Water Management Plans for High-Performance Buildings
- Educating Stakeholders to Increase Engagement
- Summary

### **Chapter 9: Sustainable Renovation and Tenant Improvement Projects**

- Introduction
- The Building Renovation and Reuse Imperative
- Sustainability for Tenant Improvement Projects
- Evaluating the Functionality of Design Layouts
- Revisiting the Typical Construction Supply Chain
- Sustainable Renovation Lifecycle Best Practices
- Summary

### **Chapter 10: Sustainable Operating Plans for High-Performance Buildings**

- Introduction
- The Sustainable Operating Plan Difference
- Indoor Air Quality and Sustainable Operating Plans
- Occupant Comfort, Welfare, Productivity, and Operational Planning
- Balancing Building Operations and Environmental Impact
- Weighing Occupant Needs against Environmental Concerns
- Summary

### **Chapter 11: Transportation Alternatives to the Single-Occupant Vehicle**

- Introduction
- Transportation Alternatives and Requirements
- Benefits of Transportation Alternatives
- Summary

### **Chapter 12: Influencing Behavior and Culture for Sustainability Engagement**

- Introduction
- Influencing Decision Making through Behavioral Economics
- Changing Corporate Culture
- Summary

**Chapter 13: Sustainable Goods Purchasing and Plans for High-Performance Buildings**

- Introduction
- Sustainable Goods Purchasing
- Third-Party Certifications to Evaluate Sustainable Goods
- Types of Sustainable Goods
- The Life Cycle of Sustainable Goods
- Components of a Sustainable Goods Purchasing Plan
- Summary

**Chapter 14: Financing Sustainability Projects in the Built Environment**

- Introduction
- Integrated Team Approach to Sustainable Building Projects
- Sustainable Building Project: Incentive and Rebate Financing
- Sustainable Building Project: Validation
- Portfolio Planning and Sustainability Projects
- Summary

**Chapter 15: Action Plan for High-Performance Sustainable Building Principles**

- Chapter 1 Action Plan: Prioritize Your Initiatives
- Chapter 2 Action Plan: Leverage Your Strengths
- Chapter 3 Action Plan: Mitigate High Energy Use
- Chapter 4 Action Plan: Select Which Design Standards to Use
- Chapter 5 Action Plan: Identify Sustainable Purchasing Options
- Chapter 6 Action Plan: Maximize Building Envelope Performance
- Chapter 7 Action Plan: Measure Internal Building Systems Performance
- Chapter 8 Action Plan: Reduce Water Consumption
- Chapter 9 Action Plan: Develop a Tenant Improvement Plan
- Chapter 10 Action Plan: Refine Procedures or Replace Equipment
- Chapter 11 Action Plan: Assess Transportation Alternatives
- Chapter 12 Action Plan: Drive Cultural Change and Engage Stakeholders
- Chapter 13 Action Plan: Build a Sustainable Purchasing Plan
- Chapter 14 Action Plan: Construct a Business Case



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## REFRIGERATION SYSTEMS & ACCESSORIES

Maintaining the proper comfort level in an office environment is essential for tenant satisfaction. Refrigeration equipment is a critical component of an air conditioning system that must be properly maintained and operated at maximum efficiency.

This course reviews the basic refrigeration cycle and system components, as well as how to operate and maintain reciprocating and absorption refrigeration systems. You will gain the skills and knowledge to describe the principles of refrigeration and identify the performance characteristics of refrigeration components. You will also learn how to establish maintenance processes and troubleshooting techniques.

Upon successful completion of this course, learners will be able to:

- Employ a working knowledge of refrigeration systems to describe how they can be integrated into an existing building
- Maintain a reliable and effective refrigeration system
- Troubleshoot refrigeration systems and accessories
- Perform general maintenance on refrigeration systems and accessories

**Chapter 1: Theory of Refrigeration**

- Introduction
- The First Law of Thermodynamics
- The Second Law of Thermodynamics
- Heat Transfer
- Pressure
- Basic Refrigeration Cycle
- Summary

**Chapter 2: Compressors**

- Introduction
- Hermetic Compressor
- Semi-Hermetic Compressor
- Open Compressor
- Types of Compressors
- Capacity Control
- Lubrication
- Compressor Accessories
- Compressor Ratio
- Summary

**Chapter 3: Metering Devices**

- Introduction
- Thermostatic Expansion Valve
- Automatic Expansion Valve
- Electronic Expansion Valve
- Capillary Tube
- Piston Metering Device
- Low-Side Float Valve
- High-Side Float Valve
- Hand-Operated Valve
- Summary

**Chapter 4: Evaporators and Condensers**

- Introduction
- Evaporators
- Design Applications
- Evaporator Types
- Condensers
- Air-Cooled Condensers
- Water-Cooled Condensers
- Evaporative Condensers
- Summary

**Chapter 5: Refrigeration System Accessories**

- Introduction
- Oil Separators
- Mufflers
- Vibration Absorbers
- Suction Accumulators
- Crankcase Heaters
- Sight Glass Moisture Indicators
- Evaporator Pressure Regulators
- Crankcase Pressure Regulators
- Diaphragm-Type Valves
- Packed Valves
- Pressure Relief Devices
- Receivers
- Check Valves
- Solenoid Valves
- Filter Driers
- Heat Exchangers
- Service Valves
- Summary

**Chapter 6: Refrigerants and Refrigeration Oils**

- Introduction
- ASHRAE Refrigerant Designations
- Physical Properties
- Thermodynamic Properties
- Refrigerants and Water
- Blended Refrigerants
- Recover, Recycle, and Reclaim
- Refrigeration Oils
- Retrofitting a System
- Summary

**Chapter 7: Various Refrigeration Systems**

- Introduction
- Split System
- Packaged Rooftop Unit
- Packaged Indoor Unit
- Through the Wall Unit
- Heat Pump
- Computer Room Unit
- Summary

**Chapter 8: Chillers**

- Introduction
- Compression Chillers
- Chiller Evaporators
- Air-Cooled vs. Water-Cooled Condensers
- Metering Devices for Chillers
- Chiller Safeties
- Motor Starting Methods
- Starting and Running a Chiller
- Absorption Chillers
- Summary

**Chapter 9: Cooling Towers and Auxiliary Equipment**

- Introduction
- How a Cooling Tower Works
- Types of Towers
- How Water is Distributed in a Cooling System
- Makeup Water Supply for Cooling Towers
- Summary

**Chapter 10: Operating and Safety Controls and Electrical Components**

- Introduction
- Basic Cycle Controls
- Other Electrical Components
- Schematics
- Summary

**Chapter 11: Leak Testing, Evacuation, and Charging**

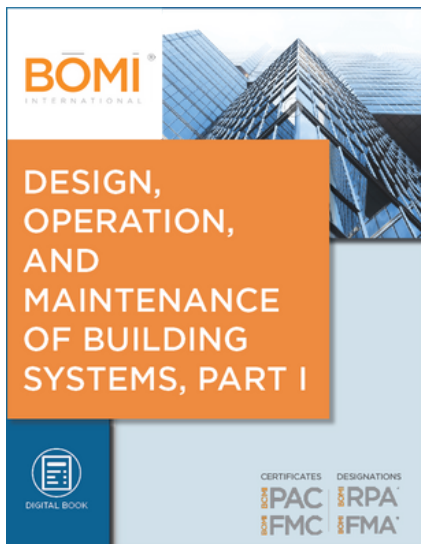
- Introduction
- Detecting Refrigerant Leaks
- Types of Leak Detection Equipment
- Pressurizing the System for Leaks
- Evacuation
- Charging the System
- Chiller Leak Testing, Evacuation, and Charging
- Summary

**Chapter 12: Troubleshooting and General Maintenance Requirements**

- Introduction
- The Properly Working System
- Miscellaneous Problems
- Applying What You've Learned
- Operating Logs
- Summary

# BOMI

Building Owners and Managers Institute



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## DESIGN, OPERATION, AND MAINTENANCE OF BUILDING SYSTEMS, PART I

The two-part Design, Operation, and Maintenance of Building Systems courses equip property and facilities managers with the well-rounded background needed to excel in the industry. In Part I of this series, you will learn about building design, construction considerations, structural systems, and air and water distribution systems.

This updated edition offers new materials and systems and an improved learning experience. You will become acquainted with contemporary advances in the industry, including energy benchmarking, efficient design, automated building systems, building filtration, efficiency credits, and improved sewer systems. Learners will find new engaging microlessons, instructor clips, and an easy-to-navigate interface.

Upon successful completion of this course, learners will be able to:

- Implement maintenance best practices for building systems to achieve efficiencies and cost savings
- Support maintenance of building structural components by selecting and recommending the appropriate materials
- Describe best practices for the design, operation, and maintenance of HVAC and plumbing systems
- Demonstrate working knowledge of the systems required for ensuring the preservation of a building's structural integrity

**Chapter 1: Building Design and Construction: Project Initiation**

- Introduction
- Who's Who in the Construction Project
- From a Vision to Reality: Planning the Program
- Types of Development and Renovation Projects
- Starting the Process of Project Development
- Steps for Designing the Project
- Meeting Project Objectives with Feasibility Studies
- Designing with Sustainability in Mind
- Summary

**Chapter 2: Building Design and Construction: Project Delivery**

- Introduction
- Choosing a Method for Project Delivery
- The Owner/Contractor Agreement
- Securing the Contract
- Estimating and Job Costing
- Implementing the Project
- The Building Commissioning Process
- Additional Project Considerations
- Implications of Green or Sustainable Design
- Summary

**Chapter 3: Fundamental Materials for Building Construction**

- Introduction
- Heat Flow in Building Materials
- Restricting Building Heat Flow with Insulating Materials
- Masonry in Building Construction
- Basic Metals for Various Building Functions
- Manufactured Products for Building Construction
- Wood: One of the First Construction Materials
- Summary

#### **Chapter 4: Structural Systems**

- Introduction
- Forces on Building Frames
- Floor Systems
- Building Walls
- Steel Structural Frame Systems
- Concrete Structural Frame Systems
- Wood Structural Frame Systems
- Structural Considerations for Sustainability
- Building Foundations
- Soil
- Building Foundation Systems
- Structural Systems Maintenance
- Summary

#### **Chapter 5: The Building Envelope**

- Introduction
- Building Envelopes and Influences on Their Design
- Design Concerns for an Efficient Building Envelope
- Curtain Walls for Modern Construction
- Curtain Wall Materials: Vision Area
- Curtain Wall Materials: Nonvision Area
- Potential Problems of Exterior Building Envelopes
- Windows in the Building Envelope
- Keeping It Like New: Retrofits and Maintenance for the Building Envelope
- Summary

#### **Chapter 6: Roofing Systems for Building Protection**

- Introduction
- Two Common Roofing Configurations
- Roofing Construction Varieties
- Roofing Projects: The Old and the New
- Selecting a Roofing System
- Materials Matter: Roofing System Elements and Construction
- Standards for Roofing Details
- Effective Planning for Ongoing Roofing Maintenance
- Summary



### **Chapter 7: Installing Interior Walls: Types, Materials, and Finishes**

- Introduction
- The Functions of Types of Interior Walls
- Metal Framing for Interior Wall Construction
- Gypsum Board for Various Building Needs
- Demountable Partitions for Functional Flexibility
- Plaster: A Premium Finish
- The Science of Paints and Coatings
- Preparation and Application for Optimal Paint Performance
- Coatings for Corrosion Protection
- Protecting Against Paint Failures and Hazards
- Wall Coverings for Decorative Finishes
- Summary

### **Chapter 8: Defining Space with Ceilings and Flooring**

- Introduction
- Ceilings: Panels, Maintenance, and Systems
- Providing a Foundation: Flooring
- Types of Flooring
- Other Flooring Systems and Treatments
- Summary

### **Chapter 9: Heating, Ventilating, and Air Conditioning for Human Comfort**

- Introduction
- The Science of Heat and Humidity
- Effective HVAC for Human Comfort
- Design Factors Impacting a Building's HVAC System
- Planning for the Impact of Heat Loads on a Building
- Balancing Human Comfort and Cost
- Summary

### **Chapter 10: Air Circulating Systems**

- Introduction
- The Air Cycle
- Air Duct Systems
- Terminal Units for Air Regulation
- Devices for Air Distribution
- Fans for Air Movement
- Coils for Heat Transfer
- Filters for Air Quality
- Other Ventilation Systems
- Summary

### **Chapter 11: Cooling Systems for the Interior Building Environment**

- Introduction
- Role of Refrigerants in the Cooling System
- Cooling for Heat Transfer
- The Heart of the System: Refrigeration Compressors
- Condensers
- Cooling Towers
- Evaporators
- Heat Pumps
- Absorption Refrigeration
- Summary

### **Chapter 12: Efficient Heating Systems for Buildings**

- Introduction
- The Science of Heat Flow
- Boiler Heating for Commercial Applications
- Hot Water Heating Systems for Commercial Properties
- Steam Heating Systems
- Care and Maintenance of Steam Systems
- Comparing Hot Water Systems to Steam Systems
- Advantages and Disadvantages of Electric Heating
- Harnessing Thermal Energy through Solar Heating Systems
- Heat Pumps and the Refrigeration Cycle
- Specific Applications for Infrared Heating Systems
- Gaining Efficiency with Heat Recovery Systems
- Summary

### **Chapter 13: HVAC Distribution Systems**

- Introduction
- HVAC Design Factors
- Classifications of HVAC Systems
- All-Air Systems
- All-Water Systems
- Air-Water Systems
- Direct Expansion Systems
- Advanced Energy Efficiencies
- HVAC Energy-Efficiency Standards
- Summary

**Chapter 14: Maximizing Comfort with HVAC Control Systems**

- Introduction
- Control Systems for Occupant Comfort
- From the Start: Control of Primary Equipment
- Greater Efficiency with Automated Building System Technology
- Features of Optimal HVAC Control
- Features of Direct Digital Control
- Summary

**Chapter 15: Ensuring Optimal HVAC Operation and Maintenance**

- Introduction
- Ensuring Effective HVAC Operation
- HVAC Maintenance for Optimal Operating Condition
- Proper Water Treatment
- Summary

**Chapter 16: Plumbing Systems**

- Introduction
- Water Distribution Systems
- Water Flow and Pressure
- Pumping Equipment
- Piping Systems
- Water Supply for a Building
- Water for Inadequate Quantity and Pressure
- Domestic Hot Water
- Hot Water Generators
- Adding Value with Plumbing Components
- Common Drainage Systems
- Sanitary Drainage Systems
- Storm Drainage Systems
- Summary

**Chapter 17: Case Study: Facilities Management at CityPark Business Tower**

- Introduction
- CityPark Business Tower
- Case Study Challenge 1: Office Space Renovations
- Case Study Challenge 2: Tenant Build-Out Project
- Case Study Challenge 3: System Efficiency

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## DESIGN, OPERATION, AND MAINTENANCE OF BUILDING SYSTEMS, PART II

The two-part *Design, Operation, and Maintenance of Building Systems* courses are designed to equip property and facilities managers with the well-rounded background needed to excel in the industry. In *Part II* of this series, you will learn about electrical systems, lighting, internal transportation systems, property maintenance, security, and safety systems.

This edition offers updates on lighting and other technological advances and an improved learning experience. *The Design, Operation, and Maintenance of Building Systems, Part II* course will also help you plan for achieving building certifications, such as BOMA BEST, as these programs require a comprehensive building approach. Learners will find new engaging microlessons, instructor clips, and an easy-to-navigate interface.

Upon successful completion of this course, learners will be able to:

- Effectively analyze, manage, and optimize building systems
- Identify opportunities to increase the efficiency of building systems
- Understand the successful management of pests, solid wastes, energy, and security and life-safety systems.
- Evaluate and implement best practices for increasing occupant safety and comfort

### **Chapter 1: Electricity and Electrical Systems**

- Introduction
- Making it Run: Electricity
- Converting Current with Transformers
- Types of Electric Current (Alternating and Direct)
- Staying Grounded
- Measuring Electricity
- Electrical Devices
- Distributing the Power
- Electrical System Design
- Safety Essentials
- Summary

### **Chapter 2: Electrical Systems Operation and Maintenance**

- Introduction
- Power Quality and Protection
- Operating Problems
- Site-Generated Power
- Electrical Systems Maintenance
- Electrical Service and the Electric Bill
- Summary

### **Chapter 3: Lighting Principles**

- Introduction
- Fundamentals of Light
- Visual Comfort
- Light and Performance
- Summary

### **Chapter 4: Lighting Applications**

- Introduction
- Selecting Lighting Solutions
- Common Lamps and Fixture Types
- Fluorescent Lighting
- Nonfluorescent Lighting
- Managing Energy: Lighting Controls
- Lighting System Maintenance
- Reducing Energy Costs of Lighting
- Lighting Laws and Regulations
- Summary

**Chapter 5: Energy Management**

- Introduction
- Building Energy Intensity
- Commit to Energy Management
- Assess and Set Goals
- Into Action: Implement the Plan
- Improve Energy Performance
- Design with Energy Performance in Mind
- Buy Utilities at the Lowest Cost
- Maximize Utility Expense Recovery
- Recover Capital Costs from Tenants
- Recognize Results
- Summary

**Chapter 6: Internal Facility Transportation Systems**

- Introduction
- Vertical Transportation Systems
- The Art of Elevating
- Elevator Systems
- Elevator Equipment
- Elevator Safety Components
- Escalators and Moving Walkways
- Summary

**Chapter 7: Maintenance and Modernization of Elevators**

- Introduction
- Building a Successful Maintenance Program
- Maintenance Guidelines
- Selecting Maintenance Providers
- Maintenance Contracts
- Elevator Modernization
- Installing New Elevator Systems
- Ensuring Safety
- Summary

**Chapter 8: Cleaning Administration**

- Introduction
- The Basics of Cleaning
- Designing for Maintainability
- Cleaning Facilities, Tools, and Supplies
- Cleaning Chemicals: Uses and Safety
- Cleaning Management
- Summary

**Chapter 9: Window Cleaning and Architectural Metal Maintenance**

- Introduction
- Window Cleaning: Sources of Dirt
- Window Cleaning: Chemicals, Tools, and Access Equipment
- Window Cleaning: Scheduling, Personnel, and Safety
- Metal Maintenance: Types of Architectural Metals
- Metal Maintenance: Application, Selection, and Care
- Maintenance and Restoration Procedures and Costs
- Summary

**Chapter 10: Landscaping and Parking**

- Introduction
- Landscape Design
- Environmental Conditions
- Types of Plantings
- Landscape Maintenance
- Indoor and Container Plants
- Parking Facilities
- Parking Facility Operations and Maintenance
- Parking Management
- Summary

**Chapter 11: Pest Management**

- Introduction
- Factors Affecting Pest Types
- Pests and Methods for Control
- Integrated Pest Management
- Designing a Pest Management Program
- Summary

**Chapter 12: Solid Waste and Recycling Management**

- Introduction
- Types of Wastes
- Waste Disposal Considerations
- Solid Waste Storage and Disposal
- Recycling
- Summary

**Chapter 13: Security Systems and Procedures**

- Introduction
- Establishing Proper Security Measures
- Physical Barriers for Defense
- Technology for Defense
- Security Personnel
- Security Procedures
- Summary

**Chapter 14: Incident Preparedness and Business Operations Continuation**

- Introduction
- Basic Preparedness Information for Occupants
- Incident Preparedness
- Development Guidelines
- Elements of a Disaster Plan
- Business Operations Continuation Plan
- Summary

**Chapter 15: Fire and Life-Safety Systems**

- Introduction
- Fire and Smoke Safety
- Codes and Standards
- Fire Prevention
- Fire Suppression Systems
- Fire Alarm Systems
- Maintenance of Fire Protection Systems
- Summary

**Chapter 16: Case Study: Facilities Management at CityPark Business Tower**

- Introduction
- CityPark Business Tower
- Case Study Challenge 1: Lighting Consultation
- Case Study Challenge 2: Internal Transportation
- Case Study Challenge 3: Grounds and Building Maintenance
- Case Study Challenge 4: Emergency Response