

# **Building Science Education Resource Guide**

*with emphasis on*

## **Heat, Air, and Moisture Flows and the Building Enclosure**

**Prepared for:  
National Renewable Energy Laboratory**

**Prepared by:  
Cold Climate Housing Program  
University of Minnesota**

**June 24, 2019**



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## Section 1. Introduction

### 1a. Project Background

Under Subcontract No. XEU-7-62518-06, the University of Minnesota Cold Climate Housing Program provided technical support to the National Renewable Energy Laboratory (NREL) in building science education for faculty and instructors of courses on the design, construction, and engineering of high-performance buildings. This task focused on the development of a building science teaching resource guide with an emphasis on heat, air, and moisture flows and the building enclosure. The scope and work was guided by current U.S. Department of Energy (DOE) building science goals and activities, including the [Guidelines for Building Science Education](#) (2015) and the [Building Science Education Solution Center](#).

The intent of the grant is to support and extend the Guidelines for Building Science Education developed by DOE and the Pacific Northwest National Laboratory (PNNL) and specifically to reach students enrolled in courses that may not have sufficient building science content. The areas of study that could be enhanced by building science include construction, construction management, design, environmental systems, and engineering. The goal of this report is to encourage faculty and instructors to include building science in their courses and to easily identify strong resources for those instructors. These resources are also meant to serve as a guide for faculty advisers participating in high-performance design competitions.

The books included in this report are those known to be primary texts for courses in the fields of building science, design and construction (including architecture), and undergraduate environmental systems. This report recognizes these textbooks as being strong in content for these individual areas of study.

The product of this report, an annotated resource guide, is intended to assist faculty advisers, instructors, and students to quickly identify high-quality resources to support their exploration and application of building science principles and best practices. The deliverable report identifies more than 50 highly rated and reasonably accessible resources that can assist those teaching classes in the fields of building science, design and construction, and environmental systems. It can also serve as a resource for faculty advisers and instructors who take part in high-performance building competitions, such as the U.S. Department of Energy Solar Decathlon<sup>®</sup> competition.

### 1b. Definitions and Terms

#### Resource Types

**Primary Resource:** A textbook (or other published resource) that can be used as the primary foundation for a college course. This category does include resources with limited building

science content because they are commonly used for key courses in construction, design, environmental systems, or engineering.

**Supplemental Resource:** A textbook (or other published resource) that can be used as a secondary or supplemental text to strengthen or cover critical topics not included in the primary text. This category includes selected resources that could enhance the breadth and depth of building science understanding for courses in construction, design, environmental systems, or engineering.

**Supportive Resource:** Published resources and web links (typically not a textbook) that are more topically focused materials that might be used to augment a specific section, lecture, or activity. This category includes selected items that could improve building science understanding and support for high-performance building design, engineering, and construction.

## Resource Evaluations

**Annotation:** This includes specific details on the resource including an overview of the content, accessibility, key building science highlights, and commentary on instructor or learner support.

**Priority Table:** This simple table provides a high-level evaluation of that resource as it specifically relates to the 14 selected priority building science topics (see the next section).

**Infusion Matrix:** All primary resources include a matrix based on the 14 priority building science topics. This matrix illustrates the strengths of that resource and then identifies specific building science resources that could be used for infusion to augment and enhance teaching for each of the 14 selected building science priority topics.

**Resource Comparison Chart:** These summary charts allow for a quick comparison of the primary resources across the 14 selected building science priority topics.

## 1c. Building Science Education Guidelines and Selected Priorities

### Introduction to Building Science Education Guidelines

This project builds from the [Building Science Education Solution Center](#). The Solution Center “provides professors, trainers, and students with accurate, easy-to-access training materials on the fundamentals of building science.” It is further based on the [Guidelines for Building Science Education](#).

The task of this project was to review Appendix B (“Final Building Science Education Matrix”) of the Guidelines and provide a compact document focusing on construction, construction management, design, environmental systems, and engineering with the intent of assisting instructors in providing good building science sources to enhance the courses they teach.

## Selection of Priority Job Classifications

Using the Building Science Education Matrix, the project team began by downselecting the job classifications. Because this guide was aimed at colleges and universities, the first task was to focus on design and construction professionals including architectural engineers, licensed architects, mechanical engineers, civil structural engineers, material science engineers, designers (nonregistered architects, interior designers, and so on), and landscape architects/site planners. Each classification was rated for both the importance and the gap relative to the current state of the profession in the design and construction of high-performance buildings noted in the chart below. The following charts indicate the priority job classifications as determined by this method. These charts use a 1 to 3 rating, with a “1” indicating the highest need and a “3” the lowest need. The priority classifications included in this report are highlighted.

Importance	Design and Constructional Professionals
1	Architectural Engineers
1	Licensed Architects
2	Mechanical Engineers
2	Civil Structural Engineers
2	Material Science Engineers
2	Designers (nonregistered architects, interior designers, and so on)
3	Landscape Architects/Site Planners
1	Construction Managers

Gap	Design and Constructional Professionals
2	Architectural Engineers
1	Licensed Architects
2	Mechanical Engineers
3	Civil Structural Engineers
2	Material Science Engineers
1	Designers (nonregistered architects, interior designers, and so on)
2	Landscape Architects/Site Planners
1	Construction Managers

## Selection of Priority Building Science Topics

Next the project team referred to the building science topics. Each of the 28 building science topics was rated for both the importance and the gap relative to the current state of high-performance buildings. These charts, provided below, use a 1 to 3 rating, with a “1” indicating the highest need and a “3” the lowest need. The priority building science topics included in this report are highlighted.

Importance	Integration of the Whole-Building System
1	Performance (energy, durability, comfort)
1	Disaster resistance/resiliency
1	Integrated design and construction
1	Quality management
2	Building and energy modeling
1	Cost trade-off analysis

Importance	Building Science Principles
1	Heat transfer (conduction, radiation, convection)
1	Moisture transport (liquid, water, psychrometrics)
1	Convective mass (air) transport, pressure
1	Material selection (indoor air quality, thermal mass, moisture control)
1	Control layers (water, air, vapor, thermal)
1	Hygrothermal analysis
1	HVAC systems (heating, cooling, ventilation)
1	HVAC interaction with the enclosure
1	Fenestration
2	Plumbing systems (plant, distribution)
2	Electrical systems
2	Lighting, appliances, miscellaneous loads
1	Indoor environmental quality
1	Control/automation systems

Importance	Operations and Maintenance
2	User interface and controls
2	Preventive maintenance
2	Replacement and renovation

Importance	Building Testing and Certification
2	Commissioning
2	Diagnostics and forensics
2	Performance monitoring/assessment
2	National codes and standards
2	Certification programs



Gap	Integration of the Whole-Building System
2	Performance (energy, durability, comfort)
2	Disaster resistance/resiliency
1	Integrated design and construction
2	Quality management
3	Building and energy modeling
3	Cost trade-off analysis
Gap	Building Science Principles
2	Heat transfer (conduction, radiation, convection)
1	Moisture transport (liquid, water, psychrometrics)
1	Convective mass (air) transport, pressure
1	Material selection (indoor air quality, thermal mass, moisture control)
2	Control layers (water, air, vapor, thermal)
1	Hygrothermal analysis
2	HVAC systems (heating, cooling, ventilation)
1	HVAC interaction with the enclosure
2	Fenestration
3	Plumbing systems (plant, distribution)
3	Electrical systems
3	Lighting, appliances, miscellaneous loads
2	Indoor environmental quality
3	Control/automation systems
Gap	Operations and Maintenance
3	User interface and controls
3	Preventive maintenance
2	Replacement and renovation
Gap	Building Testing and Certification
3	Commissioning
2	Diagnostics and forensics
3	Performance monitoring/assessment
3	National codes and standards
3	Certification programs

## 1d. Project Methodology

**Step One – Narrowing the Project Focus.** The first step for this project was to identify the critical audience and building science topics and content. The job category and core competencies in the DOE/PNNL Building Science Education Guidelines were used as the base for this task. The project team developed and used a weighting tool to reflect criticality of the job category and the gap size of the core competencies (see previous tables). The primary job categories were architects, architectural engineers, and construction managers. Fourteen priority topic areas met the criteria. These included 4 topics from the “Integration of the Whole-Building System” and 10 topics from “Building Science Principles Related to Enclosure.”

**Step Two – Reflecting on the Teaching Moment.** The second step was to identify what was determined to be primary teaching resources. These resources include textbooks or other published resources that are or could be used as the foundation for a college course in fields such as construction, design, environmental systems, or engineering. These resources did not necessarily include building science content. Instead, these are courses that the project team determined would be enhanced and better serve students with the addition of building science content. Fifteen textbooks were identified and evaluated as primary resources.

**Step Three – Supplemental Resource Identification.** Step Three (A) was to identify supplemental resources that would enhance the depth and breadth of building science for the courses identified in Step Two. These resources must have solid building science content. The supplemental resources include books or publications that may be assigned as a secondary text or a foundational resource. Twelve resources are identified as supplemental resources.

**Step Four – Supportive Resource Identification.** Step Three (B) was to identify supportive resources. These resources refer to more topically focused materials including publications, websites, and videos that could likely be assigned for a specific section or activity in a course. These sources will enhance the depth and of building science for the courses described in Step Two. There are 24 resources identified in this category.

**Step Five – Resource Evaluation.** An annotated bibliography was developed for all primary, supplemental, and supportive materials. An extended bibliography with an evaluation of building science coverage was included for the priority topics. Also included for the primary and supplemental resources is a high-level table to evaluate the coverage of the individual resource against the selected priority content areas identified in Step One.

**Step Six – Building a Matrix for Building Science Infusion.** A user guide illustrating how primary resources could be augmented to enhance the building science depth and/or breadth for the selected priority content area was created. A matrix was developed for each primary resource identifying supplemental and supportive material that could be used to support specific priority content areas. This matrix will serve as a map for infusion of enhanced building science content into existing courses based on the primary resource chosen by the instructor.

**Step Seven – Overview for Ease of Infusing Building Science Sources into Courses.** The final step is a scored resource comparison chart that allows an instructor to quickly see how the primary resources specifically address the 14 priority building science topics and content areas. The first comparison chart is aimed at textbooks that were developed with a strong building science orientation and potentially used in a building science course. A second chart is aimed at textbooks that are used to support courses in construction materials and methods, construction management, or construction documentation. The last chart looks at textbooks used to support courses in environmental systems or mechanical, electrical, and plumbing.

## **Section 2. How to Use This Guide**

### **2a. For Faculty Teaching Building Science Courses**

This guidance is aimed at faculty who are (or will be) teaching a course that is primarily focused on building science—from introductory to advanced—for high-performance buildings. This resource guide provides a quick overview of resources that might be considered for a future course or help instructors evaluate a resource to see how well it covers the selected priority building science topics. Most importantly, it can help identify key supplemental or supportive resources to augment and enhance coverage of the selected priority building science topics based on the primary textbook selected.

Section 3 is solely dedicated to building science resources ranging from primary textbooks to online resources. Under “Primary Resources” are textbook-like materials that could be the foundation of a building science course ranging from lower division introduction to upper division or graduate level. “Supplemental Resources” includes textbook or other comprehensive material that could be a secondary resource for a course. “Supportive Resources” includes a wide variety of resource material and types that can be used to augment a specific topic or section of the course.

For faculty teaching a building science course, Sections 3 and 4a provide options to review and evaluate resources that might be considered to enhance and augment the course across the 14 priority building science topics. All primary resources include three components. First is a short annotation with specific details on the resource, including an overview of the content, accessibility, key building science highlights, and commentary on instructor or learner support resources. Next is a table that provides a high-level evaluation of that resource as it specifically relates to the 14 selected priority building science topics. Finally, there is an infusion matrix that is based on the same priority building science topics. This matrix illustrates the strengths of that resource and then identifies specific building science resources that could be used for infusion to augment and enhance teaching for each of the 14 selected building science priority topics.

### **2b. For Faculty Teaching Construction Materials and Methods/Construction Management/Construction Documentation Courses**

This guidance is aimed at faculty who are (or will be) teaching a course that is primarily focused on construction materials and methods, construction management, or construction documentation. This resource guide provides a quick overview of primary resources that might be considered for a future course or help evaluate that resource to see how it covers the selected priority building science topics. Most importantly, it can help identify key supplemental or supportive resources that can augment and enhance coverage of the selected priority building science topics based on the primary textbook selected.

For faculty who might be teaching a construction materials and methods, construction management, or construction documentation course, Section 4b provides an opportunity to review and evaluate primary resources currently in use and those that might be considered. It also provides information on how they address the 14 priority building science topics. This section includes three components for each primary resource. First is a short annotation with specific details on the resource including an overview of the content, accessibility, key building science highlights, and commentary on instructor or learner support resources. Next is a table that provides a high-level evaluation of that resource as it specifically relates to the 14 selected priority building science topics. Finally, there is an infusion matrix that is based on the same priority building science topics. This matrix illustrates the strengths of that resource and then identifies specific building science resources that could be used for infusion to augment and enhance teaching for each of the 14 selected building science priority topics.

Building science resources ranging from primary textbooks to online resources are found in Section 3. Under “Primary Resources” are textbook-like materials that could be the foundation of a building science course ranging from lower division introduction to upper division or graduate level. “Supplemental Resources” includes textbook or other comprehensive material that could be a secondary resource for the course. “Supportive Resources” includes a wide variety of resource material and types that can be used to augment a specific topic or section of the course.

## **2c. For Faculty Teaching Environmental Systems/Mechanical, Electrical, and Plumbing Courses**

This guidance is aimed at faculty who are (or will be) teaching a course that is primarily focused on environmental systems or mechanical, electrical, and plumbing. This resource guide offers a quick overview of primary resources that might be considered for a future course or evaluate that resource to see how well it covers the selected priority building science topics. Most importantly, it can help identify key supplemental or supportive resources that can augment and enhance coverage of the selected priority building science topics based on the primary textbook

For faculty who might be teaching an environmental systems or mechanical, electrical, and plumbing course, Section 4c provides an opportunity to review and evaluate primary resources that might be considered and how well they address the 14 priority building science topics. This section includes three components for each primary resource. First is a short annotation with specific details on the resource including an overview of the content, accessibility, key building science highlights, and commentary on instructor or learner support resources. Next is a table that provides a high-level evaluation of that resource as it specifically relates to the 14 selected priority building science topics. Finally, there is an infusion matrix based on the same priority building science topics. This matrix illustrates the strengths of that resource and then identifies specific building science resources that could be used for infusion to augment and enhance teaching for each of the 14 selected building science priority topics.

Building science resources ranging from primary textbooks to online resources are found in Section 3. Under “Primary Resources” are textbook-like materials that could be the foundation of a building science course ranging from lower division introduction to upper division or graduate level. “Supplemental Resources” includes textbook or other comprehensive material that could be a secondary resource for the course. “Supportive Resources” includes a wide variety of resource material and types that can be used to augment a specific topic or section of the course.

## **2d. For Faculty Teaching a Capstone Course (or Leading a Student Design Competition Team) for High-Performance Buildings**

This guidance is aimed at faculty who are (or will be) teaching a design, construction, or engineering capstone course focused on a high-performance building design. This section can also support faculty who might be leading or assisting a student team participating in a high-performance design and/or construction competition such as the U.S. Department of Energy Solar Decathlon<sup>®</sup>. This resource guide gives a quick overview of primary resources that might be considered for the course or team and help evaluate that resource to see how well it covers the selected priority building science topics. Most importantly, it can help identify key supplemental or supportive resources that can augment and enhance coverage of the selected priority building science topics based on the primary textbooks that the students have used in the earlier coursework.

Section 3 is solely dedicated to building science resources ranging from primary textbooks to online resources. Under “Primary Resources” are textbook-like materials that could be the foundation of a building science course ranging from lower division introduction to upper division or graduate level. “Supplemental Resources” includes textbook or other comprehensive material that could be a secondary resource for the course. “Supportive Resources” includes a wide variety of resource material and types that can be used to augment a specific topic or section of the course.

For faculty who might be teaching a design, construction, or engineering capstone course focused on a high-performance building design or supporting a student team participating in a high-performance design and/or construction competition, Sections 3 and 4b provide an opportunity to review and evaluate resources currently being used or might be considered to enhance and augment the course across the 14 priority building science topics. All “Primary Resources” include three components. First is a short annotation with specific details on the resource including an overview of the content, accessibility, key building science highlights, and commentary on instructor or learner support resources. Next is a table that provides a high-level evaluation of that resource as it specifically relates to the 14 selected priority building science topics. Finally, there is an infusion matrix based on the same priority building science topics. This matrix illustrates the strengths of that resource and then identifies specific building science resources that could be used for infusion to augment and enhance teaching for each of the 14 selected building science priority topics.

Sections 4a, 4b, and 4c will be useful if any of those primary resources were used by students in their earlier coursework. This section will help evaluate the strengths and weaknesses of those primary resources and identify key supplemental and supportive building science resources. Section 4d is explicitly designed to help quickly identify quality resources that can enhance and augment a capstone source or assist student teams in meeting key building science requirements for a high-performance buildings design competition.

## Section 3. Building Science Resources

This section is dedicated to building science resources ranging from introductory to advanced and textbook-like to websites. It is intended to help a faculty member assess and evaluate potential resources to enhance the quality or quantity of building science principles and practices in their teaching. The resources have been divided into primary, supplemental, and supportive.

### 3a. Primary Building Science Resources

These primary resources will include an annotated bibliography, a priority table that summarizes the coverage of the 14 selected building science topics, and an infusion matrix intended to assist an instructor in the identification of supplemental or supportive resources to enhance or augment their building science coverage.

#### List of Primary Sources:

Hagentoft, C. (2001). *Introduction to Building Physics*.

Hens, H. (2017). *Building Physics – Heat, Air, and Moisture (3<sup>rd</sup> Edition)*.

Krigger, J. (2014). *Residential Energy – Cost Savings and Comfort for Existing Buildings (6<sup>th</sup> Edition)*.

Pohl, J. (2011). *Building Science: Concepts and Application*.

Rose, W. (2005). *Water in Buildings – An Architect's Guide to Moisture Control*.

Straube, J. (2012). *High Performance Enclosures*.

Straube, J. and Burnett, E. (2005). *Building Science for Building Enclosures*.





**Title:** *Introduction to Building Physics*  
**Author(s):** Carl-Eric Hagentoft

**Format:** Textbook – Hardcover  
**Publisher:** Studentlitteratur AB (Lund, Sweden)  
**Date:** 2001  
**Page Count:** 422  
**Availability:** Amazon and other online sources

**Description:** This book will help anticipate the performance and consequences of alternate designs as well as determine technical solutions before critical design and construction decisions can be made. The state and operation of the building envelope—walls, roofs, and foundation—are analyzed as well as the physical process components: heat, moisture, and air transfer. This book focuses on the theories behind the physical problems that may arise and the mathematical models used to arrive at needed solutions.

**Learner Support:** Each chapter includes an explanation of the chapter (role), the objectives for the chapter, introduction to the chapter, glossary, self-evaluation questions, and a summary.

**Priority Building Science Topics Addressed:**  
*Integration of Whole-Building Systems*

Priority	Coverage
Performance	Strong
Disaster Resistance/Resiliency	Minimal or Not Included
Integrated Design and Construction	Minimal or Not Included
Quality Management	Minimal or Not Included

*Building Science Principles*

Priority	Coverage
Heat Transfer	Strong
Moisture Transport	Strong
Air Transport	Strong
Material Selection	Minimal or Not Included
Control Layers	Strong
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Minimal or Not Included
HVAC Interaction with the Enclosure	Minimal or Not Included
Fenestration	Minimal or Not Included
Indoor Environmental Quality	Minimal or Not Included

## *Hagentoft – Introduction to Building Physics*

<b>Integration of Whole-Building System</b>	<b>Chapters</b>	<b>Level</b>	<b>Coverage</b>	<b>Supplemental</b>	<b>Supportive</b>
Performance (energy, durability, comfort)	1–16	Advanced	Strong		<i>Straube</i> – Building Enclosure Fundamentals
Disaster Resistance/Resiliency			Minimal or Not Included	<i>Brock</i> – Designing the Exterior Wall – Chapters 1–11	<i>NIBS</i> – Natural Hazard Mitigation Saves
Integrated Design and Construction			Minimal or Not Included	<i>Allen/Iano</i> – Fundamentals of Building Construction – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation....
Quality Management			Minimal or Not Included	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation....

<b>Building Science Principles</b>	<b>Chapters</b>	<b>Level</b>	<b>Coverage</b>	<b>Supplemental</b>	<b>Supportive</b>
Heat Transfer (conduction/radiation/convection)	2, 3	Advanced	Strong		<i>Touchie/Pressnail</i> – Building Science Fundamentals
Moisture Transport (liquid/vapor)	5	Advanced	Strong		<i>Treschel/Bomberg</i> – ASTM Moisture Control in Buildings
Convection Mass Transport (air)	4	Advanced	Strong		<i>Building Science Corporation</i> – Search Topic
Material Selection			Minimal or Not Included	<i>Brock</i> – Designing the Exterior Wall – Chapters 5–11 <i>Mehta et al.</i> – Building Construction – Part 2	<i>NIBS</i> – Building Envelope and Design Guide
Control Layers (air/water/thermal/vapor)	2–4	Advanced	Strong		<i>EPA</i> – Moisture Control Guidance for Design, Construction, Maintenance <i>Straube</i> – Building Science Control Layer Glossary
Hygrothermal Analysis			Minimal or Not Included	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 14	<i>Building Science Education</i> – Search Topic
HVAC Systems (heating/cooling/ventilation)			Minimal or Not Included	<i>Lechner</i> – Heating, Cooling, Lighting – Chapters 15, 16	<i>Rudd</i> – Ventilation Guide
HVAC Interaction with the Enclosure			Minimal or Not Included	<i>Reddy et al.</i> – Heating and Cooling of Buildings – Chapter 6	ACCA Manuals <i>Building Science Corporation</i> – Search Topic
Fenestration			Minimal or Not Included	<i>Carmody et al.</i> – Residential Windows	<i>NFRC Website</i>
Indoor Environmental Quality			Minimal or Not Included	<i>ASHRAE Fundamentals 2017</i> – Chapters 10–12	<i>U.S. General Services</i> – SF Tool <i>EPA</i> – Indoor airPLUS

**Title:** *Building Physics – Heat, Air, and Moisture*  
**Author(s):** Hugo Hens

**Format:** Textbook – Hardcover  
**Publisher:** Ernst and Sohn – A Wiley Company  
**Date:** 2017 (3<sup>rd</sup> Edition)  
**Page Count:** 307  
**Chapters:** 3  
**Availability:** Online from publisher and other online sources

**Description:** The author states that the subject of this book is “the physics behind heat, air and moisture in materials, building assemblies and whole buildings.” The book is based on the premise that building physics is an applied science and therefore is directed toward problem-solving. Specific topics include thermal insulation and thermal inertia, moisture and temperature-induced movements, and moisture tolerance.

This book includes many calculations but is also quite descriptive; a no-nonsense book that is written succinctly. It includes good background information even if the calculations are not specifically used by the student. The book includes a short but effective and compelling history of building physics. There are three companion texts available and a fourth yet to be published.

**Instructor Support:** Each chapter includes an extensive literature review.

**Learner Support:** Each chapter includes an extensive literature review. A problem and solution section is provided.

**Priority Building Science Topics Addressed:**  
*Integrated Whole-Building System*

Priority	Coverage
Performance	Strong
Disaster Resistance/Resiliency	Limited
Integrated Design and Construction	Minimal or Not Included
Quality Management	Minimal or Not Included

**Building Science Principles**

Priority	Coverage
Heat Transfer	Strong
Moisture Transport	Strong
Air Transport	Strong
Material Selection	Minimal or Not Included
Control Layers	Limited
Hygrothermal Analysis	Strong
HVAC Systems	Minimal or Not Included
HVAC Interaction with the Enclosure	Minimal or Not Included
Fenestration	Minimal or Not Included
Indoor Environmental Quality	Minimal or Not Included

## *Hens – Building Physics – Heat, Air, and Moisture*

<b>Integration of Whole-Building System</b>	<b>Chapters</b>	<b>Level</b>	<b>Coverage</b>	<b>Supplemental</b>	<b>Supportive</b>
Performance (energy, durability, comfort)	Introduction	Intermediate	Strong	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapters 1–3	<i>Straube</i> – Building Enclosure Fundamentals
Disaster Resistance/Resiliency	Introduction	Intermediate	Limited	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>NIBS</i> – Natural Hazard Mitigation Saves
Integrated Design and Construction			Minimal or Not Included	<i>Allen/Iano</i> – Fundamentals of Building Construction – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes
Quality Management			Minimal or Not Included	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes

<b>Building Science Principles</b>	<b>Chapters</b>	<b>Level</b>	<b>Coverage</b>	<b>Supplemental</b>	<b>Supportive</b>
Heat Transfer (conduction/radiation/convection)	1	Advanced	Strong		<i>Touchie/Pressnail</i> – Building Science Fundamentals
Moisture Transport (liquid/vapor)	1, 2, 3	Advanced	Strong		<i>Treschel/Bomberg</i> – ASTM Moisture Control in Buildings
Convection Mass Transport (air)	2, 3	Advanced	Strong		<i>Hagentoft</i> – YouTube Lectures
Material Selection			Minimal or Not Included	<i>Mehta et al.</i> – Building Construction – Part 2 <i>Brock</i> – Designing the Exterior Wall – Chapter 5–11	<i>NIBS</i> – Building Envelope Design Guide
Control Layers (air/water/thermal/vapor)	3	Intro	Limited	<i>Straube</i> – High Performance Enclosures - Chapter 4 <i>ASHRAE Fundamentals 2017</i> – Chapter 25	<i>EPA</i> – Moisture Control Guidance for Design, Construction, Maintenance <i>Straube</i> – Building Science Control Layer Glossary
Hygrothermal Analysis	2	Advanced	Strong		<i>Building Science Corporation</i> – Search Topic
HVAC Systems (heating/cooling/ventilation)			Minimal or Not Included	<i>Lechner</i> – Heating, Cooling, Lighting – Chapters 15, 16	<i>Rudd</i> – Ventilation Guide
HVAC Interaction with the Enclosure			Minimal or Not Included	<i>Reddy et al.</i> – Heating and Cooling of Buildings – Chapter 6	<i>Building Science Corporation</i> – Search Topic <i>ACCA Manuals</i>
Fenestration			Minimal or Not Included	<i>Carmody et al.</i> – Residential Windows	<i>NFRC Website</i>
Indoor Environmental Quality			Minimal or Not Included	<i>ASHRAE Fundamentals 2017</i> – Chapters 10–12	<i>EPA</i> – Indoor airPLUS <i>U.S. General Services</i> – SF Tool <i>U.S. CPSC</i> – The Inside Story

**Title:** *Residential Energy – Cost Savings and Comfort for Existing Buildings*  
**Author(s):** John Krigger

**Format:** Textbook – Softcover  
**Publisher:** Saturn Resource Management  
**Date:** 2014 (6<sup>th</sup> Edition)  
**Page Count:** 319, including Appendices Glossary (12 pages) Energy Efficient Organizations (3 pages), Bibliography (1 page), and Index (9 pages)  
**Chapters:** 10  
**Availability:** Saturn Resource Management website and Amazon

**Description:** This book focuses on energy use in a house at a basic level. It is often used as a text for those who are interested in conducting energy audits. It begins with a chapter on energy principles that includes the basics of energy and continues with the building envelope, wall components, HVAC, and health and safety. Building science principles are included at a level that can be understood by those new to building science.

The Appendix (A-1) provides basic energy-related formulas that are useful for those conducting energy loss studies in buildings.

**Instructor Support:** Excellent appendices and glossary.

**Learner Support:** Excellent appendices and glossary.

**Priority Building Science Topics Addressed:**

*Integrated Whole-Building System*

Priority	Coverage
Performance	Moderately Strong
Disaster Resistance/Resiliency	Limited
Integrated Design and Construction	Moderate
Quality Management	Minimal or Not Included

*Building Science Principles*

Priority	Coverage
Heat Transfer	Moderate
Moisture Transport	Limited
Air Transport	Moderately Strong
Material Selection	Minimal or Not Included
Control Layers	Moderate
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Moderately Strong
HVAC Interaction with the Enclosure	Limited
Fenestration	Moderate
Indoor Environmental Quality	Moderately Strong

## *Krigger – Residential Energy – Cost Savings and Comfort for Existing Buildings*

<b>Integration of Whole-Building System</b>	<b>Chapters</b>	<b>Level</b>	<b>Coverage</b>	<b>Supplemental</b>	<b>Supportive</b>
Performance (energy, durability, comfort)	2	Intro	Moderately Strong	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapters 1–3	<i>Straube</i> – <i>Building Enclosure Fundamentals</i>
Disaster Resistance/Resiliency	3, 4	Intro	Limited	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>NIBS</i> – Natural Hazard Mitigation Saves
Integrated Design and Construction	2	Intro	Moderate	<i>Allen/Iano</i> – Fundamentals of Building Construction – Chapter 1	<i>Lukachko/Gates/Straube</i> – Advanced construction Documentations for High Performance Homes – All
Quality Management			Minimal or Not Included	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>Lukachko/Gates/Straube</i> – Advanced construction Documentations for High Performance Homes – All

<b>Building Science Principles</b>	<b>Chapters</b>	<b>Level</b>	<b>Coverage</b>	<b>Supplemental</b>	<b>Supportive</b>
Heat Transfer (conduction/radiation/convection)	1, 2	Intro	Moderate	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 5	<i>Touchie/Pressnail</i> – Building Science Fundamentals
Moisture Transport (liquid/vapor)	1	Intermediate	Limited	<i>Lstiburek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Treschel/Bomberg</i> – ASTM Moisture Control in Buildings
Convection Mass Transport (air)	3	Intermediate	Moderately Strong	<i>Lstiburek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Hagentoft</i> – YouTube Lectures
Material Selection			Minimal or Not Included	<i>Mehta et al.</i> – Building Construction – Part 2 <i>Brock</i> – Designing the Exterior Wall – Chapters 5–11	<i>NIBS</i> – Building Envelope and Design Guide
Control Layers (air/water/thermal/vapor)	2,3	Intermediate	Moderate	<i>Straube</i> – High Performance Homes – Chapter 4 <i>ASHRAE</i> Fundamentals – Chapter 25	<i>EPA</i> – Moisture Control Guidance for Design, Construction, Maintenance <i>Straube</i> – Building Science Control Layer Glossary
Hygrothermal Analysis			Minimal or Not Included	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 14	<i>Hens</i> – Building Physics – Chapter 2
HVAC Systems (heating/cooling/ventilation)	6, 8	Intro	Moderately Strong	<i>Lechner</i> – Heating, Cooling, Lighting – Chapters 16 <i>Grondzik</i> – MEEB – Chapter 12	<i>Rudd</i> – Ventilation Guide
HVAC Interaction with the Enclosure	6	Intro	Limited	<i>Reddy et al.</i> – Heating and Cooling of Buildings – Chapter 6	<i>Building Science Corporation</i> – Search Topic <i>ACCA Manuals</i>
Fenestration	5	Intro	Moderate	<i>Carmody et al.</i> – Residential Windows	<i>NFRC Website</i>
Indoor Environmental Quality	10	Intro	Moderately Strong	<i>ASHRAE</i> Fundamentals 2017 – Chapters 10–12	<i>EPA</i> – Indoor airPLUS <i>U.S. General Services</i> – SF Tool <i>U.S. CPSC</i> – The Inside Story

**Title:** *Building Science: Concepts and Application*  
**Author(s):** Jens Pohl

**Format:** Textbook – Hardcover  
**Publisher:** Wiley  
**Date:** 2011  
**Page Count:** 271, including references (8 pages) and index (5 pages)  
**Chapters:** 12  
**Availability:** Wiley, Amazon, Google, and other online sources

**Description:** Pohl “introduces the reader to the underlying concepts and principles of the thermal, lighting, and acoustic determinants of building design in four integrated sections” (from the [publisher’s website](#)). The first section explores the thermal building environment and the principles of thermal comfort, translating these principles into conceptual building design solutions. The second section introduces the scientific principles of light, color, and vision. The third section deals with the various aspects of sound that impact the design of the built environment. The final section discusses the foundational concepts of ecological design as a basis for addressing sustainability issues in building design solutions. The textbook leads students through equations, calculations, and statistics. Charts, tables, and figures are used throughout.

**Instructor Support:** PowerPoint slides for lecturers.  
**Learner Support:** Website with multiple choice questions.

**Priority Building Science Topics Addressed:**  
*Integration of Whole-Building Systems*

Priority	Coverage
Performance	Moderate
Disaster Resistance/Resiliency	Minimal or Not Included
Integrated Design and Construction	Minimal or Not Included
Quality Management	Minimal or Not Included

*Building Science Principles*

Priority	Coverage
Heat Transfer	Moderately Strong
Moisture Transport	Minimal or Not Included
Air Transport	Minimal or Not Included
Material Selection	Minimal or Not Included
Control Layers	Minimal or Not Included
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Minimal or Not Included
HVAC Interaction with the Enclosure	Minimal or Not Included
Fenestration	Minimal or Not Included
Indoor Environmental Quality	Minimal or Not Included

## *Pohl – Building Science: Concepts and Application*

Integration of Whole-Building System	Chapters	Level	Coverage	Supplemental	Supportive
Performance (energy, durability, comfort)	2, 3	Intro	Moderate	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapters 1–3	<i>Straube</i> – Building Enclosure Fundamentals
Disaster Resistance/Resiliency			Minimal or Not Included	<i>Brock</i> – Designing for the Exterior Wall – Chapter 1	<i>NIBS</i> – Natural Hazard Mitigation Saves
Integrated Design and Construction			Minimal or Not Included	<i>Allen/Iano</i> – Fundamentals of Building Construction – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for HPH
Quality Management			Minimal or Not Included	<i>Brock</i> – Designing for the Exterior Wall – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for HPH

Building Science Principles	Chapters	Level	Coverage	Supplemental	Supportive
Heat Transfer (conduction/radiation/convection)	2, 3, 4	Intermediate	Moderately Strong	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 5	<i>Touchie/Pressnail</i> – Building Science Fundamentals
Moisture Transport (liquid/vapor)			Minimal or Not Included	<i>Lstiburek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Treschel/Bomberg</i> – ASTM Moisture Control in Buildings
Convection Mass Transport (air)			Minimal or Not Included	<i>Lstiburek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Hagentoft</i> – YouTube Lectures
Material Selection			Minimal or Not Included	<i>Mehta et al.</i> – Building Construction – Part 2 <i>Brock</i> – Designing the Exterior Wall – Chapters 5–11	<i>NIBS</i> – Building Envelope Design Guide
Control Layers (air/water/thermal/vapor)			Minimal or Not Included	<i>Straube</i> – High Performance Enclosures – Chapter 4 <i>ASHRAE</i> Fundamentals – Chapter 25	<i>EPA</i> – Moisture Control Guidance for Design, Construction, Maintenance <i>Straube</i> – Building Science Control Layer Glossary
Hygrothermal Analysis			Minimal or Not Included	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 14	<i>ASHRAE</i> Fundamentals 2017 – Chapter 27
HVAC Systems (heating/cooling/ventilation)			Minimal or Not Included	<i>Wujek/Dagostino</i> – Mechanical and Electrical Systems... – Chapters 6–10 <i>Lechner</i> – Heating, Cooling, Lighting – Chapters 15, 16	<i>Rudd</i> – Ventilation Guide <i>ACCA Manuals</i>
HVAC Interaction with the Enclosure			Minimal or Not Included	<i>Reddy et al.</i> – Heating and Cooling of Buildings – Chapter 6	<i>Building Science Corporation</i> – Search Topic <i>ACCA Manuals</i>
Fenestration			Minimal or Not Included	<i>Carmody et al.</i> – Residential Windows	<i>NFRC Website</i>
Indoor Environmental Quality	12	Intro	Minimal or Not Included	<i>ASHRAE</i> Fundamentals 2017 – Chapter 10–12	<i>EPA</i> Indoor airPLUS <i>U.S. General Services</i> – SF Tool



**Title:** *Water in Buildings – An Architect’s Guide to Moisture Control*

**Author(s):** William Rose

**Format:** Textbook – Hardcover

**Publisher:** Wiley

**Date:** 2005

**Page Count:** 270, including Appendices (2 pages), References (9 pages), and Index (6 pages)

**Chapters:** 9

**Availability:** Wiley website, Amazon, and other online sources

**Description:** This book is about water in buildings. The author clearly states that it is not a reference book on moisture control nor is it a “how-to or how-come” book. It is a learning book on water and moisture and the science and physics of water when applied to buildings. That said, it is a comprehensive and eloquently written book about the importance of water control in a building.

It begins with a building science overview for architecture, construction, engineering, and building codes and the importance of each of these for the understanding of how water will impact a building. The physics of water is followed by “Rethinking Moisture Control Strategies: Moisture Engineering.” The last several chapters strategically address areas where moisture control is critical. Rose finishes with the challenges of the result of moisture intrusion—rot and mold. This book, while heavy with science, should appeal to all students and perhaps especially to architecture students.

**Instructor Support:** There is an excellent and extensive reference list.

**Priority Building Science Topics Addressed:**

*Integration of Whole-Building Systems*

Priority	Coverage
Performance	Strong
Disaster Resistance/Resiliency	Minimal or Not Included
Integrated Design and Construction	Limited
Quality Management	Moderately Strong

*Building Science Principles*

Priority	Coverage
Heat Transfer	Limited
Moisture Transport	Strong
Air Transport	Limited
Material Selection	Minimal or Not Included
Control Layers	Limited
Hygrothermal Analysis	Moderately Strong
HVAC Systems	Limited
HVAC Interaction with the Enclosure	Limited
Fenestration	Minimal or Not Included
Indoor Environmental Quality	Minimal or Not Included

## Rose – Water in Buildings – An Architect’s Guide to Moisture Control

Integration of Whole-Building System	Chapters	Level	Coverage	Supplemental	Supportive
Performance (energy, durability, comfort)	1	Advanced	Strong		Straube – Building Enclosure Fundamentals
Disaster/Resiliency	9	Intro	Minimal or Not Included	<i>Brock</i> – Designing the Exterior Wall – Chapter 1–11	<i>NIBS</i> – Natural Hazard Mitigation Saves
Integrated Design and Construction	4, 6, 7	Intermediate	Limited	<i>Allen/Iano</i> – Fundamentals of Building Construction – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for HPH
Quality Management	All	Intermediate	Moderately Strong	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for HPH

Building Science Principles	Chapters	Level	Coverage	Supplemental	Supportive
Heat Transfer (conduction/radiation/convection)	4, 6, 7	Intermediate	Limited	<i>Touchie/Pressnail</i> – Building Science Fundamentals	
Moisture Transport (liquid/vapor)	2–7	Intermediate	Strong	<i>Lstiburek/Carmody</i> – Moisture Control Handbook Chapter 2	<i>Treschel/Bomberg</i> – ASTM Moisture Control in Buildings
Convection Mass Transport (air)	4–7	Intro	Limited	<i>Lstiburek/Carmody</i> – Moisture Control Handbook Chapter 2	<i>Hagentoft</i> – YouTube Lectures
Material Selection			Minimal or Not Included	<i>Mehta et al.</i> – Building Construction – Part 2 <i>Allen/Iano</i> – Fundamentals of Building Construction – Chapters 1–23	<i>NIBS</i> – Building Envelope Design Guide
Control Layers (air/water/thermal/vapor)	3–7	Intermediate	Limited	<i>Straube</i> – High Performance Enclosures – Chapter 4 <i>ASHRAE</i> Fundamentals – Chapter 25	<i>EPA</i> – Moisture Control Guidance for Design, Construction, Maintenance <i>Straube</i> – Building Science Control Layer Glossary
Hygrothermal Analysis	3	Intermediate	Moderately Strong	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 14	Building Science Corporation/Building Science Education – Search Topic
HVAC Systems (heating/cooling/ventilation)	6–8	Intermediate	Limited	<i>Wujek/Dagostino</i> – Mechanical and Electrical Systems... – Chapters 6–10	<i>Rudd</i> – Ventilation Guide
HVAC Interaction with the Enclosure	8	Intermediate	Limited	<i>Reddy et al.</i> – Heating and Cooling of Buildings – Chapter 6	<i>ACCA Manuals</i>
Fenestration			Minimal or Not Included	<i>Carmody et al.</i> – Residential Windows	<i>NFRC Website</i>
Indoor Environmental Quality	9	Intro	Minimal or Not Included	<i>ASHRAE</i> Fundamentals 2017 – Chapters 10–12	<i>EPA</i> – airPlus <i>U.S. General Services</i> – SF Tool <i>U.S. CPSC</i> – The Inside Story

**Title:** *High Performance Enclosures*  
**Author(s):** John Straube

**Format:** Textbook – Hardcover  
**Publisher:** Building Science Press  
**Date:** 2012  
**Page Count:** 336, including three appendices  
**Chapters:** 6 (including 3 appendices, a glossary, and index)  
**Availability:** Online from publisher and other online sources

**Description:** As the author states in the Introduction, Chapter One, “the environmental damage caused by a building’s energy consumption and its production is by far the largest impact, usually dwarfing the impact of the materials used to construct a building.” This book is intended to provide students with a strong basis for building science. Straube threads the science with the practical.

The photos, charts, and figures in this book are easy to read, look at, and understand. The appendices and supporting articles provide even more depth to the book.

**Learner Support:** Appendix A is 17 pages of basic information on heat flow that will be of great assistance to learners in addition to the 13 short articles in Appendix B.

**Priority Building Science Topics Addressed:**  
*Integration of Whole-Building Systems*

Priority	Coverage
Performance	Strong
Disaster Resistance/Resiliency	Minimal or Not Included
Integrated Design and Construction	Strong
Quality Management	Limited

*Building Science Principles*

Priority	Coverage
Heat Transfer	Strong
Moisture Transport	Strong
Air Transport	Strong
Material Selection	Moderately Strong
Control Layers	Strong
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Moderate
HVAC Interaction with the Enclosure	Moderate
Fenestration	Moderate
Indoor Environmental Quality	Minimal or Not Included

## *Straube – High Performance Enclosures*

<b>Integration of Whole-Building System</b>	<b>Chapters</b>	<b>Level</b>	<b>Coverage</b>	<b>Supplemental</b>	<b>Supportive</b>
Performance (energy, durability, comfort)	2, 3, 4	Intermediate	Strong		<i>Straube</i> – Building Enclosure Fundamentals (paper)
Disaster Resistance/Resiliency			Minimal or Not Included	<i>Brock</i> – Designing the Exterior Wall – Chapter 1–11	<i>NIBS</i> – Natural Hazard Mitigation Saves
Integrated Design and Construction	3	Intermediate	Strong	<i>Allen/Iano</i> – Fundamentals of Building Construction – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes
Quality Management	4, 5	Intermediate	Limited	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes

<b>Building Science Principles</b>	<b>Chapters</b>	<b>Level</b>	<b>Coverage</b>	<b>Supplemental</b>	<b>Supportive</b>
Heat Transfer (conduction/radiation/convection)	3 Appendix B.10	Intermediate	Strong	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 5	<i>Touchie/Pressnail</i> – Building Science Fundamentals
Moisture Transport (liquid/vapor)	3, Appendix B.11	Intermediate	Strong	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 5	<i>Treschel/Bomberg</i> – ASTM Moisture Control in Buildings
Convection Mass Transport (air)	3 App. A.1, A.2, B.13	Intermediate	Strong	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 5	<i>Hagentoft</i> – YouTube Videos
Material Selection	1–23	Advanced	Moderately Strong	<i>Brock</i> – Designing the Exterior Wall – Chapters 5–11	<i>NIBS</i> – Building Envelope Design Guide
Control Layers (air/water/thermal/vapor)	3, 4 Appendices B.1, B.2, B.7	Intro	Strong	<i>ASHRAE Fundamentals 2017</i> – Chapters 25	<i>EPA</i> – Moisture Control Guidance for Design, Construction, Maintenance <i>Straube</i> – Building Science Control Layer Glossary
Hygrothermal Analysis			Minimal or Not Included	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapters 1–3	<i>ASHRAE Fundamentals 2017</i> – Chapter 25
HVAC Systems (heating/cooling/ventilation)	Appendix B.13	Intro	Moderate	<i>Grondzik/Kwok</i> – MEEB - Chapters 5, 12 <i>Reddy et al.</i> – Chapters 3, 15–21	<i>Rudd</i> – Ventilation Guide ACCA Manuals
HVAC Interaction with the Enclosure	Appendix B.2	Intro	Moderate	<i>Reddy et al.</i> – Heating and Cooling of Buildings – Chapter 24	<i>Building Science Corporation</i> – Search Topic ACCA Manuals
Fenestration	Introduction, Chapters 1–5	Intro	Moderate	<i>Carmody et al.</i> – Residential Windows	<i>NFRC Website</i>
Indoor Environmental Quality			Minimal or Not Included	<i>ASHRAE Fundamentals 2017</i> – Chapters 10–12	<i>EPA</i> – Indoor airPLUS <i>U.S. General Services</i> – SF Tool <i>U.S. CPSC</i> – The Inside Story

**Title:** *Building Science for Building Enclosures*

**Author(s):** John Straube and Eric Burnett

**Format:** Textbook – Hardcover

**Publisher:** Building Science Press

**Date:** 2005

**Page Count:** 549, including an index (7 pages). Note: References are included with each chapter.

**Chapters:** 15

**Availability:** buildingscience.com, Amazon, other online sources

**Description:** The authors are clear that this text is intended for engineer or technical specialists who design, construct, operate, repair, rehabilitate, and renovate buildings.

This is a walk-through of heat, air, and moisture in buildings in a straightforward manner with language that is easy for the student to read. It is intended for engineer and/or technical specialists involved in the design, building, and care of buildings. The authors also consider the users (the people) who live and work in buildings, recognizing the five-step hierarchy of human needs. Graphics and charts are well placed and easy to read. Some chapters include problems and solutions.

**Learner Support:** Problems and solutions are provided in appropriate chapters.

**Priority Building Science Topics Addressed:**

*Integration of Whole-Building Systems*

Priority	Coverage
Performance	Strong
Disaster Resistance/Resiliency	Moderately Strong
Integrated Design and Construction	Limited
Quality Management	Limited

*Building Science Principles*

Priority	Coverage
Heat Transfer	Strong
Moisture Transport	Strong
Air Transport	Strong
Material Selection	Minimal or Not Included
Control Layers	Limited
Hygrothermal Analysis	Strong
HVAC Systems	Minimal or Not Included
HVAC Interaction with the Enclosure	Limited
Fenestration	Minimal or Not Included
Indoor Environmental Quality	Minimal or Not Included

## *Straube and Burnett – Building Science for Building Enclosures*

<b>Integration of Whole-Building System</b>	<b>Chapters</b>	<b>Level</b>	<b>Coverage</b>	<b>Supplemental</b>	<b>Supportive</b>
Performance (energy, durability, comfort)	1–3	Intro	Strong		<i>Straube</i> – Building Enclosure Fundamentals
Disaster Resistance/Resiliency	3	Intermediate	Moderately Strong	<i>Brock</i> – Designing the Exterior Wall – Chapters 1–11	<i>NIBS</i> – Building Envelope Design Guide
Integrated Design and Construction	1, 2, 9, 15	Intro	Limited	<i>Allen/Iano</i> – Fundamentals of Building Construction – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for HPH
Quality Management	1	Intro	Limited	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for HPH

<b>Building Science Principles</b>	<b>Chapters</b>	<b>Level</b>	<b>Coverage</b>	<b>Supplemental</b>	<b>Supportive</b>
Heat Transfer (conduction/radiation/convection)	4, 5	Intermediate	Strong	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 5	<i>Touchie/Pressnail</i> – Building Science Fundamentals
Moisture Transport (liquid/vapor)	4, 6, 10	Intermediate	Strong	<i>Lstiburek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Treschel/Bomberg</i> – ASTM Moisture Control in Buildings
Convection Mass Transport (air)	4, 7, 11	Intermediate	Strong	<i>Lstiburek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Hagentoft</i> – YouTube Lectures
Material Selection			Minimal or Not Included	<i>Mehta et al.</i> – Building Construction – Chapters 4, 13–37 <i>Allen/Iano</i> – Fundamentals of Building Construction – Chapters 1–23	<i>Allen/Iano</i> – Fundamentals of Building Construction – Chapters 1–23
Control Layers (air/water/thermal/vapor)	5–11	Intro	Limited	<i>Straube</i> – High Performance Enclosures – Chapter 4 <i>ASHRAE</i> Fundamentals – Chapter 25	<i>EPA</i> – Moisture Control Guidance for Design, Construction, Maintenance <i>Straube</i> – Building Science Control Layer Glossary
Hygrothermal Analysis	14	Advanced	Strong		Building Science Corporation/Building Science Education – Search Topic
HVAC Systems (heating/cooling/ventilation)			Minimal or Not Included	<i>Wujek/Dagostino</i> – Mechanical and Electrical Systems... – Chapters 6–10 <i>Lechner</i> – Heating, Cooling, Lighting – Chapters 15, 16	<i>Rudd</i> – Ventilation Guide
HVAC Interaction with the Enclosure	11	Intro	Limited	<i>Reddy et al.</i> – Heating and Cooling of Buildings – Chapter 6	<i>Building Science Corporation</i> – Search Topic ACCA Manuals
Fenestration			Minimal or Not Included	<i>Carmody et al.</i> – Residential Windows	<i>NFRC Website</i>
Indoor Environmental Quality			Minimal or Not Included	<i>ASHRAE</i> Fundamentals 2017 – Chapters 10–12	<i>EPA</i> Indoor airPLUS <i>U.S. General Services</i> – SF Tool <i>U.S. CPSC</i> – The Inside Story

### 3b. Supplemental Building Science Resources

These supplemental resources will include an annotated bibliography and a priority table that summarizes the coverage of the 14 selected building science topics.

#### List of Supplemental Building Science Resources:

Air Conditioning Contractors Association. (2016). *Manuals J, B, D, T, and RS*.

ASHRAE. 2017 *ASHRAE Handbook—Fundamentals*.

Bomberg, M, and Kisilewicz, T. (2017). *Introduction to Environmental Quality Management*.

Carmody, J., Selkowitz, S., Heschong, L., and Arasteh, D. (2007). *Residential Windows – A Guide to New Technologies and Energy Performance*.

Gatley, D. (2005). *Understanding Psychrometrics* (2nd Edition).

Lstiburek, J. (2006). *Water Management Guide*.

Lstiburek, J. and Carmody, J. (1993). *Moisture Control Handbook*.

National Institute of Building Sciences. (2017). *Building Envelope Design Guide*.

Rudd, A. (2011). *Ventilation Guide (Revised)*.

Straube, J. and Lstiburek, J. *Solar Decathlon Building Science Training* [Note: These are videos and available only to registered participants in the U.S. Department of Energy Solar Decathlon competition.]

Touchie, M. and Pressnail, K. (online videos). *Building Science Fundamentals*.

U.S. Environmental Protection Agency. (2013). *Moisture Control Guidance for Building Design, Construction and Maintenance*.

**Titles:** *Heating, Ventilation, and Air Conditioning Manuals*

**Author(s):** Air Conditioning Contractors Association

**Format:** Manuals – Softcover

**Publisher:** Air Conditioning Contractors Association

**Pub Date:** 2016

**Availability:** Online at ACCA

**Descriptions:**

**Manual J (8th Edition) – Residential Load Calculation** is the national ANSI-recognized standard for producing HVAC equipment sizing loads for single-family detached homes, small multiunit structures, condominiums, town houses, and manufactured homes.

**Manual B – Balancing and Testing Air and Hydronic Systems** is designed to help technicians test and balance HVAC equipment in a way that improves the balancing process.

**Manual D<sup>®</sup> – Residential Duct Systems** is the ANSI-recognized national standard for residential HVAC duct design.

**Manual T – Air Distribution Basics** shows how to prevent drafts and stagnant air problems caused by improper sizing or incorrect equipment selection. It gives examples of how to use manufacturers’ comprehensive performance data, calculate pressure losses, and control noise.

**Manual RS – Comfort, Air Quality, and Efficiency by Design** takes contractors through the design stage to the completion of a successful residential heating and cooling system installation.

**Note:** See free educational downloads under Power Your Lessons Up at <https://www.acca.org/members/industry/schools>

**Priority Building Science Topics Addressed:**

***Integration of Whole-Building System***

Priority	Coverage
Performance	Strong
Disaster Resistance/Resiliency	Minimal or Not Included
Integrated Design and Construction	Minimal or Not Included
Quality Management	Strong

***Building Science Principles***

Priority	Coverage
Heat Transfer	Strong
Moisture Transport	Strong
Air Transport	Strong
Material Selection	Minimal or Not Included
Control Layers	Minimal or Not Included
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Strong
HVAC Interaction with the Enclosure	Strong
Fenestration	Minimal or Not Included
Indoor Environmental Quality	Strong



**Title:** 2017 ASHRAE Handbook—Fundamentals  
**Author(s):** ASHRAE

**Format:** Handbook – Hardcover  
**Publisher:** ASHRAE  
**Date:** 2017  
**Chapters:** 37 (Applicable chapters: 4, 9, 10, 11, 15, 17, 18, 25–27, 35, 36)  
**Availability:** Amazon, Booktopia, other online sources.

**Description:** The 2017 ASHRAE Handbook—Fundamentals covers basic principles and data used in the HVAC and refrigeration industry. It covers basic principles such as thermodynamics, psychrometrics, and heat transfer, providing practical guidance on building envelope, indoor environmental quality, load calculations, duct and piping system design, refrigerants, energy resources, sustainability, and more.

Each print volume is published in either inch-pound (I-P) or International System (SI) units. An accompanying searchable CD-ROM contains PDFs of all the volume's chapters in both I-P and SI units.

**Instructor and Learner Support:** CD-ROM with additional content and weather files is provided with each book.

**Priority Building Science Topics Addressed:**  
*Integration of Whole-Building System*

Priority	Coverage
Performance	Strong
Disaster Resistance/Resiliency	Limited
Integrated Design and Construction	Minimal or Not Included
Quality Management	Minimal or Not Included

*Building Science Principles*

Priority	Coverage
Heat Transfer	Strong
Moisture Transport	Strong
Air Transport	Strong
Material Selection	Strong
Control Layers	Strong
Hygrothermal Analysis	Strong
HVAC Systems	Strong
HVAC Interaction with the Enclosure	Moderate
Fenestration	Strong
Indoor Environmental Quality	Strong

**Title:** *Introduction to Environmental Quality Management*  
**Author(s):** Mark Bomberg and Tomasz Kisilewicz

**Format:** Textbook – Online and Hardcover  
**Publisher:** Research Gate  
**Date:** 2017  
**Page Count:** 296  
**Chapters:** 5

**Availability:** Online – download chapters from  
<http://buildingscienceeducation.net/introduction-to-environmental-quality-management-eqm-mark-bomberg-and-tomasz-kisilewicz/>

**Description:** This a basic text on heat, air flow, and moisture based on years of research, teaching, and writing on these issues. It includes chapters on the durability of materials, materials in environmental control, and hygrothermal insulations. The hardcover version is [Methods of Building Physics](#) by Bomberg, Kisilewicz, and Christopher Mattock (2015), which addresses heat, air, and moisture transport in building enclosures, and its impact on enclosure assemblies, components, and materials.

**Priority Building Science Topics Addressed:**  
*Integration of Whole-Building System*

Priority	Coverage
Performance	Strong
Disaster Resistance/Resiliency	Strong
Integrated Design and Construction	Moderately Strong
Quality Management	Moderately Strong

*Building Science Principles*

Priority	Coverage
Heat Transfer	Strong
Moisture Transport	Strong
Air Transport	Strong
Material Selection	Moderately Strong
Control Layers	Strong
Hygrothermal Analysis	Strong
HVAC Systems	Limited
HVAC Interaction with the Enclosure	Limited
Fenestration	Strong
Indoor Environmental Quality	Minimal or Not Included

**Title:** *Residential Windows – A Guide to New Technologies and Energy Performance*  
**Author(s):** John Carmody, Stephen Selkowitz, Dariush Arasteh, and Lisa Heschong

**Format:** Textbook – Softcover  
**Publisher:** W.W. Norton & Company  
**Date:** 2007 (3rd Edition)  
**Page Count:** 264, including Appendices (16 pages), References (9 pages), Glossary (7 pages), and Index (4 pages)  
**Chapters:** 6  
**Availability:** Online from publisher and other online sources

**Description:** In its third edition, this book remains an excellent source on performance characteristics of windows, glazing materials, window assembly, design implications of energy-efficient windows, and considerations of window selection. It includes a short history of window developments and an overview of the National Fenestration Rating Council program. The drawings and graphics are excellent.

This is a very inclusive and easy to follow book on all aspects of windows. The science of windows has not changed. This book gives students a way to evaluate windows in every way.

**Instructor Support:** Good references and excellent glossary.

**Learner Support:** Excellent drawings and photos. Easy to read and understand. Covers the building science directly and simply. Excellent glossary.

**Priority Building Science Topics Addressed:**

*Integration of Whole-Building System*

Priority	Coverage
Performance	Strong
Disaster Resistance/Resiliency	Minimal or Not Included
Integrated Design and Construction	Limited
Quality Management	Minimal or Not Included


*Building Science Principles*

Priority	Coverage
Heat Transfer	Moderate
Moisture Transport	Moderate
Air Transport	Moderate
Material Selection	Moderate
Control Layers	Minimal or Not Included
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Minimal or Not Included
HVAC Interaction with the Enclosure	Minimal or Not Included
Fenestration	Strong
Indoor Environmental Quality	Minimal or Not Included

**Title:** *Understanding Psychrometrics*  
**Author(s):** Donald P. Gatley

**Format:** Textbook – Hardcover  
**Publisher:** ASHRAE  
**Date:** 2005 (2nd Edition)  
**Page Count:** 382, including Additional Information (32 pages), Appendices (84 pages), Glossary (22 pages), Bibliography (6 pages), and Index (15 pages)  
**Chapters:** 26  
**Availability:** Amazon, Barnes & Noble, Google

**Description:** The author begins the book with a chapter on vocabulary and one on etymology setting the stage so that readers and students will be on the same page. This book is not only a science book, but also a history book (see Chapter 8 as an example). Some chapters are as short as three pages (such as Chapter 18, Water Vapour Pressure) and some are as long as 24 pages (such as Chapter 19, Psychrometrics Processes). This textbook is practical but also daunting. The author explains the importance of the subject and breaks it down into parts that lead the reader/student logically along. There are small clock face icons that indicate a 4- to 6-hour learning session.

**Instructor Support:** The text includes a CD containing executable file hw.exe, PDF files of the 25 ASHRAE I-P and SI psychrometric chart, and more. See page XV of the preface. 

**Priority Building Science Topics Addressed:**  
*Integration of Whole-Building System*

Priority	Coverage
Performance	Minimal or Not Included
Disaster Resistance/Resiliency	Minimal or Not Included
Integrated Design and Construction	Minimal or Not Included
Quality Management	Minimal or Not Included

*Building Science Principles*

Priority	Coverage
Heat Transfer	Limited
Moisture Transport	Moderately Strong
Air Transport	Limited
Material Selection	Minimal or Not Included
Control Layers	Moderate
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Minimal or Not Included
HVAC Interaction with the Enclosure	Minimal or Not Included
Fenestration	Minimal or Not Included
Indoor Environmental Quality	Minimal or Not Included

**Title:** *Water Management Guide*

**Author(s):** Joseph Lstiburek

**Format:** Softcover – Guidebook

**Publisher:** Building Science Press, Inc.

**Date:** 2006

**Page Count:** 101

**Chapters:** 5

**Availability:** Online at <https://www.buildingscience.com/bookstore/ebook/ebook-water-management-guide>

**Description:** This relatively small guide addresses one of the most important issues in buildings—controlling rain and ground water. The prose is succinct and to the point. The graphics are outstanding. The guide is divided into five sections: Principles, Window Installation, Risk Factors (including an Average Annual Rainfall Map), Details, and More Details. The graphics are aimed mostly at wood-framed and concrete-framed walls and window installation in various wall assemblies. This could be called a how-to for water management in buildings.

**Priority Building Science Topics Addressed:**

*Integration of Whole-Building Systems*

Priority	Coverage
Performance	Strong
Disaster Resistance/Resiliency	Strong
Integrated Design and Construction	Strong
Quality Management	Moderately Strong

*Building Science Principles*

Priority	Coverage
Heat Transfer	Limited or Not Included
Moisture Transport	Strong
Air Transport	Moderately Strong
Material Selection	Minimal or Not Included
Control Layers	Moderately Strong
Hygrothermal Analysis	Limited or Not Included
HVAC Systems	Limited or Not Included
HVAC Interaction with the Enclosure	Limited or Not Included
Fenestration	Strong
Indoor Environmental Quality	Limited or Not Included

**Title:** *Moisture Control Handbook*  
**Author(s):** Joseph Lstiburek and John Carmody

**Format:** Textbook – Hardcover  
**Publisher:** Van Nostrand Reinhold  
**Date:** 1993 (Note: An updated version expected in late 2019.)  
**Page Count:** 214, including References and Bibliography (3 pages) and Index (5 pages)  
**Chapters:** 7  
**Availability:** Amazon, Barnes and Noble, Wiley, other online sources

**Description:** This book, while not written as a traditional textbook, has become a classic text on moisture control. It is not specifically a “science” book; the authors tend to explain mold, moisture, and condensation in non-scientific terms. Excellent graphics that hit every part of the building envelope. The authors demonstrate due diligence in the consideration of the differences of moisture control in heating, mixed, and cooling climates. The case studies (Chapter 7) provide good examples of what and what not to do based on climate.

**Note:** A revised version of this book is scheduled to be released in late 2019 and will serve as a companion resource for the Building America [Building Science Advisor](#).

**Priority Building Science Topics Addressed:**  
*Integration of Whole-Building Systems*

Priority	Coverage
Performance	Moderate
Disaster Resistance/Resiliency	Minimal or Not Included
Integrated Design and Construction	Strong
Quality Management	Minimal or Not Included

*Building Science Principles*

Priority	Coverage
Heat Transfer	Moderate
Moisture Transport	Strong
Air Transport	Moderate
Material Selection	Limited
Control Layers	Moderately Strong
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Minimal or Not Included
HVAC Interaction with the Enclosure	Minimal or Not Included
Fenestration	Minimal or Not Included
Indoor Environmental Quality	Minimal or Not Included

**Title:** *Building Envelope Design Guide*  
**Author(s):** National Institute of Building Sciences

**Format:** Website

**Availability:** <http://www.wbdg.org/guides-specifications/building-envelope-design-guide>

**Description:** The National Institute of Building Sciences (NIBS), under guidance from the past Federal Envelope Advisory Committee, developed this comprehensive guide for exterior envelope design and construction for institutional/office buildings. The publication list for each topic raises the level of information available when accessing this source.

This site is intended to be a living source. Users are invited to add information or suggest additions. The scope covers buildings constructed of steel, reinforced concrete, reinforced masonry, and reinforced concrete masonry units and includes low-, mid-, and high-rise buildings.

The following building envelope systems are covered in separate chapters: below grade construction, exterior walls, fenestration, roofs, and atria.

**Instructor Support:** Each chapter includes a section of resources.

**Priority Building Science Topics Addressed:**  
*Integration of Whole-Building System*

Priority	Coverage
Performance	Moderate
Disaster Resistance/Resiliency	Strong
Integrated Design and Construction	Strong
Quality Management	Minimal or Not Included

*Building Science Principles*

Priority	Coverage
Heat Transfer	Minimal or Not Included
Moisture Transport	Moderate
Air Transport	Moderate
Material Selection	Strong
Control Layers	Moderate
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Minimal or Not Included
HVAC Interaction with the Enclosure	Minimal or Not Included
Fenestration	Strong
Indoor Environmental Quality	Limited

**Title:** *Ventilation Guide*  
**Author(s):** Armin Rudd

**Format:** Softcover – Guidebook  
**Publisher:** Building Science Press  
**Date:** 2011 (Revised Version)  
**Page Count:** 117, including Appendices (4 pages)  
**Chapters:** 7  
**Availability:** <https://buildingscience.com/bookstore/books/2011-ventilation-guide>

**Description:** This very practical guide explains why ventilation is so important, how ventilation should be integrated into a house, and includes a description of ways to ventilate and how to determine the best system for a particular house. It addresses the importance of proper controls of ventilation systems. Rudd devotes the bulk of the guide to Chapter 6, “Best Practices System Details,” which includes excellent charts and graphic depictions of several ventilation configurations. Chapter 7 is devoted to avoiding mistakes when designing a ventilation system.

**Priority Building Science Topics Addressed:**  
*Integration of Whole-Building System*

Priority	Coverage
Performance	Strong
Disaster resistance/Resiliency	Minimal or Not Included
Integrated Design and Construction	Strong
Quality Management	Minimal or Not Included

*Building Science Principles*

Priority	Coverage
Heat Transfer	Minimal or Not Included
Moisture Transport	Minimal or Not Included
Air Transport	Moderate
Material Selection	Minimal or Not Included
Control Layers	Minimal or Not Included
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Strong
HVAC Interaction with the Enclosure	Minimal or Not Included
Fenestration	Minimal or Not Included
Indoor Environmental Quality	Limited



**Title:** *Solar Decathlon Building Science Training*  
**Author(s):** John Straube and Joe Lstiburek

**Format:** Videos

**Availability:** Available only to participants of the U.S. Department of Energy Solar Decathlon® competition. Refer to the Solar Decathlon website (<https://www.solardecathlon.gov/index.html>) for information on how to participate in this competition.

**Description:** Ten on-demand, 1-hour modules with additional special lessons on building science topics. Check for more information, including recommended reading material, at: <https://www.solardecathlon.gov/education-resources.html>

**Priority Building Science Topics Addressed:**  
*Integration of Whole-Building System*

Priority	Coverage
Performance	Strong
Disaster Resistance/Resiliency	Moderately Strong
Integrated Design and Construction	Moderately Strong
Quality Management	Minimal or Not Included

*Building Science Principles*

Priority	Coverage
Heat Transfer	Moderate
Moisture Transport	Moderately Strong
Air Transport	Moderately Strong
Material Selection	Moderate
Control Layers	Strong
Hygrothermal Analysis	Moderate
HVAC Systems	Moderate
HVAC Interaction with the Enclosure	Moderate
Fenestration	Limited
Indoor Environmental Quality	Moderately Strong

**Title:** *Building Science Fundamentals*  
**Presenters:** Marianne Touchie and Kim Pressnail

**Format:** Web-based online course

**Publisher:** University of Toronto

**Availability:** <http://edtech.engineering.utoronto.ca/project/building-science-fundamentals>

**Description:** This online course is a basic building science course presented in a way that is easy to watch and listen to by professors with years of teaching experience in civil engineering at the University of Toronto. From the course listing: “This online course package consists of a set of 7 modules. These modules support the teaching of an introductory course in Building Science for College and University-level students studying Architecture or Engineering. Basic principles and applications of building science including the control of heat, moisture, air movement and solar energy are presented. These modules are intended to supplement existing lecture-based course materials. However, given that the course package is comprehensive, the modules could also be used as a substitute for traditional lectures.” Whether used as supplements or as a substitute for lectures, instructors are encouraged to support these online materials with hands-on tutorials and laboratory activities.

**Learner support:** To provide feedback for the self-guided learner, a series of knowledge checks have been provided throughout.

**Priority Building Science Topics Addressed:**  
*Integration of Whole-Building System*

Priority	Coverage
Performance	Moderate
Disaster Resistance/Resiliency	Minimal or Not Included
Integrated Design and Construction	Minimal or Not Included
Quality Management	Minimal or Not Included

*Building Science Principles*

Priority	Coverage
Heat Transfer	Strong
Moisture Transport	Strong
Air Transport	Strong
Material Selection	Moderate
Control Layers	Moderate
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Minimal or Not Included
HVAC Interaction with the Enclosure	Minimal or Not Included
Fenestration	Minimal or Not Included
Indoor Environmental Quality	Minimal or Not Included

**Title:** *Moisture Control Guidance for Building Design, Construction and Maintenance*  
**Author(s):** U.S. Environmental Protection Agency

**Format:** Softcover – Guidebook  
**Publisher:** U.S. Environmental Protection Agency  
**Date:** 2013

**Page Count:** 99 (Excluding Appendices A–G and Glossary). References are included at the end of each chapter.

**Chapters:** 4

**Availability:** <https://www.epa.gov/sites/production/files/2014-08/documents/moisture-control.pdf>

**Description:** The Environmental Protection Agency conducted a study between 1994 and 1998 and found that 85% of the 100 buildings randomly selected (from all climates) were damaged by water and that 45% had leaks at the time the buildings were examined. This guide is about how water can affect the life of a building and impact the people who use the building. It was specifically created for those who design and produce drawings for buildings, those who specify materials for buildings, erect buildings from construction documents, and professionals who operate and maintain buildings. It is also for those who inspect the building and finishes in the building. There are excellent references with each chapter.

Photos, graphics, and charts enhance the understanding of the damage that will be caused when designing and erecting buildings without a deep consideration for moisture control. Appendix A includes the “pen test” for integrity and continuity of the control layers.

**Priority Building Science Topics Addressed:**

*Integration of Whole-Building System*

Priority	Coverage
Performance	Strong
Disaster Resistance/Resiliency	Minimal or Not Included
Integrated Design and Construction	Strong
Quality Management	Strong

*Building Science Principles*

Priority	Coverage
Heat Transfer	Minimal or Not Included
Moisture Transport	Strong
Air Transport	Minimal or Not Included
Material Selection	Minimal or Not Included
Control Layers	Strong
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Limited
HVAC Interaction with the Enclosure	Limited
Fenestration	Minimal or Not Included
Indoor Environmental Quality	Minimal or Not Included



### 3c. Supportive Building Science Resources

These supportive resources include an annotated bibliography only.

#### List of Supportive Building Science Resources:

ASHRAE. *Advanced Energy Design Guides*.

ASHRAE. *GreenGuide: Design, Construction, and Operation of Sustainable Buildings*.

ASHRAE. *Indoor Air Quality Guide*.

Building Science Corporation. *Building Science Corporation Articles and Papers*.

Building America. *Building Science Advisor*.

Building America. *Building America Solution Center*.

Building America. *Building Science Education Solution Center*.

Building America. *Zero Energy Ready Home*.

“Efficient Windows Collaborative” website.

Environmental Protection Agency. *Indoor airPLUS Construction Specifications Version 1 (Rev. 04)*.

Foundation Design Handbook. *Oak Ridge National Laboratory*.

“Green Building Advisor” website.

Hagentoft, Carl-Eric. *Building Science Introduction Lectures*.

“Joint Committee on Building Science Education” website.

Lukachko, Gates, and Straube. *Strategy Guideline: Advanced Construction Documentation for High Performance Homes*.

National Fenestration Ratings Council website.

National Institute of Building Sciences. *Natural Hazard Mitigation Saves: 2018 Report*.

“Net-Zero Energy Residential Test Facility” website. National Institute of Standards.

Straube, John. *Building Enclosure Fundamentals: A Concise Introduction*.

Straube, John. *Control Layer Definitions*.

Trechsel, Heinz, and Mark Bomberg. *Moisture Control in Buildings – The Key Factor in Mold Prevention*.

Trechsel, Heinz, and Mark Bomberg. *Water Vapor Transmission Through Building Materials and Systems: Mechanisms and Measurement*.

U.S. Consumer Product Safety Commission. *The Inside Story – A Guide to Indoor Air Quality*.

U.S. General Services Administration. *Sustainable Facilities Tool*.

**Title:** *Advanced Energy Design Guides*  
**Author:** ASHRAE

**Publisher:** ASHRAE  
**Format:** Website

**Available:** Free download at <https://www.ashrae.org/technical-resources/aedgs>

**Description:** ASHRAE, in collaboration with the American Institute of Architects, the Illuminating Engineering Society of North America, the U.S. Green Building Council, and the Department of Energy, continues to develop the Advanced Energy Design Guide series.

The ASHRAE Advanced Energy Design Guides are a series of publications designed to provide recommendations for achieving energy savings over the minimum code requirements of ANSI/ASHRAE/IESNA Standard 90.1. This is the first step in the process toward achieving a net zero energy building, defined as a building that, on an annual basis, draws from outside resources equal or less energy than it provides using on-site, renewable energy sources.

**Title:** *GreenGuide: Design, Construction, and Operation of Sustainable Buildings*  
**Author:** ASHRAE  
**Publisher:** ASHRAE  
**Format:** Guidebook – Softcover  
**Date:** 2018  
**Page Count:** 528, including References and Resources (21), Terms and Definitions (4), and Index (9)  
**Chapters:** 20  
**Availability:** ASHRAE, Amazon, and other online sources

**Description:** This book is intended to be used as a reference over a book that would be read from front to back. Throughout the book numerous techniques, processes, measures, and special systems are described.

However, the book follows the construction of a building from design through completion of construction and beyond. This book stresses the quality of the indoor environment, including air quality, thermal regime, illumination, acoustics/noise, and visual aspects to provide comfortable human physiological and psychological perceptions. Chapter 8 focuses on indoor environmental quality; Chapter 11 on lighting; and Chapter 13 on smart building systems.



**Title:** *Indoor Air Quality Guide*  
**Author(s):** ASHRAE

**Format:** Guidebook – Softcover  
**Publisher:** ASHRAE  
**Page Count:** 697, including 57 pages of appendices  
**Chapters:** 16  
**Availability:** Free download at

<https://www.ashrae.org/technical-resources/bookstore/indoor-air-quality-guide>

**Description:** This guide presents best practices for design, construction, and commissioning that have proven successful in building projects. It provides information and tools that architects and design engineers can use to achieve an indoor air quality-sensitive building that integrates indoor air quality into the design and construction process along with other design goals, budget constraints, and functional requirements. Target audience includes architects, building owners, commission authorities, product and material specifiers, rating programs, facility managers, and building operators.

**Title:** *Building Science Corporation Articles and Papers*  
**Author(s):** Multiple contributing authors

**Format:** Online

**Availability:** [www.buildingscience.com](http://www.buildingscience.com)

**Description:** Articles and papers based on research and the technical credentials of the authors, all of whom have advanced degrees in areas critical to building science. The majority are composed for both students and the general public.\*

There are six categories of papers and articles, including:

Building Science Insights. Authored by Joseph Lstiburek, this section includes more than 100 articles that cover all aspects of heat, moisture, and air. They are written with humor but make solid points about how to build buildings without heat, moisture, and air problems.

Building Science Digests. This includes 60 papers by various authors, providing a more in-depth look at heat, moisture, and air topics.

Published Articles. This section includes 27 articles published in journals such as *Journal of Building Physics*, *Journal of Building Enclosure Design*, *Journal of Light Construction*, and magazines including *Fine Homebuilding*, *Home Energy*, *Builder Magazine*, and *Sprayfoam Professionals*.

Conference Papers. This section includes more than 25 research papers presented at professional conferences.

Research Reports. This includes 57 research reports covering materials, construction practices, pressure, ventilation, and other topics related to buildings.

Building America. The Building Science Corporation website also includes Building America Reports including *Strategy Guideline: Modeling Enclosure Design in Above-Grade Walls*. This work describes how to model and interpret results of models for above-grade walls, and 2) analyzes the failure thresholds and criteria for above-grade walls. It can be downloaded at [https://www1.eere.energy.gov/buildings/publications/pdfs/building\\_america/65479.pdf](https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/65479.pdf)

These papers, reports, and articles can aid instructors and learners by providing information that can supplement a text. The website allows search by topic, title, keywords, and climate zone.

These papers, reports, and articles cover the complete list of Priority Building Science Topics.

*\*Note. The number of articles and papers listed are as of early 2019. New articles and papers continue to be added to each of the categories listed.*

**Title:** *Building Science Advisor*

**Author:** Building America

**Format:** Website

**Publisher:** U.S. Department of Energy

**Availability:** Online at <https://basc.pnnl.gov/building-science-advisor>

**Description:** The Building Science Advisor is a website providing expert advice on anticipated building wall performance from the industry's best researchers and building scientists. This tool promotes better-informed decisions regarding energy-efficient and moisture-durable wall designs. The Building Science Advisor helps users to identify risk associated with moisture durability.

**Instructor and Learner Support:** The Building Science Advisor offers the reader potential options for energy efficient and advanced wall systems. Use the "Expert" pathway within the tool to design energy efficient walls. Educational guides can help step through the material selection process while providing feedback. Advice from the tool can help focus on the design process and avoid moisture and energy problems in the field.

The following article will accompany the above website:

J. Lstiburek, K. Ueno, and S. Musunura. 2016. *Strategy Guideline: Modeling Enclosure Design in Above-Grade Walls*. U.S. Department of Energy Office of Energy Efficiency and Renewable Energy. [https://www1.eere.energy.gov/buildings/publications/pdfs/building\\_america/65479.pdf](https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/65479.pdf).

**Title:** *Building America Solution Center*  
**Author:** Building America

**Format:** Website  
**Publisher:** U.S. Department of Energy  
**Availability:** Online at <https://basc.pnnl.gov/resource-guides>

**Description:** This website provides access to many resources, including a library, a series of guides on energy-efficient buildings, case studies, an image gallery, videos, and more. This website is provided by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy.

**Title:** *Building Science Education Solution Center*  
**Author:** Building America

**Format:** Website  
**Publisher:** U.S. Department of Energy  
**Availability:** Online at <https://bsesc.energy.gov/>

**Description:** Currently in beta form, the Building Science Education Solution Center provides professors, trainers, and students with accurate, easy-to-access training materials for a full range of building-related professions included in the Guidelines for Building Science Education. This resource is intended to provide stakeholders with content needed to provide training consistent with the Guidelines.

**Title:** *Zero Energy Ready Home*  
**Authors:** Building America

**Format:** Website  
**Publisher:** U.S. Department of Energy

**Availability:** Online at <https://www.energy.gov/eere/buildings/zero-energy-ready-home>

**Description:** The *DOE Zero Energy Ready Home* offers builders, architects, and designers a timely solution for differentiating their product from existing homes as well as minimum code new homes. The *DOE Zero Energy Ready Home* label—*The Home of the Future Today*—makes it easy for consumers to identify high-performance homes that are so energy efficient a renewable energy system can offset most or all annual energy consumption.

**Title:** *Efficient Windows Collaborative*  
**Author(s):** Efficient Windows Collaborative

**Format:** Website  
**Publisher:** Efficient Windows Collaborative  
**Availability:** Online at <https://www.efficientwindows.org/>

**Description:** The Efficient Windows Collaborative is a nonprofit, 501(c)3 organization that partners with window, door, skylight, and component manufacturers, research organizations, federal, state, and local government agencies, and others interested in expanding the market for high-efficiency fenestration products. Its goals are to increase market penetration of efficient window technologies and to make National Fenestration Rating Council labeling a near-universal practice in U.S. markets. The members of Efficient Windows Collaborative are manufacturers, suppliers, and affiliates.

This website guides consumers and builders/remodelers/homeowners through the process of choosing a window suited to the climate they live in and their needs.

**Title:** *Indoor airPLUS Construction Specifications Version 1 (Rev. 04)*  
**Author(s):** Environmental Protection Agency

**Format:** Guide Document – Online  
**Publisher:** Environmental Protection Agency  
**Date:** 2018

**Availability:** Downloadable online at <https://www.epa.gov/indoorairplus/indoor-airplus-program-documents>

**Description:** These specifications were developed by the U.S. Environmental Protection Agency to recognize new homes equipped with a comprehensive set of indoor air quality features. They were developed with significant input from stakeholders based on best available science and information about risks associated with indoor air quality problems and balanced with practical issues of cost, builder production process compatibility, and verifiability. This guide includes a verification checklist that will be valuable to both builders and owners.

The Indoor airPLUS Program fully integrates ENERGY STAR Certified Home requirements as a prerequisite. In addition, both the ENERGY STAR Certified Home label and the Indoor airPLUS label are prerequisites for the Department of Energy's Zero Energy Ready Home Program and the PHIUS+ certification by Passive House Institute US, both of which are additional certification options in building high performance, sustainable homes. In addition to these Construction Specifications, the Indoor airPLUS Program periodically publishes a Policy Record document.



**Title:** *Green Building Advisor*  
**Author(s)** Various authors

**Format:** Website

**Publisher:** The Taunton Press

**Availability:** <https://www.greenbuildingadvisor.com/>

Note that membership is required for some articles and information.

**Description:** This website offers basic and new information on all aspects of the building process based on green and sustainable practices.

**Title:** *Foundation Design Handbook*  
**Author(s):** Oak Ridge National Laboratory

**Format:** Website

**Availability:** Online at <https://foundationhandbook.ornl.gov/handbook/toc.shtml>

**Description:** The purpose of this handbook is to provide information that will enable designers, builders, and homeowners to understand foundation design problems and solutions.

Section 1.1 explains the practical and economic advantages of good foundation design. The organization and scope of this handbook is described in Section 1.2. Section 1.3 discusses the considerations that affect choosing a foundation type. Because radon represents a major health hazard, a special introduction to radon appears in Section 1.4.

**Title:** *Building Physics Introduction Lectures*

**Author:** Carl-Eric Hagentoft

**Format:** Online Video Lectures

**Availability:** YouTube at  
[https://www.youtube.com/playlist?list=UUe1SFf4pcWEH4S\\_Xf0HFd\\_A](https://www.youtube.com/playlist?list=UUe1SFf4pcWEH4S_Xf0HFd_A)

**Description:** Series of 14 videos on heat, moisture, and air flow ranging in time from 5 to 10 minutes. Basic concepts of heat, air, and moisture transport are covered. Includes interactions between moisture and materials.

**Title:** Joint Committee on Building Science Education  
**Author(s):** Building Science Education

**Format:** Website

**Availability:** <http://buildingscienceeducation.net/resources>  
<http://buildingscienceeducation.net/resources/teaching-resources/>

**Description:** An online site that includes an extensive list of resources helpful to both faculty and students of building science, engineering, architecture, construction management and any other profession related to the design and construction of buildings. The site also provides information about a number of programs and task groups working to enhance excellence in building science education.

The mission of the Joint Committee on Building Science Education is to “support the transformation of the education and training of the design and construction industry profession such that it’s professionals, educated, trained and certified in building science and related advanced design and construction management practices routinely design and build quality, high performance buildings that are safe, healthy, durable, comfortable and highly energy efficient and always provide the highest value to their clients.”

**Instructor Support:** The information provided can lead instructors to numerous textbooks, research papers, and websites that will support courses in building science at all levels. It also links to a document based on the work of many experts working in the field of building science. The Building America Building Science Education Roadmap is a resource that can assist instructors.

**Key Resources:** Below are several links provided to support the development and enhancement of building science curricula include:

- [Shared University Curricula](#)
- [Supplemental Teaching Resources](#) (Links to Teaching Resources page with supplemental resources from John Straube, Joe Lstiburek, Carl-Eric Hagentoft, UMN, U Toronto and more.)
- [Building Energy Software Tools](#)
- [Bibliography of Building Science Education Publications](#)
- [Online Resources for Building Science](#)
- [US Government and other Resources Useful for Building Science Education.](#)

**Title:** Strategy Guideline: Advanced Construction Documentation for High Performance Homes  
**Authors:** A. Lukachko, C. Gates, and J. Straube, Building Science Corporation  
**Publisher:** Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy  
**Date:** 2011  
**Availability:** Online at <https://www.nrel.gov/docs/fy12osti/53459.pdf>

**Description:** From the introduction: “[This] Guideline identifies differences between the requirements for construction documents for high performance housing and the documents that are typically produced for conventional housing. The reader will be presented with four changes that are recommended to achieve improvements in energy efficiency, durability, and health in Building America program houses: create coordination drawings, improve specifications, improve detail drawings, and review drawings and prepare a Quality Control Plan. Each recommendation is discussed using lessons learned from the National Institute of Science and Technology Net Zero Energy Lab House, a recent Building Science Corporation BA project that will test the implementation of energy efficiency technologies intended for future use in production homebuilding.”

**Title:** *National Fenestration Rating Council Website*

**Format:** Website

**Publisher:** National Fenestration Rating Council

**Availability:** Online at <http://www.nfrc.org/>

**Description:** The National Fenestration Rating Council (NFRC) is an independent nonprofit organization that establishes objective window, door, and skylight energy performance ratings to compare products and assist with informed purchase decisions in the following ways:

Communicating the energy performance of products using the NFRC label

Helping buyers and installers understand the different categories of energy performance

Providing tips, tools, and educational resources


Narrowing your product search through NFRC Certified Product Directory

Delivering friendly, expert support to homeowners, builders, and installers.

**Title:** *Natural Hazard Mitigation Saves: 2018 Report*  
**Author:** National Institute of Building Sciences

**Format:** Website 

**Availability:** <https://www.nibs.org/page/mitigationsaves>

**Description:** This report addresses options of restoring areas where a natural hazard has occurred and emphasizes that only after “the overall risk is fully understood should mitigation measures be identified, prioritized, and implemented.” It includes a section on relevant codes and regulations and a lengthy section of additional resources. The audience is all trades involved in the restoring and rebuilding of areas that have experienced a natural hazard. 

The website describes this report in the following way. “This report, issued by the National Institute of Building Sciences, looks at the benefits of designing buildings to meet the *2018 International Residential Code* and *2018 International Building Code*—the model building codes developed by the International Code Council—versus the prior generation of codes represented by 1990-era design and National Flood Insurance Program requirements. The report is a compilation of the project team’s results to this point and includes the finding from the *2017 Interim Report*, released in January 2018, and a second report, *Natural Hazard Mitigation Saves: Utilities and Transportation Infrastructure*, released in October 2018. The project team found a national benefit of \$11 for every \$1 invested.”

**Title:** Net-Zero Energy Residential Test Facility  
**Author(s):** National Institute of Standards

**Format:** Website

**Availability:** <https://www.nist.gov/el/net-zero-energy-residential-test-facility>

**Description:** Existing as both a laboratory and a house, the two-story, four bedrooms, three-bath Net-Zero Energy Residential Test Facility was designed and built to be approximately 60% more energy efficient than homes built to meet the requirements of the 2012 International Energy Conservation Code. During the first year of operation (July 2013–June 2014) the house exceeded its goal with enough surplus energy to power an electric car for about 1,400 miles. The current estimated yearly electrical bill in Maryland where the house is located is \$4,400. A (virtual) family of four residing in the all-electric home were able to export energy to the electric grid. Additional details can be found by reading “NIST Test House Exceeds Goal; Ends Year with Energy to Spare” (<https://www.nist.gov/news-events/news/2014/07/nist-test-house-exceeds-goal-ends-year-energy-spare>).

Changes in Operational Strategy associated with the heating and ventilation systems and milder weather allowed the Net-Zero Energy Residential Test Facility to quadruple the amount of excess energy sent to the grid relative to the first year (2,139 versus 484 kilowatt hours). The team is currently conducting research as part of the third phase of operation. Key experiments being conducted include the following:

- A comparison of the performance of a small-duct, high-velocity heat pump to one that uses conventional metal ductwork
- Measurement approaches and data collection for assessing thermal comfort
- Measurement of hot water distribution effectiveness
- Measured impact of heat pump water heater on the space conditioning requirements
- Assessment of the spatial variation in outdoor temperature measurement and its impact on modeling of thermal loads introduced by ventilation system.

Ongoing information can be followed on the website.



**Title:** *Building Enclosure Fundamentals: A Concise Introduction*  
**Author:** John Straube, University of Waterloo and RDH Building Science

**Availability:** <http://buildingscienceeducation.net/wp-content/uploads/2017/06/Building-Enclosure-Fundamentals-2017.pdf>

**Description:** This short document introduces the technical aspects of building enclosures with a focus on high-performance walls. The functions required of all building enclosures, commercial and residential, are presented followed by concise descriptions of control functions.

**Title:** *Control Layer Definitions*

**Author:** John Straube. University of Waterloo and RDH Building Science

**Availability:** <http://buildingscienceeducation.net/wp-content/uploads/2017/06/Control-Layer-definitions-glossary.pdf>

**Description:** The author sums the explanation of the definitions of control layer here: “Control layers are notional concepts used to describe which materials/assemblies provide the control functions in a building enclosure and as aid to ensure continuity of the functions in design and construction. They are comprised of one or several materials and formed into planes to create a three dimensional boundary.” This document explains the control layers of an enclosure.

**Title:** *Moisture Control in Buildings – The Key Factor in Mold Prevention*  
**Editors:** Heinz Trechsel and Mark Bomberg, Editors

**Format:** Downloadable Book  
**Publisher:** ASTM Compass  
**Date:** 2009 (2nd Edition)  
**Page Count:** 611, including a 5-page index. References are included with each article.  
**Chapters:** 28, each a research article.  
**Availability:** Download at <https://compass.astm.org/download/MNL18-2ND-EB.22805.pdf>.  
Note that an ASTM Compass subscription is required.

**Description:** This edited book contains 28 articles addressing moisture issues in buildings. It consists of four parts:

Part 1. *Fundamentals* – Articles discuss moisture transfer, condensation, and evaporation. Moisture-related properties of building materials, organisms and health effects, climate, and moisture sources are also included.

Part 2. *Applications* – Articles discuss the technologies that affect moisture balance in buildings and the techniques used to determine the suitability of materials, components, systems, and structures. There are chapters on air infiltration and ventilation, design tools, measurement techniques and instrumentation, troubleshooting, and a chapter on case studies.

Part 3. *Construction Principles and Recommendations* – Articles include discussions of and recommendations for best construction practices of both new and existing commercial and high buildings, new and existing residential buildings, manufactured buildings, and historic buildings.

Part 4. *Implementation* – Articles discuss implementation mechanisms. This section is organized along a simple concept, that buildings should be designed, built, and repaired in accordance with the contract documents that contain the principles outlined in the earlier sections and chapters.

**Title:** *Water Vapor Transmission Through Building Materials and Systems: Mechanisms and Measurement (STP1039)*  
**Author(s):** Heinz Trechsel and Mark Bomberg, Editors  
**Publisher:** American Standards for Testing and Materials  
**Date:** 1989  
**Format:** Selected Technical Papers  
**Availability:** Available online at [https://www.astm.org/DIGITAL\\_LIBRARY/STP/SOURCE\\_PAGES/STP1039.htm](https://www.astm.org/DIGITAL_LIBRARY/STP/SOURCE_PAGES/STP1039.htm)

**Description:** This includes 15 peer-reviewed papers by separate authors covering mechanisms, field observations, and measurement of moisture in buildings. The papers are primarily written for those engaged in research on moisture movement and those concerned with material properties relating to water vapor transmission.

**Title:** *The Inside Story – A Guide to Indoor Air Quality*  
**Author(s):** U.S. Consumer Product Safety Commission

**Format:** Guidebook – Online  
**Publisher:** U.S. Consumer Product Safety Commission  
**Pages:** 32, including resources (4 pages) and glossary (1 page)  
**Availability:** Free download at Consumer Product Safety Commission  
<https://www.cpsc.gov/Safety-Education/Safety-Guides/Home/The-Inside-Story-A-Guide-to-Indoor-Air-Quality>

**Description:** This guide begins with short sections on the cause of indoor air problems and how the outdoor air enters the house or apartment. It moves on to an introduction of how to improve the air quality in a dwelling, identifying air quality problems, measuring levels of a pollutant, and weatherizing a dwelling. It then discusses the three basic strategies to addressing indoor air issues. The bulk of the guide is devoted to a list of indoor pollutants and includes the source, health effects, levels in home (if appropriate), and steps to reduce each pollutant.

**Title:** *Sustainable Facilities Tool*  
**Publisher:** U.S. General Services Administration

**Availability:** Online at <https://sftool.gov/>

**Description:** This website covers information and links to information on all aspects of indoor environmental quality topics including but not limited to air quality, acoustic conditions, lighting, and thermal comfort. It includes links to additional U.S. governmental sites and to other sites such as ASHRAE, Green Seal, Building Commissioning Association, SMACNA, and more.

Each topic is briefly introduced with a condition that should be addressed. Topics include noise pollution, occupant comfort, human health, indoor air quality. Links to other sources follow.

**Instructor and Learner Support:** Sources link to research, guides, standards, and factsheets.

## **Section 4. Guidance for Building Science Infusion**

This section is designed for the faculty member who is looking to augment or enhance building science principles and practices into an existing course. Based on the primary textbook used for the course, the infusion matrix will direct the instructor to specific supplemental or supportive building science resources in each of the 14 priority building science topics.

This section is divided into four categories that are aimed at four different types of courses:

- 4a. Dedicated Building Science Course
- 4b. Construction Materials and Methods/Management/Documentation Course
- 4c. Environmental Systems/Mechanical, Electrical, and Plumbing Course
- 4d. Capstone Course on High-Performance Whole-Building Design





## 4a. Dedicated Building Science Courses

Primary resources are considered in this report to be a book or significant work that could be used as a main text for a building science course focused on the fundamentals and applications of heat, air, and moisture mechanisms. The following is a list of the textbooks that have been determined to be the Primary Resources. To see the specific annotations, priority tables, and infusion matrices for these seven resources, see Section 3a.

### List of Primary Resources

Hagentoft, C. (2001). *Introduction to Building Physics*.

Hens, H. (2017). *Building Physics – Heat, Air, and Moisture* (3<sup>rd</sup> Edition).

Krigger, J. (2014). *Residential Energy – Cost Savings for Existing Buildings* (6th Edition).

Pohl, J. (2011). *Building Science: Concepts and Application*.

Rose, W. (2005). *Water in Buildings – An Architect’s Guide to Moisture Control*.

Straube, J. (2012). *High Performance Enclosures*.

Straube, J. and Burnett, E. (2005). *Building Science for Building Enclosures*.

## Comparison Chart

This is a quick guide to compare these seven building science primary resources across the selected priority building science topics.

<b><i>Integration Design and Construction</i></b>	Hagentoft	Hens	Krigger	Pohl	Rose	Straube	Straube/Burnett
Performance (energy, durability, comfort)	5	5	4	3	5	5	5
Disaster Resistance/Resiliency	1	2	2	1	1	1	4
Integrated Design and Construction	1	1	3	1	2	5	2
Quality Management	1	1	1	1	4	2	2

<b><i>Building Science Principles</i></b>	Hagentoft	Hens	Krigger	Pohl	Rose	Straube	Straube/Burnett
Heat Transfer	5	5	3	4	2	5	5
Moisture Transport (liquid/vapor)	5	5	2	1	5	5	5
Convective Mass Transport (air)	5	5	4	1	2	5	5
Material Selection	1	1	1	1	1	4	1
Control Layers (air/water/thermal/vapor)	5	2	3	1	2	5	2
Hygrothermal Analysis	1	5	1	1	4	1	5
HVAC Systems (heating/cooling/ventilation)	1	1	4	1	2	3	1
HVAC Interaction with the Enclosure	1	1	2	1	2	3	2
Fenestration	1	1	3	1	1	3	1
Indoor Environmental Quality	1	1	4	1	1	1	1

### Key for Comparison Chart

- 1 = Minimal or Not Included
- 2 = Limited
- 3 = Moderate
- 4 = Moderately Strong
- 5 = Strong

## **4b. Construction Materials & Methods/Management/Documentation Courses**

Below are primary resources considered in this report to be a book or significant work that could be used as a main text for a Construction Materials and Methods, Construction Management, or Construction Documentation course. The following is a list of the textbooks that have been determined to be the Primary Resources for this project. The specific annotations, priority tables, and infusion matrices for each of these resources follow this list.

### **List of Primary Resources**

Allen, Edward, and Joseph Iano. (2014). *Fundamentals of Building Construction: Materials and Methods* (6th Edition).

Allen, Edward, and Patrick Rand. (2016). *Architectural Detailing: Function, Constructability, Aesthetics*.

Brock, Linda. (2005). *Designing the Exterior Wall*.

Mehta, Madan, Walter Scarborough, and Diane Armpriest. (2018). *Building Construction – Principles, Materials, and Systems* (3rd Edition).



**Title:** *Fundamentals of Building Construction: Materials and Methods*  
**Author(s):** Edward Allen and Joseph Iano

**Format:** Textbook – Hardcover  
**Publisher:** Wiley  
**Pub Date:** 2014 (6th Edition)  
**Page Count:** 1,007, including Appendix (12 pages), Glossary (30 pages), and Index (9 pages)  
**Chapters:** 24  
**Availability:** Online from publisher and other online sources

**Description:** As the title states, this textbook is a construction manual. It covers both materials and processes in a very practical, straightforward, and logical manner. The illustrations are good though photos are black and white and appear somewhat dated. This edition includes many updates on process and materials. It includes sections on sustainable building materials, zoning ordinances, building codes, construction standards, and sequencing of a building project.

**Instructor Support:** Each chapter concludes with key terms, review questions, exercises, selected references, and a solid listing of websites with information from that chapter. An interactive resource center is available with the purchase of the book. The text’s encyclopedic details for instructors and students is available at: [www.wiley.com/go/constructioneducation6e](http://www.wiley.com/go/constructioneducation6e). There is a test bank, PowerPoint lecture slides, and an instructor’s manual for instructors only.

**Learner Support:** At the above website students can find flashcards and interactive self-test questions. There are also sketch-up exercises and animations. A companion document, Exercises in Building Construction (along with answer key) is available to students.

**Priority Building Science Topics Addressed:**  
*Integration of Whole-Building Systems*

Priority	Coverage
Performance	Minimal or Not Included
Disaster resistance/Resiliency	Minimal or Not Included
Integrated Design and Construction	Strong
Quality Management	Moderately Strong

*Building Science Principles*

Priority	Coverage
Heat Transfer	Minimal or Not Included
Moisture Transport	Minimal or Not Included
Air Transport	Minimal or Not Included
Material Selection	Strong
Control Layers	Limited
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Minimal or Not Included
HVAC Interaction with the Enclosure	Minimal or Not Included
Fenestration	Moderate
Indoor Environmental Quality	Minimal or Not Included

*Allen and Iano – Fundamentals of Building Construction: Materials and Methods*

Integration of Whole-Building System	Chapters	Level	Coverage	Supplemental	Supportive
Performance (energy, durability, comfort)	1	Intro	Minimal or Not Included	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapters 1–3	<i>Straube</i> – Building Enclosure Fundamentals
Disaster Resistance/Resiliency	1–21	Intro	Minimal or Not Included	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>NIBS</i> – Natural Hazard Mitigation Saves
Integrated Design and Construction	1–21	Advanced	Strong		<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes
Quality Management	1–21	Advanced	Moderately Strong		<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes

Building Science Principles	Chapters	Level	Coverage	Supplemental	Supportive
Heat Transfer (conduction/radiation/convection)		Intro	Minimal or Not Included	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 5	<i>Touchie/Pressnail</i> – Building Science Fundamentals
Moisture Transport (liquid/vapor)	19	Intro	Minimal or Not Included	<i>Lstiburek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Treschel/Bomberg</i> – ASTM Moisture Control in Buildings
Convection Mass Transport (air)	19	Intro	Minimal or Not Included	<i>Lstiburek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Hagettaft</i> – YouTube Lectures
Material Selection	1–23	Advanced	Strong		<i>NIBS</i> – Building Envelope Design Guide
Control Layers (air/water/thermal/vapor)	7, 19	Intro	Limited	<i>ASHRAE Fundamentals 2017</i> – Chapter 25 <i>Straube</i> – High Performance Enclosures – Chapter 4	<i>EPA</i> – Moisture Control Guidance for Design, Construction, Maintenance <i>Straube</i> – Building Science Control Layer Glossary
Hygrothermal Analysis			Minimal or Not Included	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 14	<i>Building Science Corporation</i> – Search Topic
HVAC Systems (heating/cooling/ventilation)			Minimal or Not Included	<i>Lechner</i> – Heating, Cooling, Lighting – Chapter 16 <i>Grondzik</i> – MEEB Chapter 12	<i>Rudd</i> – Ventilation Guide
HVAC Interaction with the Enclosure			Minimal or Not Included	<i>Reddy et al.</i> – Heating and Cooling of Buildings – Chapter 6	<i>ACCA</i> Manuals
Fenestration	18	Intro	Moderate	<i>Carmody et al.</i> – Residential Windows	<i>NFRC Website</i>
Indoor Environmental Quality			Minimal or Not Included	<i>ASHRAE Fundamentals 2017</i> – Chapters 10–12	<i>U.S. General Services</i> – SF Tool <i>EPA</i> – Indoor airPLUS <i>U.S. CPSC</i> – The Inside Story

**Title:** *Architectural Detailing: Function, Constructability, Aesthetics*  
**Author(s):** Edward Allen and Patrick Rand

**Format:** Textbook – Softcover  
**Publisher:** Wiley (3rd Edition)  
**Pub Date:** 2016  
**Page Count:** 363, including Appendices (7 pages), and Index (7 pages)  
**Chapters:** 17  
**Availability:** Amazon and other online sources

**Description:** From the introduction: “This book is intended to help students and young professionals become proficient with architectural detailing.” The authors expect students to know that a basic understanding of physics and biological and chemical processes are a part of detailing. The book is divided into parts. *Part One: Detail Patterns* includes the controlling of heat flow, water vapor, sound, as well as the movement of materials, structural support, passages for mechanical and electrical service, health and safety, issues for aging, assembly, efficient use of construction resources forgiving details, and aesthetics. *Part Two: Detail Development* includes details on working with light frame, concrete, and brick facing on a concrete frame. The text is easy to read, and the diagrams (over 500) and text bring building science into all aspects of detailing.

**Instructor and Learner Support:** Appendix A provides references on detailing; Appendix B is a guide on formulating exercises for self-study, studio, and classroom use.

**Priority Building Science Topics Addressed:**  
*Integrated Whole-Building System*

Priority	Coverage
Performance	Strong
Disaster Resistance/Resiliency	Moderate
Integrated Design and Construction	Moderate
Quality Management	Moderate

*Building Science Principles*

Priority	Coverage
Heat Transfer	Limited
Moisture Transport	Moderately Strong
Air Transport	Limited
Material Selection	Moderate
Control Layers	Moderate
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Minimal or Not Included
HVAC Interaction with the Enclosure	Minimal or Not Included
Fenestration	Moderate
Indoor Environmental Quality	Limited

*Allen/Rand – Architectural Detailing: Function, Constructability, Aesthetics*

Integration of Whole-Building System	Chapters	Level	Coverage	Supplemental	Supportive
Performance (energy, durability, comfort)	1–10	Intro	Strong	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapters 1–3	<i>Straube</i> – Building Enclosure Fundamentals
Disaster Resistance/Resiliency	10	Intro	Moderate	<i>Brock</i> – Designing for the Exterior Wall – Chapter 1	<i>NIBS</i> – Natural Hazard Mitigation Saves
Integrated Design and Construction	1–13	Intro	Moderate	<i>Allen/Iano</i> – Fundamentals of Building Construction – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for HPH
Quality Management	Part II	Intro	Moderate	<i>Brock</i> – Designing for the Exterior Wall – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for HPH

Building Science Principles	Chapters	Level	Coverage	Supplemental	Supportive
Heat Transfer (conduction/radiation/convection)	3	Intro	Limited	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 5	<i>Touchie/Pressnail</i> – Building Science Fundamentals
Moisture Transport (liquid/vapor)	1, 4	Intermediate	Moderately Strong	<i>Ltibusrek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Treschel/Bomberg</i> – ASTM Moisture Control in Buildings
Convection Mass Transport (air)	2	Intro	Limited	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapters 8–10 <i>ASHRAE Fundamentals 2017</i> – Chapters 4, 6	<i>Hagentoft</i> – YouTube Lectures
Material Selection	9, 10, 13, 15–17	Moderate	Limited	<i>Mehta et al.</i> – Building Construction – Part 2 <i>Brock</i> – Designing the Exterior Wall – Chapters 5–11	<i>NIBS</i> – Building Envelope Design Guide
Control Layers (air/water/thermal/vapor)	1, 2, 3, 4, 6	Intro	Moderate	<i>Straube</i> – High Performance Enclosures – Chapter 4 <i>ASHRAE Fundamentals</i> – Chapter 25	<i>EPA</i> – Moisture Control Guidance for Design, Construction, Maintenance <i>Straube</i> – Building Science Control Layer Glossary
Hygrothermal Analysis			Minimal or Not Included	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 14	<i>ASHRAE Fundamentals 2017</i> – Chapter 27
HVAC Systems (heating/cooling/ventilation)			Minimal or Not Included	<i>Wujek/Dagostino</i> – Mechanical and Electrical Systems... – Chapters 6–10 <i>Lechner</i> – Heating, Cooling, Lighting – Chapters 15, 16	<i>Rudd</i> – Ventilation Guide <i>ACCA Manuals</i>
HVAC Interaction with the Enclosure			Minimal or Not Included	<i>Reddy et al.</i> – Heating and Cooling of Buildings Chapter 6	<i>Building Science Corporation</i> – Search Topic <i>ACCA Manuals</i>
Fenestration	2, 3, 10	Intermediate	Moderate	<i>Carmody et al.</i> – Residential Windows	<i>NFRC Website</i>
Indoor Environmental Quality	12	Intro	Limited	<i>ASHRAE Fundamentals 2017</i> – Chapter 10–12	<i>EPA</i> Indoor airPLUS <i>U.S. General Services</i> – SF Tool <i>U.S. CPSC</i> – The Inside Story



**Title:** *Designing the Exterior Wall*  
**Author(s):** Linda Brock

**Format:** Textbook – Hardcopy  
**Publisher:** Wiley  
**Pub Date:** 2005  
**Page Count:** 400, including Appendices, Notes, Bibliography, Resources, and Index  
**Chapters:** 11  
**Availability:** Online from publisher and other online sources

**Description:** This book is written to teach students of architecture, building science, and architects how and why buildings fail. It covers a variety of climates and includes many case studies. It is both a science text and one that recognizes the liability of those who design, build, and own buildings. It covers both theory and construction. As an example, Chapter Two (“Water Barriers and Flashings”) begins with an insert section on the definition of water. It then leads the reader through the process of how water should be managed and uses description and simple diagrams to discuss the various ways water management can be successful based on the wall structure. Photos graphically show the damage that is done when water is not carefully integrated into the design and construction of a building.

**Priority Building Science Topics Addressed:**  
*Integrating of Whole-Building Systems*

Priority	Coverage
Performance	Moderately Strong
Disaster Resistance/Resiliency	Strong
Integrated Design and Construction	Strong
Quality Management	Strong

*Building Science Principles*

Priority	Coverage
Heat Transfer	Strong
Moisture Transport	Strong
Air Transport	Strong
Material Selection	Strong
Control Layers	Moderate
Hygrothermal Analysis	Minimal or Not included
HVAC Systems	Minimal or Not included
HVAC Interaction with the Enclosure	Minimal or Not included
Fenestration	Minimal or Not included
Indoor Environmental Quality	Minimal or Not included

## *Brock – Designing the Exterior Wall*

<b>Integration of Whole-Building System</b>	<b>Chapters</b>	<b>Level</b>	<b>Coverage</b>	<b>Supplemental</b>	<b>Supportive</b>
Performance (energy, durability, comfort)	1, Part 2	Intro	Moderately Strong	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapters 1–3	<i>Straube</i> – Building Enclosure Fundamentals
Disaster Resistance/Resiliency	1	Intermediate	Strong		<i>NIBS</i> – Natural Hazard Mitigation Saves
Integrated Design and Construction	2–4	Intro	Strong	<i>Allen/Iano</i> – Integrated Design and Construction – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes
Quality Management	1, 2	Intermediate	Strong		<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes

<b>Building Science Principles</b>	<b>Chapters</b>	<b>Level</b>	<b>Coverage</b>	<b>Supplemental</b>	<b>Supportive</b>
Heat Transfer (conduction/radiation/convection)	3	Intro	Strong	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 5	<i>Touchie/Pressnail</i> – Building Science Fundamentals
Moisture Transport (liquid/vapor)	2, 3	Intro	Strong	<i>Lstiburek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Treschel/Bomberg</i> – ASTM Moisture Control in Buildings
Convection Mass Transport (air)	2, 3	Intro	Strong	<i>Lstiburek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Hagentoft</i> – YouTube Lectures
Material Selection	2–11	Advanced	Strong		<i>NIBS</i> – Building Envelope and Design Guide
Control Layers (air/water/thermal/vapor)	1 - 3	Intro	Moderate	<i>Straube</i> – High Performance Enclosures – Chapter 4 <i>ASHRAE Fundamentals 2017</i> – Chapter 25	<i>EPA</i> – Moisture Control Guidance for Design, Construction, Maintenance <i>Straube</i> – Building Science Control Layer Glossary
Hygrothermal Analysis	1	Intro	Minimal or Not Included	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 14	<i>Building Science Corporation</i> – Search Topic
HVAC Systems (heating/cooling/ventilation)			Minimal or Not Included	<i>Wujek/Dagostino</i> – Mechanical and Electrical Systems... – Chapters 6–10	<i>Rudd</i> – Ventilation Guide
HVAC Interaction with the Enclosure			Minimal or Not Included	<i>Reddy et al.</i> – Heating and Cooling for Buildings – Chapter 6	<i>Building Science Corporation</i> – Search Topic <i>ACCA Manuals</i>
Fenestration			Minimal or Not Included	<i>Carmody et al.</i> - Residential Windows	<i>NFRC Website</i>
Indoor Environmental Quality			Minimal or Not Included	<i>ASHRAE Fundamentals 2017</i> – Chapters 10–12 <i>Wujek/Dagostino</i> – Mechanical and Electrical Systems – Chapter 3.6	<i>U.S. General Services</i> – SF Tool <i>EPA</i> – Indoor airPLUS <i>U.S. CPSC</i> – The Inside Story

**Book Title:** *Building Construction – Principles, Materials, and Systems*  
**Author(s):** Madan Mehta, Walter Scarborough, and Diane Arm Priest

**Format:** Textbook – Hardcopy  
**Publisher:** Pearson Education Inc., publishing as Prentice Hall  
**Date:** 2018 (3rd Edition)  
**Page Count:** 952, including Appendices (17 pages), Glossary (16 pages), References (2 pages), and Index (12 pages)  
**Chapters:** 37  
**Availability:** Pearson Education Inc., Amazon, other online sources

**Description:** The authors of this text acknowledge that “the study of principles alone is not sufficient to master or fully grasp a subject.” Their belief is that principles should be demonstrated by both current and traditional practices with the goal of relating to real-world design and construction. The text has two parts: the first 10 chapters cover the performance of both building materials and building assemblies, and the remaining 27 chapters address specific materials and assemblies. This book covers material and methods that have been proven over time. It does not cover new and emerging technologies that have not been field tested.

**Instructor Support:** Teaching resources for this text include an instructor’s manual, PowerPoint presentations, and test bank.

**Learner Support:** It allows access to *Students’ Homework and Classroom Assignment Manual*. Chapters include both review questions and quizzes. The answers to chapter questions are included in the manual back cover.

**Priority Building Science Topics Addressed:**  
*Integration of Whole-Building Systems*

Priority	Coverage
Performance	Minimal or Not Included
Disaster Resistance/Resiliency	Minimal or Not Included
Integrated Design and Construction	Minimal or Not Included
Quality Management	Minimal or Not Included

*Building Science Principles*

Priority	Coverage
Heat Transfer	Moderate
Moisture Transport	Limited
Air Transport	Limited
Material Selection	Strong
Control Layers	Limited
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Minimal or Not Included
HVAC Interaction with the Enclosure	Minimal or Not Included
Fenestration	Minimal or Not Included
Indoor Environmental Quality	Minimal or Not Included

*Mehta, Scarborough, Armpriest – Building Construction – Principles, Materials, and Systems*

Integration of Whole-Building System	Chapters	Level	Coverage	Supplemental	Supportive
Performance (energy, durability, comfort)	5	Intro	Minimal or Not Included	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapters 1–3	<i>Straube</i> – Building Enclosure Fundamentals
Disaster Resistance/Resiliency			Minimal or Not Included	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>NIBS</i> – Natural Hazard Mitigation Saves
Integrated Design and Construction			Minimal or Not Included	<i>Allen/Iano</i> – Fundamentals of Building Construction – Chapter 6	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes
Quality Management	1	Intro	Minimal or Not Included	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>Allen/Iano</i> – Fundamentals of Building Construction – Chapters 1–21

Building Science Principles	Chapters	Level	Coverage	Supplemental	Supportive
Heat Transfer (conduction/radiation/convection)	5	Intro	Moderate	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 5	<i>Touchie/Pressnail</i> – Building Science Fundamentals
Moisture Transport (liquid/ vapor)	6	Intro	Limited	<i>Lstiburek/Carmody</i> – Moisture Control Handbook Chapter 2	<i>Treschel/Bomberg</i> – ASTM Moisture Control in Buildings
Convection Mass Transport (air)	6	Intro	Limited	<i>Lstiburek/Carmody</i> – Moisture Control Handbook Chapter 2	<i>Hagentoft</i> – YouTube Lectures
Material Selection	4, 13–37	Advanced	Strong		<i>NIBS</i> – Building Envelope Design Guide
Control Layers (air/water/thermal/vapor)	5, 6	Intro	Limited	<i>Straube</i> – <i>High Performance Enclosures</i> – Chapter 4 <i>ASHRAE Fundamentals</i> – Chapter 25	<i>EPA</i> – Moisture Control Guidance for Design, Construction, Maintenance <i>Straube</i> – Building Science Control Layer Glossary
Hygrothermal Analysis			Minimal or Not Included	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 14	<i>Hens</i> – Building Physics – Chapter 2
HVAC Systems (heating/cooling/ventilation)			Minimal or Not Included	<i>Lechner</i> – Heating, Cooling, Lighting – Chapters 15–16	<i>Rudd</i> – Ventilation Guide <i>ACCA Manuals</i>
HVAC Interaction with the Enclosure			Minimal or Not Included	<i>Reddy et al.</i> – Heating and Cooling for Buildings – Chapter 6	<i>Building Science Corporation</i> – Search Topic <i>ACCA Manuals</i>
Fenestration	30	Intro	Moderate	<i>Carmody et al.</i> – Residential Windows	<i>NFRC Website</i>
Indoor Environmental Quality			Minimal or Not Included	<i>ASHRAE Fundamentals 2017</i> – Chapters 10–12	<i>EPA</i> – airPlus <i>U.S. General Services</i> – SF Tool

## Comparison Chart

This is a quick guide to compare these four Construction Materials and Methods, Construction Management, Construction Documentation primary resources across the selected priority building science topics.

<b><i>Integration of Whole-Building System</i></b>	Allen/Iano	Allen/Rand	Brock	Mehta et al.
Performance (energy/durability/comfort)	1	5	4	1
Disaster Resistance/Resiliency	1	3	5	1
Integrated Design and Construction	5	3	5	1
Quality Management	5	3	5	1

<b><i>Building Science Principles</i></b>	Allen/Iano	Allen/Rand	Brock	Mehta et al.
Heat Transfer	1	2	5	3
Moisture Transport (liquid/vapor)	1	4	5	2
Convective Mass Transport (air)	1	2	5	2
Material Selection	5	3	5	5
Control Layers (air/water/thermal/vapor)	2	3	3	2
Hygrothermal Analysis	1	1	1	1
HVAC Systems (heating/cooling/ventilation)	1	1	1	1
HVAC Interaction with the Enclosure	1	1	1	1
Fenestration	3	3	1	1
Indoor Environmental Quality	1	2	1	1

### Key for Comparison Chart

- 1 = Minimal or Not Included
- 2 = Limited
- 3 = Moderate
- 4 = Moderately Strong
- 5 = Strong



#### **4c. Environmental Systems/Mechanical, Electrical, and Plumbing Courses**

Below are primary resources, considered in this report to be a book or significant work that could be used as a main text for an Environmental Systems or Mechanical, Electrical, and Plumbing course. The following is a list of the textbooks that have been determined to be the Primary Resources for this project. The specific annotations, priority tables, and infusion matrices for each of these resources follow this list.

##### **List of Primary Resources**

Grondzik, Walter, and Alison Kwok. (2015). *Mechanical and Electrical Equipment for Buildings* (12th Edition).

Lechner, Norbert. (2015). *Heating, Cooling, Lighting – Sustainable Design Methods for Architects* (4th Edition).

Reddy, T. Agami, J. Krieder, P. Curtiss, and A. Rabl. (2017). *Heating and Cooling of Buildings – Principles and Practice of Energy Efficient Design* (3rd Edition).

Wujek, Joseph, and Frank Dagostino. (2010). *Mechanical and Electrical Systems in Architecture, Engineering and Construction* (5th Edition).





**Title:** *Mechanical and Electrical Equipment for Buildings*  
**Author(s):** Walter Grondzik and Alison Kwok

**Format:** Textbook – Hardcover  
**Publisher:** Wiley  
**Date:** 2015 (12th Edition). Note: A 13th edition is expected in January 2020.  
**Page Count:** 1,828, including appendices (239 pages) and index (33 pages).  
**Chapters:** 34  
**Availability:** Online from publisher and other online sources

**Description:** This book is extensive in scope. It is presented in 10 parts including the appendices. They include two parts on design, one each on the passive and active environmental systems, and one each on acoustics, fire protection, electricity, signal systems, transportation, and the appendices. In the preface, the author states that “This book is written with the student, the architect- or engineer-in-training, and the practicing professional in mind.”

This book includes excellent drawings, photos, and charts, and the tables are clear and appropriate. The 12 appendices include tables on such topics as Conversions, Solar Heat Gain Factors, Solar Performance, and Sound Transmission Data.

**Instructor Support:** A 12th Edition Instructor’s Manual is available for instructor using this book for their courses.

**Learner Support:** There is a set of learning resources at: [www.wiley.com/go/meeb12e](http://www.wiley.com/go/meeb12e).

**Priority Building Science Topics Addressed:**  
*Integration of Whole-Building System*

Priority	Coverage
Performance	Moderate
Disaster Resistance/Resiliency	Minimal or Not Included
Integrated Design and Construction	Moderately Strong
Quality Management	Minimal or Not included

*Building Science Principles*

Priority	Coverage
Heat Transfer	Moderately Strong
Moisture Transport	Moderate
Air Transport	Limited
Material Selection	Minimal or Not Included
Control Layers	Limited
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Strong
HVAC Interaction with the Enclosure	Limited
Fenestration	Moderately Strong
Indoor Environmental Quality	Moderately Strong

## Grondzik/Kwok – Mechanical and Electrical Equipment for Buildings

Integration of Whole-Building System	Chapters	Level	Coverage	Supplemental	Supportive
Performance (energy, durability, comfort)	1, 4	Limited	Moderate	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapters 1–3	<i>Straube</i> – Building Enclosure Fundamentals (paper)
Disaster Resistance/Resiliency	1	Intro	Minimal or Not Included	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>NIBS</i> – Natural Hazard Mitigation Saves
Integrated Design and Construction	1	Intermediate	Moderately Strong	<i>Allen/Iano</i> – Fundamentals of Building Construction – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes
Quality Management	1	Intro	Minimal or Not Included	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes

Building Science Principles	Chapters	Level	Coverage	Supplemental	Supportive
Heat Transfer (conduction/radiation/convection)	7	Intermediate	Moderately Strong	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 5	<i>Touchie/Pressnail</i> – Building science Fundamentals
Moisture Transport (liquid/vapor)	7	Intro	Moderate	<i>Lstiburek/Carmody</i> – Moisture Control Handbook Chapter 2	<i>Treschel/Bomberg</i> – ASTM Moisture Control in Buildings
Convection Mass Transport (air)	7	Intro	Limited	<i>Lstiburek/Carmody</i> – Moisture Control Handbook Chapter 2	<i>Straube</i> – Control Layers Definitions <i>Hagentoft</i> – YouTube Lectures
Material Selection			Minimal or Not Included	<i>Mehta et al.</i> – Building Construction – Part 2	<i>NIBS</i> – Building envelope Design Guide
Control Layers (air/water/thermal/vapor)	7	Intro	Limited	<i>Straube</i> – High Performance Enclosures – Chapter 4 <i>ASHRAE Fundamentals 2017</i> – Chapter 25	<i>EPA</i> – Moisture Control Guidance for Design, Construction, Maintenance <i>Straube</i> – Building Science Control Layer Glossary
Hygrothermal Analysis			Minimal or Not Included	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 14	<i>ASHRAE Fundamentals 2017</i> – Chapter 27
HVAC Systems (heating/cooling/ventilation)	12	Advanced	Strong		<i>Rudd</i> – Ventilation Guide <i>ACCA Manuals</i>
HVAC Interaction with the Enclosure	12	Intermediate	Limited	<i>Reddy et al.</i> – Heating and Cooling of Buildings – Chapter 6	<i>Building Science Corporation</i> – Search Topic
Fenestration	7	Intermediate	Moderately Strong	<i>Carmody et al.</i> – Residential Windows	<i>NFRC Website</i>
Indoor Environmental Quality	3, 4, 5	Intermediate	Moderately Strong	<i>ASHRAE Fundamentals 2017</i> – Chapter 10–12	<i>EPA</i> – Indoor airPLUS <i>U.S. CPSC</i> – The Inside Story

**Title:** *Heating, Cooling, Lighting – Sustainable Design Methods for Architects*  
**Author(s):** Norbert Lechner

**Format:** Textbook – Hardcover  
**Publisher:** Wiley  
**Pub Date:** 2015 (4th Edition). Note: A 5th edition is expected in January 2020.  
**Page Count:** 702, including Index (10 pages), Appendices (81 pages), and Bibliography (6 pages)  
**Chapters:** 19

**Description:** The preface states that “The information in this book is presented to support the three-tier approach to sustainable design of the heating, cooling, and lighting of buildings.” The three tiers are 1) load avoidance that works to minimize the need for heating, cooling, lighting, 2) using natural energies including passive solar, passive cooling, ventilation, and daylighting, and 3) designing mechanical and electrical equipment that will meet the needs of the building not met by the first two.”

The goal of this book is to provide “appropriate knowledge at the level of complexity needed at the schematic design stage.” A new addition to the edition is a chapter that includes a checklist to assist in the design of low energy, sustainable buildings. There are many well-done illustrations, graphics, and photos. This book includes an excellent Appendix (K) of additional resources.

**Instructor and Student Support:** At the end of each chapter the following are provided: Key Ideas, References, Resources, appropriate papers, and websites of organizations.

**Priority Building Science Topics Addressed:**  
*Integration of Whole-Building Systems*

Priority	Coverage
Performance	Strong
Disaster Resistance/Resiliency	Moderately Strong
Integrated Design and Construction	Limited
Quality Management	Moderate

*Building Science Principles*

Priority	Coverage
Heat Transfer	Moderate
Moisture Transport	Limited
Air Transport	Moderate
Material Selection	Minimal or Not Included
Control Layers	Limited
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Strong
HVAC Interaction with the Enclosure	Minimal or Not Included
Fenestration	Moderate
Indoor Environmental Quality	Minimal or Not Included

*Lechner – Heating, Cooling, Lighting – Sustainable Design Methods for Architects*

Integration of Whole-Building System	Chapters	Level	Coverage	Supplemental	Supportive
Performance (energy, durability, comfort)	1–3	Intermediate	Strong	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapters 1–3	<i>Straube</i> – Building Enclosure Fundamentals
Disaster Resistance/Resiliency	1, 2	Intermediate	Moderately Strong	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>NIBS</i> – Natural Hazard Mitigation Saves
Integrated Design and Construction	1	Intro	Limited	<i>Allen/Iano</i> – Fundamentals of Building Construction – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes
Quality Management	19	Intro	Moderate	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes

Building Science Principles	Chapters	Level	Coverage	Supplemental	Supportive
Heat Transfer (conduction/radiation/convection)	15	Intermediate	Moderate	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapters 5	<i>Touchie/Pressnail</i> – Building Science Fundamentals
Moisture Transport (liquid/vapor)	15	Intermediate	Limited	<i>Lstiburek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Treschel/Bomberg</i> – ASTM Moisture Control in Buildings
Convection Mass Transport (air)	10, 15	Intermediate	Moderate	<i>Lstiburek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Hagentoft</i> – YouTube Lectures
Material Selection	15	Intro	Minimal or Not Included	<i>Brock</i> - Designing the Exterior Wall – Chapter 5–11 <i>Mehta et al.</i> – Building Construction – Part 2	<i>NIBS</i> – Building Envelope Design Guide
Control Layers (air/water/thermal/vapor)	15	Intro	Limited	<i>Straube</i> – High Performance Enclosures – Chapter 4 <i>ASHRAE Fundamentals</i> – Chapters 24–25, 36	<i>EPA</i> – Moisture Control Guidance for Design, Construction, Maintenance <i>Straube</i> – Building Science Control Layer Glossary
Hygrothermal Analysis	15	Intro	Minimal or Not Included	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 14	<i>Building Science Corporation</i> – Search Topic
HVAC Systems (heating/cooling/ventilation)	16	Intermediate	Strong	<i>Wujek/Dagostino</i> – Mechanical and Electrical Systems... – Chapters 6–10	<i>Rudd</i> – Ventilation Guide <i>ACCA Manuals</i>
HVAC Interaction with the Enclosure	16	Intro	Minimal or Not Included	<i>Reddy et al.</i> – Heating and Cooling of Buildings – Chapter 6	<i>Building Science Corporation</i> – Search Topic <i>ACCA Manuals</i>
Fenestration	10, 13, 15	Intro	Moderate	<i>Carmody/Selkowitz/Heschong</i> – Residential Windows	<i>NFRC Website</i>
Indoor Environmental Quality			Minimal or Not Included	<i>ASHRAE Fundamentals 2017</i> – Chapters 10–12	<i>EPA</i> – airPLUS <i>U.S. General Services</i> – SF Tool <i>U.S. CPSC</i> – The Inside Story

**Title:** *Heating and Cooling of Buildings – Principles and Practice of Energy Efficient Design*

**Author(s):** T.A. Reddy, J. Kreider, P. Curtiss, A. Rabl

**Format:** Textbook – Hardcopy

**Publisher:** C.R.C. Press (Taylor and Francis Group)

**Date:** 2017 (3rd Edition)

**Page Count:** 845, including Appendix (25 pages) References are included with each chapter.

**Chapters:** 24

**Availability:** Online (both print and ebook)

**Description:** The authors state this book is to be considered a bridge, “providing the scientific principles along with how these concepts are modified into working equations and procedures suitable for actual design practice and analysis.” The intended audience includes students of architecture, building science, and engineering. The easily-read text and explanations of concepts in this book are enhanced with appropriate equations. The text is supplemented with excellent figures that are well labeled.

**Instructor Support:** Each chapter provides a problem set. Instructors can access a CD-ROM from the 2nd Edition. Solutions for the end of chapter problems are available as well as PowerPoint slides, pdf versions of figures and tables, and a summary of important concepts from each chapter.

**Priority Building Science Topics Addressed:**

*Integration of Whole-Building Principles*

Priority	Coverage
Performance	Moderate
Disaster Resistance/Resiliency	Minimal or Not Included
Integrated Design and Construction	Limited
Quality Management	Limited

*Building Science Principles*

Priority	Coverage
Heat Transfer	Moderately Strong
Moisture Transport	Moderately Strong
Air Transport	Moderately Strong
Material Selection	Minimal or Not Included
Control Layers	Moderately Strong
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Strong
HVAC Interaction with the Enclosure	Moderately Strong
Fenestration	Moderately Strong
Indoor Environmental Quality	Strong

***Reddy, Krieder, Curtiss, Rabl – Heating and Cooling of Buildings – Principles and Practices of Energy Efficient Design***

<b>Integration of Whole-Building System</b>	<b>Chapters</b>	<b>Level</b>	<b>Coverage</b>	<b>Supplemental</b>	<b>Supportive</b>
Performance (energy, durability, comfort)	3	Intermediate	Moderate	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapters 1–3	<i>Straube</i> – Building Enclosure Fundamentals
Disaster Resistance/Resiliency			Minimal or Not Included	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>NIBS</i> – Natural Hazard Mitigation Saves
Integrated Design and Construction	1, 24	Intermediate	Limited	<i>Allen/Iano</i> – Fundamentals of Building Construction – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes
Quality Management	1, 2, 24	Intermediate	Limited	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes

<b>Building Science Principles</b>	<b>Chapters</b>	<b>Level</b>	<b>Coverage</b>	<b>Supplemental</b>	<b>Supportive</b>
Heat Transfer (conduction/radiation/convection)	2, 4 7	Intermediate	Moderately Strong	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 5	<i>Touchie/Pressnail</i> – Building Science Fundamentals
Moisture Transport (liquid/vapor)	2, 3, 13	Advanced	Moderately Strong	<i>Lstiburek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Lstiburek/Carmody</i> – Moisture Control Handbook
Convection Mass Transport (air)	2, 6	Advanced	Moderately Strong	<i>Lstiburek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Hagentoft</i> – YouTube Lectures
Material Selection			Minimal or Not Included	<i>Mehta et al.</i> – Building Construction – Part 2 <i>Brock</i> – Designing the Exterior Wall – Chapters 5–11	<i>NIBS</i> – Building Envelope Design Guide
Control Layers (air/water/thermal/vapor)	2, 8	Intermediate	Moderately Strong	<i>Straube</i> – High Performance Enclosures – Chapter 4 <i>ASHRAE Fundamentals</i> – Chapter 25	<i>EPA</i> – Moisture Control Guidance for Design, Construction, Maintenance <i>Straube</i> – Building Science Control Layer Glossary
Hygrothermal Analysis			Minimal or Not Included	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 14	Building Science Corporation – Search Topic
HVAC Systems (heating/cooling/ventilation)	3, 6, 7, 9–21	Advanced	Strong		<i>Rudd</i> – Ventilation Guide
HVAC – Interaction with the Enclosure	24	Intermediate	Moderately Strong	<i>Reddy et al.</i> – Heating and Cooling of Buildings – Chapter 6	<i>Building Science Corporation</i> – Search Topic ACCA Manuals
Fenestration	5	Intermediate	Moderately Strong	<i>Carmody et al.</i> – Residential Windows	<i>NFRC Website</i>
Indoor Environmental Quality	3	Advanced	Strong		<i>EPA</i> – airPlus <i>U.S. General Services</i> – SF Tool <i>U.S. CPSC</i> – The Inside Story

**Title:** *Mechanical and Electrical Systems in Architecture, Engineering and Construction*

**Author(s):** Joseph Wujek and Frank Dagostino

**Format:** Textbook – Hardcopy (also available on Kindle)

**Publisher:** Prentice Hall

**Date:** 2010 (5th Edition)

**Page Count:** 930, including five appendices and index

**Chapters:** 25

**Availability:** Amazon and other online sources

**Description:** According to the authors, “this book is intended to provide a broad-scope introduction to building mechanical and electrical materials, equipment, systems, design concepts, and engineering principles” at a basic working level. To do so, they have provided a background of basic building science principles including heat, moisture, and air transport, and indoor air quality so students of mechanical and electrical systems, architecture, engineering, and construction will have a foundation of building science as they move into their careers.

**Learner Support:** Study questions for each chapter are provided.

**Priority Building Science Topics Addressed:**

*Integration of Whole-Building Systems*

Priority	Coverage
Performance	Moderately Strong
Disaster Resistance/Resiliency	Minimal or Not Included
Integrated Design and Construction	Minimal or Not Included
Quality Management	Minimal or Not Included

*Building Science Principles*

Priority	Coverage
Heat Transfer	Strong
Moisture Transport	Moderate
Air Transport	Minimal or Not Included
Material Selection	Minimal or Not Included
Control Layers	Moderate
Hygrothermal Analysis	Minimal or Not Included
HVAC Systems	Strong
HVAC Interaction with the Enclosure	Moderate
Fenestration	Minimal or Not Included
Indoor Environmental Quality	Limited

*Wujek and Dagostino – Mechanical and Electrical Systems in Architecture, Engineering and Construction*

Integration of Whole-Building System	Chapters	Level	Coverage	Supplemental	Supportive
Performance (energy, durability, comfort)	1	Advanced	Moderately Strong	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapters 1–3	<i>Straube</i> – Building Enclosure Fundamentals
Disaster Resistance/Resiliency			Minimal or Not Included	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>NIBS</i> – Natural Hazard Mitigation Saves
Integrated Design and Construction			Minimal or Not Included	<i>Allen/Iano</i> – Fundamentals of Building Construction – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes
Quality Management			Minimal or Not Included	<i>Brock</i> – Designing the Exterior Wall – Chapter 1	<i>Lukachko/Gates/Straube</i> – Strategy Guideline: Advanced Construction Documentation for High Performance Homes

Building Science Principles	Chapters	Level	Coverage	Supplemental	Supportive
Heat Transfer (conduction/radiation/convection)	2, 4	Advanced	Strong		<i>Touchie/Pressnail</i> – Building Science Fundamentals
Moisture Transport (liquid/vapor)	3	Intermediate	Moderate	<i>Lstiburek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Lstiburek/Carmody</i> – Moisture Control Handbook
Convection Mass Transport (air)			Minimal or Not Included	<i>Lstiburek/Carmody</i> – Moisture Control Handbook – Chapter 2	<i>Hagentoft</i> – YouTube Lectures
Material Selection	2	Intro	Minimal or Not Included	<i>Brock</i> – Designing the Exterior Wall – Chapters 5–11 <i>Mehta et al.</i> – Building Construction – Part 2	<i>NIBS</i> – Building Envelope Design Guide
Control Layers (air/water/thermal/vapor)	2	Intermediate	Moderate	<i>Straube</i> – High Performance Enclosures – Chapter 14 <i>ASHRAE Fundamentals 2017</i> – Chapter 25	<i>EPA</i> – Moisture Control Guidance for Design, Construction, Maintenance <i>Straube</i> – Building Science Control Layer Glossary
Hygrothermal Analysis			Minimal or Not Included	<i>Straube/Burnett</i> – Building Science for Building Enclosures – Chapter 14	<i>ASHRAE Fundamentals 2017</i> – Chapter 25
HVAC Systems (heating/cooling/ventilation)	6–11	Advanced	Strong		<i>Rudd</i> – Ventilation Guide
HVAC – Interaction with the Enclosure	4, 8, 9	Intermediate	Moderate	<i>Reddy et al.</i> – Heating and Cooling of Buildings – Chapter 6	<i>Building Science Corporation</i> – Search Topic ACCA Manuals
Fenestration	3	Intro	Minimal or Not Included	<i>Carmody et al.</i> – Residential Windows	<i>NFRC Website</i>
Indoor Environmental Quality	3	Intro	Limited	<i>ASHRAE Fundamentals 2017</i> – Chapters 10–12	<i>EPA</i> – airPlus <i>U.S. General Services</i> – SF Tool <i>U.S. CPSC</i> – The Inside Story



## Comparison Chart

This is a quick guide to compare these four primary Environmental Systems and Mechanical, Electrical, and Plumbing primary resources across the selected priority building science topics.

<b><i>Integrated Design and Construction</i></b>	Grondzik/Kwok	Lechner	Reddy et al.	Wujek/Dagostino
Performance (energy/durability/comfort)	3	5	3	4
Disaster Resistance/Resiliency	1	4	1	1
Integrated Design and Construction	4	2	2	1
Quality Management	1	3	2	1

<b><i>Building Science Principles</i></b>	Grondzik/Kwok	Lechner	Reddy et al.	Wujek/Dagostino
Heat Transfer	4	3	4	5
Moisture Transport (liquid/vapor)	3	2	4	3
Convective Mass Transport (air)	2	3	4	1
Material Selection	1	1	1	1
Control Layers (air/water/thermal/vapor)	2	2	4	3
Hygrothermal Analysis	1	1	1	1
HVAC Systems (heating/cooling/ventilation)	4	5	5	5
HVAC Interaction with the Enclosure	2	1	4	3
Fenestration	4	3	4	1
Indoor Environmental Quality	5	1	5	2

### Key for Comparison Chart

- 1 = Minimal or Not Included
- 2 = Limited
- 3 = Moderate
- 4 = Moderately Strong
- 5 = Strong



## 4d. Capstone Course on High-Performance Whole-Building Design

This section is focused on faculty who might be teaching a senior capstone design course focused on a high-performance building design. It could also be for a faculty member who is advising a student team for a high-performance building design or construction competition. The format is driven by the 14 priority building science topics that were selected for this project. There are some supportive resources that are not primarily building science-related and therefore not fully annotated; however, they are noted with an asterisk and cited in Appendix A.

### Key Resources for the 14 Priority Building Science Topics

#### Integration of the Whole-Building System

##### Performance (energy, durability, comfort)

- Introductory: Straube, J. *Building Enclosure Fundamentals: A Concise Introduction* (Paper).  
Rose, W. (2005). *Water in Buildings – An Architect’s Guide to Moisture Control*.
- Intermediate: Allen, E., and Rand, P. (2016). *Architectural Detailing*.  
Lechner, N. (2015). *Heating, Cooling, Lighting – Sustainable Design Methods for Architects* (4th Edition).  
Straube, J. (2012). *High Performance Enclosures*.
- Advanced: Hagentoft, C. (2001). *Introduction to Building Physics*.  
Hens, H. (2012). *Building Physics – Heat, Air, and Moisture* (2nd Edition).

##### Disaster Resistance/Resiliency

- Introductory: National Institute of Building Sciences. *Natural Hazard Mitigation Saves: 2018*.  
Building America. *Building Science Education Solution Center*.
- Intermediate: Brock, L. (2005). *Designing the Exterior Wall*.  
FEMA Building Science Resources.\*
- Advanced: IBHS FORTIFIED Performance Requirements.\*

##### Integrated Design and Construction

- Introductory: National Institute of Standards (website). *Net-Zero Energy Residential Test Facility*.
- Intermediate: Brock, L. (2005). *Designing the Exterior Wall*.  
Straube, J. (2012). *High Performance Enclosures*.
- Advanced: Allen, E., and Iano, J. (2014). *Fundamentals of Building Construction: Materials and Methods* (6th Edition).

##### Quality Management

- Introductory: Brock, L. (2005). *Designing the Exterior Wall*.
- Intermediate: Allen, E., and Iano, J. (2014). *Fundamentals of Building Construction: Materials and Methods* (6th Edition).
- Advanced: Lukachko, Gates, and Straube. *Strategy Guideline: Advanced Construction Documentation for High Performance Homes*.

#### Building Science Principles

##### Heat Transfer (conduction, radiation, convection)

- Introductory: Pohl, J. (2011). *Building Science: Concepts and Application*.  
Touchie, M. and Pressnail, K. (online videos). *Building Science Fundamentals*.

- Intermediate: Straube, J. and Burnett, E. (2005). *Building Science for Building Enclosures*.  
Wujek, J. (2010). *Mechanical and Electrical Systems in Architecture, Engineering and Construction* (5th Edition).  
Hagentoft, C. (2001). *Introduction to Building Physics*.  
Reddy, T. Agami, Krieder, J., Curtiss, P., and Rabl, A. (2017). *Heating and Cooling of Buildings – Principles and Practice of Energy Efficient Design* (3rd Edition).
- Advanced: Bomberg, M, and Kisilewicz, T. (2017). *Introduction to Environmental Management*.  
Hens, H. (2012). *Building Physics – Heat, Air, and Moisture* (2nd Edition).

#### Moisture Transport (liquid, water, psychrometrics)

- Introductory: Lstiburek, J. (2006). *Water Management Guide*.  
Brock, L. (2005). *Designing the Exterior Wall*.
- Intermediate: Lstiburek, J. and Carmody, J. (1993). *Moisture Control Handbook*.  
Rose, W. (2005). *Water in Buildings – An Architect’s Guide to Moisture Control*.  
Gatley, D. (2005) *Understanding Psychrometrics* (2nd Edition).  
Straube, J. (2012). *High Performance Enclosures*.  
Hagentoft, C. (2001). *Introduction to Building Physics*.
- Advanced: Straube, J. and Burnett, E. (2005). *Building Science for Building Enclosures*.  
Bomberg, M, and Kisilewicz, T. (2017). *Introduction to Environmental Management*.  
Hens, H. (2012). *Building Physics – Heat, Air, and Moisture* (2nd Edition).

#### Convective Mass (air) Transport (pressures)

- Introductory: Brock, L. (2005). *Designing the Exterior Wall*.
- Intermediate: Straube, J. (2012). *High Performance Enclosures*.  
Hagentoft, C. (2001). *Introduction to Building Physics*.
- Advanced: Straube, J. and Burnett, E. (2005). *Building Science for Building Enclosures*.  
Bomberg, M, and Kisilewicz, T. (2017). *Introduction to Environmental Management*.  
Hens, H. (2012). *Building Physics – Heat, Air, and Moisture* (2nd Edition).

#### Material Selection (indoor air quality, thermal mass, moisture control)

- Introductory: Brock, L. (2005). *Designing the Exterior Wall*.
- Intermediate: Allen, E., and Iano, J (2014). *Fundamentals of Building Construction: Materials and Methods* (6th Edition).
- Advanced: Mehta, M., Scarborough, W., and Armpriest, D. (2018). *Building Construction – Principles, Materials, and Systems* (3rd Edition).

#### Control Layers (water, air, vapor, thermal)

- Introductory: Straube, J. *Control Layer Definitions*  
U.S. Environmental Protection Agency. (2013). *Moisture Control Guidance for Building Design, Construction and Maintenance*.
- Intermediate: Straube, J. (2012). *High Performance Enclosures*.  
ASHRAE. *ASHRAE Handbook of Fundamentals 2017*.
- Advanced: Hagentoft, C. (2001). *Introduction to Building Physics*.  
Straube, J. and Burnett, E. (2005). *Building Science for Building Enclosures*.

### Hygrothermal Analysis

Introductory: Building America. *Building Science Advisor*.

Intermediate: Rose, W. (2005). *Water in Buildings – An Architect’s Guide to Moisture Control*.  
ASHRAE. *ASHRAE Handbook of Fundamentals 2017*.

Advanced: Straube, J. and Burnett, E. (2005). *Building Science for Building Enclosures*.  
Hens, H. (2012). *Building Physics – Heat, Air, and Moisture* (2nd Edition).

### HVAC Systems (heating, cooling, ventilation)

Introductory: Krigger, J. (2014). *Residential Energy – Cost Savings for Existing Buildings* (6th Edition).

Air Conditioning Contractors Association. (2016). *Manuals J, B, D, T, and RS*.

Intermediate: Lechner, N. (2015). *Heating, Cooling, Lighting – Sustainable Design Methods for Architects* (4th Edition).

Wujek, J. (2010). *Mechanical and Electrical Systems in Architecture, Engineering and Construction* (5th Edition).

Advanced: Reddy, T. Agami, Krieder, J., Curtiss, P., and Rabl, A. (2017). *Heating and Cooling of Buildings – Principles and Practice of Energy Efficient Design* (3rd Edition).

### HVAC Interaction with the Enclosure

Introductory: Straube, J. (2012). *High Performance Enclosures*.

Intermediate: Reddy, T. Agami, Krieder, J., Curtiss, P., and Rabl, A. (2017). *Heating and Cooling of Buildings – Principles and Practice of Energy Efficient Design* (3rd Edition).

Advanced: Building Science Corporation (Online)

### Fenestration

Introductory: Window Resources from the Florida Solar Energy Center (FSEC).

Intermediate: Carmody, J., Selkowitz, S., and Heschong, L. (2007). *Residential Windows – A Guide to New Technologies and Energy Performance*.  
Building America. *Building Science Education Solution Center*. \*

Advanced: Grondzik, Walter, and Alison Kwok. (2015). *Mechanical and Electrical Equipment for Buildings* (12th Edition).  
Reddy, T. Agami, Krieder, J., Curtiss, P., and Rabl, A. (2016). *Heating and Cooling of Buildings – Principles and Practice of Energy Efficient Design* (3rd Edition).

### Indoor Environmental Quality

Introductory: U.S. Consumer Product Safety Commission. *The Inside Story – A Guide to Indoor Air Quality*.

Environmental Protection Agency. *Indoor airPLUS CONSTRUCTION SPECIFICATION Version 1 (Rev. 04)*.

Intermediate: Krigger, J. (2014). *Residential Energy – Cost Savings for Existing Buildings* (6th Edition).

Rudd, A. (2011). *Ventilation Guide* (Revised).

Grondzik, Walter, and Alison Kwok. (2015). *Mechanical and Electrical Equipment for Buildings* (12th Edition).

Advanced: Reddy, T. Agami, Krieder, J., Curtiss, P., and Rabl, A. (2017). *Heating and Cooling of Buildings – Principles and Practice of Energy Efficient Design* (3rd Edition).



## Appendix A. Other Supportive Resources

[BC Housing Research Library](#), including [Building Envelope Thermal Bridging Guide](#) and [Low Thermal Energy Demand for Large Buildings](#) (with introduction to Thermal Energy Demand Intensity).

[Canadian Mortgage and Housing Corporation](#). *Best Practice Guides* (online). An example for wood frame buildings is found at [ftp://ftp.cmhc-schl.gc.ca/chic-ccdh/Archives/CA1\\_MH\\_06W52.pdf](ftp://ftp.cmhc-schl.gc.ca/chic-ccdh/Archives/CA1_MH_06W52.pdf)

Construction Specifications Institute. (2005). *The Project Resource Manual – CSI Manual of Practice*. Available at: <https://www.amazon.com/Project-Resource-Manual-PRM-Practice-ebook/dp/B005H6VHBI>

Disaster Resistance and Resiliency [Teaching Materials](#) on PNNL’s Building Science Education Solution Center website.

[DOE Building Energy Codes Resource Center](#) with tools and [training resources](#) for energy code compliance, development, adoption, implementation, and enforcement.

[FEMA Building Science Resources](#).

Florida Solar Energy Center. [Window Resources](#). Ross McCluney and Paul Jindra.

[IBHS FORTIFIED Performance Requirements](#).

[National Research Council Canada Publications](#), including a [Publications Archive](#) with some access to IRC reports.