

Excellence in Building Science Education: Criteria, Collaboration, and Consensus

Building Science Education Update

Westford, MA – August 3, 2014

Patrick H. Huelman & John Straube, Co-Chairs

Task Group on Excellence in Building Science Curricula

Joint Committee on Building Science Education

<http://www.BuildingScienceEducation.net>



Energy Efficiency &
Renewable Energy



NorthernSTAR

UNIVERSITY OF MINNESOTA
Driven to DiscoverSM



The Big Picture

- DOE Long-term Goal
 - To increase the quantity/quality of building science education
 - In support of high-performance buildings

- DOE Short-term Goal
 - Identify solid building science resources that can support:
 - DOE Student Competitions
 - Race to Zero
 - Solar Decathlon
 - Better Buildings
 - High-Performance Building Programs
 - Zero Energy Ready Homes, Better Buildings, ENERGY STAR,
 - PassiveHouse, LEED for Homes, etc.



Building Science Education Outreach Activities

- Westford 2013
- EEBA – Phoenix, AZ
- DOE Building America – Washington, DC
- Joint Webinars – Criteria Task Group/BETEC Education Committee
- BUILDINGS XII – Clearwater, FL
- NIBS-BETEC Symposium – Washington, DC
- ASHRAE – New York, NY
- NAHB-IBS, NCHRC, NAHB Student Chapter Faculty Advisors – Las Vegas, NV
- ASC Conference – Washington, DC
- ASTM/NIBS/Joint Committee Building Science Education Workshop – Toronto
- DOE Peer Review – Arlington, VA
- DOE Race to Zero Student Design Competition – Golden, CO
- Penn State Programs – State College, PA
- AHSRAE TC Meeting & Board of Directors Presentation – Seattle, WA
- Westford 2014



EXCELLENCE IN BUILDING SCIENCE EDUCATION

Transforming the Design/Construction Profession

➤ Brief Update

- Review of “Criteria” Task Group
- Award for Excellence in Building Science Education
- Race to Zero Student Design Competition

➤ Identifying Teaching Resources (faculty & design competitions)

- Introduction to Building Science Fundamentals
- Infusion of Building Science into Key Traditional Courses (e.g., modules)
- Special Courses (Building Enclosures; HVAC Interactions)
- Support for Competition Submissions (analysis, detailing, etc.)

➤ Request for Participation and Support (review & development)

- Working Group (BS 101/201, Infusion Modules; etc.)
- Sequel to Toronto Session
- Other





Joint Committee on Building Science Education

- Established as a standing joint committee on building science education, by the NCHRC (National Consortium of Housing Research Centers) and ASC (Associated Schools of Construction) to facilitate excellence in building science education.

- The Joint Committee is hosted by the Consortium and their program is guided by partnering university organizations, including:
 - Architectural Engineering Institute,
 - NIBS/BETEC Education Committee,
 - and others



Joint Committee – Mission

- The mission of the Joint Committee on Building Science Education is to **support the transformation** of education and training for the **design and construction professions**;
- Such that its professionals are **educated, trained, and certified in building science** and related advanced design and construction management practices;
- So as to **routinely design and build** quality, high performance buildings that are safe, healthy, durable, comfortable, and energy efficient to **provide the highest value** to their clients.



Joint Committee – Initial Task Groups

- **Criteria for Excellence in Building Science Task Group**
 - Co-Chairs: Pat Huelman, UMN & John Straube, U Waterloo
 - Identifying, reviewing and sharing teaching resources
 - Support of multi-discipline student competitions
 - Support of industry certifications and credentialing
- **Excellence in Building Science Education Award**
 - Co-Chairs: Joe Laquatra, Cornell & Matt Syal, MSU
 - Nominations are currently open for this year's award



Joint Committee – Initial Focus

- Curricular support by identifying, reviewing, rating, and sharing:
 - curricula
 - key course modules and teaching resources
 - teaching methodologies
- Support University partners, DOE, technical societies
 - Multi-discipline student competitions
 - Share curricula and teaching resources
 - Recognize excellence in building science education
 - Enhance credentialing, accreditation, certification, and licensure





Criteria Task Group on the Web

- Website: www.BuildingScienceEducation.net
 - “Programs/Task Groups”
 - “Criteria for Excellence in B.S. Curricula”
 - “Working Files”

- Other Information Available
 - “Events” for meetings/announcements
 - “Resources” page



Graduates Face a Rapidly Changing Market

- With 40% of our energy used in buildings, DOE continues to foster **new technologies** and **stricter codes and standards**.
- The market demands **better performing, and more comfortable, efficient, durable, and healthy buildings**.
- The **response** is a focus on **building science education** that will support **quality, high-performance buildings**.
 - Universities and colleges are restructuring and
 - May need support to equip their students to meet changing market needs.





Support for Quality, High Performance Buildings

- **Residential (new):** DOE Zero Energy Ready Home or better
- **Commercial (new):** congressional definition of high performance
 - Better Buildings Challenge
 - New FEMP requirements
 - Near Zero Ready
- **HIGHER PERFORMANCE RETROFITS – TRADE-OFFS** in terms of
 - Functional & economic constraints
 - Health & safety, durability
 - Sustainability (energy efficient; green)



How Can We Help Academic Programs Respond to Industry Needs?

Changing Market Needs, Codes & Standards



Changes in Industry & Job Requirements



Demand for New Core Competencies



Revision of Coursework & Curricula





EXCELLENCE IN BUILDING SCIENCE EDUCATION
Transforming the Design/Construction Profession

Race to Zero Student Design Competition



U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy



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DOE Race to Zero Student Design Competition

- **2013-14 Student Design Competition was a Huge Success**
 - 340+ Students
 - 26 Universities
 - 28 Teams

- **2014-15 Race to Zero Will be Even Better**
 - It's time to start building your “multi-discipline” teams
 - including Industry Support (Advisors/Mentors, etc.)
 - Revised Competition Guide will be out next month
 - Registration Deadline is November 27, 2014
 - Submissions packages will be due on March 31, 2015
 - Competition and Award Ceremony will be in April ??, 2105





Current “Criteria Task Group” Activities

- Development of 3 databases
 - Contact list (participating & interested parties)
 - University building science-related programs
 - Building science teaching resources
- Support for Building Science Matrix
- Assisting in development of “core competencies”
- Recent BETEC/Joint Committee meetings sought recommendations for teaching resources
 - Promote discussion on teaching resources





Identifying Existing Programs & Resources

- Develop an Inventory of Existing Programs
 - Strong U.S. and Canadian focus
 - But should build on international experiences
 - Where/What/Who
 - Currently collaborating with BETEC Education Committee
- Ultimate goal is a “teaching resource guide”
 - Basic info: title, author, media type, etc.
 - Access info: location, purchasing, links, etc.
 - Commentary: guidance for potential users



Identifying Existing Programs & Resources

- Institution
 - program home (college, department, etc.)
- Program name and focus
- Curricular information
 - courses
 - content
 - resources*
- Key contacts



The Building Science Education Matrix

- DOE's B.S. Matrix presents “proficiency level needed by various job classifications for core B.S. content”
 - still need to build consensus on “what is building science”
- DOE solicited comments on the “draft” matrix
 - comments were submitted in January
 - revisions have been completed
- The Criteria Task Group is focusing on design and construction professionals and university curricula supporting those professions
 - ACI, EEBA, ACCA, BPI and others will address continuing education and training for practitioners



EXCELLENCE IN BUILDING SCIENCE EDUCATION

Transforming the Design/Construction Profession

Building Science Education Matrix v5
CLASSIFICATION

- Proficiency Levels:**
 1 = Remember (knowledge)
 2 = Understand (comprehension)
 3 = Apply (application)
 4 = Analyze (analysis)
 5 = Evaluate (synthesis)
 6 = Create (design)

	1. High school graduates	2. Builders/Contractors	3. Builders	4. Insulation Contractors	5. HVAC Contractors	6. Enclosure/Service Contractors	7. Home performance contractors	8. Program and Project Managers	9. Utility Program Managers	10. Project Managers	11. Transmission Process	12. Real estate agent/sales agent	13. Appraisers	14. Home Inspectors	15. Insurers	16. Underwriters	17. Design and Construction Professionals	18. Licensed Architects	19. Licensed Engineers - Mechanical	20. Licensed Engineers - Civil/Structural	21. Designers	22. Construction Managers	23. Building Science Professionals	24. Building Science Forensic Professionals	25. Quality Assurance/Quality Control	26. Commissioning Agents	27. Home Energy Professionals	28. Energy Auditors/Assessors	29. Field Technicians (Diagnostics)	30. Code Officials
1. Systems Thinking																														
a. Energy																														
b. Durability																														
c. Indoor Air Quality																														
d. Environmental																														
e. Cost-effectiveness analysis																														
f. Disaster Resistance/Resiliency																														
2. Building Enclosure																														
a. Heat transfer																														
- Conduction																														
- Radiation																														
- Convection																														
b. Moisture transport																														
- Liquid																														
- Vapor (psychrometrics)																														
c. Convective mass transport (air transport)																														
- Pressures																														
- Flows																														
d. Material Selection																														
- IAQ																														
- Thermal mass																														
- Moisture																														
e. Control layers																														
- Thermal																														
- Vapor																														
- Water																														
- Air																														
f. Hygrothermal analysis																														
g. HVAC interactions																														
h. Thermal comfort																														
3. Building Services																														
a. HVAC Systems																														
- Heating systems																														
- Cooling systems																														
- Ventilation systems																														
b. Plumbing Systems																														
- Water heating																														
- Distribution																														
c. Electrical Systems																														
d. Lighting/Appliances & Misc. Loads																														
e. Enclosure Interactions																														
f. Indoor Environmental Quality																														
- Health & safety																														
- Indoor air quality																														
4. Operations and Maintenance																														
a. User Interface and controls																														
b. Preventative maintenance																														
c. Replacement & renovation																														
5. Building Testing																														
a. Commissioning																														
b. Diagnostics & Forensics																														
c. Performance monitoring/assessment																														
6. Systems Integration																														
a. Integrated design																														
b. Construction processes																														
c. Quality management																														
d. Building and Energy Modeling																														
e. Cost Analysis																														
f. Other																														

CORE COMPETENCIES



The Building Science Education Matrix

➤ Job Classifications

- High School Graduate
- Builders/Contractors/Trades
- Program & Project Managers
- Transaction Process
- Design & Construction Professionals
- Building Science Professionals
- Energy / Inspections / Code Officials



The Building Science Education Matrix

➤ Core Competencies

- Systems Thinking
- Building Enclosure
- Building Services
- Operations and Maintenance
- Building and Systems Testing
- Systems Integration & Processes





Proficiency Levels

(Based on Bloom's Taxonomy)

- 1 = Remember (knowledge)
- 2 = Understand (comprehension)
- 3 = Apply (application)
- 4 = Analyze (analysis)
- 5 = Evaluate (synthesis)
- 6 = Create (design)



Development of Core Competencies

- Joint Committee's "Criteria Task Group"
- ASTM E06-55 – Certification Program for Building Enclosure Professionals
- DOE/NIBS Credentialing Council
- DOE Task Force on Building Science Education
 - Design & Construction Professionals
 - EEBA/ACI/BPI/RESNET Certifications
- Industry staffing plans & hiring targets
- Others



Example of Core Competencies (for Building Enclosure Professionals)

- An understanding and competency in building physics
- Understanding of psychrometrics
- Ability to use hygrothermal modeling tools
- Broad understanding of lighting, acoustics, fire/smoke, and security
- Understanding of the four major building enclosure systems



Example of Core Competencies

- Ability to draw design details – adequate for control layer transitions/ discontinuities
- Understanding of both commercial and residential construction
- Understanding of testing equipment
- Understanding of HVAC interaction with the building enclosure
- Ability to analyze building performance



Core Competencies – Education & Training

- Accreditation Processes
- Curricula and Course Learning Outcomes (LO)
 - Linked to CC by LO Assessment Process
- Professional Licenses & Certification
 - Accredited degrees
 - Internships & experience
 - demonstrate proficiency towards CC
 - License exams / certification requirements



Key Content & Skill Areas

- Building Science Fundamental (BS-101)
- Building Enclosure Characterization & Optimization
- Building Material Science
- HVAC (& MEP, etc.) Systems Design, Analysis & Installation
- Indoor Environmental Quality
- Building Performance Tools and Analysis
- Advanced Design/Construction Documentation
- Quality Management and Commissioning
- Integrated Design Process / Multi-Disciplinary Project Management
- Systems (and subsystems) Engineering & Integration
- Other
 - Facility Operations & Management
 - Testing, Forensics, Other



EXCELLENCE IN BUILDING SCIENCE EDUCATION

Transforming the Design/Construction Profession

Key "Building Science" Courses For Quality, High-Performance Buildings	Engineering				Design		Construction Management	Other Sustainability /Housing Studies/ etc.
	Civil	Mech.	Arch. Engr.	Other (Mat Science)	Architecture (Bldg. Perf.)	Other		
Accreditation	ABET				NAAB, other		ACCE	Other
Building Science Fundamentals (Building Science 101)								
Building Enclosure Characterization & Optimization (Hygrothermal Analysis; Structure & Control Layers)								
Material Science for Buildings								
HVAC (MEP/other Building Services) Design, Analysis & Installation								
Indoor Air Quality								
Building Performance Tools & Analysis								
Advanced Design/ Construction Documentation (detailing, scopes-of- work, specifications, etc.)								
Quality Management/ Commissioning								
Integrated Design Process/ Multi- Disciplinary Project Management								
Systems Engineering/Integration- (ability to assess system implications)								
Other, e.g., <ul style="list-style-type: none"> Facility operations & management Testing; forensics BIM, Etc. 								



Need for Building Science Fundamentals

- To support faculty and competitions
- Some thoughts and proposal from:
 - Joe Lstiburek, BSC



Need for Building Science Infusion

- Modules to support faculty and competitions and professional preparation
- Some thoughts and proposal from:
 - Julie Szabo, WJE
 - Amanda Hatherly, SFCC



Need for Building Science Special Courses

- To support faculty and competitions and professional preparation
- Some thoughts and proposal from:
 - John Straube, University of Waterloo



Announcement – New Academic Journal

- **Journal for Housing & Residential Construction**
 - Under AEJ supported by ASCE
 - Editor: Ali Memari, Penn State
 - Actively seeking research papers in:
 - building technology / systems / materials
 - construction management
 - building science / building performance
 - structural design and evaluation
 - energy / sustainability / green buildings / healthy homes



Next Steps

- Joint Webinars – Task Force WG
- AEI Board of Directors – Reston, VA
- EEBA/DOE Task Force – St. Louis, MO
- Sequel to Toronto at NIBS Conference – Washington, DC
- ASHRAE – Chicago, Ill
- NAHB-IBS, NCHRC – Las Vegas, NV
- DOE Race to Zero Student Design Competition – Golden, CO
- TBD



EXCELLENCE IN BUILDING SCIENCE EDUCATION

Transforming the Design/Construction Profession

- **Comments and suggestions will be greatly appreciated!**
- **Please help us identify, review, and share teaching resources.**
- **Don't forget the Excellence in Building Science Education website**
 - www.BuildingScienceEducation.net
- **Contact Information**
 - Patrick H. Huelman
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 - St. Paul, MN 55108
 - 612-624-1286
 - phuelman@umn.edu



EXCELLENCE IN BUILDING SCIENCE EDUCATION

Transforming the Design/Construction Profession





Towards Better Building Science Programs

- How do we get more?
 - Building new programs
 - Improving existing programs
- Key Strategies
 - Faculty
 - Administration
 - Accreditation boards
 - Licensing boards
 - Professional societies



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ASTM / Industry Partners

- Characterize the Building Enclosure Professional
 - Job requirements – in terms of:
 - core competencies and
 - academic requirements

- Provide Universities with Core Competencies/KSA's
 - Entry Level Building Enclosure Technologist
 - Commissioning Provider (“Authority”)
 - Building Enclosure Professional

- Support University Programs & Students



Next Steps for Academia

- Recognize the impact of changes in the market on job requirements and – in turn – on core competencies.
- Provide curricula, incorporating building science, with learning outcomes responsive to changing core competencies.
 - Develop specialized courses:
 - Building Science Fundamentals (for example)
 - Update standard courses:
 - Building Science for Building Enclosures
 - Integrated Design & Project Management that establishing multi-disciplinary project and communication skills
 - Advanced Design & Construction Documentation that integrates building science, quality management, etc. (see working files)



Next Steps for Academia

- Retool University & Student Programs
 - Facilitate **internships & co-ops** that are involved with quality, high-performance buildings
 - Participate in multi-disciplinary **student competitions** requiring building science
 - Augment classes with **guest lectures & adjunct positions** with industry building science experts
 - Collaborate with Joint Committee in **identifying and sharing** of excellent curricula, course modules and teaching resources.





Architecture & Engineering Faculty

- **Proficiency in building science** is required in the planning, design, analysis, construction, commissioning, and operation of complex, quality, high-performance building projects.
- Building Enclosure Professionals (see core competencies):
 - Provide critical technical expertise to **multi-discipline project teams**: Engineers, Construction Managers, Architects,
 - Develop clear technical reports with supporting analysis
 - **Analyze and communicate functional requirements** associated with various enclosure subsystems
 - Analyze and communicate the **system implications and interactions** in proposing design and technology choices
 - **Develop design/construction document packages** with clear details (particularly for control layer transitions and discontinuities)
- Will Your Students be Ready?



Criteria Task Group Focus

- Architecture/Design
- Construction Management
- Engineering
 - Civil
 - Mechanical
 - Architectural
- Building & Material Science
- Other Related Programs
 - Sustainability
 - Housing Studies/Technologies





Construction Management Faculty

- **Proficiency in building science** is required to manage the planning, construction, commissioning, and operation of quality, high-performance buildings.
- Construction Managers must manage the risks of technically complex projects by working with Building Enclosure Professionals.
 - **Hire and manage** professionals for multi-discipline project teams: Engineers, Building and Material Scientists, Architects,
 - **Review, evaluate and act** on their technical reports
 - Understand **functional requirements** associated with various enclosure subsystems and their application details as a **risk management strategy**
 - Understand **system implications and interactions** when making design and technology choices
- Will Your Students be Ready?



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Key "Building Science" Courses For Quality, High Performance Buildings	Engineering				Design		Construction Management	Other - Sustainability /Housing Studies/ etc.
	Civil	Mech.	Arch. Engr.	Other (Mat. Sci.)	Architecture (Bldg. Perf.)	Other		
Accreditation			ABET		NAAB, other		ACCE	Other
Building Science Fundamentals (Building Science 101)			6				6	
Building Enclosure Characterization & Optimization (Hygrothermal Analysis; Structure & Control Layers)			5+				1+	
Material Science for Buildings			5				2	
HVAC (MEP/other Building Services) Design, Analysis & Installation			5				2	
Indoor Air Quality			5				2	
Building Performance Tools & Analysis			5				2	
Advanced Design/ Construction Documentation (detailing, scopes-of- work, specifications, etc.)			6				6	
Quality Management/ Commissioning			5				6	
Integrated Design Process/ Multi- Disciplinary Project Management			5				6	
Systems Engineering/Integration- (ability to assess system implications)			6				3	
Other, e.g., <ul style="list-style-type: none"> • Facility operations & management • Testing; forensics • BIM, Etc. 								