Sustainable and Energy Efficient Buildings Class Curriculum

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SUMMARY

A workshop was held in the fall of 2006 for the purpose of developing courses related to “Energy Efficient Integrated Sustainable Design for the Built Environment” for university, college, and vocational schools. The objectives of this workshop were to determine the key elements for students to know related to integrated energy efficient sustainable design; to identify specific learning objectives for each of those elements; and to identify resources available to use in these courses. The workshop was attended by a selected interdisciplinary group of well recognized engineering, architecture and building science professors, representatives of related professional organizations and national laboratories, and individuals working with the US DOE Building America teams. This paper presents a listing of the key topics identified and the learning objectives related to each of those topics.

INTRODUCTION

Sustainability and energy efficiency are topics which are covered in wide variety of different college courses in America. They are now being widely taught though community colleges, professional organizations’ continuing education programs, and general university and adult education programs. The basics however traditionally have been in the curricula of architecture, engineering and building science programs.

The accreditation board for professional degree programs in architecture is the National Architectural Accrediting Board which “… is committed to the provision of effective professional architectural education through the establishment and application of accrediting procedures …” and “… strives to foster an educational foundation that prepares students who are both broadly and professionally educated for the profession of architecture.” [1] For the purpose of accreditation, NAAB indicates that graduating students must demonstrate an understanding or ability in 34 different areas. Most relevant to the purposes of this paper is “#15 Understanding of the principles of sustainability in making architecture and urban design decisions that conserve natural and built resources, including culturally important buildings and sites, and in the creation of healthful buildings and communities.” Similar references are also made to the areas of: site conditions, environmental systems, building envelope systems, building systems integration, building materials and assemblies, construction cost control and comprehensive design.

Specific references to sustainability are not as explicitly described in the accrediting body in the field of engineering, ABET. This group indicates in the program outcomes and assessment that a school undergoing accreditation must demonstrate that their students attain an ability, understanding, recognition, or knowledge in eleven different areas. The one related to the area of sustainability indicates that students must demonstrate “(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic,
environmental, social, political, ethical, health and safety, manufacturability, and sustainability.”[2]

In a meeting of land grant institution teachers and researchers discussing energy efficient residential construction it was recognized that there many different approaches and materials used to discuss energy efficient sustainable design. During the breakout session it was also recognized that there was a pressing need for a systematic discussion to share ideas and basic concepts between the various educational disciplines, professional organizations and research teams. This discussion needed to determine the knowledge base of what was needed by students as to the key elements of integrated sustainable design, to develop curriculum related to these key elements, and to identify the resources used in the delivery of these courses.

METHODOLOGY

In order to address the needs identified, a workshop was held in the fall of 2006 for the purpose of developing courses related to “Energy Efficient Integrated Sustainable Design for the Built Environment” for university, college, and vocational schools. The objectives were to determine the key elements for students to know related to integrated energy efficient sustainable design; to identify specific learning objectives for each of those elements; and to identify resources available to use in these courses. Although the topic was considered to be applicable to all building sectors, it was determined that the first focus should be on the low-rise residential market. The workshop was attended by an interdisciplinary group of 30 selected well recognized engineering, architecture and building science professors, representatives of related professional organizations and national laboratories, and individuals working with the US DOE Building America teams.

RESULTS

The interdisciplinary group met for a 3 ½ day intensive workshop and identified the key elements of knowledge which a student should know in this area. While the extent of the courses might vary between the professional degree programs (such as architecture or engineering) and the two-year associates degree programs; the key elements remained the same. It was thought that these key elements could be used as the basis for the first course on energy efficient sustainable design for the built environment and were therefore laid out as separate modules. Depending upon the level of instruction (i.e. professional design instruction such as engineering versus a technical school) the modules could be modified to suit the needs of the audience. Each one could be the topic of a one day adult education workshop, one-week instructional modules in an introductory course, or serve as the basic outline for an entire semester in an advanced course.

The underlying learning objectives for each of the modules were then identified.

Seventeen modules were identified and learning objectives for each were developed. The modules and the topics contained and learning objectives for each are given below.

- Define terms of building science, ecological systems, economics of consumption
- Relate building science perspective, ecology, social science
- Explain historical energy and environmental issues related to buildings
• Compare site and source energy
• Examine the health, safety and comfort issues in buildings
• Examine the general context for building solutions (The goal of net-zero energy green home with durability.)
• Explain a basic overview of the sufficiency of alternative energy (total solar flux and wind availability)
• Examine cash flow to homeowners
• Demonstrate ability to find, evaluate and synthesize knowledge regarding building performance and sustainability
• Define Business case – career opportunities
• Explain appropriate technology and systems (and how to research them with every lesson)
• Define interconnections / inter-relationships among building systems

Module 2. Introduction to Sustainable Design & Building Performance
Learning Objectives:
• Recognize that a building works as a system
• Learn about the roles of air, heat, water, and vapor flows
• Recognize the importance of climate-specific design details
• Understand the issues on health, IEQ and productivity.
• Building performance and relations to overall sustainability
• Differentiate between the available fuel choices and characteristics
• Recognize roles, responsibilities and respect of the participants in design and construction

Learning Objectives:
• Comprehend specific issues related to pressure- and temperature-induced flows
• Grasp the significance of water flows and their roles in building details related to the drainage plane and other building elements
• Recognize the need to manage relative humidity and prevention of condensation
• Understand the air change rate and its relationship to above concepts

Module 4. Building Materials and Their Properties
Learning Objectives:
• Understand building material porosity and the impact it has on properties, such as wetting and drying, capillarity action
• Understand and be able to use:
  • Vapor perm ratings
  • Air perm ratings
  • R-values/U-values – all materials, including glazing
• Understand the difference between individual material properties and assembly performance
• Understand the impact of mass and phase change materials
• Recognize the life span of materials and their embodied energy
• Understand the need for waste reduction, regionally appropriate and ecological materials
Module 5. Climate and Designing with Nature
Learning Objectives:
• Understand the importance of climate-appropriate design
• Recognize relationships among temperature, precipitation, and construction techniques
• Learn about hygro-thermal regions and how design and construction details vary across them
• Understand building details related to seismic conditions, hurricane-resistance, wind, corrosion and other climate-specific factors that affect structural durability
• Understand solar geometry, daylighting, natural ventilation
  o Understand building geometry related to the local environment
  o Understand daylighting performance in building design
  o Understand shading devices in building design
  o Understand building designs that utilize natural ventilation

Learning Objectives:
• Understand air leakage control through design details and blower door testing
• Understand HVAC design and integration issues as well as testing protocols
• Gain competence in performance of building commissioning and management of commissioning records
• Understand the role of design details, specifications, and trade contractor scopes of work with respect to quality and high performance
• Understand diagnostics techniques and reports

Module 7. Site: Drainage, Pest Control, Landscaping
Learning Objectives:
• Understand the role of site grading and water run-off
• Understand management of termites, rodents, and other pests
• Understand proper placement of vegetation, mulch, and other decorative land cover
• Comprehend soil properties and soil conditioning
• Know native vegetation and the role of irrigation and reduction of water usage

Module 8. Foundation: Moisture Control and Energy Performance
Learning Objectives:
• Understand foundation construction techniques essential for the prevention of moisture and soil gas entry
• Understand the contribution of the foundation system to overall building energy performance
• Understand climate-specific use of alternative foundation insulation systems

Learning Objectives:
• Learn roof and wall assembly materials and techniques essential to water management (including flashing)
• Learn roof and wall assembly materials and techniques essential to air infiltration
• Learn roof and wall assembly materials and techniques essential for the prevention of vapor intrusion and drying of interstitial spaces
• Learn climate- and design-specific use of alternative glazing systems
• Understand selection criteria and application details of cavity and attic insulation materials
• Understand alternative approaches to vapor retarder and house wrap systems
• Understand the energy and lighting implications of alternative window treatments
• Gain an appreciation and understanding of the dual roles of weather barrier and energy performance

Learning Objectives:
• Understand equipment and duct issues
• Understand integration of mechanical system design and architectural design
• Understand best practices of selection and installation of mechanical equipment
• Understand efficiency standards and appliance ratings
• Understand the importance of plug loads, appliances and lighting systems
• Understand the principles of the systems for
  o Space temperature conditioning (heating and cooling systems)
  o Hot water distribution
  o Duct layout
  o Controls and monitoring
  o Pollutant source control
  o Evaporative cooling

Learning Objectives:
• Understand applicable ASHRAE ventilation Standards (ASHRAE 62.2)
• Understand backdrafting issues, combustion gas management, and sealed combustion systems
• Understand proper placement and penetration sealing of electrical wires, plumbing pipes, and HVAC ducts
• Understand the role of indoor relative humidity in building performance and the conditions-based need for dehumidification/humidification
• Understand the basics of alternative heating systems
  o Dual fuel heat pumps
  o Wood burners and fireplaces
• Understand on-site generation systems
  o Photovoltaic and wind
  o Solar thermal
  o Combined heat and power (CHP)
  o Fuel cells

Learning Objectives:
• Understand applicable energy codes, standards and best practice recommendations
• Demonstrate the ability to use tools to analyze buildings and make design decisions (energy, environment, etc.)
• Know how to measure performance and make adjustments.
Module 13. Field Issues: Construction Management, Building Codes, and Other Regulatory Matters
Learning Objectives:
- Understand practical matters that affect implementation of design details, specifications or purchasing requirements, and scopes of work including construction labor issues and homebuyer concerns
- Understand code enforcement and zoning ordinance issues that may obstruct the construction of high performance housing and effective counter strategies
- Understand the impact of codes/standards on building performance and sustainable design
- Understand local public policy; Impact of policy, regulation and enforcement
- Be aware of the processes of policy development and change
- Understand contracts and contract law

Module 14. The Business Case, Communications and the Community Scale Perspective
Learning Objectives:
- Understand valuation methodologies for building performance and sustainable design
- Gain communications skills / tools to achieve effective team functioning
- Value the ability to use peers as a resource not a competitor
- Understand the relationship between single building & site land use, infrastructure and ecological impacts
- Learn about utility systems and interconnections
- Comprehend rate structure, base and peak usage
- Understand time-of-day usage and electrical marginal dispatch
- District heating and cooling
- Transportation – people, waste, water and energy

Module 15. Putting it all Together: Experiential Learning in the Field / Office
Learning Objectives:
- Through a partnership with a high performance builder, shadow a construction manager for an assigned time during a one-week period
- Be able to apply the principles to
  - Case studies
  - Performance verification studies
- Analyze examples given in videos

Module 16. Homeowner Education (Communicating with the Consumer)
Be able to communicate the following with the consumer
- Tax incentives
- Financing & insurance
- Occupant lifestyle impact
- Energy improvement mortgages
- Commissioning, punch lists, owner manual
- Operation and maintenance
- TED
- Selling energy efficiency
- Home energy audits
- Cleanliness of the job site
Module 17. Conclusions, Implications, Directions of Future Research

Learning Objectives:
- Highlight and review materials covered and studio and field experiences
- Understand current research issues regarding high performance buildings
- Understand need for life long learning
- Reflection

The resources to be used in the modules were also identified in the workshop. This material will be expanded upon in another workshop to be held in the summer of 2007.

SUMMARY AND CONCLUSIONS

A workshop with faculty and building industry leader participants was held to develop university and community college courses related to the design of energy efficient and sustainable buildings. The objective was to determine the key topics and the elements of these topics which need to be taught and to develop the learning objectives for each of the segments. Courses were developed to be taught at the architectural and engineering schools, at community colleges and vocational schools, and for general education in colleges, universities and general adult extension education. The topics and learning objectives for each of the topics are presented in the paper.

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REFERENCES