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Blueprint for Developing a Laboratory and Curriculum for Energy Efficiency, Renewable and Alternative Energy Programs

Introduction

Environmental issues, U.S. dependence on foreign oil and depleting fossil fuel reserves: all of these issues represent an increasing awareness of the need for energy efficiency and alternative and renewable energy education. Almost half (49%) of all energy produced in the U.S. is consumed by the building sector. This is almost the same amount of energy consumed by both transportation (28%) and industry (23%) combined. [1] According to the U.S. Energy Information Administration, fossil fuels supply 76% of the total building sector energy consumption. To address the building sector, architect Edward Mazria, in 2002, established Architecture 2030, a non-profit, non-partisan, and independent organization. Architecture 2030 issued The 2030 Challenge asking the global architecture and building community to adopt the following targets: 1) All new buildings, developments, and major renovations shall be designed to meet a fossil fuel, green house gas emitting, energy consumption performance standard of 60% below the regional (or country) average for that building type. 2) The fossil fuel reduction standard for all new buildings and major renovations shall be increased to 70% in 2015, 80% in 2020, 90% in 2025, and carbon-neutral in 2030 (using no fossil fuel green house gas emitting energy to operate). These targets may be accomplished by implementing innovative sustainable design strategies, generating on-site renewable power and/or purchasing (20% maximum) renewable energy. The National Association of Home Builders has introduced an educational program *Green Building for Building Professionals* leading to the designation of Certified Green Professional (CGP). The LEED, Leadership in Energy and Environmental Design, program quantifies a building's sustainable design and operation. These are but a few of the efforts to reduce energy consumption and environmental issues with respect to a building's design and operation and the use of fossil fuels.

To reduce the environmental impact of buildings and the use of fossil fuels, community colleges and universities are now educating architects, engineers, technicians, and the workforce to design and operate buildings and their systems in a sustainable manner and further reduce the use of fossil fuels with their replacement with renewable and alternative energy sources. The roles for colleges and universities in this educational process, while overlapping to some degree, address different educational requirements. Universities are educating researchers, engineers, designers, and architects while community colleges are educating students so they can further their education at universities, and they are educating the workforce to implement the designs and operations provided by the engineers, designers, and architects.

Curricula for Community Colleges

The need for such programs is supported by the rising cost of energy and depleting resources. Energy efficiency measures in the design of new buildings whether residential, commercial, or industrial, require a workforce knowledgeable in the energy efficient design and operation of these buildings. As more energy is consumed by existing buildings, a workforce knowledgeable in retrofitting buildings to improve their energy efficiency is required. Such a workforce must be

knowledgeable in building envelope design, mechanical system design, operational procedures, and industrial processes.

Some of the program opportunities for community colleges can be divided into energy efficiency, renewable energy, and/or alternative energy. The energy efficiency programs address a building's envelope design, mechanical systems, and operational procedures and industrial processes. The renewable/alternative energy programs address the design and installation of systems such as solar photovoltaic, solar thermal, wind turbine and biofuels. Each of these programs has nationally recognized certifying bodies. Each of these programs requires a laboratory for support of required student activities.

A community college energy efficiency program addresses a building's envelope. A course of study including heat transfer, thermal barrier, air barrier, insulating materials and their installation, performance ratings on windows and doors, weather files, and simulation software are but a few the topics included. As the design and operation of mechanical systems of buildings, heating, air conditioning and ventilation systems, lighting systems, and plumbing systems affect the building's energy performance, they are vital topics included in an energy efficiency program. The operational procedures of a building are perhaps one of the more cost effective approaches to reducing a building's energy use. These operational procedures are another topic of study included in an energy efficiency program. While somewhat unique and not included in most residential and commercial buildings, industrial processes and equipment are large energy consumers and are addressed as a course of study in more complete community college energy efficiency programs.

A community college initiating and/or completing the development of an energy efficiency program is challenged to include the proper course materials and in the proper sequence. Fortunately, some educators have been developing such programs for many years and share their combined efforts through ATEEC, Advanced Technology Environmental and Energy Center. The ATEEC website [2] offers a *Model Energy Services Curriculum.* [3] Upon entering the site, go to Category, then Energy and finally Curricula to review the material available. The *Model Energy Services Curriculum* provides course title, course description, textbook, general course goals, course competencies/student outcomes, and topical outline for the suggested courses in the curriculum. The curriculum includes:

- Alternative and Renewable Energy Sources
- Heating Systems
- Cooling Systems
- Electrical Lighting and Motors
- Energy Control Strategies/Technologies
- Energy Costs, Economic and Environmental Analysis
- Energy Efficiency Methods
- Energy Analysis Capstone

Many community colleges have courses in their programs that are included in full or in part in the *Model Energy Services Curriculum.* Adjustments are easily made in the suggested program to fit each college's unique situation. This suggested curriculum is an excellent starting point.

Certifications

There are certifications that can be offered to the students in energy efficiency programs. The Building Performance Institute [4] is a national standards development and credentialing organization for residential energy efficiency retrofit work. They primarily address existing housing stock. Through both written and field exams they offer certification in:

- Building Analyst Professional
- Envelope Professional
- Heating Professional
- A/C or Heat Pump Professional
- Manufactured Professional

The Building Performance Institute also offers certification in:

- Multifamily Building Analyst
- Multifamily Energy Efficient Building Operations
- Multifamily Hydronic Heating System Designer
- Multifamily Advanced Heating Plant Technician

In order for a community college to offer Building Performance Institute certification they are required to become a BPI Affiliate or to contract with an existing BPI Affiliate. A BPI Affiliate can conduct certain recognized training, refer to nationally recognized BPI standards and protocols, administer BPI written and field exams, and provide qualified candidates with access to nationally recognized certification and recertification credentials available through BPI. The requirements for becoming a BPI Affiliate are on the BPI website. [5]

There are both written and field exam requirements in the BPI certification process. The written exam is administered by a BPI recognized Proctor as defined in the Affiliate requirements. The field exam is also administered by a BPI recognized Proctor and requires equipment ranging from, but not limited to, a blower door, pressure pan and pressure probe, monometer, combustible gas leak tester, CO test equipment, and smoker. The field test requires a home or a full scale mockup in which to conduct the test. These tests can be performed by the Affiliate if they have a Proctor on staff or can be contracted.

The Building Performance institute requires a very extensive course of study that must meet with their approval. The community college can develop their course material and submit it for approval or secure a license with a recognized approved program provider.

The information with respect to the Building Performance Institute requirements and procedures is offered to assist community colleges who may wish to offer this certification. The author does not take responsibility for the accuracy of the information above but advises the verification of all the information at the Building Performance Institute website. [4]

Home Energy Services Network, RESNET, [6] offers certifications for Home Energy Raters and Home Survey Professionals. A Home Energy Rater conducts an analysis of a new home's

construction plans and performs on-site inspections. A certified energy rater conducts a comprehensive energy audit and with the use of diagnostic equipment and computer software, derives an energy efficiency rating on the standardized HERS Index. The HERS Index is use to determine if a home meets ENERGY STAR performance guidelines. A Home Energy Survey Professional (HESP) is certified to perform a visual walk-through evaluation to ascertain the general energy performance of an existing home. A community college can become a Provider of the required training and certification process. The procedures for becoming a Provider are given on the Home Energy Services Network, RESNET, website. [7] [8].

Textbook and Materials

There are materials and textbooks that are helpful in developing the curriculum for weatherization and auditing courses. Not intended to be a complete list, but some books the author found helpful are:

Saturn Energy Auditor Field Guide by John Krigger and Chris Dorsi, ISBN 978-1-880120-17-0 [9]
Residential Energy by John Krigger and Chris Dorsi, ISBN 1-880120-12-7 [10]
Builder's Guide to Cold Climates by Joseph Lstiburek, ISBN 0-9755127-1-4 [11]

The Weatherization Assistance Program Technical Assistance Center, WAPTAC, [12] [13] has many materials and presentations that can be used to develop class lectures, worksheets, and handouts.

For community colleges entering into renewable energy education, the North American Board of Certified Energy Practitioners, NABCEP, [14] is a recognized certifying organization for solar photovoltaic, solar thermal, and wind. They outline a specific task analysis and give an installer certification examination for solar PV [15], solar thermal, [16] and small wind. [17] NABCEP offers an Entry Level Exam for solar photovoltaic. Community colleges can become a Provider for this Entry Level Exam. There are specific requirements to become a provider. These requirements can be found at the NABCEP website. [18] NABCEP is currently in the process of offering an entry level exam for solar thermal. Community colleges will be able to become Providers for this exam also.

The NABCEP task analysis for solar PV, solar thermal, and small wind provide an outline to develop the course materials. The Midwest Renewable Energy Association [19] offers workshops and materials which are helpful in developing course materials for solar PV, solar thermal, and small wind. Not intended to be a complete list, but some books the author found helpful for renewable energy are:

Renewable Energy by Godfrey Boyle, ISBN 0-19-926178-4 [20]
Photovoltaic Systems by James P. Dunlop, ISBN 978-0-8269-1308-1 [21]
Photovoltaics Design and Installation Manual by Solar Energy International, ISBN 978-0-86571-520-2 [22]
Solar Water Heating by Bob Ramlow and Benjamin Nusz, ISBN 978-0-86571-668-1 [23]

Solar Hot Water Systems, Lessons Learned by Tom Lang ISBN 13: 978-1607250616 [24]

Assessment

An Advisory Board will ensure that the program is aligned with the needs of the industry and community. The members of the board should consist of energy auditors, commercial and industrial assessors, architects, mechanical system designers, renewable energy system designers and installers, and employers in the energy efficiency and renewable energy industry. As graduates of the energy efficiency and/or renewable energy program are employed, the Advisory Board members can provide valuable feedback as to the graduates skills and knowledge.

Community Partnerships

A component that is lacking in many community colleges' energy efficiency and/or renewable energy programs is field experience. This component can be supported by establishing partnerships with businesses and non-profits within the community. Many non-profits have homes and/or facilities that can benefit from energy assessments. Partnerships with non-profits provide the students with real world experience in energy auditing, weatherization and energy saving measures for both residential and commercial buildings. Utility data can be collected before and after the retrofits to validate the estimated energy savings and the effectiveness of the weatherization measures and energy saving procedures. The partnerships with non-profits can be established by creating a list of non-profits in the area, making initial contact, and offering a no cost service to help them reduce their utility costs. Most non-profits are very receptive to this partnership. As most non-profits do not engage in renewable energy installations, partnerships must be established with small businesses that are engaged in the installation of renewable energy facilities. Large companies and/or utility companies install utility scale solar PV. Partnerships with large companies, when available, provide students with excellent field experience. Contacting these companies and sharing the benefits to both company and student many times leads to a partnership or collaboration. As NABCEP requires field experience for anyone who whishes to take the installer's exam, this field experience of the student can meet some that requirement.

Laboratory Requirements

The laboratory requirements for an energy efficiency program that includes the presented certifications are:

Mock-up of a house or equal
Blower door
Pressure pan
Smoker
Duct blaster
CO monitor
Measuring tape, hand tools, etc.

A complete recommended list of equipment and materials, and approximate cost of each, can be obtained at the Building Performance Institute Equipment Checklist. [25]

The NABCEP certification for solar photovoltaic and solar thermal requires a working solar PV system either grid-tied or stand-alone and a working solar thermal system. The solar thermal system does not need to be tied into the hot water system. With the installation of these solar systems, it is most beneficial to have them at a location accessible to the students. The location may reduce system performance but increase student learning. A wind turbine should be available if offering small wind installation. It is more difficult to have student access to the turbine, but the other system components such as the controller can be located for student access.

Researching the BPI or RESNET websites and available information will list the required equipment for a certification program. An internet search and contact with local suppliers will lead to the location to purchase this equipment. However, creating a list for the required equipment for solar PV, solar thermal, and small wind is more complicated. All of the components of a system must be sized to function as a unit. An excellent way to accomplish this is to locate a local supplier/installer of these systems and obtain their help in developing the required list. As they will most likely be supplying the materials, it is a winning situation for both the supplier and the community college.

Summary

The need for the reduction of energy use in both new and old buildings and industrial facilities is well documented. The need to replace fossil fuels with renewable energy sources is also well documented. As many universities are now offering undergraduate and graduate degrees in energy efficiency and renewable energy, community colleges can align their programs to educate students to further their education at these four year universities. Community colleges can also provide workforce training, certificates, and degrees in energy efficiency and renewable energy. The certificates and degrees for energy efficiency programs require a complete curriculum. The certificates in renewable energy such as solar PV, solar thermal, and small wind fit into short-term, workforce development programs.

Bibliography

1 Source: U.S. Energy Information Administration (2009). To create a U.S. Building Sector, the residential buildings (operations) sector, commercial buildings (operations) sector, and industrial buildings (operations and materials embodied energy estimates) were combined.

2 ATEEC, Advanced Technology Environmental and Energy Center. http://www.ateec.org/store/

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10*Residential Energy* by John Krigger and Chris Dorsi, ISBN 1-880120-12-7

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24 *Solar Hot Water Systems, Lessons Learned* by Tom Lang ISBN 13: 978-1607250616

25 Building Performance Institute.http://www.bpi.org/files/pdf/BPI_Energy_Audit_testing_equipment_checklist.pdf