Focus Group Report

Environmental Control Technology Industry Education Initiative:

Developing a Next-Generation Community College Curriculum for Energy-Efficient High-Performance Building Operations

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Peralta Community College District
&
Lawrence Berkeley National Laboratory

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CONTEXT

The dramatic evolution of the skill requirements for technicians has been apparent to observers for more than a decade. As noted by Carnevale (1991) "with the assistance of flexible information technologies, technicians are assuming functions previously performed by scientists and engineers." In response to this trend, the education of technicians must provide a solid academic *and* practical foundations, preparing them not only to be technically knowledgeable and capable but also to be comfortable with problem solving, creative thinking, working autonomously, and working effectively with others. The necessary transformation of technician education is widely recognized throughout the industrialized world, as are the challenges posed by the need to raise the status of technicians and to attract more capable students into technician-level fields (Mahoney and Barnett,1998).

Those who successfully acquire new skills will be able to participate in emerging professional specialties such as managing building energy use and maintaining optimal performance and analyzing and correcting all-too-common building system faults. In fact, entirely new technical specializations—e.g. "building commissioning" [1]—have emerged for which there is today no community-college-level training.

As suggested in recent announcements from the U.S. Department of Labor and the Air Conditioning and Refrigeration Institute, training provided by existing building operator education programs is insufficient to meet evolving industry needs of nearly 60,000 new jobs per year (Fitzgerald 2003). In our view, this number is an under-estimate of the workforce needed to address the issue of building performance. Many of the required skills for this sector are often associated only with more academic-oriented careers, for example, systems engineering or information technology. The underestimate is evident in the fact that the emerging energy service company sector grew from $250 million per year in 1990 to over $2 billion in the year 2000 (Goldman *et al.* 2002).

On September 5, 2003 Peralta Community College District and Lawrence Berkeley Laboratory held a half-day focus group meeting to obtain critique and recommendations for their "Environmental Control Technology Industry Education Initiative." The Initiative focuses on modernizing community college curriculum to equip building technicians with skills required to commission and operate high-performance buildings, with particular emphasis on energy efficiency and indoor environmental quality in the context of HVAC&R equipment and control systems. An experienced facilitator (Rick Diamond) guided the process.

FOCUS GROUP OUTCOMES

The overarching aim of the Focus Group meeting was to advance the understanding of industry needs and to obtain an informed critique of a "straw-man" curriculum plan and innovative teaching methods, which will be piloted at Laney College, in Oakland California. A draft of this report was prepared following the meeting and circulated to the participants as well as interested parties who could not attend. Their comments are incorporated in this final report.

The 47 participants represented a broad spectrum of industry stakeholders (Figure 1), including contractors and consultants, facility owners and managers, equipment manufacturers, energy policymakers, energy providers, researchers, and educators (high school and community college).[2] There appears to be considerable appetite for new approaches to the education of building operators, as evidenced by the turnout and enthusiasm exhibited at the meeting.

[1] 'Commissioning' includes the process of systematically testing the operation of building systems and diagnosing and correcting faults that would significantly impair performance

[2] Input is included from several individuals who were unable to attend (as indicated in the Roster in Appendix A), but provided suggestions following the workshop. The focus group was informed by a workshop held by the Partnership for Environmental Technology Education and the NSF-funded Advanced Technology Environmental Education Center (ATEEC) in the year 2000, in which 22 participants characterized education and skills needs across a very broadly defined "Energy Services" sector (PETE and ATEEC 2000). Our group explored in depth approximately 5 of the 28 "top job" areas covered in the 2000 meeting, i.e. those relating to building construction and operations, environmental controls, and diagnostics.

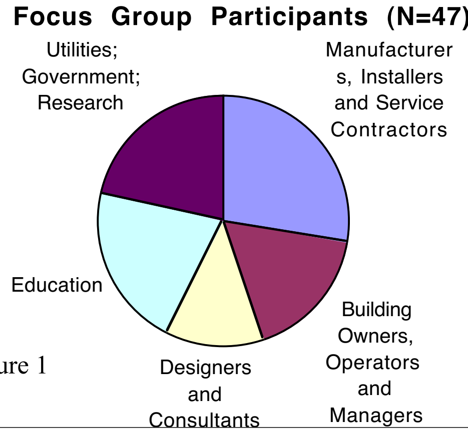

Figure 1

Trades Represented

- Refrigeration Equipment & Service
- Residential Design & Service
- Equipment Manufacturer
- Mechanical Contractor
- Controls Sales & Service
- Commissioning
- Energy Management
- Building Owner; Facilities Manager
- Engineering and Specifying
- Educators

The focus group considered three broad issue areas: (1) Industry Needs, Opportunities, and Skills Required; (2) Curriculum Analysis and Development; and (3) Learning Methods. Breakout sessions were held among five working groups representing various trades or segments of the industry. Participants provided written and verbal reports.

The participants concurred that many of the problems seen today in achieving and maintaining energy savings in buildings can be traced to inadequacies in the operation of facilities, and lack of awareness and knowledge about how existing systems are intended to be used. Successful operation of buildings requires understanding and preserving the "design intent" behind the systems, an ability to respond to changing conditions, and an appreciation of the link between energy-using systems and human comfort and occupant satisfaction, etc. Participants and others we interviewed[3] confirmed that while these issues are addressed in various graduate-level and continuing education programs, they are virtually absent at the community college level.

Industry Needs, Employment Opportunities, and Skills Required

A number of key market trends and drivers were identified, underpinning the need for evolutionary changes community college curriculum. These include:

1. Emergence of new technologies and practices (which correspond, in part, to an associated shift from mechanical to electronic equipment).
2. Growing awareness of the economic and non-economic costs of equipment performance problems, especially as relates to worker productivity (Fisk 1997).
3. New "green building" mandates by local and state governments (Kats *et al*. 2003), and industry initiatives such as LEED (Leadership in Energy and Environmental Design).
4. The role that sophisticated building operators can play in addressing macro-level energy system challenges such as peak demand management and reliability, rising concerns about indoor air quality and mold, and risk management.
5. The trend towards increasing energy prices and more complex energy rate structures (e.g. time-of-use tariffs), which calls for a new awareness among building operators in order to understand and take advantage of cost-savings opportunities.
6. The rapidly increasing importance of performance measurement and verification.
7. Emerging recognition of the specialized performance problems and opportunities in high-tech facilities (laboratories, cleanrooms, data centers), ultra cold environments, and other specialized applications (Tschudi *et al.* 2002)

[3] Including three controls and equipment manufacturers interviewed subsequent to the focus group meeting—Carrier, Automated Logic, and Circon Systems—and feedback from a meeting of the California Commissioning Collaborative, with approximately 20 individuals who work in the field.

Participants described the fundamental critical change as a shift from the traditional "component-level" focus on buildings to a more integrated "systems" perspective, coupled with better bridging of theory and practice and understanding the underlying concepts and logic. The increasing role and sophistication of controls technologies are both a source of the "problem" and a fundamental enabling element of this transition. The emerging role of building commissioning reflects the aforementioned industry shift.[4]

Numerous more specific gaps were identified between the education today received by building operators and current needs. Areas that were frequently (and sometimes universally) noted include:

<u>Technical Skills</u>

- Basic building science: physics and math and theory of how building systems work
- Diagnosing and trouble-shooting problems
- Control system programming (e.g. sequences of operations)
- Sustainable design & green buildings
- Performance measurement and analysis (e.g. collection *and* assessment of energy data)
- Information technology and networking
- Safety and risk management

<u>Business Skills</u>

- Working with people, reporting, computer literacy, etc.
- Economic and financial analysis (including assessment of non-economic benefits)
- Communicating analyses and recommendations to decision makers
- Critical thinking & problem solving

Curriculum Analysis and Development

The Laney College Environmental Control Technology (ECT) program has a thirty-year history. In its current form, the program is similar in content to HVAC&R programs at community colleges around the United States. Typical certificate programs range in length from two to three semesters, with associates' degree programs adding a fourth semester. Completing the current program requires two full semesters plus one lighter semester.

The proposed curriculum improvement project builds on Laney's existing core curriculum in ECT. It "builds in" through the adoption of new instructional technologies and methods; it "builds out" through the creation of new program strands associated with emerging occupational clusters, through the addition of physics, statistical methods, and communications courses, and through the addition of a rigorous associates degree option; it "builds up" through the addition of advanced courses associated with the new strands to serve both current students and incumbent workers needing skills upgrades; and it "builds through" by providing an articulated sequence of courses so that students may transition to four-year institutions.

A "straw-man" curriculum consisting of the existing Laney core program supplemented with proposed new courses and strands was presented to an industry Focus Group. Participants were invited to make recommendations to improve the curriculum to better address industry needs. Input was solicited on core courses, on proposed new courses, and on new courses not already identified by the Laney team. Based on comments and feedback on the straw-man course matrix, new courses were added, additional content was added to existing courses, additional courses were moved into the core curriculum, and changes were made regarding recommended and required courses for various occupational clusters. Participant comments were also incorporated into the detailed course descriptions (see Appendix B).

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[4] In their 2002 study entitled "California Commissioning Market Characterization Study", PECI identified a need for approximately 350 full-time "fully experienced" commissioning specialists to serve the California market alone. The analysis covered new and existing buildings and was based on applicability to buildings larger than 25,000 square feet. This number would increase by 50 to 100% after accounting for the roles of junior engineers in supporting the commissioning specialists. The analysis assumes 2%/year penetration for existing buildings and 30% for new ones.

Figure 2 summarizes the resulting revised curriculum.[5] The rows represent courses, and the columns show occupational “strands” that will correspond to specific certificate and degree options. The matrix indicates which courses exist in the current Laney College curriculum, and which will be created or adapted through the proposed project. In all, sixteen new courses have been identified.

The projected curriculum matrix of core and advanced courses differs significantly from that typically found at the community college level. Existing programs focus primarily on component-level technologies and provide a superficial treatment of the broader energy and other building performance issues. Nor are the key emerging issues such as the role of performance monitoring, fault detection, and diagnostics systematically addressed. Several community college programs are at the early stages of adding coursework in basic digital controls, but none we could identify have any of the advanced courses called for in the revised matrix.

Among the elements unique to the proposed curriculum are in-depth treatment of advanced digital control systems, data collection, analysis, and correlation with operating equipment and systems, fundamental emphasis on system-level analysis and troubleshooting, specialized courses on high-tech facilities, ultra-cold facilities and eutectic cooling, integration of indoor air quality analysis,[6] analysis of peak-load responsiveness (as distinct from energy use and efficiency), and issues facing building operators when needing to respond to a threat of biological or chemical attacks[7]. In addition, we have found no other program that utilizes computer simulation in the way we propose (described below).

At the Focus group meeting, representatives of the Oakland high school district reinforced the importance of articulation between high school and community college. They were interested in career opportunities for their students and offered to assist in identifying students and developing instructional materials that would motivate students to pursue careers in environmental control technology, and continued education at the community college level. They have committed to helping design a standards-based physics course emphasizing core knowledge linked to the building sciences including thermodynamics, heat transfer, temperature-pressure relationships, entropy, etc. Although many skilled technician jobs in this field are available—and the number is expected to grow—there is little awareness among students of the job opportunities.

Creating a “modular” set of offerings supports practitioners seeking continuing education was noted as an important function of the program. Linking to other continuing-education training programs, e.g. offered by utilities or trade organizations, was suggested by a number of the participants. The one-unit courses shown in Figure 2 are particularly accessible to practicing technicians.

[5] Note: a lighting course will also be added.

[6] Subsequent to the focus group, we consulted with two experts in this field (Building Science Corporation and the Chelsea Group) who explained that there were numerous continuing education options for practicing building operators, but nothing of merit at the community college level.

[7] LBNL has developed special expertise in this area, and is already providing practical information on the subject: see http://securebuildings.lbl.gov/info.html.

Figure 2

LANEY COLLEGE

ENVIRONMENTAL CONTROL TECHNOLOGY (HVAC) CURRICULUM (Existing and Proposed Courses)

<--------- Proposed Certificate and Degree Program Strands to Be Develeoped------->

	Course Status	Semester Units	Hours for Lecture / Lab	REFRIGERATION TECHNICIANS	HVAC TECHNICIANS	BUILDING OPERATORS	CONTROLS TECHS	COMMISSIONING TECHS
Core Courses								
Basic Environmental Control Technology	E	4	3 / 3	X	X	X	X	X
Residential & Light Commercial HVAC Troubleshooting	E	4	3 / 3	X	X	X	R	X
Mechanical & Electrical Devices	E	4	3 / 3	X	X	X	X	X
Principles & Practices of Env. Control Tech.	E	4	3 / 3	X	X	X	X	X
Special Processes & Devices	E	4	3 / 3	N/R	X	X	X	X
HVAC Principles & Practices	E	4	3 / 3	N/R	X	X	X	X
Physics for Building Science	E	4	3 / 3	X	X	X	X	X
Fundamentals of Energy Mgt & Efficiency	N	1	1 / 0	R	X	X	X	X
Electricity & Instrumentation	E	4	3 / 3	X	X	X	X	X
Brazing & Soldering	E	1	.5 / 1.5	X	X	X	N/R	N/R
Blue Print Reading & Interpretation	E	2	2 / 0	R	X	X	X	X
Motors & Drives	N	2	1 / 3	X	X	X	X	X
DDC Controls - I	N	2	1 / 3	N/R	X	X	X	X
Building Commissioning - I	N	2	1 / 3	N/R	X	X	X	X
Intro. To Computer Info Systems	E	2	1 / 3	X	X	X	X	X
Expanded Curriculum								
Intermediate Algebra	E	4	4 / 0	R	X	X	X	X
Professional Communications	E	3	3 / 0	R	X	X	X	X
Psychrometrics & Load Calculations	N	2	1 / 3	X	X	X	N/R	R
HVAC System Design	N	2	1 / 3	N/R	R	R	X	X
Mechanical & Electrical Codes	N	2	2 / 0	X	X	X	N/R	X
Testing, Adjusting, & Balancing	N	2	1 / 3	N/R	X	X	N/R	X
Intro To Bldg. Energy Management Systems	N	1	1 / 0	N/R	X	X	X	X
Statistical Methods for Data Analysis	E	4	3 / 3	R	X	X	X	X
DDC Controls - II	N	2	1 / 3	N/R	X	R	X	X
Building Commissioning - II	N	2	1 / 3	N/R	R	R	N/R	X
Building Envelope & Indoor Air Quality	N	1	1 / 0	N/R	R	X	N/R	X
Distributed Power Generation	N	1	1 / 0	N/R	R	X	X	R
Eutectic Refrigeration	N	1	.5 / 1.5	R	N/R	N/R	N/R	N/R
Ultra-low Refrigeration Systems	N	1	.5 / 1.5	R	N/R	N/R	N/R	N/R
High-Tech Facilities (Cleanrooms, Data Centers, Hospitals, etc.)	N	1	.5 / 1.5	R	X	X	R	R

KEY

Required Course	X
Recommended Course	R
Course Not Required	N/R
Existing Course	E
New Course	N

Instructional Strategies

The idea has been promoted widely in the United States that virtually all front-line workers needed to develop higher-order cognitive skills including creative thinking, problem solving, and systems thinking. For technicians such "habits of mind" are viewed as particularly critical for success in the "information-based workplace" which values reduced hierarchy, greater worker independence, teamwork, communications skills, non-routine problem solving, and understanding of complex systems (Grubb 2000). For building science technicians, the need for and value of system thinking skills is even more compelling.

This shift in our thinking about what constitutes some key dimensions of workplace basics has been the source of much deliberation by educators about how to teach the new skills, marked by a decided tilt toward constructivist teaching strategies, and a new emphasis on teaching for understanding (Wiggins and McTighe 1998). In this new model of less teaching and more learning, students must figure things out, students must be immersed in complex problems often with multiple solutions, and must operate in a problem-solving context.

The Focus Group examined alternative teaching strategies and methods to extend the knowledge and understanding of students preparing for technical careers in the building sciences. Laney faculty are already committed to extending the existing teaching lab far beyond the norm to include an operating HVAC system that would replicate a system in a commercial building and would immerse students in a complex, hands-on operating system. To this, Laney and LBNL have added another category of instructional tool, computer-based simulators that could also immerse students in progressively more complex problem-solving scenarios from components to systems, and emphasizing skills in the area of fault diagnostics and remediation (Haves 1997; 1991).[8] In addition, the team began to explore a strategy using field analysis of data and operating equipment to further immerse students in real-world problems and issues.

Focus Group, participants provided positive feedback on the proposed strategy of adopting a diversity of approaches to teaching, with a blend of laboratory, simulation, and real-world problem solving. These included in-field work such as internships with actual practitioners, teaching proficiency in computer tools (e.g., controls programming and energy analysis software), and the use of "flight simulator" types of tools that would give students the ability to diagnose and troubleshoot progressively more complex problems. Team learning was suggested as a way to reinforce systems-level thinking. Many participants suggested that practitioners be brought into the classroom, and quite a few volunteered to collaborate with us in this fashion as well as in providing internship opportunities.

Follow-on Commitments

At the close of the Focus Group session, participants were invited to indicate ways in which they were willing to continue work with the project. Nine options were offered, and, as shown in the Supplemental Documentation Section, 27 of the 39 participants (excluding Peralta and LBNL team members) selected at least one, for a total of 86 distinct commitments (Table 1). The individuals are listed in Appendix C, which identifies the diverse group that has agreed to serve on a 17-person Project Advisory Committee.

[8] The proposed simulator—for commercial building systems—will be built using the SPARK engine; see http://www.eere.energy.gov/buildings/tools_directory/software/spark.htm. An existing simulator for residential buildings, the Home Energy Saver, is being used for high-school education (see http://EnergizedLearning.lbl.gov).

Table 1. Indications of participant interest in continued involvement.

Summary of Follow-on Comittments Made at Focus Group Meeting	Number of Participants
Serving on an Advisory Board associated with this project: curriculum/content, industry outreach; instructional methods (twice per year, or as needed).	17
Donating equipment, software, or instruments to the teaching laboratory.	5
Being a guest speaker in one of the courses.	16
Hosting interns who are enrolled in the Laney program.	7
Assisting with review and critique of draft teaching materials.	14
Hosting instructional field trips or other field opportunities for student learning.	5
High school program development.	8
Participating as an adjunct faculty member to teach a specialized advanced course.	5
Other: (contributing data for student analysis, establish concurrent high school program, possible co-funding).	9
Total Commitments	86

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DETAILED NOTES

Opening Comments

We're thinking about the next generation of scientists and engineers and looking for a seamless integration of research, technology and education. This has been done at the graduate level. This project is new: a partnership with the community colleges on a specific agenda – the Environmental Control Technology program at Laney College.

Presentation of the Proposed Curriculum and Key Questions for Participants

Students usually study for two semesters to complete the core curriculum and basic certificate. But there are also continuing education students, workers returning for further training and skill enhancement. The returning students have different needs.

There are differences in the required courses for each area. Questions that the participants can help us with today:

- What do students need to be successful at a particular job?
- Are all these courses necessary?
- Do courses need to be added?
- How can we best teach the skills needed to perform well in these jobs?
- Does the curriculum satisfy the needs?
- If not, how can we improve it?

Results of Breakout A. Opportunities/Trends (next five years)

Shift from mechanical to electronic systems
Increased importance and complexity of control systems
Increased skills needed
Need for equipment programming skills: programming controllers for installation, maintenance, and troubleshooting
Logic behind electronic control systemms
System complexity
Computer networking
Technology development
Reducing operating costs and failures
Drivers:

- Energy costs increasing
- Environmental Initiatives (e.g. LEED)
- Time-of use pricing
- Utility energy efficiency programs
- Increasing mandates for performance verification
- Government programs
- Growing concerns about moisture, mold, indoor air quality
- Rising standards for equipment reliability
- Equipment failures and process interruptions are becoming increasingly costly
- New/existing building commissioning
- CHIPS program
- Retro-commissioning for energy savings
- Performance verification
- Growing needs in high-tech facilities (labs, cleanrooms, data centers)

A parallel path should involve educating the consumers (building Owners) that the people that operate and maintain there building need to have this skill set and need to be compensated accordingly. There may need to be some sort of parallel marketing type program that targets that issue. Otherwise, we will generate graduates with the necessary skill set who will not be able to find people willing to compensate them at a level commensurate with their education.

Key Skills Needed
"Lifelong Learning"
  literacy; numeracy
  written and verbal communication
  problem solving
  stepwise/critical thinking
  people skills
Computers: programming, systems, troubleshooting
Computer networks
Diagnostics
- Component level
- Systems level

Cross-training
Energy auditing
Commissioning
Duct sealing
Logic of electronics
Logic of computers
Life-cycle analysis
Theory of refrigeration
Foundations of the temperature-pressure relationship
Basic thermodynamics
Understand systems; control architecture; control logic
How to measure; field measurement
How to report the data
How to utilize the data
Computer networking
How to use economic tools
Quantification of benefits: energy, indoor air quality; system operationg, reduced maintenance
HVAC tune-ups for improved performance
Controls: sequence of operations

Results from Breakout B: Comments on Curriculum:
(All tables submitted additional specific suggestions for changes on the matrices)

<u>Table 1: Transportation Refrigeration Techs</u>
<u>Commercial Refrigeration Techs; High School Education</u>
- Fundamentals of Energy Management Course should be recommended rather than required.
- DDC Controls course shouldn't be required.
- Add a required refrigeration/AC Tech course.
- The High Tech Facilities course should be required.
- New strand for residential HVAC&R techs
- Computer networking
- New course in ultra-low refrigeration
- Eutectics (for transport and marine refrigeration)
- Interesting concepts for high-school course
    - Phase-change materials for refrigeration
    - Temperature-pressure laws and science of refrig

<u>Table 2: Commissioning Techs</u>
- There should be an orientation and an overview course ("Introduction to Facilities Management", or "Chief Engineer"), career opportunities, introduction to economic tools, interacting with management, managing staff. Skills/aptitude assessment to help students pick right strand.
- Add Commissioning I to the core – everyone should have basic knowledge of this
- Soldering class may not be necessary as a requirement.

- HVAC and electrical systems and operations courses
- Cost-Benefit Analysis should be taught.
- Emphasize safety and how systems work together.
- Students should be taught analytical and decision-making skills.
- The Commissioning II class should include communication skills, documentation, developing test procedures, use of trend logs, field testing, and use of web tools.
- Maybe statistics should be taught?
- Add an advanced measurement class
- DDC II should include comparative DDC systems
- Add cogeneration to the renewables class: rename "On-Site Power Generation"

Table 3: Controls Techs

- Switch Controls 1 and 2 – Controls 1 should cover what's in advanced programming and controls 2 should cover what's in basic programming. Students should be exposed to the basics in DDC 1, and DDC 2 should be more inclusive.
- Proper installation of wiring and programming should be taught in DDC 1. BACNET should be taught in DDC II
- Add a course (or course content) on networking.
- Controls techs need basic HVAC education. Often trained in-house today with an excessively superficial coverage of HVAC. This is the root of many of the problems we are trying to address.
- Consider what we expect from Controls Techs. They need more required courses.

Table 4: Residential and Light Commercial HVAC Techs
Commercial and Industrial HVAC Techs

- Change HVAC System Design course to recommended for residential.
- Add a basic business skills course (writing proposals, engineering, economics, people skills, communication skills, interviewing).
- Teach design intent documentation
- Major role for simulation
- Duct systems
- Troubleshooting of drives
- Diagnostics
- Electrical demand management
- Understand rate structures; Time-of-use pricing (issues/opportunities)
- Building science

Table 5: Building Maintenance Techs and Building Operators

- There should be a lighting course.
- Economic data and reporting should be taught.
- Courses should cover interpersonal skills
- Fundamentals of Energy Management should be deeper (at least 2 units, rather than 1; plus a lab).

Notes Relevant to High School Education

- Existing high school teachers don't always have the passion, experience, or time to do this – need to bring outside professionals to help with teaching.
- Big need for "marketing" this material to students. It is not perceived "sexy" in comparision to hi-tech jobs, etc. Prospective students are not aware of the field and that there are real and interesting jobs there. Have in-class visits from experts and graduates.
- Create 5-minute recruitment videos for each strand, e.g. "A Day in the Life of A Commissioning Tech."
- Important to begin teaching workplace etiquite, style, skills, etc.
- Partner with Chabot Space and Science Center (4:30 – 6:30 course, available to all students in the Oakland Unified School District. In this case, it could be held at Laney in their new HVAC Lab. Target 11^{th} and 12^{th} graders.
- Regional Occupation Program (Crabtree facilitiates)

- Creating a concurrent enrollment option (between High School and Community College) would be a big draw

Additional Comments During Group Discussion

- Consider making Core required of all students (common foundation). Perhaps two-levels of "Core", with just the first universally required.
- A course on being a professional would be helpful: etiquette, business practices, etc.
- Could Controls Tech training be absorbed into other tracks?
- What about a Management Facility Engineer Tech? Training for this position would require technical and business management skills.
- How could we market this program at the community college?
- Are there too many specific tracks?
- Need to work on the basic skills/prerequisites that students need (math, etc)
- Explore linking with trade certification (may be a big plus for future employers), e.g. Refrigeration service engineers society, Air conditioning and refrigeration institute, and North American Technician Excellence, Inc. Refrigeration Service Engineers Society
- Add course or course content on construction practices - Overview of the construction process, what's going on construction managers, Owner interface with the process including design review and construction observation, what you have to deal with if a construction project occurs on or around your site including unexpected outages, extra dust and dirt, diesel exhaust fumes, settling due to excavation next to your site, run-off, etc.
- Introduction to Energy Efficiency course: suggested topics
    - Big picture: why care?
    - Economics of efficient energy uuse
    - Range of available efficient technologies
    - Operations versus hardware vs controls: systems/components
    - Information resources (internet)
    - Useful software tools
    - Energy monitoring and data analysis
    - Quality assurance; commissioning
    - Energy-related codes and standards
    - Energy audits

- Matrix Suggestions:
    - Are the "hours" shown per week, per month? Clarify.
    - Fill in missing numbers of class/lab units
    - Add footnote: "1 unit = 36 hours/semester" (or proper def'n)
    - Put a note that the one-unit courses are also suitable for continuing education

Results from Breakout C: Learning Strategies

- Three complementary aspects
    - Fundamentals (lecture format)
    - Applied Skills (lab or field experience)
    - Context (practitioner presentations on how the field and business work)
- Balance teaching the fundamentals with lab or field-based experience – one suggestion was 20% lecture/academics and 80% hands-on work (for example, in configuring controls). Use the textbook first and then problem-solve according to what was learned.
- Use real-world problems from organizations for students to diagnose.
- Place learning material in context – recruit professionals with expertise to speak in the classroom. Make sure students learn what it's like to be in the profession. Also, workers could teach classes.
- <u>Show</u> the process of troubleshooting – a worker could record his/her experience at a site. Emphasize learning from mistakes made in real situations. Enable students to observe/follow a professional in the field. Short video features could be a great way to do this. Could be viewed on the web.
- Mentoring/job shadowing
- Students from different tracks could assemble a project, each using skills from their areas.

- Look into concurrent enrollment for high school students
- UC a-g certification may be too much at this point – it may work out, it may not, but it shouldn't be the focus.
- Use simulation tools (for example, HVAC components of a building: refrigeration, boiler system, air). Simulate actual problems and troubleshooting approaches. Address improperly designed systems and how to deal with sub-optimal circumstances.
- Use real buildings on campus or elsewhere in the community as "living laboratories"
- Teach software tools: design intent, benchmarking, energy analysis, drafting, …Look into ones available from manufacturers (Johnson Controls; White Rodgers)
- Incorporate the problems workers encounter when systems are not properly designed. What are some coping methods for this problem? How can workers modify or compensate for what doesn't work? Students need to know some ways to handle this.
- Students could analyze the economic aspects of a system to determine the benefits of repairing it.
- Make sure students learn about the whole building as a system, not just their specific area. (i.e., residential HVAC techs need to know when a problem goes beyond the HVAC area – if they don't have an overview of the whole building, they may not be able to solve the problem. Example of Clorox building and the curtains.)
- Environmentally sustainable buildings should figure into the curriculum
- Team Learning: have multiple student strands work together on problems.
- There are some parallels between the training for building operations and community college training for an A&P license. According to one participant, many of the best building operators come from aviation backgrounds or out of the Navy. If cross trained, they would have a lot of flexibility regarding employment and dealing with the ups and downs of the aviation industry.

Wrap-Up Comments

<u>Considerations</u>

- Can CEC help to fund this program?
- About 25-32 students a year get certificates from the Environmental Control Technology program. Many more people take a few courses and get jobs right away ("jobbing out")
- Think about a pre-college program.
- Would federal agencies be interested in the program? Navy journeymen could take courses.
- What else could we do to foster this type of program for other schools? Are there funds for this?
- Unions (problems/opportunities)
    - Need to make linkages/partnerships
    - Barriers, e.g. non recognition of non-union apprenticeships
    - The federal government must use union workers; barrier to internships from community colleges.
    - Possible Union/Navy/Community College partnerships?

<u>Final Comments on Curriculum and Teaching Methods</u>

- Strands differentiate the pathways, but they can be changed.
- The Tech course could be the same for HVAC, Controls, and Commissioning.
- Over-specialization can be a problem. The matrix can be simplified.
- Different topics should be combined, but Basic and Advanced should be clearly delineated: basic requirements for basic certificate and entry level positions, more advanced for higher certificates and higher job levels. Students have the option of taking the basic and returning later to take more advanced courses.
- A core program and an advanced core program may be desirable, depending on the jobs. More specialized advanced courses could be geared towards different jobs. Can we offer a basic certificate and an advanced certificate? (Certificate Level A and Certificate Level B?)
- Systems Information instruction is needed in the core, but a lot more practical information is needed in the advanced core.

- Consider the role of simulations. Additional software could make systems visible to students when real equipment isn't feasible or accessible. A web-based visualization tool could be useful. There are some simulation programs available, for refrigeration techs, for example, but these are mostly for parts rather than whole systems.
- Think of a simulator as a tool that can be used at all levels, even high school. It can be used superficially or on a deeper level throughout the entire program. A simulator could be designed on a basic level and then deepened along pathways to become more complex. We could limit the scope at each level. Is it possible to incorporate some simulation and some real equipment all the way through the program? Students need to know 1) that there's complexity and 2) that they can think about the real world through simulation.
- Curriculum design should support continuing education for existing professionals, as well as return of graduates of the simpler degree/certification strands for more in-depth training.

Appendix A. Environmental Control Technology Industry Education Initiative

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September 5, 2003
Oakland International Airport Hilton, Empire Room
10 am to 1 pm

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Appendix B

ENVIRONMENTAL CONTROL TECHNOLOGY: Laney College
Draft Course Outlines

ECT-210 BASIC ENVIRONMENTAL CONTROL TECHNOLOGY

This course will introduce the students to the rapidly changing field of environmental control technology for buildings, job opportunities, sub-specializations, and the broader context for the field (e.g. energy and environmental benefits from improved building operation). Technical content includes basic refrigeration systems and components, such as compressors, condensers, evaporators, and metering devices and accessories. Students will learn to analyze refrigeration systems, thermodynamic properties of the refrigerants, heat transfer, system design and its operation, heat load calculation, and a detailed system investigation of building components. Students will learn the different methods of charging, recovering, vacuuming systems, and also learn brazing, soldering, and bending with different types of materials. Students will also learn to properly identify the different types of materials, methods, and tools used in assembling refrigeration systems in the industry. This course will also cover safety, EPA laws and regulations for proper and safe handling of refrigerants, combustible gases, lubricants, and equipment.

Students will be able to:

1. Describe the fundamental rationale for evaluating and improving building environmental control.
2. Explain the basic physical, chemical and engineering principles of refrigeration.
3. Define basic refrigeration terms.
4. Explain the principles of heat transfer.
5. Demonstrate proper refrigerant recovery, evacuation and charging procedures.
6. Describe the basic refrigeration cycle and its components.
7. Design a simple refrigeration system including its basic components.
8. Explain the physical laws, which apply to refrigeration.
9. Identify the different types of pipes and fittings use in the industry.
10. Demonstrate proper procedures of banding, brazing and soldering.
11. Demonstrate proper and safe use of tools, equipment and the handling of refrigerants.

ECT-010 RESIDENTIAL AND LIGHT COMMERCIAL TROUBLESHOOTING

This course will introduce the students to practical applications of residential and commercial air conditioning and refrigeration systems, such as, installing, diagnosing, maintaining and repairing system components. This course will also cover the theory of controls and their applications, enabling students to understand and properly identify the types of systems required to control temperature, pressure, humidity, air-circulation, and defrost procedures. Emphasis will be placed on analyzing existing systems, and identifying and correcting faults.

Students will be able to:

1. Identify, test, replace, repair and describe the functions of all components.
2. Demonstrate a thorough understanding of all mechanical components.
3. Demonstrate a working knowledge of such components as compressor, condenser, evaporator, metering devices and accessories.
4. Identify types of mechanical and electrical controls and their use.
5. Recognize and correct installation errors and service problems.
6. Demonstrate thorough understanding of troubleshooting controls as they relate to the operation of refrigeration and air conditioning systems.

ECT-011 MECHANICAL AND ELECTRICAL DEVICES

This course will introduce the students to the fundamentals of electricity and electronics, as applied to building operations. It will cover Ohm's law, power, basic electrical AC and DC circuits, electrical materials, electrical and electronic devices, and programmable controls, and also cover electrical wiring diagrams, sequence of operation of a system and troubleshooting procedures on mechanical, electrical, and electronic devices. In this course we will cover the instruments and tools used in the industry, such as Voltmeters, Ammeters, Ohmmeters, and electrical safety procedures.

Students will be able to:

1. Identify, test, replace, repair and describe the functions of all electrical and electronic components.

2. Demonstrate a good working knowledge of working safely with high and low voltage.
3. Demonstrate troubleshooting procedures and the use of instruments.
4. Identify the different types of transformers and motors.
5. Explain the basic concepts of electricity and Ohm's low.
6. Describe the relevant sequence of operation of the system.
7. Demonstrate the ability to interpret electrical diagrams.
8. Exhibit familiarity with energy management and efficiency.
9. Demonstrate a thorough understanding of electrical safety procedures.

ECT-221 PRICIPLES AND PRACTICES OF E.C.T

Building on ECT-210, this course will introduce students to more complex and detailed methods of investigating system component requirements, such as pressure-enthalpy diagram and its use. It will also introduce students to heat pumps, ice machines, water coolers, low temperature defrost methods, evaporative condensers, capacity controls, multistage systems, programmable controls and devises, such as (VFD) variable frequency drives, (VAV) variable air volume and wiring of control system components.

Students will be able to:

1. Explain how evaporation provides a cooling affect and identify the basic mechanical refrigeration system.
2. Explain various applications for mechanical and electrical systems.
3. Describe the operation of various mechanical and electrical systems.
4. Explain the refrigeration systems used in ice machines and water coolers.
5. Perform basic related keyboarding and computer operation skills.
6. Describe how (VFDs) work and how they control the speed of a motor.
7. Describe the function of the (VAV) box and its purpose.

ECT- 222 SPECIAL PROCESS AND DEVICES

This course will introduce the students to the practical applications of building systems and contemporary methods of maintaining, diagnosing and repairing heating and air conditioning systems, ignition systems, humidifiers, dehumidifiers, economizers, filtering systems. Students will also be introduced to hydronic systems, such as chillers, boilers, cooling towers and water pumps and introduced to testing and balancing of air and water systems. This course will also introduce students to basic concepts of energy management and energy efficiency.

Students will be able to:

1. Identify, test, replace and repair Heating and Air Conditioning equipment.
2. Describe the function of all components in specialized refrigeration applications.
3. Explain the different mechanical and electrical components found in specialized environmental systems.
4. Explain various strategies in Energy Management.
5. Troubleshoot different types of ignition systems.
6. Perform required maintenance, service, and repairs for optimal system efficiency.
7. Exhibit good skills in record keeping and data logging.
8. Demonstrate basic knowledge of hydronic systems.
9. Demonstrate knowledge of proper use of diagnostic tools and instruments.

ECT-020 HVAC PRICIPLES AND PRACTICES

This course will introduce the students to the properties and treatment of air and water, Psychrometric chart, ventilation, filtering, air distribution and diffusion. It will also introduce the type of systems and their application, heat gain determination, load calculation and equipment selection and cover electric, pneumatic and electronic control systems and system components. It will also cover basic commissioning procedures and applications and expose them to different energy measuring software tools such as Cal Arch, Edge Plat, Ez-Sim and others.

Students will be able to:

1. Calculate the psychrometric properties of air, filtering, ventilation, distribution of air, heating and cooling load for equipment selection.
2. Demonstrate the skills necessary to troubleshoot electrical, pneumatic and electronic control system.

3. Using the psychrometric chart as a tool for evaluating thermal comfort conditions and troubleshooting systems.
4. Demonstrate proficiency in the electrical and mechanical aspects of Air Conditioning and Refrigeration.
5. Understand the commissioning process and its benefits.
6. Use different software tools to measure and analyze HVAC energy use.

FUNDAMENTALS OF ENERGY MANAGEMENT & EFFICIENCY

This course provides students with necessary knowledge and information on the main technical and economic operating principles of devices and appliances that are in common use and information on which to make cost-effective decisions in selecting the most energy efficient and economical choice. These devices are day-to-day appliances such as refrigerators, stoves, ovens, washers, driers, and heating, cooling and etc. This course also will cover mechanical equipment, insulation of walls and attic, doors, windows, lighting, solar systems, water heaters and air conditioning principles.

Students will be able to:

1. Discuss voluntary and mandatory state and national policies pertaining to residential and commercial energy usage.
2. Demonstrate the necessary knowledge and techniques for selecting the most efficient appliances and equipment.
3. Define heat energy, and calculate conduction and infiltration heat loss/gain.
4. Describe common locations of conduction and infiltration energy loss.
5. Describe construction methods and materials and its affect on heat flow.
6. Evaluate proper sizing of HVAC equipment, and its effect on energy use and first cost.
7. Describe various types of solar and water heating systems.
8. Perform a home or building energy usage analysis using blueprints and on-site information.
9. Describe the role of the energy auditor, the audit process, and motivate people to take action.
10. Perform computer modeling of commercial and residential energy-efficiency options.
11. Analyze utility bills and sub-metered energy end-use data
12. Conduct cost-benefit analysis of energy-efficiency improvements

ELECTRICITY AND INSTRUMENTATION:

This course will provide more in-depth study on buildings-related topics such as the structure of matter, behavior of electrons and magnetism. Students will be able to identify the fundamental parts of commercial/industrial power distribution systems and understand how power is delivered to commercial HVAC system components. Students will be able to calculate air-conditioning (AC) power from common electrical measurements and apply power measurements to problem diagnosis and determining energy efficiency.

Students will be able to:

1. Understand basic AC power concepts, such as phase angle and power factor.
2. Read and understand single line power distribution diagrams.
3. Wire Y and Delta connections, step up and step down applications.
4. Use proper instruments for diagnosing electrical problems.
5. Display safe wiring practices including the concepts of grounding.
6. Demonstrate electrical safety, including the use of PPE and first aid.
7. Read and draw electrical schematic and pictorial diagrams.
8. Identify motor starters and over-current protection.

BRAZING AND SOLDERING
This course will introduce students to the theory and practice of brazing and soldering, and the science of joining metals. The course will concentrate on hands-on projects. It will introduce the use of different types of filler materials, and brazing and soldering techniques. The course will concentrate on application of the joining concepts through laboratory exercises.
Students will be able to:
1. Describe the process principles, definitions, and factors controlling the properties of brazing and soldering.
2. Demonstrate safe practices related to brazing and soldering processes.
3. Demonstrate torch brazing and soldering techniques and discuss safe applications.
4. Describe the correct applications for copper/copper and copper/steel and brass.
5. Select appropriate brazing and soldering and filler materials.
6. Demonstrate skills of metal surface preparation and proper use of fluxes.
7. Test their work by using visual inspections and leak detection methods.

MOTORS AND DRIVES
This course will introduce the students to types of motors and drives used in commercial and industrial air conditioning and refrigeration applications. It will introduce students to the different applications, including variable-frequency drives for improved control and energy savings. It will also introduce the students of the program configuration of drives.
Students will be able to:
1. Identify the different types motors and their applications.
2. Identify the different types of drives and their uses.
3. Describe the various contactors and starters.
4. Utilize proper instrumentation to troubleshoot motors.
5. Perform maintenance and adjustments to direct- and belt-driven motors.
6. Explain the difference between the single-phase and three-phase motors.
7. Describe the function of the (VFD) Variable Frequency Drive and its application.
8. Demonstrate the ability to program the various parameters in a VFD.
9. Demonstrate the necessary safety procedures when working with motors.

BLUE PRINT READING AND INTERPRETATION
This course will introduce students to basic techniques for reading and interpreting typical design documents, drawings, and specifications. Emphasis will be given to interpreting mechanical and electrical drawings. The course will also cover the concepts of control diagrams and sequence of operation documentation. Architectural features will be explained in sufficient detail to allow the students to understand building orientation, significant building details, building exposures and the relative location of spaces within the building.
Students will be able to:
1. Identify the basic type of HVAC system by reading the design documents.
2. Determine the extent and location of HVAC zones.
3. Identify elements located within the title book of a detailed drawing.
4. Identify piping-system components shown in a single-line drawing.
5. List some principle applications of a ladder diagram.
6. Determine and locate the equipment that controls each zone.
7. Determine the location of equipment within a structure.

PSYCHROMETRICS AND LOAD CALCULATIONS
This course covers the study of physical properties of air essential to the understanding of air conditioning. Understanding the properties of air is a prerequisite to Psychrometry, which is the science dealing with the physical changes within an Air Conditioning system and the implications for occupant comfort.
Students will be able to:
1. Define Psychrometrics.
2. Define the terms dry-bulb temperature, relative humidity, specific humidity or grains of moisture, and dew point.
3. Identify the lines and scales representing these terms on the psychrometric chart.

4. Use the psychrometric chart to determine the condition of air and occupant comfort conditions.
5. Use instruments such sling psychrometer and air flow meters to gather relevant data.
6. Explain the relationship of specific volume to air density and how this affects fan and fan motor sizing.
7. Describe the variations in the solar heat load through glass areas of a building in relation to the time of day.
8. Identify heat sources that affect the cooling load.
9. Identify heat losses that affect the heating load.

HVAC SYSTEM DESIGN
This course will introduce the students to the various types of air conditioning systems, and system controls. Students will focus on the equipment and systems that perform HVAC processes. The three principal ASHRAE HVAC systems will be covered, all-air systems, all-water systems and air-water systems. Students will also be introduced to basics design principles and will use this knowledge to properly select equipment, for small commercial and residential systems.
Students will be able to:

1. Recognize the components and functions of air conditioning systems, including boilers, chillers, cooling towers and their associated controls.
2. Understand how hydronic sub-system works, including the basic principles of pumping, flow balancing and control.
3. Demonstrate the ability to properly select and size ducts and piping systems.
4. Demonstrate the ability to design a small light commercial system.
5. Explain, in some detail, the various methods for implementing an all-air system, including all of the single duct variations.
6. Identify the various methods for zone temperature control.

MECHANICAL AND ELECTRICAL CODES
This course will provide a general introduction to codes, regulations and standards that govern the design, installation and operation of Air Conditioning, Heating and Ventilation systems. Students will develop an understanding of the code making process from the development of a model code through its adoption and enforcement by local building authority. This course emphasizes the general awareness of codes and the content of codes, but will also major codes in more detail.
Students will be able to:

1. Understand code application and enforcement mechanisms.
2. Identify the more prevalent codes that affect the design and operation of the environmental control system.
3. Identify common model codes and standards from organizations such as ICBO, NFPA, and ANSI.
4. Describe which codes are applicable in California.
5. Demonstrate a good understanding of the general structure and content of these codes.
6. Understand code application and enforcement mechanism.
7. Explain the code making process and the process of periodic code updates.

DIRECT DIGITAL CONTROLS (DDC) I -- Fundamentals of Direct Digital Controls
This course will cover the introduction of direct digital control systems and building automation systems. We will overview the various approaches to system architecture, hardware, software, and system components. This will be accomplished through presentation, demonstration, classroom instruction, and hands-on lab work.
Students will be able to:

1. Explain the fundamentals of the digital control.
2. Explain control system terminology.
3. Utilize direct digital controls application strategies.
4. Demonstrate the ability to interface digital controls with conventional control devices.
5. Demonstrate the ability to maintain and troubleshoot direct digital control systems.
6. Discuss proportional and proportional plus integral differences.
7. Identify energy management features and methods of control.
8. **Read and interpret a control software output.**

DIRECT DIGITAL CONTROLS (DDC) II -Advanced Direct Digital Controls

This course will introduce students to the advanced concepts and operation of DDC controls. We will cover input and output (IO) devices, and programming strategies for DDC systems, translating sequence of operation documents for an HVAC control system into an operations program for a DDC system, and interpreting the control specifications for generation and commissioning of a DDC system. We will also cover how to convert a sequence of operations for an HVAC systems into a viable DDC specification, and how to ensure the proper installation and debugging of the system through a comprehensive commissioning procedure.

Students will be able to:

1. Demonstrate the proper installation, wiring, and programming of a building control system.
2. Generate proper documentation for DDC systems.
3. Demonstrate necessary skills for troubleshooting both hardware and software problems.
4. Demonstrate necessary calibration procedures for input and output devices.
5. Read and write sequence of operations for HVAC systems.
6. Create comprehensive commissioning test procedures for testing control systems.

TESTING, ADJUSTING, AND BALANCING BUILDING ENVIRONMENTAL SYSTEMS

This course will provide a basic overview of various procedures for testing, adjusting and balancing building environmental systems. Will also cover the review related issues of building architecture, system components, testing procedures, and testing equipment.

Students will be able to:

1. Demonstrate knowledge of testing, adjusting and balancing.
2. Describe mechanical system fundamentals and testing procedures.
3. Demonstrate electrical system fundamentals and testing procedures.
4. Explain procedures in testing, adjusting and the balancing terminologies.
5. Exhibit basic knowledge of building control systems.
6. Collect and read relevant engineering data, tables and charts.

COMMISSIONING I: Fundamentals of Building Commissioning

This course will cover the fundamentals of commissioning mechanical and electrical building systems. Coverage includes a comprehensive review of building equipment such as boilers, chillers, air handlers, fans, pumps, variable frequency drives, variable air volume boxes, building automation controls, and electrical controls.

Students will be able to:

1. Explain the process of building commissioning, with distinctions between new and existing buildings.
2. Describe the building system fundamentals.
3. Explain commissioning terminologies.
4. Utilize the direct digital controls and energy management systems for commissioning.

COMMISSIONING II: Building System Commissioning

Expanding on Commissioning I, this course will cover the building commissioning process from the conceptual design, through the construction process, acceptance testing, to the training of maintenance and operation staff. Information on different commissioning approaches, cost and benefits of commissioning, developing commissioning plans, guide specifications, and creating forms for specifying and executing the commissioning process will be covered in detail.

Students will be able to:

1. Identify the key components of the commissioning process.
2. Develop a commissioning plan.
3. Develop commissioning guide specifications and forms.
4. Create appropriate test procedures and data collection protocols..
5. Ensure operation and maintenance documentation is complete.
6. Ensure operation and maintenance staff is adequately trained.

INTRODUCTION TO COMPUTER INFORMATION SYSTEMS AND APPLICATION SOFTWARE

This course will introduce students to the general nature of computer hardware, software, and systems, with emphasis on practical applications in the building environmental control arena. Emphasis will be on hands-on applications including introduction to word processing, spreadsheet analysis, database management and presentation software, and a brief introduction to web browsing and e-mail.

Students will be able to:

1. Use at basic Microsoft Windows operations for the IBM PC (examples: find start file, and folder creation, etc.).
2. Use and demonstrate proficiency in applications software for word processing, spreadsheet analysis, database and presentations, as well as web browsing and basics of e-mail by performing the operations specified:

For Word Processing, Spreadsheets, Databases, Presentations:

1. Load any application software from a disc.
2. Create and save a file onto a disk.
3. Reload and modify the file from a disk.
4. Print the file.
5. Exit from the application and return to the operating system.

For Web browsing software:

1. Load a Web browser and find a specific URL (web address).
2. Follow a web-link from a web address and return to Home again.
3. Read and send e-mail from a web browser. Master (demonstrate proficiency) in the following generic operations regardless of application: Searching; Downloading files; completing forms, emailing file attachments.

INTRODUCTION TO BUILDING ENERGY MANAGEMENT AND CONTROL SYSTEMS (EMCS)

This course will introduce students to the different types of EMCS, energy management components, their purpose and benefits, processing algorithms, and implementing energy strategies using Computers. It will also cover Residential and Light Commercial Components and Commercial and Industrial applications.

Students will be able to:

1. Explain the purpose and benefits of energy management systems.
2. Explain how computers and related equipment and software are used to implement energy management strategies.
3. Explain the common terms used in computer controlled systems.
4. Identify the components of a selected energy management system and describe their relationship.
5. Identify the processing algorithms used to control HVAC equipment.
6. Identify the components and describe the operation of an energy management system used in residential and commercial application.
7. Identify the components and describe the operation of an energy management system used in large commercial applications.

BUILDING ENVELOPE AND INDOOR AIR QUALITY

This course will introduce the students to indoor air quality issues and associated problems faced by workers and managers. It will also cover the building envelope and the maintenance of building ventilation systems.

Students will be able to:

1. Explain the need for good indoor air quality.
2. Identify the symptoms of poor indoor air quality.
3. Explain how to inspect and evaluate a building’s structure and equipment for potential causes of poor indoor air quality.
4. Identify the HVAC equipment and accessories that are used to sense, control, and enhance indoor air quality.
5. Explain how to use selected test instruments to measure or monitor the quality of indoor air.
6. Describe the general procedures used to clean the ducts and HVAC systems.
7. Describe the proper procedures used for changing filters.

DISTRIBUTED ENERGY SYSTEMS

This course will introduce students to the application of building-located power sources and energy storage techniques. Classroom lecture and laboratory exercises will acquaint the students with established and emerging distributed energy systems, such as solar water heating, photovoltaic power generation, cogeneration, and fuel cells and their present and future applications with air conditioning systems. We will also discuss energy storage systems having more immediate applications, such as chilled water storage systems.

Students will be able to:

1. Describe the basic functions of distributed energy systems.
2. Develop rough estimates of the amount of solar energy available at a given site and orientation.
3. Describe the application of passive solar heating system.
4. Explain, in general terms, the economics that control the application of distributed energy systems.
5. Design a small residential solar hot water heating system.
6. Commission and monitor a photovoltaic energy array and battery storage system.

Appendix C

Participants in Focus Group or Subsequent Discussions & Follow-Up Comittments

Last Name	First Name	Title	Affiliation	Serve on Advisory Board	Donating Equipment, software, or instruments to the teaching laboratory	Being a guest speaker in one of the courses	Hosting interns who are enrolled in the Laney program	Assisting with review and critique of draft teaching materials	Hosting instructional field trips or other field opportunities for student learning	High school program development	Participating as an adjunct faculty member to teach a specialized advanced course	Other
Count:		**Count:**	**86**	**17**	**5**	**16**	**7**	**14**	**5**	**8**	**5**	9
Boghosian	Stan	Consultant				x					x	
Breedlove	Bret	Sales Manager	ACCO Air Conditioning Company, Inc	x						x		
Ceniceros	Bruce	Energy Specialist II	California Energy Commission									
Clark	Mark	Regional Manager	Automated Logic		x							
Commins	Tav		California Energy Commission									
Crabtree*	Peter	District Development Officer	Peralta Community College District									
Deringer*	Joe	President	The Derringer Group									
Diamond	Rick	Staff Scientist	USDOE/Lawrence Berkeley National Lab									
Doyle	Patrick	Owner	CPC Technologies									
Elliott	Charles	Project Manager	Ferreira Service Inc. Project Manager									
Ensenat	Eric	Sales Manager	ACCO Engineering Systems									
Finch	Walter		Building Operator and Managers Association (BOMA)	x		x	x	x	x			Promoting the program to BOMA's large membership
Freeman	Llewellyn	Owner	Freeman Heating and Air Conditioning	x	x	x		x				
Frost*	Chuck	Facilities Manager	Laney College & LLNL Facilities									
Gillespie	Ken		PG&E	x		possibly	possibly					
Graciolett	Toni	Chief Engineer	Peralta Community College District	x		x		x	x	possibly		
Gray	David	Owner	New Mechanical and Service	x		x						
Greenberg	Steve		USDOE/Lawrence Berkeley National Lab					x				
Hartshorn	Hadley	Mechanical Engineer	USDOE/Lawrence Livermore National Lab	x		x		x			x	
Haves*	Phil	Staff Scientist	USDOE/Lawrence Berkeley National Lab									
Hogeboom	Steve	Service Manager	Melins Commercial Refrigeration	x		x	x	x		x	x	
Hydeman	Mark		Steve Taylor Engineering		x	x				x		Share field data from controls for student analysis; Donating mechanical design services for Lab
Jump	David		Quantum Consulting/Oakland Energy Partnership	x		x						
Koelle*	Katie	Professional Development Coordinator; Tech Prep	Peralta Community College District									
Koistinen	Dale	School Tour Director	USDOE/Lawrence Berkeley National Lab									
Kyriakopedi*	Nick	Instructor	Laney College									
Laflin	Kirk	Executive Director	PETE					x				Dissemination
Levi	Mark		GSA									
Little	Don	Senior Project Manager	Farnsworth Group	x						x		
Lord Walker	Janice	Teacher on Special Assignment	Secondary Science Education; Oakland Unified School District							x		Implement concurrent program in Oakland School District
Mills*	Evan	Staff Scientist	USDOE/Lawrence Berkeley National Lab									
Morgan	Larry	Manager, Buildign Engineering	Oracle Corporation	x		x		x				Assist with promotion/deployment
Noonan	Katie	Director of Environmental Sciences Academy	Oakland High School									
Otto*	Rollie	Head, Center for Science & Engineering Education	Lawrence Berkeley Lab	x			x	x	x	x		$150k co-funding for articulation and outreach
Parks	John	Air Conditioning Instructor/Program Manager	Fresno City College					x				Test-teaching the curriculum
Parks	Jim	Program Manager, and Energy Efficiency and Customer Research & Development	Sacramento Municipal Utility District			x						
Piette*	Mary Ann	Staff Scientist	USDOE/Lawrence Berkeley National Lab									
Pong	Alan	Project Manager	Ferriera Service, Inc									
Scheving	Patty	Account Manager	Yamas Controls Inc.	x	x	x	x					
Scruton	Chris		California Energy Commission	x				x				Co-sponsorship
Sellars	Dave		PECI, Inc.	x		x		x		x		
Shockman	Chris	Principal	Shockman Consulting									
Tan	Kim	Sales Engineer	Trane Co.		x	x					x	
Welker	Phil		PECI, Inc.									
Wentworth	Scott		City of Oakland	x			x		x			
Wheeler	Adam	P.E.	Sherrill Engineering Inc.	x		x	x	x	x		x	
Yuill	G.K.	Director	Architectural Engineering Program, University of Nebraska					x				Articulation agreement with U. Neb. 4-year program

* Core team member