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Retrofitting the Workforce: Report #1

Commissioning and Retro-Commissioning

Good Company
ASSOCIATES

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This report is designed to offer useful information to Texas' workforce investment boards and community colleges about the availability and potential of green jobs.

Thanks to all members of the Green Jobs Business Council and the Green Corridor Consortium. Particular thanks to all those who gave time and expertise to contribute to the report, listed in Appendix B.

EXECUTIVE SUMMARY

Commissioning is "a systematic process of ensuring that the performance of the facility and its systems meet the specified design intent and operational needs."[1] Retro-commissioning refers to the same process performed on an existing building. (The term commissioning in this report, unless otherwise specified, will refer to both commissioning of new buildings and retro-commissioning of existing buildings.)

The best industry studies of commissioning suggest an industry of over $1 billion annually for new building commissioning[2] and $200 million annually for retro-commissioning nationally[3]. Trends for both are up in recent years.

Demand for commissioning has been driven by a variety of factors. First and foremost, it provides quick paybacks in energy savings: about one year for retro-commissioning and less than five years on average for new buildings, according to the Lawrence Berkeley National Laboratory[4]. Other factors include:

- Leadership in Energy and Environmental Design, or LEED, certification requires some commissioning for new and existing buildings.
- Building codes sometimes include commissioning.
- Utility programs sometimes provide incentives for commissioning.

While the market for commissioning is robust and the trend is up, it is still a small – but significant – fraction of the overall "green retrofit" market[5], which one industry estimate put at $2.1-$3.7 billion annually. The market for commissioning has been constrained by a lack of awareness and several other factors, many of which can be overcome by education and incentives.

Another problem for the commissioning industry is the proliferation of credentials. There are at least seven commissioning certificates offered, with varying degrees of rigor. Building owners are often unsure of what they are getting when they hire someone with a building commissioning credential.

To overcome this problem, we recommend developing a tiered training program as a collaboration between Green Corridor Consortium community colleges and Texas A&M Energy Systems Lab (ESL). ESL

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[1] National Energy Management Institute (NEMI) (2005).
[2] *Ibid.*
[3] Mills, Evan (July 2009). "Building Commissioning: A Golden Opportunity." Lawrence Berkeley National Laboratory. http://cx.lbl.gov/documents/2009-assessment/LBNL-Cx-Cost-Benefit.pdf
[4] *Ibid.*
[5] As defined by McGraw Hill Construction. See Moresco, Justin (October 28, 2009). "US Green Building Retrofit Market to Hit $15 billion by 2014: Report." Earth2Tech.com. http://earth2tech.com/2009/10/23/u-s-green-building-retrofit-market-to-hit-15b-by-2014-report/

has developed an internationally respected brand of commissioning called Continuous Commissioning® (CC)[6]. The program's levels for commissioning training could include:

1. Executive or continuing education for building owners and facility managers.
2. Occupational Certificate program for HVAC technicians.
3. Two-year Associate's degree program for HVAC technicians.
4. Four-year Bachelor's degree and graduate level programs.

While the Bachelor's degree and graduate programs would occur at A&M, it is important to align the certificate and associate's degree programs with the higher degrees to create a seamless path for students who wish to attain higher credentials.

Texas community colleges could also collaborate with Laney Community College in California, which has introductory and advanced courses in building commissioning created in a National Science Foundation (NSF) grant. Laney is also developing courses in advanced controls and has a suite of other related efficiency courses in existence or under development. A deliverable for Laney to the NSF is to share their curriculum with interested institutions.

We also recommend that colleges consider creating a business development and sales module to be integrated into each of the tiers of the educational programs so that certificants/graduates will be able to communicate the benefits of commissioning to potential customers.

Finally, it is important that community colleges reach into high schools, establish dual credit courses and internships so that high school students see a career path in energy efficiency related green jobs. Too many young people only think of solar panels and windmills when they think of green jobs, but there are in fact many more jobs in energy efficiency than in solar or wind.

[6] For definition, see p.8.

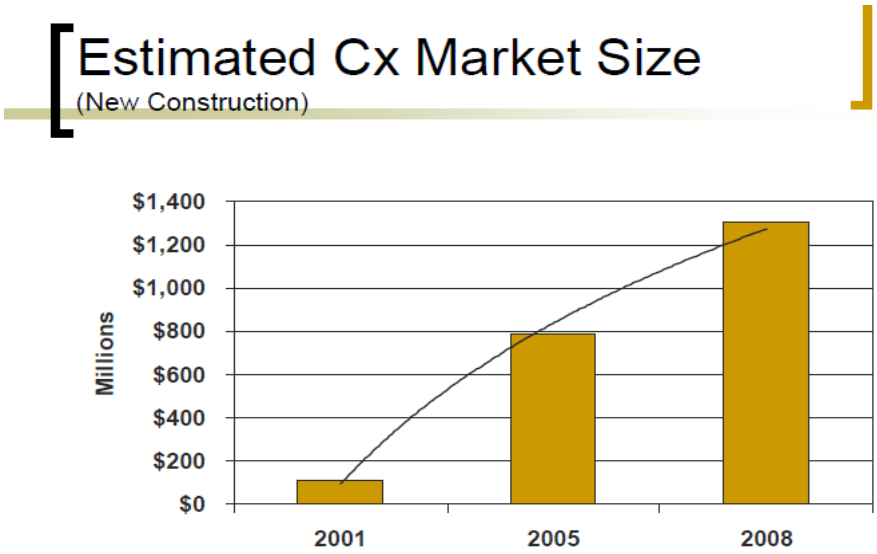
National Market Summary and Trends

Size of the Market and Potential

There is a significant upward trend in the retrofitting and commissioning industries and all signs point to an even steeper upward curve in the near and medium term. Commissioning is "a systematic process of ensuring that the performance of the facility and its systems meet the specified design intent and operational needs."[7] Retro-commissioning refers to the same process performed on an existing building. (The term commissioning in this report, unless otherwise specified, will refer to both commissioning of new buildings and retro-commissioning of existing buildings.) Commissioning "extends through all phases of a construction, renovation, or retrofit project, from concept through occupancy."[8]

The National Energy Management Institute did a market analysis in 2001 and updated it in 2005. Here is what they found:

> Overall, our research indicates significant growth in building commissioning for new construction. In 2001, we estimated the total market (all providers) to be $114 million. **For 2005, we believe this market could be $788 million, a nearly 600% increase over the past four years.** Growth has been driven primarily by greater market awareness, largely due to the success of the LEED certification program and the U.S. Green Building Council. As a result of greater market awareness, survey respondents indicate more than twice the percent of new construction incorporating commissioning. **Over the next three years, we estimate this market will grow by 65% to $1.3 billion.**



[7] National Energy Management Institute (NEMI) (2005).
[8] Welker, Phil. "Phil Welker Commissioning." (Power point by Executive Director of Portland Energy Conservation Institute). http://www.slideshare.net/luigiseta/phil-welker-commissioning

Source: NEMI (2005) (2001 and 2005 figures are actual; 2008 is projected.)

The percentage of commissionable buildings also sharply increased. It's interesting to note that the projections by survey respondents from 2001 were very accurate.

2001 vs. 2005 Survey Results Regarding the Percent of Buildings Commissioned

Sector	2001 Survey Results		2005 Survey Results	
	Commissioned Now (2001)	Commissioned 3 Years from Now (2004)	Commissioned Now (2005)	Commissioned 3 Years from Now (2008)
Commercial	10%	22%	25%	37%
Industrial	13%	25%	26%	33%
Institutional	16%	33%	38%	54%
Multifamily	2%	8%	6%	15%

Those charts reference the new building commissioning arena. It is much harder to arrive at figures for retro-commissioning, though it is a lower current number, and a higher potential, than new building commissioning.[9] The best estimate available of the size of the commissioning industry is from the Lawrence Berkeley National Laboratory (LBNL): "The fledgling existing-buildings commissioning industry has reached a size of about $200 million per year in the United States."[10]

The overall "green building retrofit and renovation"[11] market is enormous. McGraw Hill puts the industry nationwide at between $2.1 and $3.7 billion this year alone, or about 5-9% of the total retrofit market. They project a four-fold increase by 2014, to about $10.1-$15.1 billion, or 20-30%.[12] The McGraw Hill Construction study did not focus on retro-commissioning, but rather focused predominantly on upgrading equipment and building systems. This approach assumes longer payback periods (11% of the building owners surveyed assumed a payback period of longer than 10 years). With

[9] Conversation with Evan Mills, Lawrence Berkeley National Laboratory.
[10] Mills (2009).
[11] As defined in Bernstein, Harvey (October 2009). "Green Building Retrofit & Renovation: Rapidly Expanding Market Opportunities through Existing Buildings." SmartMarket Report. McGraw Hill Construction.
[12] Moresco, Justin (October 28, 2009). US Green Building Retrofit Market to Hit $15 billion by 2014: Report." Earth2Tech.com. http://earth2tech.com/2009/10/23/u-s-green-building-retrofit-market-to-hit-15b-by-2014-report/

some education and marketing, retro-commissioning—with its much quicker paybacks—could potentially be a very large part of this market.

The chart below summarizes the market numbers and projections:

Type of activity	Size of market	Projected Size/Year	Source
New Building Commissioning	$688 million (2005)	$1.3 billion (2008)	NEMI
Retro-Commissioning	$200 million	$4 billion (no time frame)	Berkeley National Lab
Retrofits	$2.1-$3.7 billion	$10.1-$15.1 billion (2014)	McGraw Hill Construction

VALUE PROPOSITION

The Lawrence Livermore National Laboratory estimates that 20% of all energy delivered to buildings is wasted[13], equal to a $78 billion loss annually to the US economy[14], or over $6 billion wasted in Texas alone[15]. If energy prices rise as they are expected to[16], the cost of wasted energy will increase even further and an increased emphasis will be placed on conservation and efficiency.

Commissioning provides the best value for dollars spent on energy efficiency, whether in new buildings or for retrofits. According to the definitive study on commissioning out of the Lawrence Berkeley Laboratory (LBNL): **"Projects with a comprehensive approach to commissioning attained nearly twice the overall median level of savings and five-times the savings of the least-thorough projects."**[17]

The LBNL study aggregated data from 643 commissioned buildings in 26 states. Here is how they described the cost:

> The commissioning projects for which data are available revealed over 10,000 energy-related problems, resulting in 16% median *whole-building* energy savings in existing buildings and 13% in new construction, with payback time of 1.1 years and 4.2 years, respectively. Median benefit-cost ratios of 4.5 and 1.1, and cash-on-cash returns of 91% and 23% were attained for existing and new buildings. High-tech buildings were particularly cost-effective, and saved higher amounts of energy due to their energy-intensiveness.

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[13] http://www.nytimes.com/imagepages/2008/04/06/weekinreview/06revkin.html
[14] Total energy expenditures for buildings was $392 billion in 2006, the last year data was available from the Energy Information Administration. http://buildingsdatabook.eren.doe.gov/docs/xls_pdf/1.2.3.pdf
[15] Figure based on Texas' population proportionate share. Figure is probably too low given Texas' climate.
[16] EIA (March 2009) The EIA forecasts a 15% increase to 2030 in its reference case, 19% in its high growth scenario. http://www.eia.doe.gov/oiaf/aeo/electricity.html
[17] Mills (2009). pg. 1.

Texas A&M's Energy Systems Laboratory (ESL) has achieved similar results. ESL has retro-commissioned over 300 buildings with their Continuous Commissioning® (CC™)[18] process.

> While most commissioning processes focus on bringing building operation to the original design intent, Continuous Commissioning® is different. Continuous Commissioning® (CC®) focuses on optimizing HVAC system operation and control for the existing building conditions...Continuous Commissioning® maintains long-term savings by ongoing monitoring of energy savings with follow-up commissioning, as needed; improves the system reliability and building comfort by optimizing system operation and control schedules based on actual building conditions; upgrades the operating staff's skills by allowing direct participation of O&M staff; and reduces O&M costs.[19]

For retro-commissioning, they report a 2-year payback and 20% energy savings on average[20]. It is possible to build, renovate or retrofit a building without commissioning, but the systematic approach yields significant economic benefits.[21]

Commissioning also holds the most promise for cost-effective means of meeting pollution reduction goals while strengthening the economy. The National Science Foundation estimates that if every building in America were to be retro-commissioned, we would reduce peak load power needs by nearly 2000 megawatts and NOx emissions by 81.9 million pounds. The savings from the peak load reductions alone would total $2.3 billion[22].

Again, according to the LBNL report:

> Thanks to energy savings valued more than the cost of the commissioning process, associated reductions in greenhouse gas emissions come at "negative" cost. In fact, the median cost of conserved carbon is *negative*— -$110/ton for existing buildings and -$25/ton for new construction—as compared with market prices for carbon trading and offsets in the +$10 to+$30/ton range.

Stated more clearly, commissioning reduces emissions *and returns money* to the owner of the building[23]. This is shown graphically on the next page in the McKinsey "carbon abatement cost curve." The items on the left side represent carbon reductions which result in negative cost: the further below

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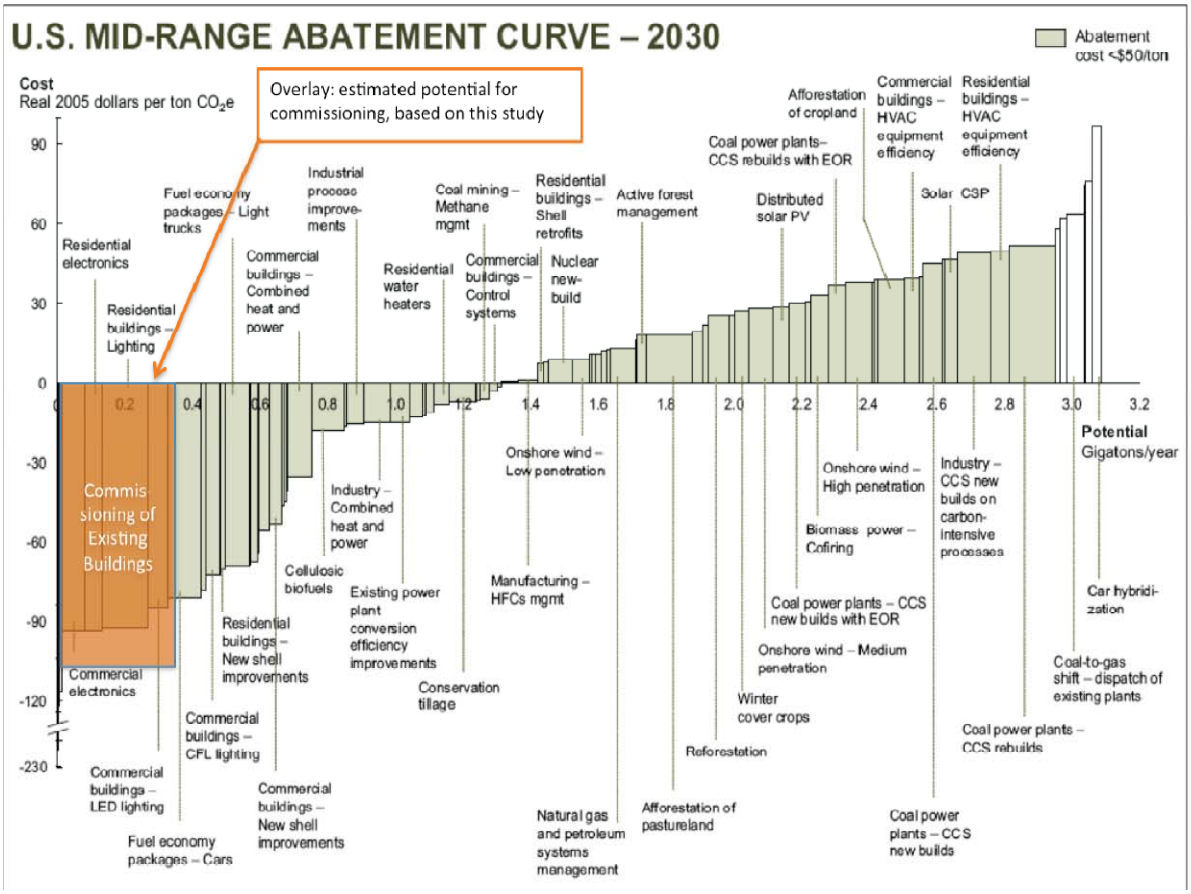
[18] Texas A&"M and Texas Engineering and Experiment Station have trademarked the term Continuous Commissioning to ensure uniform meaning of the term.
[19] Liu, Mingsheng, et al. (2002). Continuous Commissioning Guidebook for Federal Energy Managers. US Department of Energy.
[20] http://esl.eslwin.tamu.edu/continuous-commissioning-.html
[21] *Ibid*.
[22] http://cbpd.arc.cmu.edu/ebids/pages/strategy.aspx?group=2&strategy=5#eassociated
NSF/ IUCRC Center for Building Performance and Diagnostics,
Carnegie Mellon University Advanced Building Systems Integration Consortium
[23] Renters might also see savings from lower energy bills if the building uses sub-metering.

the zero line, the greater the return to the economy (and the building owner in this case); the wider the bar, the bigger the carbon reduction. Note the orange box overlaid on top of McKinsey's cost curve by Evan Mills[24] of the Lawrence Berkeley National Lab to show the potential of commissioning:

Figure 21. *Potential U.S. carbon savings from commissioning in context with other options.*



Source: McKinsey Consulting and Evan Mills, Berkeley Lab

There are other negative cost carbon reduction opportunities, but none as profitable as retro-commissioning. Unfortunately, despite the value proposition, building commissioning is far from standard practice. In fact, a 2005 study showed that less than one-third of all new buildings are commissioned[25], but even that figure is too high when looking at a building's energy systems[26]. Only 5%

[24] Mills (2009).
[25] NEMI (2005) and conversation with Evan Mills, Lawrence Berkeley Laboratory, October 27, 2009.
[26] Mills, Evan (July 2009). "Building Commissioning: A Golden Opportunity." Lawrence Berkeley National Laboratory. http://cx.lbl.gov/documents/2009-assessment/LBNL-Cx-Cost-Benefit.pdf

of all existing buildings were retro-commissioned, according to the same 2005 survey, but again that figure is likely much lower.

MARKET BARRIERS AND DRIVERS

Part of the reason there is so little adoption of commissioning despite the value proposition, is that there is often what is commonly referred to as a split incentive. Building owners do not pay utility bills, so energy savings do not matter very much to them. Tenants are transitory, so even short pay back periods may not make economic sense and there are only a small range of benefits in a tenant's leased space, which is usually a small fraction of a whole building.

This problem can be overcome, and is being overcome, through many drivers:

(1) **Utility Programs**. All the investor owned transmission and distribution utilities in Texas have energy efficiency programs mandated by law. Only one, CenterPoint in the Houston area, has a retro-commissioning program[27]. Austin Energy, a municipally owned utility, also has a retro-commissioning program, which provides incentives for AE customers who use Continuous Commissioning®[28]. The size of the market – and energy efficiency benefits – could increase substantially if other utilities would add commissioning programs to their energy efficiency portfolios.

(2) **LEED**. The very popular Leadership in Energy and Environmental Design (or LEED) certification for new buildings (LEED-NC) from the United States Green Building Council requires commissioning. The LEED-EB O&M (Existing Buildings, Operations and Maintenance) requires an energy audit, an energy management plan, and awards extra points for retro-commissioning[29]. This has increased demand for commissioning services in recent years.

(3) **Building Codes**. The cities of Dallas and Houston both require commissioning for certain new buildings. Legislation that passed the US House of Representatives would require commissioning for all new buildings throughout the US.[30] The International Green Construction Codes are undergoing a change to require commissioning for new buildings as well[31].

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[27] http://www.centerpointefficiency.com/recx/index.htm

[28] http://www.austinenergy.com/Energy%20Efficiency/Programs/Rebates/Commercial/Commercial%20Energy/bldgTuneupOverview.pdf

[29] Boehland, Jessica (November 2008). "LEED for Existing Buildings." Greensource. http://continuingeducation.construction.com/article.php?L=5&C=465&P=3

[30] American Clean Energy and Security Act, p. 323 established ASHRAE 90.1-2004 as "baseline code" for commercial buildings. http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_bills&docid=f:h2454pcs.txt.pdf. ASHRAE 90.1 requires commissioning. See here, p. 102: http://www.energycodes.gov/training/pdfs/ashrae_90_1_2004.pdf

[31] Mortice, Zack (October 16, 2009). "International Green Construction Code Effort Tackles Building Commissioning and Adoptability." American Institute of Architects Industry News. http://info.aia.org/aiarchitect/thisweek09/1016/1016n_greencode.cfm

(4) **State Legislation and Regulation**. HB 1937, passed in the 2009 Texas Legislative Session, allows cities to fund energy efficiency retrofits and have them paid back by building owners as a voluntary assessment on their property tax bill over 15-20 years. This bill, if implemented by cities—and several are considering it—could be a big market driver as one of the biggest barriers (upfront capital costs) would be removed. Also, regulations that would require an increasing share of the state's demand growth come from energy efficiency could provide an increase in investor owned utility's support for retro-commissioning.

(5) **National Legislation and Regulation**. In October, Vice President Biden announced a program called "Recovery through Retrofit" which will seek to put people to work retrofitting old buildings and homes to improve energy efficiency[32]. Talk of a $23 billion "Cash for Caulkers" has surfaced in the weeks before publication of this paper[33], but no bills have yet been filed to make that plan a reality. The Administration plans to implement that program quickly if it does go through Congress, presenting challenges to workforce boards and community colleges to train enough workers quickly enough.

While utility programs, LEED certifications, regulations, legislation, and building codes undoubtedly spur the commissioning market, ultimately, demand is—and should be—driven by its bottom line benefits. For every $100 a building owner spends, they got $50 back every year thereafter[34]. Incentives and codes help overcome the split incentives that hold building owners back.

There are other barriers that get in the way of widespread use of commissioning:

- **Lack of awareness**. Many building owners are unaware of the benefits of commissioning. To remedy this we make two recommendations: First, offer an executive level, or continuing education course at community colleges for building owners and facility managers. Second, make business development and sales part of all certification and degree programs in Texas so that technicians and commissioning agents can make the value proposition to building owners and facility managers.
- **Lack of trained commissioning workforce**. The tremendous opportunities for energy savings—and a strengthened state economy—cannot be captured with present infrastructure and personnel. Even with the limited size of the industry at present, there are not enough trained professionals to meet current demand, according to members of the Green Jobs Business Council and others in the industry.

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[32] Middle Class Task Force and Council on Environmental Quality (October 2009). "Recovery Through Retrofit." http://www.whitehouse.gov/assets/documents/Recovery_Through_Retrofit_Final_Report.pdf

[33] Leonhardt, David (November 17, 2009). "Cash for Caulkers: The Details." New York Times Economix Blog.

[34] Mills (2009) looked at the persistence of savings, which is beyond the scope of this paper. While it's not 100%, Mills did find that most measure produced considerable savings many years beyond the payback period.

OCCUPATIONAL OVERVIEW

Commissioning is usually led by a specialist or engineer who works with contractors responsible for sub-systems. The commissioning process on new construction can include: engineers, electricians, carpenters, plumbers and pipefitters, sheet metal workers, facility managers, building maintenance staff, building owners, designers, HVAC technicians and installers, roofers, building inspectors, and insulation workers. The commissioning process can include all of these but will usually include only some combination.[35]

O*Net, the Occupational Information Network, published a paper earlier this year entitled *Greening of the World of Work*, in which three occupational categories of green jobs were identified[36], each with different effects from the greening of work[37]. All of these categories are important for educational institutions and workforce boards as **all require new capacity and/or trainings be developed.**

(1) *Green Increased Demand Occupations*. The impact of green economy activities and technologies is an increase in the employment demand for an existing occupation. However, this impact does not entail significant changes in the work and worker requirements of the occupation. The work context may change, but the tasks themselves do not.
(2) *Green Enhanced Skills Occupations*. The impact of green economy activities and technologies results in a significant change to the work and worker requirements of an existing O*NET-SOC occupation. This impact may or may not result in an increase in employment demand for the occupation. The essential purposes of the occupation remain the same, but tasks, skills, knowledge, and external elements, such as credentials, have been altered.
(3) *Green New and Emerging (N&E) Occupations*. The impact of green economy activities and technologies is sufficient to create the need for unique work and worker requirements, which results in the generation of a new occupation relative to the O*NET taxonomy.

The attempt to categorize N&E Occupations is only beginning. In its FY 2010 Budget Request, the Bureau of Labor Statistics asked for 8 full time employees to track, categorize, and report on green-collar jobs,

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[35] For more on "The Retro-commissioning Team," see California Commissioning Collaborative (2006). "California Commissioning Guide: Existing Buildings." Pages 19-30. http://www.cacx.org/resources/documents/CA_Commissioning_Guide_Existing.pdf

[36] Dierdorff, Erich C., et al. (February 2009). O*Net rightly points out "the need to shift the level of specificity from 'job' to 'occupation' when discussing the workforce implications of the green economy. The current literature focuses almost exclusively on green jobs – or simply green job titles - *rather than taking a perspective more conducive to workforce development efforts: an occupational perspective*." [emphasis added]

[37] O*Net's definition of green jobs is as follows: The green economy encompasses the economic activity related to reducing the use of fossil fuels, decreasing pollution and greenhouse gas emissions, increasing the efficiency of energy usage, recycling materials, and developing and adopting renewable sources of energy.

with a first report due in FY 2011.[38] Texas Foundation for Innovative Communities and Good Company Associates is assisting SkillsNet, a leading "skills content management" company, to develop the classification of green jobs and better refine the lists and define the occupations below.

Here are some of the occupations related to commissioning in the three O*Net defined categories[39]:

(1) New and Emerging Occupations (star denotes high demand)[40]

- 17-3029.02 Electrical Engineering Technologists*
- 17-2199.03 Energy Engineers*
- 13-2099.01 Financial Quantitative Analysts*
- 11-2011.01 Green Marketers[41]
- 17-3029.07 Mechanical Engineering Technologists*
- 13-1199.05 Sustainability Specialists
- n/a Sustainable Design Specialists
- n/a Testing Adjusting and Balancing TAB Technicians
- 17-2199.02 Validation Engineers*
- 47-4099.03 Weatherization Installers and Technicians

(2) Green Enhanced Skills Occupations[42]

- 17-1011.00 Architects, Except Landscape and Naval
- 47-4011.00 Construction and Building Inspectors
- 47-2061.00 Construction Laborers
- 11-9021.00 Construction Managers
- 17-3023.03 Electrical Engineering Technicians
- 17-2071.00 Electrical Engineers
- 17-3024.00 Electro-Mechanical Technicians
- 17-2072.00 Electronics Engineers, Except Computer
- 11-9041.00 Engineering Managers
- 17-3025.00 Environmental Engineering Technicians
- 17-2081.00 Environmental Engineers
- 49-9021.01 Heating and Air Conditioning Mechanics and Installers
- 17-1012.00 Landscape Architects
- 49-9042.00 Maintenance and Repair Workers, General
- 11-2021.00 Marketing Managers
- 17-2141.00 Mechanical Engineers
- 47-2152.01 Pipe Fitters and Steamfitters
- 47-2152.02 Plumbers

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[38] Page 27-28 http://www.dol.gov/dol/budget/2010/PDF/CBJ-2010-V3-01.pdf

[39] Note that these are just the occupations that are directly related with commissioning; there are many other, unrelated green occupations on these O*Net lists.

[40] http://www.onetcenter.org/green/emerging.html

[41] It is interesting to note that while O*Net did not categorize Green Marketers as a high demand, nearly 90% of respondents to a TFIC survey indicated a need for sales and marketing expertise.

[42] http://www.onetcenter.org/green/skills.html

- 53-7081.00 Refuse and Recyclable Material Collectors
- 47-2181.00 Roofers
- 41-4011.00 Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products
- 47-2211.00 Sheet Metal Workers

(3) Green Increased Demand Occupations
- 47-2011.00 Boilermakers
- 47-2051.00 Cement Masons and Concrete Finishers
- 27-1021.00 Commercial and Industrial Designers
- 15-1032.00 Computer Software Engineers, Systems Software
- 47-2031.01 Construction Carpenters
- 43-4051.00 Customer Service Representatives
- 47-2111.00 Electricians
- 17-3023.01 Electronics Engineering Technicians
- 49-1011.00 First-Line Supervisors/Managers of Mechanics, Installers, and Repairers
- 47-3012.00 Helpers--Carpenters
- 49-9098.00 Helpers--Installation, Maintenance, and Repair Workers
- 47-2131.00 Insulation Workers, Floor, Ceiling, and Wall
- 49-9021.02 Refrigeration Mechanics and Installers
- 47-2031.02 Rough Carpenters
- 51-4121.06 Welders, Cutters, and Welder Fitters

OCCUPATIONAL SKILL & KNOWLEDGE REQUIREMENTS (INCLUDING EMERGING STANDARDS AND CERTIFICATIONS)

The business of commissioning is changing rapidly. As an example, the HVAC industry—HVAC commissioning is included in over 90% of commissioning projects[43] and is the focus of Continuous Commissioning®—is undergoing rapid changes. Industry insiders report that new textbooks for HVAC technicians released this year are radically different than their predecessors as they take into account increasing sophistication of automated controls, high efficiency variable speed motors, and other features which were once considered exotic or expensive, but are now nearly mainstream.[44]

The American National Standards Institute (ANSI) has released new standards for HVAC quality installation specifications, approved by every major trade group, again taking into account proper installation of HVAC units using new technologies. These will likely be included in the International Energy Conservation Codes in 2012[45]. The new technologies make the equipment more efficient and "smart" but also make them harder to commission and service. Technicians and commissioning agents need more specialized and technological training than ever before. The same is true for other fields that are integral to the commissioning process.

Many IT companies are marketing energy management products and digital controls that are becoming an increasingly important part of building systems. An understanding of older, standard equipment is essential for those involved in commissioning, but so is the latest wave of digital products, which enable auto-monitoring of a building's systems to detect faults automatically.

Building automation systems (BAS) represent further opportunities for growth—and further challenges for trainers. Many buildings that are retro-commissioned will require installation of BAS so that commissioning can truly be continuous. This has been dubbed monitored commissioning[46]. In other words, digital controls – if properly used – could signal to a facilities manager that a system was not functioning optimally. An intervention could prevent significant costs down the road and increase occupant comfort.

Further, demand response programs—programs to voluntarily reduce energy usage on days when the grid is most stressed and electricity prices are highest—can be implemented using BAS[47]. The Chief Technology Officer of Honeywell Inc., a leading manufacturer of advanced controls, asserts that: "With today's existing technology, we can save 15% to 20% of U.S. energy use. And 30% is a very realistic

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[43] NEMI (2005)
[44] Conversation with Stan Johnson, Chairman Air Conditioning Contractors of America
[45] *Ibid*.
[46] Mills (2009) and California Energy Commission (September 2008). "Savings Persist with Monitoring-Based Commissioning." Public Interest Research Program.
[47] See EnerNOC. "Achieving New Levels of Efficiency with Monitoring-Based Commissioning (MCBx)." http://www.enernoc.com/resources/files/mbcx.pdf

goal."[48] These controls are becoming increasingly commonplace. Laney Community College in California is currently developing an Associate's degree level course, as part of its Environmental Controls Technician degree program, in BAS.

Many leading Information and Communication Technology (ICT) companies, including Nokia, Dell, Sun Microsystems, Microsoft, and others, have formed the Digital Energy Services Campaign which is working to advance smart metering and digital solutions to meet the nation's energy challenges. In a letter to Congress, the DESC advocated for "programs for emerging careers and technical training in the fields of renewable energy, energy efficiency and climate change mitigation (ACES, Title IV, Secs. 421, 423)."[49] On their website, they further assert:

> The [Information and Communications Technology] industry is investing billions of dollars to research, develop and market advanced, energy-efficiency technologies and business process solutions, creating **thousands of new, high paying jobs in a fast-growing part of the industry**.

Microsoft[50], Google, IBM, SAP[51], CA[52], and a host of other ICT have developed smart energy applications in a hope to capture market share. Many of these companies are among the largest in the world and they view this sector as a job creator and profit center.

Cisco Systems reports that they have converted lighting and HVAC systems to Internet Protocol (IP), such that they can be monitored and adjusted remotely, from the web. Cisco bundles these efficiency tools with security and connectivity features and calls them Connected Real Estate. They project adding their digital controls in retrofit projects will be a major growth area for their company. (Cisco replaced GM in the Dow Jones Industrial Average on June 1, 2009.) They have already implemented this system several places in Texas including 515 Congress in Austin, University Health Systems in San Antonio, and Giddings Independent School District[53].

They offer certifications through Cisco Networking Academies and license the training to community colleges. They have also created a Cisco Academy for K-12, with a Texas Education Agency (TEA) accredited curriculum.

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[48] Johnson, Keith (November 17, 2009). "Honeywell, SoCal Edison Team Up to Curb Electricity Demand." Wall Street Journal, Environmental Capital Blog.

[49] http://www.behindthegreen.org/storage/documents/desc_letter_to_lawmakers.doc

[50] CNET.COM (OCTOBER 14, 2009). "MICROSOFT EYES SMART GRID WITH UTILITY SOFTWARE." HTTP://NEWS.CNET.COM/8301-11128_3-10374771-54.HTML?PART=RSS&TAG=FEED&SUBJ=GREENTECH

[51] Press Release (May 19, 2009). "SAP Spotlights New Smart Grid Developments for More Energy Efficiency." http://www.sap.com/about/newsroom/press.epx?pressid=11361

[52] ZDNet.com (October 21, 2009). "CA jumps into eco software market." http://blogs.zdnet.com/BTL/?p=26282

[53] Conversation with Bob Cooper, Cisco Connected Real Estate, October 8, 2009

Further, one of the Green Corridor Consortium members, Dallas County Community College District, is part of a partnership with Collin College and others that received National Science Foundation funding in part to develop "green IT curriculum."[54]

As information and communications technologies become increasingly integrated into building systems such as HVAC systems, the qualifications and skills for technicians are changing rapidly. **This dramatic change and constant flux provides an excellent opportunity for community colleges to increase their usefulness to businesses**. According to several interviewees, continuing education is going to become needed far more frequently for technicians[55]. Where once continuing education was necessary mainly for engineers and architects in the retrofit business, it is becoming increasingly needed for the workers who install and maintain new and complicated equipment.

Anyone involved in commissioning must understand the old systems they encounter in existing buildings and these new, advanced technology systems which are mainstreaming rapidly. They must also understand how to integrate renewable sources of energy into a building's infrastructure. As solar, geothermal, and small wind power become more common, this skill set will also be in high demand.

[54] Collin College News Release (October 15, 2009). "NSF Awards Collin College $1.56 Million Grant."
[55] Conversations with Stan Johnson, Chairman, Air Conditioning Contractors of America, and Warren Lupson, Director of Education, Air Conditioning, Heating, and Refrigeration Institute.

INVENTORY OF EXISTING TRAININGS

The chart below gives a sense of the variety of trainings available and the scale to which those trainings and certifications are used in Texas. There are seven organizations that offer certifications that are specifically related to commissioning; those are highlighted below. A brief description of each training and certification follows in Appendix B.

Organization	Name of commissioning certification(s)	specific to Texas conditions ?	offered in Texas?	offered by Texas community college?	number certified in Corridor?
AABC Commissioning Group (AGC)	Certified Commissioning Technician	?	Yes.	No.	37 in Tx; 20 in corridor
Assoc. of Energy Engineers	Certified Energy Manager (CEM); Certified Building Commissioning Professional (CBCP); many, many more	No.	Yes.	No.	~250 CEM 28 CBCP (as of 9/9/09)
ASHRAE	Commissioning Process Management Professional (CPMP)	Divides US into 9 regions.	Yes.	No.	5
Building Commissioning Association	Certified Commissioning Professional	No.	No.	No.	2 (in all of Texas)
National Energy Management Institute (NEMI)	TABB Certified Technician, TABB Certified Commissioning Supervisor or TABB Certified Commissioning Contractor	No.	Yes. Online.	No.	1 TABB Technician (in Dale, TX) 0 for commissioning
National Environmental Balancing Bureau	Building System Commissioning; Retro-Commissioning; Testing and Balancing	No.	Only in SA.	No. Cannot be offered by cc's.	~30 certified firms in Corridor
Texas A&M Energy Systems Lab	License for Continuous Commissioning®	No, but was developed in TX.	In College Station.	In planning stages with Cedar Valley in DCCCD.	6 licensees nationally; 3 in Texas

COMMUNITY COLLEGE COURSES FOCUSED ON COMMISSIONING

Laney Community College in California has developed courses in Building Commissioning (including retro-commissioning; see Appendix D for syllabi) as part of a National Science Foundation grant. Working with Lawrence Berkeley National Laboratory, they have developed a curriculum for an Associate's Degree in Environmental Control Technology which includes commissioning and building controls. As a continuation of their NSF grant, they are currently creating a course specifically on Building Automation Systems (BAS).

Laney Community College has made the offer to share and collaborate so that Texas community colleges do not have to start from scratch for these courses. In fact, as part of their NSF grant, they are required to share it, and will even pay for travel to a conference where they teach other instructors how to replicate their programs.

Texas community colleges could take advantage of this resource and use Texas A&M's Energy Systems Lab as a resource to revise the curriculum where appropriate to meet Texas's specific circumstances, and to allow a seamless career path for technicians who wish to go on for a four-year engineers degree or graduate work in engineering focused on commissioning. The chart on the next page shows where these courses might fit within existing offerings at community colleges in the Green Corridor Consortium.

Sacramento City College also has some courses in commissioning which could be used a model or resource by Texas' community colleges. They have established a commissioning certificate program which requires 12 units in addition to an HVAC technician certification or degree. They are finding that many of their students in their final semester are wanting to stay and complete the additional certificate because industry demand is so high. Many incumbent workers are coming to the College to earn the certificate as well.

The following courses are currently taught there; course descriptions are Appendix E.

- Mechanical Systems Commissioning
- Energy Auditing and Calculations for Commercial Buildings
- Instrumentation
- Air and Water Balance
- Automatic Controls

INVENTORY OF CENTRAL TEXAS COMMUNITY COLLEGE PROGRAMS RELATED TO COMMISSIONING

None of these degree or certificate programs currently include commissioning but all are related enough that they could. The colleges in the chart below are members of the Green Corridor Consortium.

College	Industrial Systems Technology	Environmental Control Technology (HVAC)	Energy Systems Technology	Construction Crafts Technology	Civil and Construction Management Technology
Alamo Colleges		AAS Degree, Certificate			AS Degree
Austin Community College		AAS Degree, Certificate		Woodworking Certificate, Carpentry Certificate	AAS Degree, Certificate
Central Texas College		AS Degree, Certificate		Certificate of Completion	
Dallas County Community College District		AS Degree, Certificate			AS Degree, Certificate
McLennan Community College					
Temple College					
Texas State Technical College-Waco	AAS Degree	AS Degree, Certificate			AAS Degree, Certificate

CURRENT EMPLOYMENT STATUS AND FORECASTED EMPLOYMENT NEEDS

The commissioning business is growing rapidly, yet **there are very few technicians and engineers trained in commissioning in Texas**. Most estimates, and our own research, suggest about 100-150 certified commissioning professionals operate in Texas. One expert reported that a significant number of commissioning professionals are brought in from outside of Texas[56].

Part of the problem is that no training or certifications for commissioning are offered at any of Texas' community colleges. There is a tremendous potential for community colleges to provide certifications and associates' degrees in commissioning to make their graduates far more marketable to employers.

Companies involved in commissioning buildings report steady demand, even with current market conditions[57]. Many of them continue to hire in the midst of the "Great Recession" and all expect to be hiring for new projects at a brisk pace in the next year or two. Nearly all of them expect a continued focus on sustainability and greenhouse gas reductions to increase the demand for commissioning but without business development and sales professionals versed in commissioning, much of the opportunity will be missed.

N**early everyone in the industry interviewed for this report lamented the lack of trained workers already and worried that coming demand will further widen the gap between demand and supply of qualified employees**.

The problem is not just with a lack of trained commissioning professionals and technicians. Existing occupations related to energy efficiency—HVAC technicians are a prime example—are in high demand and will continue to be in high demand. Several air conditioning companies report that they already cannot find enough qualified people for basic technician services. The Air Conditioning, Heating, and Refrigeration Institute estimates: "By 2014, the United States will need 29 percent more HVACR and 21 percent more plumbing technicians, or more than 100,000 skilled workers to perform these important jobs, which cannot be outsourced overseas."[58]

Texas' population proportionate share would equal about 8,000. The Texas chapter of the Air Conditioning Contractors of America estimates a need of 20,000 new HVAC technicians in the next several years[59]. Clearly Texas' community colleges could place many students into jobs if training capacity could be increased. (A future study should focus on training plumbers and pipefitters in

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[56] Conversation with Phil Welker, Executive Director, Portland Energy Conservation, Inc.
[57] Conversations with Glenn Randle, YPS and Brian Keller, Goetting & Associates.
[58] http://www.ahrinet.org/Content/InstructorWorkshop_245.aspx, based on Department Labor Figures according to conversation with Warren Lupson, AHRI, October 22.
[59] Conversation with

commissioning systems involving water usage and waste of water is at least as problematic as energy waste.)

Creating training for HVAC technicians to be certified or degreed in commissioning is a no-risk strategy. The added workforce is greatly needed, with or without commissioning training, but if commissioning turns out, as we expect it will, to be a major growth industry, the credentialed commissioners will be much more attractive employers than their counterparts trained elsewhere. And Texas will benefit from this advanced expertise which yields greater energy savings, reduced electric bills, and lower pollution.

CONCLUSIONS, RECOMMENDATIONS, AND NEXT STEPS

C^3: COMMISSIONING AT COMMUNITY COLLEGES

Our first recommendation is **for the community colleges in the Green Corridor Consortium to consider including commissioning training within certificate and degree programs for construction trades and environmental controls technicians.** This could mean development of new courses or simply integrating the knowledge and skills required to do commissioning into existing courses.

One model to consider is the content from Laney Community College (see Appendix D). Colleges and their industry advisory boards could look at the knowledge and skills taught in Laney's Intro to Building Commissioning (certificate level) and Advanced Building Commissioning (Associate's Degree level) courses to see if there are elements that would fit within existing programs. Sacramento City College also has courses worth reviewing (see Appendix E).

They could use experts in commissioning from Texas A&M's Energy Systems Lab (and Texas Engineering and Experiment Stations) as a resource during this review. Ideally, content integrated into training programs would be seamless with A&M's four-year degree in commissioning (under development) and graduate level programs.

Fortunately, A&M and Cedar Valley Community College (part of Dallas County Community College District) have begun working together to begin technician training in A&M's Continuous Commissioning. Also, ESL does Continuous Commissioning for Alamo College and could easily get students there involved in the process as part of their training program[60]. The National Council for Workforce Education recommends that community colleges use their campuses as living laboratories by getting students involved in integrating renewables and becoming increasingly energy efficient.[61]

In TFIC's first report[62], we recommended three tiers of training, which we modify slightly below, and add a newly suggested fourth tier.

The elements of the commissioning curriculum could include:

1. Technician or Occupational Certification
   This could be a program ranging from several months to one year for HVAC technicians and building operators who will be closely involved with commissioning activities on an ongoing

[60] Conversation with Malcolm Verdict, Texas A&M Energy Systems Lab
[61] Feldbaum, Mindy (2009). "Going Green: The Vital Role of Community Colleges in Building a Sustainable Future and a Green Workforce." National Council for Workforce Education and Academy for Educational Development.
[62] Texas Foundation for Innovative Communities (July 2009). Year One Report.

basis. It will include both classroom and laboratory experience focused on techniques for ensuring efficient building-systems operation.

2. Associates Degree
   This could be a new 2-year degree program, or a revised Environmental Controls Technicians degree program, focused on the efficient operation of commercial HVAC systems, including detailed classroom instruction in system operating fundamentals, combined with hands-on training in monitoring system installation and application.

3. Four-year Bachelor's Degree and Graduate Level Training
   This will be an expansion and enhancement of the current instruction offered within the mechanical engineering program offered through ESL. It will include both self-study work, and detailed field experiments conducted at the A&M campus. The program of study will lead to a higher certification. ESL will also incorporate elements of the curriculum into existing graduate and undergraduate HVAC courses offered through the Mechanical Engineering Department, enabling the certification of students in both levels of coursework.

4. Continuing Education
   We recommend this be a short course, ranging from a half-day to a week, available particularly for building owners and facility managers who want to know more about commissioning and efficient operation of buildings in order to save energy and money.

There should be a long term goal for all community college graduates in a trade that could potentially be involved in commissioning to at least have some training, or even a certificate, in commissioning.

LINKS TO HIGH SCHOOL VOCATIONAL TRAINING

Just as the certificate, associate's degree, graduate and post-graduate degrees should be in alignment to create a seamless career path, so should extensions into high schools. Many young people are interested in "green jobs" but most wouldn't imagine that HVAC technicians are green workers. High school students need to understand there are opportunities to make a good living and help the environment by getting training in commissioning.

Some dual credit Career and Technical Education (CTE) course could be created to establish a link to high school students.

BUSINESS DEVELOPMENT AND SALES TRAINING

It is vital to the growth of the industry that business development and sales professionals also receive training to be able to discuss with a potential customer the financial and environmental impacts of their decisions and to empower them to save money and energy. A building owner or homeowner always has the choice to stay with the status quo, even if it is an economically irrational choice (i.e., they're wasting money by wasting energy). In fact, the vast majority of us do that now.

There are very few business development and sales professionals focused on the commissioning industry now but 90% of survey respondents reported that they need these workers (survey was for a cross section of clean energy companies, including but not limited to, commissioning)[63]. That was a higher percentage than the need for any other type of worker. Clearly, there is an important opportunity for community colleges and workforce boards is to **develop the trainings for business development and sales for the commissioning industry**.

A White House Council on Environmental Quality report noted the lack of training in this area as a real problem[64]:

> [A] lack of business skills training has been a barrier to the widespread success of efficiency retrofits programs. Business skills training and business development must therefore be a key component of any large-scale efficiency retrofit workforce capacity development initiative to ensure that a commercially viable effort can be maintained by small- and medium-sized businesses in the open market over the long-term. Developing a workforce equipped with both technical and business skills will improve the rate of success for small efficiency retrofit businesses and increase the ability to respond to rising retrofit demand."

Without this training, the market will never develop to its full potential.

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[63] Texas Foundation for Innovative Communities (July 2009). Year One Report.
[64] Council on Environmental Quality (October 2009). "Recovery Through Retrofit."
http://www.whitehouse.gov/assets/documents/Recovery_Through_Retrofit_Final_Report.pdf

NEXT STEPS

- Convene a workgroup of HVAC-R instructors from all of the Consortium community colleges to discuss best practices and leverage existing strengths (e.g., Dallas Community College's partnership with Collin College to develop "green IT curriculum," etc.)

- Set up conference call between workgroup and Laney Community College instructors to discuss commissioning and BAS courses to determine if Texas community college instructors would like to use some of their materials.

- A&M's Energy Systems Lab and Alamo Colleges should work together and identify opportunities for Alamo students to learn from Continuous Commissioning projects at the College.

- Convene workgroup of workforce boards in the Consortium to determine how best to ramp up and enhance training for HVAC technicians.

- Work with high schools to create dual enrollment courses; demonstrate opportunity and career paths for high school students who do not wish to go to a four-year university.

- Explore ways community college HVAC-R instructors and union apprenticeship trainers can work together. A "train-the-trainer" event—currently being organized for the week of January for community college instructors to learn from a national expert on commissioning—could be a good forum to explore collaboration.

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APPENDICES

APPENDIX A: TYPES OF COMMISSIONING

The chart below provides an excellent reference point for the various types of commissioning which are explained in a little further detail below the chart. Please note that the chart does not include Texas A&M Energy Systems Lab's patented approach called Continuous Commissioning®.

	Commissioning	Retro-Commissioning	Re-Commissioning	Auto-Monitoring
Application	New Construction	Existing buildings that have never been previously commissioned, or if building age or modifications render commissioning plans obsolete	Existing buildings that have been commissioned or retro-commissioned	All applications
Timing	As early as possible i.e. pre-design	Occurs in response to under-performance or problems in the building systems	Occurs periodically or in scheduled intervals as part of the O&M, or in response to specific operating issues	Any time after building systems are installed and operational
Purpose	Ensures building systems will perform optimally	Solves problems that prevents buildings from performing optimally	Ensures building is still performing optimally, maintains level of previous commissioning	Continuously maintains optimal performance
Frequency	Once during the initial design and construction	Once, as needed due to age; 10-15yrs	Every 3-5yrs	Once installed, provides continual commissioning for the life of the building
Cost[6]	Varies with size and complexity of systems: $0.50 to $3.00/ft², median is $1.00/ft²	$0.05-$0.40/ft², median is $0.27/ft²	Costs will be similar to retro-commissioning	Too large a range of functions and costs to currently compare. Has potential to be most cost effective method.
Benefit[6]	$1.00/ft² energy saving with a median payback of 4.8 yrs. One time non-energy benefit = $1.24/ft²	$0.27/ft² for 15% energy savings and payback of 0.7 yrs, one time non-energy benefits = $0.18/ft²	Similar to retro-, depending on frequency	Similar to retro- and re-commissioning with continuous benefits for the length of operation.

Source: Architectural Energy Corporation

The following is from the California Commissioning Collaborative[65]

The term commissioning comes from shipbuilding. A commissioned ship is one deemed ready for service. Before being awarded this title, however, a ship must pass several milestones. Equipment is installed and tested, problems are identified and corrected, and the prospective crew is extensively trained. A commissioned ship is one whose materials, systems, and staff have successfully completed a thorough quality assurance process.

[65] Hassl and Henemeier (2006).

Building commissioning takes the same approach to new buildings. When a building is initially commissioned it undergoes an intensive quality assurance process that begins during design and continues through construction, occupancy, and operations. Commissioning ensures that the new building operates initially as the owner intended and that building staff are prepared to operate and maintain its systems and equipment.

Retro-commissioning is the application of the commissioning process to existing buildings. Retro-commissioning is a process that seeks to improve how building equipment and systems function together. Depending on the age of the building, retro-commissioning can often resolve problems that occurred during design or construction, or address problems that have developed throughout the building's life. In all, retro-commissioning improves a building's operations and maintenance (O&M) procedures to enhance overall building performance.

Re-commissioning is another type of commissioning that occurs when a building that has already been commissioned undergoes another commissioning process. The decision to re-commission may be triggered by a change in building use or ownership, the onset of operational problems, or some other need. Ideally, a plan for re-commissioning is established as part of a new building's original commissioning process or an existing building's retro-commissioning process.

APPENDIX B: INTERVIEWS

Michael Bettersworth, TSTC, Austin
Michael Brown, SkillsNet
David Claridge, Texas A&M Energy Systems Lab
Jeffrey Connor, Chair of Education Committee for Building Commissioning Association
Bob Cooper, Cisco Connected Real Estate, Austin
Charles Culp, Texas A&M Energy Systems Lab
Michael Cunningham, Texas Building Trades Council
Joe Deringer, Institute for the Sustainable Performance of Buildings (SU-PER-B), Berkeley, CA
Richard Halpin, American YouthWorks, Austin
John Hamilton, COO, Testing, Adjusting, Balancing Bureau (TABB/NEMI)
Orbry Holden, Texas Business Education Coalition
Marcus Johnson, Trane, Dallas
Stan Johnson, Stan's AC and Chair of Air Conditioning Contractors of America, Austin
Brian Keller, Goetting Associates, San Antonio
Rick Levy, AFL-CIO, Austin
Jeff Looper, TSTC, Dept Head, HVACR, Waco
Warren Lupson, Director of Education, Air Conditioning, Heating, and Refrigeration Institute
Mike Martin, Texas Engineering and Experiment Station, San Antonio
Evan Mills, Lawrence Berkeley National Laboratory
Patrick Murphy, NATE, PAHRA, Virginia
Glenn Randle, YPS, Austin
Glenn Rhoden, Texas Energy Managers Association, Energy Manager, Cy-Fair ISD
Steve Stagner, Engineers Council, Austin
John Stevenson, Chairman, National Environmental Balancing Bureau, Austin
Al Thumman, Executive Director, Association of Energy Engineers, Atlanta
Malcolm Verdict, Texas A&M Energy Systems Lab, College Station
Chandler von Schrader, EnergyStar, EPA 202 343 9096
Phil Welker, Executive Director, Portland Energy Conservation, Inc.
Joyce Williams, District Dir. of Workforce Development, Dallas County Community College
Raymond Wolf, CEO, Green Integrated Services

APPENDIX C: INVENTORY OF EXISTING INDUSTRY IN TEXAS

Company	Principal/Contact	Cx	R-Cx	Employees	Cities
Advance Air Systems	(NEBB)	Yes.			DFW, Austin
Air Balancing Company	Brett Privitt	Yes.		12	Ft. Worth
AIR Engineering and Testing, Inc	Gerald Kettler	Yes.		12	DFW
Air Technologies, Inc.		?	?	12	Austin
A.J. Monier & Company	(NEBB)	Yes.	No.		SA
Apollo BBC, Inc.		Yes.	Yes.		Bellair
Applied Mechanical Corp.		Yes.			Austin
Aramark Tech Services		Yes.		19	Waco
Automated Logic		Yes.	Yes.		SA, Aus
Bartlett Cocke General Contractors	Bill Bayne	Yes.	No.	2	Austin, SA, Houston
Beck Group	Betsy del Monte	Yes.			Dallas
Brandt Engineering	Mark Zilbermann	Yes.	Yes.	1000+	Austin,SA,DFW, Waco
Building Performance Testing	David Varian	Yes.			Austin
Campos Engineering Inc.	Joe D. Campos	Yes.		30	Dallas
Class One Solutions, Inc.	Andrew Clendenen			6	DFW,-Arlington

Company	Principal/Contact	Cx	R-Cx	Employees	Cities
Cleary Zimmerman Engineers		Yes.			SA
Command Commissioning	Mitchell Factor	Yes.		2	Dallas-Ft Worth-Arlington
Dynamic Systems		Yes.			Austin
Electrical Power Solutions	Kelvin Wrenn, Partner Rebecca Wrenn, Partner	Yes.		5	Houston-Baytown-Sugar Land
Engineered Air Balance	Gary Miller			80	San Antonio
EMC Engineers	Leslie Cook	Yes.	Yes.	11	El Paso
Engineering EcoNo.mics	Kevin Branch	Yes.	Yes.	62	San Antonio (HQ in CO)
Entech Sales and Service		Yes.			Austin, DFW
Estes, McClure and Associates, Inc.	Gary Bristow			46	Tyler
Facility Engineering Associates Inc	Jeffrey T. Hunt	Yes.	Yes.	60	Dallas
Fluid Balance Int.	Jerry Steinbrecher	Yes.			Austin
Fuller Cotter Associates Inc	Brian Cotter			3	DFW
Glumac	Steve Straus	Yes.			No. office in TX
Goetting and Associates Commissioning	Brian Keller	Yes.	Yes.	80	San Antonio, Austin, DFW
Henneman Engineering	Kyle Lambert (Dir of Commissioning Services	Yes.			Dallas

Company	Principal/Contact	Cx	R-Cx	Employees	Cities
INP International	Stephanie L. Fuentes - director	Yes.		45	Houston, Baytown, Sugar Land
Jacobs Engineering		Yes.	No.		Nationwide (Austin San Antonio, DFW offices)
JAGarcia Construction Management	James Garcia	Yes.		1	San Antonio
Jasmine Engineering	Mary Serna	Yes.	Yes.	13	Austin
Kirkland Commissioning Services	Larry Kirkland, President	Yes.			Waxahachie
Lackey Carvajal Cx	Mike Lackey	Yes.	Yes.	8	San Antonio
NexRev Inc.	William Wright	Yes.		9	Plano.
Purdy-McGuire	Douglas Ekstrom, Kip Hanzlicek	Yes.		35	DFW
Sebesta Blomberg	Glin Jay	Yes.	Yes.	5	Dallas-Ft Worth-Arlington
Siemens	Bob Pouland	Yes.			Dallas
Specialty Engineering	Thelma Dieckert, Partner, Joseph Dieckert, Partner	Yes.		5	College Station - Bryan
Summit Consultants	Mary Serna	Yes.	Yes.	13	Ft Worth
Systems Commissioning, Inc. (EMCOR)		Yes.	Yes.		Houston
TAB TechNo.logies	John Stevenson	Yes..	Yes..		Austin, Dallas
TD Industries	John Taylor	Yes.		1600	statewide

Company	Principal/Contact	Cx	R-Cx	Employees	Cities
Testing Specialties	Wes Harvey	Yes.	Yes.	13	San Antonio
Texas Energy Engineers, Inc.	Bruce Kester, Saleem Khan	Yes.		140	DFW
The Delphi Groupe, Inc.	Robert Baron	Yes.		58	Austin-Round Rock
TLC Engineering for Architecture	John Piazza	Yes.		22	Dallas
Trane	Marcus Johnson	Yes.	Yes.		Statewide
Working Buildings	Craig Spikes, Ray Sanchez	Yes.	Yes.	36	Austin, Houston (HQ in Atlanta)
YPS	Glenn Randle	Yes.	Yes.		Austin

APPENDIX D: COMMISSIONING COURSE SYLLABI

LANEY COLLEGE
Environmental Control Technology
Fall Semester -2009
Course: Introduction to Building Commissioning
Course Number/code: ECT 025, 41431
Time: Thursday, Lecture, 7:00 PM – 8:20 PM and Lab, 8:30-9:50 PM

Instructor: Hadley Hartshorn

Office: B151 **Units:** 2 units.

Phone: (510) 464-3292

Course Description: This course will introduce the students to the fundamentals of building commissioning with practical emphasis and practice on commissioning HVAC systems. The course will cover the various types of commissioning, roles of the commissioning agent, activities in the various phases of commissioning and the use of common commissioning forms. The students will get experience with the processes by developing and implementing plans on various parts of the Laney ECT HVAC Lab.

Outcomes:

Understand the different types of commissioning and where each type might be applied
Understand the different Phases of a typical HVAC Commissioning Process and develop simple plans for each phase type
Gain experience with the selection and use of pre-functional checklists
Gain experience with the selection and use of functional checklists
Develop a simple commissioning report.

Prerequisites: none

Text: None. Handouts will allow the students to build up a class text and reference in a 3 ring binder. The contents of the binder tabs will be class handouts and other material acquired during the coursework

Supplies Needed: Three ring binder with 10 tabs

Recommended Tools: none

Topics:

Class	Date	Day	Unit Description
1	8/25/2009	Lecture	Introduction to Commissioning
	8/25/2009	Lab	----------none----------
2	9/1/2009	Lecture	Commissioning Process Overview
		Lab	Commissioning Examples (Discussion)
3	9/8/2009	Lecture	Types of Commissioning
		Lab	Laboratory Design Status
4	9/15/2009	Lecture	Program Phase procedures
		Lab	Design Intent and System Manual - 1
5	9/22/2009	Lecture	Design Phase Activities
		Lab	Design Intent and System Manual -2
6	9/29/2009	Lecture	Forming the Commissioning Team
		Lab	Development of Commissioning Plan
7	10/6/2009	Lecture	Construction Phase Activities
		Lab	The Commissioning Specification
8	10/13/2009	Lecture	----------*MIDTERM EXAM*----------
		Lab	----------*none*----------
9	10/20/2009	Lecture	----------*NO CLASS*----------
		Lab	----------*NO LAB*----------
10	10/27/2009	Lecture	Pre-Functional Checklists
		Lab	Pre-Functional Testing
11	11/3/2009	Lecture	Functional Testing
		Lab	Functional Test Plan development
12	11/10/2009	Lecture	Commissioning of Air Handling Systems
		Lab	Air Handling System TAB/Commissioning
13	11/17/2009	Lecture	Commissioning of Boiler/Hot Water Systems
		Lab	Boiler/Hot Water System TAB/Commissioning
14	11/24/2009	Lecture	Commissioning of Chiller/Cooling Systems
		Lab	Cooling Tower Commissioning
15	12/1/2009	Lecture	Retro-Commissioning
		Lab	Retro-Commissioning the HVAC Lab
16	12/8/2009	Lecture	Commissioning DDC Systems

		Lab	DDC system Practice
17	12/15/2009	Lecture	----------*FINAL EXAM*----------
		Lab	----------none----------

LANEY COLLEGE
ENVIRONMENTAL CONTROL TECHNOLOGY
FALL SEMESTER 2009

Course: Advanced Building Commissioning
Course No. /Code: ECT 026
Units: 3 Units
Date/Time: Monday, Lecture, 7:00 – 9:30 PM
Wednesday, Lab., 7:00 – 9:30 PM
Instructor: Adan Rosillo
Email: arosillo@comcast.net

Course Description: After completing this course the students will be able to develop a commissioning plan for new and existing facilities, use data collection instrumentation and protocols, analyze data to identify and solve issues on building systems specifically on HVAC systems. The student will learn how to write a commissioning report and calculate cost and benefits from commissioning existing buildings. *This course will focus on commissioning of existing buildings (retro-commissioning)*

Outcomes:
Identify key components of the commissioning process.
Develop commissioning plans for new and existing buildings.
Identify cost and benefits of the commissioning process
Develop test procedures and data collection protocols
Demonstrate proficiency in data analysis.
Develop training protocols for building operators

Prerequisites: NONE
Text: None
Supplies Needed: Three ring binder, "thumb" drive.
Special Notes: The following is recommended but not a requisite to take this course:
Email account to received electronic files
Laptop computer
Knowledge of spreadsheets (excel)
Class Schedule:

Week	Class	Date	Type	Description
1	1	8/24	Lecture	Commissioning process review
	2	8/26	Lab	Commissioning plan development
2	3	8/31	Lecture	Commissioning plan: New VS Existing building
	4	9/2	Lab	Benchmarking
3		**9/7**	**No Class**	**LABOR DAY**
	5	9/9	Lab	Benchmarking _ Bldg Loads
4	6	9/14	Lecture	Utility Analysis

	7	9/16	Lab	Practice Exercises: Benchmarking and Utility Analysis
5	8	9/21	Lecture	Data Collection: As-Operated, M&T Plan, Data Acquisition System
	9	9/23	Lab	Data Collection: HVAC Lab
6	10	9/28	Lecture	Data Collection: HVAC Lab (CONTINUE)
	11	9/30	Lab	Data collection: Setting up loggers, trends, etc.
7	12	10/5	Lecture	Building Air Systems Commissioning: Air Economizers
	13	10/7	Lab	Air Economizers data collection & analysis
8		**10/12**	**Lecture**	**MIDTERM EXAM**
	14	10/14	Lab	Midterm exam review
9	15	10/19	Lecture	Building Air Systems Commissioning: Supply and exhaust fans
	16	10/21	Lab	SF & EF data collection & analysis
10	17	10/26	Lecture	Building Air Systems Commissioning: Chilled and hot water coils, VAV boxes, air supply diffusers
	18	10/28	Lab	Chilled and Hot water coils, VAV boxes, air supply diffusers data collection & analysis
11	19	11/02	Lecture	Chilled & Hot Water Distribution Systems Commissioning: VFDs, and valves
	20	11/04	Lab	VFDs, and valves data collection & analysis
12	21	11/09	Lecture	Central Plant: Pumps, distribution water loops
		11/11	**NO CLASS**	**VETERAN'S DAY**
13	22	11/16	Lecture	Central Plant: Chillers, cooling towers, free cooling
	23	11/18	Lab	Chilled and hot water central plant data collection, the M&T plan
14	24	11/23	Lecture	Energy Management System Commissioning
	25	11/25	Lab	EMS data collection and analysis
15	26	11/30	Lecture	Commissioning report
	27	12/02	Lab	Assembling a commissioning report
16	28	12/07	Lecture	Energy and cost savings analysis
	29	12/09	Lab	Final commissioning report
17		**12/14**	**Lecture**	**FINAL EXAM**

APPENDIX E: SACRAMENTO CITY COLLEGE COMMISSIONING COURSES[66]

MET 391 Mechanical Systems 3 Units
Commissioning

Prerequisite: MET 381, 383, and 384 with grades of "C" or better
Advisory: MET 395 and MET 396 with a grade of "C" or better or concurrent enrollment in MET 395 and MET 396.
Course Transferable to CSU
Hours: 36 hours LEC; 54 hours LAB

This course focuses on the techniques and practices of commissioning controls and mechanical systems that are used in heating, ventilation, air conditioning, pumping, renewable and sustainable energy, and water treatment. Units of instruction include energy conservation; developing and implementing a comprehensive commissioning plan; inspection and testing of control systems, mechanical equipment, field devices and user interfaces to ensure that they are installed, programmed, and operated precisely as the design intent. Components of this course may be offered online. Students may be required to have access to a computer and the Internet and have some familiarity with a computer.

MET 382 Air Conditioning Systems Calculations

Prerequisite: MET 372 with a grade of "C" or better
Advisory: MET 381, MET 383, and MET 384 with a grade of "C" or better or concurrent enrollment in MET 381, MET 383, and MET 384.
Course Transferable to CSU
Hours: 54 hours LEC

This course provides an introduction to the use of computer applications in solving problems concerned with the design, installation, and operation of air conditioning systems. Units of instruction include calculating heating and cooling loads, piping, air distribution, equipment selection, psychometric and economic analysis. Components of this course may be offered online. Students may be required to have access to a computer and the Internet and have some familiarity with a computer.

MET 383 Instrumentation 4 Units

Prerequisite: MET 361 and 364 with grades of "C" or better
Advisory: MET 381, MET 382, and MET 384 with a grade of "C" or better or concurrent enrollment in MET 381, MET 382, and MET 384.
Course Transferable to CSU
Hours: 54 hours LEC; 54 hours LAB

This course provides instruction in the theory and practice of using instruments for testing and analyzing the operation of refrigerating, air conditioning, mechanical, electrical, and building systems. Units of instruction include a study of measurement principles including temperature, humidity, flow, light, sound, velocity, pressure, combustion emissions, air quality, voltage, level, force, and vibration. Laboratory activities will emphasize the practical applications of sensors and measuring instruments. Components of this course may be offered online. Students may be required to have access to a computer and the Internet and have some familiarity with a computer.

MET 384 Automatic Control Systems II 3 Units

Prerequisite: MET 371 and 374 with grades of "C" or better
Advisory: MET 381, MET 382, and MET 383 with a grade of "C" or better or concurrent enrollment in MET 381, MET 382, and MET 383.
Course Transferable to CSU
Hours: 36 hours LEC; 54 hours LAB

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[66] http://www.scc.losrios.edu/Documents/catalog/scccatalog09-10.pdf

This is the second of two courses (see MET 374) that focus on the study of controls and devices used in heating, ventilation, air conditioning, pumping, water treatment, and manufacturing systems. Units of instruction include electronic and direct digital controls, networks, interoperable systems, and programming of controllers. Components of this course may be offered online. Students may be required to have access to a computer and the Internet and have some familiarity with a computer.

MET 396 Air and Water Balance of Mechanical Equipment

(formerly MET 386)

Prerequisite: MET 381 and 383 with grades of "C" or better
Advisory: MET 391, and MET 395 with a grade of "C" or better or concurrent enrollment in MET 391, and MET 395.
Course Transferable to CSU
Hours: 54 hours LEC
This course focuses on air and water flow theory; air and water systems and components; air flow measuring instruments, their calibration, and use; and typical water flow balance work. Components of this course may be offered online. Students may be required to have access to a computer and the Internet and have some familiarity with a computer.