Writing Exercises Integrated with a Guest Lecture Series in a Senior-Level Engineering Course

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Abstract

Communication skills are essential in engineering and this paper discusses one way to introduce more writing exercises. One course in which writing has been emphasized is a senior-level, design-oriented, technical-elective course: ME 4343 Heating, Air-Conditioning and Refrigeration Design. In this course, a 13-week guest lecture series was implemented. Expert guests from outside the University were invited to speak on specific topics of relevance to the course. The topics often represented timely "hot" areas which are not emphasized in a traditional textbook, yet are being discussed elsewhere. The students were required write-up a summary of each presentation. Feedback was provided by the instructor. At the beginning of the series, the write-ups revealed major problems and prompt feedback allowed the students to significantly improve during the semester. Observations include many students: (1) confused the purpose of their write-up, (2) made serious "mechanical" errors such as misspelling the speakers name or title, and (3) conveyed little understanding of the speaker's issues or points. With prompt feedback and specific recommendations for improvements, students were able to significantly improve. There was a startling improvement in the quality of the write-ups. Students began to convey mature understandings of the presentations. Overall, the instructor was pleased by the professional atmosphere established in the later part of the semester, especially as students participated in question and answer sessions to clarify main points. This paper summarizes how the lecture series was organized, types of mistakes made by students, the type of feedback provided, and examples of how student written communication improved throughout the semester.

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Introduction

In many engineering programs, it is common to see a number of initiatives directed at improving writing. At the university level, there may be a "Writing Across the Curriculum" (WAC)[1] initiative like one being discussed at the University of Texas at San Antonio (UTSA). Similarly, there may be a thrust for engagement to promote student learning and success such as one through the Building Engagement and Attainment for Minority Students (BEAMS) project[2], of which UTSA has been a cohort since 2003. In BEAMS projects, writing is used to promote engagement. In engineering programs there is the desire for ABET accreditation.[3,4] ABET has program criteria "g" concerning the ability of students to communicate effectively. Often engineering courses are identified as having significant writing assignments. Lastly, there may be persistent employer feedback that recent engineering graduates need strong communication skills[5,6]. As these drivers converge, engineering faculty look for effective ways to strengthen written communication as well as reinforce course content within reasonable expectations of student time and effort.

The purpose of this work is to share one approach where modest writing assignments have been used to build engagement and promote a deeper understanding of the material while improving communication skills. In short, what is suggested here is an example of a writing-to-learn assignment which requires reflective thinking and synthesis.[7] These types of writing assignments are observed to significantly enhance learning by writing. The method in which the writing was crafted was within a guest lecture series.

Guest Lecture Series

In preparation for the class, the instructor contacted potential outside speakers and asked if they would be willing to give a 50 minute presentation with 10 minute questions/answers at UTSA. The instructor had the overall idea of the breadth of topics desired and contacted speakers in those areas. The presentations would be geared toward senior-level mechanical engineering students that were enrolled in ME 4343 Heating, Air Conditioning and Refrigeration Design, although they would be open to anyone who wanted to attend. The presentations were held in a large lecture hall and advertised to attract those from the College, University, and local Community. The local professional ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) chapter as well as student chapter at UTSA advertised the events. Somehow the first two events were picked-up by the San Antonio public radio station which gave them a broad appeal which did attract a few interested members of the public. As a result, there were a large number of attendees with about two-thirds being from ME 4343. This had the positive impact of creating a professional atmosphere. The list of speakers is in Appendix A, and this was distributed within the UTSA community and through the ASHRAE chapter email list.

In Appendix A, the speaker affiliation is given and it can be noted that all of the speakers were from outside UTSA. The topics were arraigned from broad to the more detailed.

The first three were thought to have the greatest appeal and did attract the widest audience, especially the first two which received radio advertisement. The third was attended by a local newspaper and an article was published about the presentation.[8]

Flyers were prepared and posted throughout the UTSA campus to attract attendees. An example of a flyer is in Appendix B. The flyers were professional and helped establish the atmosphere for the presentations.

Writing Guidance

There are a number of excellent resources to help prepare students to write clear, concise and informative summaries.[9] Some are available on-line at university writing centers.[10] Specific guidance was given to the students which emphasized the need to convey the key ideas of the presented in a coherent framework.

After attending the lecture, the students are asked to write an internal company memo that summarizes the presentation. The audience for such a memo is a company colleague or immediate supervisor. The audience is expected to have a technical background, yet not be intimate with the speaker's topic area. Maybe the presentation was given at a conference where only one representative of the company attended. Being a representative of the company, the student is asked to write a brief memo that will allow others to benefit from presentation.

It is a good strategy to show students examples of how they are to write. When this is repeated, a few example memos will be available from the Fall 2004 semester. Good and bad examples will be distributed and students will struggle with trying to understand the original presentation from the write-ups. It is expected that students will learn from reading the works of other students.

The memo is to convey the key ideas of the presentation and not be an independent criticism of the presenter's ideas. If the presentation had five key ideas, then the memo should reflect each of these ideas. Key terms are to be defined, especially if the terms are unfamiliar. The student is required to link together the ideas without changing the facts or perspective of the presentation. The overall topic area was often very new to the student so they were forced to be extremely attentive. The PowerPoint slides were not available after the presentation nor were the presentations recorded for review. This forced student to actively listen to the speakers and take good notes.

Active Listening

Active listening was one of the surprising results of this work. It quickly became apparent that students were mentally engaged during the presentation as they tried to grasp the key ideas and struggle with summarizing the speaker's main points. The only time in which to ascertain the speaker's points was during the presentation, and they knew their grade would suffer if they omitted major points. A simple data dump also

would not be sufficient nor a bullet list of ideas. The major points needed to be presented in a sentence structure. A numbered list within a paragraph was acceptable and often encouraged, but the main points needed to be discussed. Because of the length limit, students were very active in trying to understand what the speaker was saying.

Feedback

It was readily apparent that prompt detailed feedback was needed to help students improve. The first write-up was graded in detail with specific comments and suggestions to improve. A few recurring topics are listed here.

(1) Speaker name, affiliation, title of presentation and date. A large number of students failed to document this information. This information is critical to give the context to the memo. Likewise, trivial misspellings were not acceptable. This type of information was listed in the flyer and schedule, yet a few students didn't get it right. It was recommended to students that the first paragraph be devoted to this information and kept to a minimum of length. It can often be accomplished in 2 to 4 sentences.

(2) Major points. Most speakers explicitly shared an outline or followed an outline. A good write-up will give the outline and not miss any major points. A strategy of using "number lists in a paragraph" was recommended, and specific examples shared:

> "Five major areas of LEED certification are: 1) …"
> "… talk highlighted six green activities in the San Antonio area: 1) …"

(3) Understanding. Students struggled to assess the conclusion of each major point as well as that of the overall talk. Key words or phrases are often used by the speaker to convey main points such as: "solving customer's problems", "assessing value" or "sustainable". Often the speaker used a memorable phrase: "we are not inheriting the world from parents, but borrowing from children". At times, the speaker would ask questions like: "how can you make San Antonio green?" or "what is UTSA doing to be green"? Major themes can often be placed in the ending sentence of a paragraph devoted to one of the major points.

(4) Paragraphs. Most students didn't make good use of paragraphs to organize the memo. Some had run-on paragraphs or only one paragraph for the entire memo. Some would break sections into paragraphs without any reason or some just stop the paragraph without any sense of conclusion. It because obvious that a review of writing mechanics was needed along with noteworthy examples. An acceptable recipe was established by the class. The first paragraph was devoted to relaying the who, when and what of the talk. It often ended with an outline of the talk in a numbered list. Each subsequent paragraph delved into the major sections of the talk, and ended with a conclusion or summary of the section. The final paragraph summarized the overall purpose of the talk. Sometimes the speaker provided contact information and stated a willingness to continue the discussion. If so, this was included in the closing paragraph. Also, if a noteworthy

question was asked, it could be related in the closing paragraph. Overall, paragraphs are used to organize the write-up.

(5) Trivial detail. Some students thought the memo should be filled with details. Although some detail is essential, much of it was simply trivial, especially if there was not use of the details. After the write-ups were returned, the class did discuss what could be considered trivial with some examples: "Board of directors for MEP include: … ", or "net present value of $49/sft …" Overall, students were warned to keep the memo alive and avoid dead list of facts or bulleted list of items without insight. They were expected to convey understanding, as well as sufficient information to give the understanding context.

(6) In the news. Students were encouraged to highlight things in the news that were discussed by the speaker. How was the topic relevant? Was recent legislation driving the effort? Were recent tools or technology discussed? Was there a new organization or a new name? Specific examples were shared to show how the importance is enhanced by reference to recent events.

(7) Acronyms. Students tended to either avoid the use of, use without defining, or incorrectly define acronyms. It was obvious that each speaker used acronyms extensively and often without introduction. Although the instructor was familiar with many, students often were not. Hence it was emphasized that they should introduce and clearly define terms like: MPE, LEED, SEER, SB-5, SECO, TCEQ, USGBC. Similarly, they were not to belabor terms that the audience is familiar with like: ASHRAE and HVAC. As with names, it is essential that acronyms be correctly identified. A discussion of acronyms provided another opportunity to emphasize the intended audience of the writing.

(8) Personal subjective statements. Some students tented to have statements like: "I thought the presentation was informative" or the "speaker did a wonderful job of ". These statements convey little information about what the speaker said. Students were encouraged to avoid personalizing their subjective opinions, and concentrate on conveying the presenter's perspective. Some presenters did have good summaries or quotes that could be used to wrap-up the overall presentation and memo. Hence, the personal opinions of the presenter were often included in the memo, without revealing if the writer agreed or disagreed with the speaker.

(9) Help the reader. Students were encouraged to avoid repeating ideas, dead wood, and jargon. Likewise, they were encouraged to use active tense and keep sentences short and focused. They were to avoid joining dissimilar ideas, often in run-on sentences. Likewise, some students used an excessive number of parentheses for sub-ideas. These are distracting and make it difficult to read. A good way to convince students of the importance of clear writing is to have them read what other students write. In the future, it is recommended that they be prepared by being forced to read and assess multiple write-ups. When one has to read poorly written material, it becomes easier to understand.

(10) Discouragement. It was obvious many students worked hard on write-ups that received low grades. Because the prompt feedback was provided with specific suggestions for improvement, the students felt the grading was legitimate and helpful. They had both the guidance and opportunity for improvement. Without positive feedback, it would be easy to become discouraged. It was observed that many students worked hard and were happy to see their grades improve during the semester, even if they never attained A status.

Conclusions

By the end of the semester, most students were doing an exceptional job of producing well written memos that reflected a mature grasp of what the speakers had said. Having thirteen weekly guest lectures allowed sufficient opportunity to provide meaningful feedback to students and see improvement. A professional atmosphere was established which is considered helpful in preparing the students for careers in engineering. The level of instructor effort was noted to be high, and this is a draw back. One may want to explore options to reduce the amount of instructor time needed to read and mark writing assignments, yet this appears to be the cost of instruction. The grading time did drop significantly as more feedback was provided and the write-ups improved. The main benefits are: (1) significant practice with subsequent improvement in written communication, (2) improvement in listening and comprehension skills, (3) wide exposure to current design issues, and (4) exposure to those practicing in the fields related to engineering. Based on the experience, the instructors suggests to those who may want to implement this type of writing opportunity to: (1) host many guests speakers, (2) limit the length of the write-up to ~500 words, (3) read each write-up to assess understanding, (4) provide prompt and detailed feedback, (5) be stingy with grades until the write-ups deserve good grades, and (6) be encouraging to avoid losing students. Overall, good technical writing is hard work and may engineering students feel they have week writing skills. With proper guidance, the guest lecture series established an environment where there was significant improvement in technical writing skills over the semester.

References

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5 Davies, John W. and Glynis Cousin, "Engineering Students' Writing Skills," International Conference on Engineering Education, Manchester UK, August 2002.

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RANDALL D. MANTEUFEL

Dr. Manteufel currently serves as an Associate Professor of Mechanical Engineering at The University of Texas at San Antonio (UTSA). He received his Ph.D. degree in Mechanical Engineering from the Massachusetts Institute of Technology in 1991. His teaching and research interests are in the thermal sciences. In 1999 he was awarded the Dow Chemical Outstanding New Faculty Award for ASEE Gulf Coast Southwest section. He is currently the faculty advisor for SAE and ASHRAE at UTSA.

Appendix A: Flyer Promoting Series

UTSA

HVACR Design Issues – Guest Lecture Series

College of Engineering and the
American Society of Heating, Refrigerating, and
Air-Conditioning Engineers, Inc. (ASHRAE).

Fall 2004, Fridays 4:30 – 5:30 pm, EB 2.04.06

August 27	Linda Stone *Metropolitan Partnership for Energy*	Promoting Sustainable Energy
September 3	Kristin Heinemeier *Brooks Energy and Sustainability Lab*	Certified Green Buildings: Why & How
September 10	Andrew MacDonald *Adaetus Engineering*	Homeland Security for Buildings
September 17	Richard Fryer *Carrier*	Equipment Selection
September 24	William Burrus *City of San Antonio*	Fire Life Safety: Codes & Compliance
October 1	Danny Zimmermann *Marmon-Mok*	Office Building Issues
October 8	George Briley *Technicold*	Industrial Refrigeration
October 15	Andrew MacDonald *Adaetus Engineering*	Medical Facilities
October 22	Al Garza *Alamo Controls*	Building Automation Systems
October 29	Dick Lux *Five Star Electric Motors*	Electric Motors
November 5	Mike Donovan *Heat Transfer Solutions*	Electric Chillers
November 12	Pat Kotara *City Public Service*	Absorption Air Conditioning & Desiccant Dehumidification
November 19	Kristin Heinemeier *Brooks Energy and Sustainability Lab*	Building Commissioning

Appendix B: Example of Flyer for Each Presentation.

UTSA

Linda Stone
Executive Director
Metropolitan Partnership for Energy

Will speak on:

Promoting Sustainable Energy

Friday August 27, 2004
4:30 – 5:30 pm
EB 2.04.06

Topic:
The Metropolitan Partnership for Energy (MPE) was founded after the 2001 passage of Senate Bill 5 – the Texas Emissions Reduction Act. The Director will give a brief history of MPE's goals, partners, and programs. Ms. Stone will touch on current programs such as: Cities for Climate Protection, for which it is co-hosting an Urban Heat Island workshop; the Energy Efficiency Initiative it conducts with Fannie Mae; Build San Antonio Green, the region's first residential green building program, and MPE's second annual conference, Emissions Reduction & Energy Leadership Summit 2004.

Biography:
Linda Stone, Executive Director of the Metropolitan Partnership for Energy, is responsible for developing and promoting energy efficiency and sustainable energy programs for the San Antonio region. She has helped develop an energy policy for the City and County, coordinated development of Build San Antonio Green, a residential green building program, and provides information and educational materials to the public. Additionally, MPE puts on an annual Energy Leadership conference for local government, businesses, the building trades, and students. Previously, Linda served as Director of the Mayor's Office of Environmental Affairs in New Orleans. In that capacity she administered a variety of programs including the Cities for Climate Protection Campaign, which monitors and reduces energy use and carbon dioxide emissions. Prior to working in local government, Linda founded and directed The Green Project, a community-based nonprofit which has received numerous awards for its innovative, sustainable programs. Linda received her Bachelor of Arts in Architecture from the University of California at Berkeley and her Master of Urban and Regional Planning from the University of New Orleans.

HVACR Design Issues – Guest Lecture Series

College of Engineering and the
American Society of Heating, Refrigerating, and
Air-Conditioning Engineers, Inc. (ASHRAE).

For more information, contact: Dr. Randall D. Manteufel, 458-5522

Appendix C: Examples of Student Writing

Memorandum

To: UTSA Engineering Students

From:

Date: November 14, 2004

Re: Presentation by Pat Kotara on November 12, 2004

On November 12 Pat Kotara, from City Public Service, gave a presentation on absorption air conditioning and desiccant dehumidification. He discussed the advantages and disadvantages of these systems compared to traditional systems.

Absorption air conditioning ~~is a~~ cycle ~~that~~ uses a combination of fluids, typically water (H2O) and lithium bromide (LiBr), or ammonia and water. It the case of the H2O/LiBr the water vapor is the refrigerant. The water and LiBr combine into a single liquid. A pump is then used to increase the pressure of the fluid. Heat is then added to boil out the LiBr from the water. The water then goes to an expansion valve to decrease its pressure. At low pressures the boiling point of water is ~~decrease to a point~~ below the required air temp so it will absorb heat from the air. The water vapor is then combined again with the LiBr to complete the cycle.

water then air

There are many advantages to the absorption system. Pumping liquid to a high pressure requires less energy than compressing a gas. The absorption cycle does require additional heat to be added to the system, but the heat may be cheaper than the additional electricity. This is especially true if a source of waste heat is available such as from a generator. Having a pump as the only moving part makes the system very quiet, and has up to a 50 percent operation and maintenance cost versus a vapor compression system. The system also has a variable output and it can be driven off of various heat sources.

gas turbine

There are also disadvantages to an absorption chiller. The chiller is physically larger and heavier than a vapor compression system, and requires a 30-35% larger cooling tower. There is a lower coefficient of performance for this system, about 0.7 to 1.0, and a higher initial cost. Additional information can be found at www.tech-4-you/esc_cooling and www.gasairconditioning.org.

Dehumidifying air can be done in two ways, through a cooling coil below the dew point temperature or by using a desiccant material that absorbs moisture. The cooling coil also decreases the air temperature, which is undesirable during cold periods. Desiccant systems do not have this draw back. The desiccant material absorbs moisture at all temperatures by having a low surface vapor pressure. Moisture absorbed by a desiccant can be removed by heating the material. Using a desiccant system has the advantage of lower humidity levels, reduced condensation, smaller chillers and ducts, and more efficient handling of increased volume of fresh air.

Looking at all available technologies when designing a HVAC system provides for the best possible system for any given circumstances.

TO: Engineering Colleagues

FROM:

SUBJECT: Summary Report of HVAC&R Guest Lecture on October 29, 2004 – Dick Lux: "Basics of Electric Motors"

DATE: November 3, 2004

The topic "Basics of Electric Motors" was presented by Dick Lux as part of the HVAC&R Guest Lecture Series. Mr. Lux is founder and current chairman of Five Star Electric Motors, a Texas-based group that provides motor-related technical solutions. The focal point of the presentation was AC induction motors, with details on economic significance; energy usage; construction advantages; torque, field orientation, rotating field concepts; and constant flux operation.

A motor converts electrical energy to mechanical energy and consists of a stator (stationary part) and rotor (spins within stator). Electric motors consume approximately 50% of the electric power generated in the world. The breakdown of motor types is as follows: 92% induction, 4% direct current, and 4% synchronous. It was noted that AC induction motors consume 55% of the generated electricity. Variable frequency drives (VFD) could result in electric power savings of up to $6 billion per year. A brief history of motors was presented. The first patent was issued in 1888, and the first standard, called the "Original Frame," was established by the National Electrical Manufacturer's Association (NEMA) which began in 1926. New standards introduced motor improvements, making motors smaller and with higher operating temperatures.

Performance standards include rated hp, full load amps, and service factor, phase, and voltage ratings. The correct magnetic flux must be maintained: high and low voltages can both have adverse effects. The NEMA design code rating was explained, with details presented on every class, including Class E motors, which have higher energy efficiency. Class E motor materials incorporate greater amounts of copper and iron than other class motors and have seven to nine times the in-rush current of other motors. Synchronous speed was defined as follows: (phase angle * frequency)/# of poles. NEMA specification MG-1 also requires that each motor indicate rpm and locked rotor amperes on the motor nameplate, in addition to the previously mentioned performance standards. Factors affecting motor temperature include ambient temperature, rise of the motor, and insulation class. The frame size dictates dimensional standards necessary for manufacturer interchangeability.

A sine wave graph represents alternating current flow, with the three-phase current offset by 120 degrees. The dependency of torque on rated speed and motor horsepower was represented in the following equation: T=(hp * 5252)/S, where T=torque and S is the actual full-load speed in rpm. A note on motor circuit sizing was also made. In general, it is simpler to go down in motor size than to go up. The passage of the Energy Policy Act of 1992 (EPACT) required increased energy efficiencies in motors and greater in-rush currents.

Angular mechanics was briefly discussed, with the initial statement that "every motor is part of a mechanical system." Tesla demonstrated torque generation as a result of applying polyphase AC voltages to the stator. A point was made about the dependency of the current and voltage of a motor. An applied AC voltage will develop a stator flux. Motors are considered "active loads;" the current-carrying coils must be located perpendicular to the flux field as a key to the operation of motors.

VFDs can save up about $230,000 and are used in applications including centrifugal fans, blowers and pumps. Benefits include energy efficiency, improved productivity, soft start features with lower electrical stresses, and environmental benefits. VFDs are typically used in motors rated at or above 25 hp. Motor development is based on performance in the U.S. and on safety in Europe.

Mr. Lux ended by stating the predominance of electric motors in converting electricity to rotating mechanical energy and how it is logical to save on motor loads. For further information on motor technical solutions visit http://www.fivestarelectric.com.

Memorandum

To: Engineering Students
From:
CC: Dr. R. D. Manteufel, Associate Professor of Mechanical Engineering
Date: November 3, 2004
Re: Guest Lecture Series Summary: *Electric Motors*, by Dick Lux

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Date and Time: October 29, 2004 at 4:30pm
Lecturer: Dick Lux of Five Star Electric Motors

Inductor motors are used in 92% of today's applications. The focus of this lecture is on 3-phase induction motors. Dick broke his talk down into economics, energy, construction, torque, flux and variable frequency drives (or VFDs).

The motor is made up of two primary components the aperture and stator. The aperture is the rotor that spins and includes the shaft. The stator is the stationary part of the motor, is usually made with a laminating process, and has a wire core. A cooling fan is usually part of the rotor, however external cooling can be necessary. The rotor spins within the stator.

With energy costs rising selecting an efficient motor is very important. 55% of all energy generated in the U.S. consumed by induction motors, which translates to about 45 billion dollars per year.

Dick states that Elihu Thompson drew up the first patent for a motor in 1878*. Today the National Electrical Manufactures Association (NEMA), established in 1926, dictates dimensions and other standards for motors in order to improve compatibility and promote competition. Other governing organizations include The Institute of Electrical and Electronics Engineers (IEEE), Underwriter Laboratories (UL), Consumer Electronics Association (CE), and the American Petroleum Institute (API). In addition to these organizations, the National Electrical Code (NEC) governs much of how the motor is labeled and rated.

Motors are rated by performance standards. These ratings include horsepower, full load amps, service factor, number of phases, and voltage. Motors also fall into different slip classes. These range from A to E with high torque, high current starter type motors to highly efficient motors respectively. The motor speed can be calculated by speed = 120 [V] * frequency [Hz] / # of poles. The actual speed is usually less than this value due to slippage.

The Energy Policy Act of 1992 (EPACT) greatly affected the electric motor industry. With this came a desire for higher efficiencies, and lower costs.

The VFD creates a higher efficiency by reducing wasted work. To do this it changes the voltage and frequency of the power supplied to the motor in order to change its shaft speed. This will improve energy efficiency, allow for process optimization and improve end user comfort.

During the post lecture questions and answers, Dick states that the two most common reasons for failure of motors are heat and over greasing.

For more information regarding Star Delta Motor Controls Inc,

4729 Shavano Oak
San Antonio, TX 78249-4020
(210) 492-4200 Voice
Dick Lux: Email: dlux@vfd.com

* This statement is in dispute as some research shows that Thomas Davenport actually had the first patent for an electric motor in the early 1800's

Interoffice Memo: Building Commissioning 11-19-2004

To: All department Heads

From:

Speaker: Kristin Heinemeier, Ph.D., P.E.
Brooks Energy and Sustainability Lab

Dr. Ms. Heinemeier, who also gave the second lecture, ended our series with a lecture on building commissioning. Commissioning (Cx) in as intentional, systematic process, based on a team effort among owners, Cx administrators, designers, contractors, and suppliers for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria. Basically, it is a way for owners, financers, or others to keep the construction of a building in check, to assure in quality construction. Ms. Heinemeier began by discussing building construction problems and ended with the benefits of commissioning.

First off, buildings use 1/3 of our energy, 2/3 of our electricity, 12% of fresh water supply, 88% of potable water supply, 40% of raw materials, and account for 20% of our economy in their construction and operation. Buildings also contribute 36% of anthropogenic CO_2, 1/3 of solid waste, 46% of SO_2, and 19% of NO_X to our environment. Many of these issues are caused by coincident heating / cooling, chiller oversizing, instability due to design flaws, poor workmanship leading to bacteria growth and other problems, wrong VFD control settings, wrong static pressure set points, and improper duct layout. There are many different parties that can be responsible for these problems, ranging from the architect, to the engineers, to the contractors, and even the owners. The point of Cx is to be involved with all the different parties to make sure corners are not being cut, and poor designs are not being implemented.

Quality control in building construction differs from the automotive and manufacturing industries in that buildings are normally built as cheap as possible. Then a walkthrough after construction to check and test the systems which will hopefully work or else the quickest and easiest fix to a given problem will result. The better way to apply quality control is to start in the design phase with a Cx administrator who will engage the designer to apply previous lessons to the present problem, and to incorporate the customer's inputs in the construction process.

The commissioning process involves a thorough review during each of the following construction phases, planning, design, turnover, and finally, occupancy. The key elements of the Cx process are communication, coordination, site observations, field verifications, start-up, functional performance testing, and training and documentation of design intent objectives. If these elements are sufficiently applied, one can expect reduced energy costs (10 – 20% anecdotal), reduced operation and maintenance costs, an improved building based on improved design, construction, and turnover processes.

A Cx administrator is the owner's champion for quality. They do not have the authority to accept a building or direct contractors. They have the role of making suggestions, communicating, coordinating, documenting, and having a "fresh set of eyes." A good Cx administrator will have a solid design and field background, will be technically proficient, will be detail, communication and forensically oriented, and will have good people skills. A Cx profession is often a sub-specialty in HVAC. Normally it requires specialized training, and a Cx certification will demonstrate proficiency.

Not a lot of Cx is done right now, but it is required by some public sector owners, such as the military, and some cities and states. Cx is also required for California building standards and a LEED sustainable building rating. Resources for more information on building commissioning are the Building Commissioning Association available at www.BCxA.org, the Portland Energy Conservation available at www.PECI.org, the California Commissioning Collaborative available at www. CaCx.org, the ASHRAE technical committee 7.9 available through www.ASHRAE.org, as well as the NEBB, AABC, AEE, and the University of Wisconsin.

I need define