Replacing Electrons with Neurons: Industrial Workforce Education & Training Energy Efficiency Programs

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ABSTRACT

Industrial energy efficiency measures are an attractive target for utility efficiency programs as they generate large energy savings for relatively little investment (fast simple payback and low total resource cost (TRC))[1]. Achieving these savings has traditionally relied on information transfer through energy audits, staff training classes, training to market partners (such as equipment representatives) and design guides. More recently, industrial process energy requirements included in California and national energy codes have added education and training for compliance as a new method of communicating repeatable energy efficiency measures. This paper builds upon adult learning theory as a basis for implementing work force education and training programs. This approach starts with a needs assessment of the major market participants (equipment manufacturers, distribution channels, specifiers and end-users) to develop an overall performance improvement plan that often includes a training plan. These plans frequently include "role-based training" targeted at the specific activities performed by each type of market participant with actionable information that promotes the desired changes specific to their role in the market. This paper describes a performance assessment based methodology for developing a training compliance enhancement program for industrial efficiency measures recently adopted into the California Title 24 building energy efficiency code, and makes recommendations for applying role-based training to future education and training efforts.

New Opportunities in Industrial Energy Efficiency

Factories and other industrial facilities have historically been a rich source of energy savings from energy efficiency. There are a number of reasons why utility programs and those industries that sell energy assessments have focused on the industrial sector. These reasons, both directly and indirectly related to energy savings include:

- High energy intensity – A lot of energy is often used in a small area. Even saving a small fraction results in saving a large amount of energy in absolute terms.
- Process efficiency – Increased process efficiency can mean less downtime for a certain machine, saving money on labor, or the ability to increase the number of units produced

[1] Total Resource Cost is the primary indicator of energy-efficiency program cost-effectiveness that the California investor owned utilities (IOUs) use. The TRC measures the net resource benefits from the perspective of all ratepayers by combining the net benefits of the program to all ratepayers, both participants and non-participants (CPUC 2008).

per hour using the same or less energy. These indirect energy savings are an additional way for an industrial facility to recoup money spent on an energy efficiency project.

- Waste reduction – By improving the efficiency of a process, the amount of waste product can be reduced. This leads to both energy and resource savings and can reduce expenditures on waste disposal.
- Long operational hours – Many manufacturing operations have more than one shift and thus operate for relatively long hours. As a result, a given efficiency measure will likely yield a quicker return on investment in an industrial setting than in commercial or residential ones.
- Inconspicuous savings opportunities – Energy inefficiencies can be obscured by the massive energy consumed by weighty manufacturing processes. When energy consumption from a facility's main process is in millions of kWh per, increased HVAC usage by hundreds of thousands of kWh may go unnoticed, even though this is costing tens of thousands of dollars per year.
- Process complexity – Industrial plants can be complex. The main focus is on keeping everything running and thus less attention goes to maintaining top efficiency.

Many large companies are aware of the opportunities to capture additional profit by squeezing more products out of less energy and materials, and these large companies typically have more manpower to dedicate staff to energy management. Small and medium businesses, however, frequently do not have the perceived critical mass of energy expenditures to dedicate someone to energy efficiency. In many cases, energy management is just another added responsibility of the facility operator – after they make sure processes are up and running and all maintenance is performed to avoid unplanned downtime.

Hypotheses of Industrial Efficiency Gaps

The following hypotheses are based on anecdotal information from circa 100 industrial energy assessments conducted by one of the authors. In the development of a performance assessment, the program design analyst interviews subject matter experts to help develop working hypotheses that are then tested via interviews with market actors.

Companies don't want to waste energy and money. The basis of energy assessment programs is to correct knowledge and skill gaps that impede industrial entities from employing cost-effective energy efficiency investments and practices. The following bullets highlight a series of barriers that impede adoption of efficient practices and technologies that could be corrected by assessment and training programs:

- Scalable design – Facility owners and manufacturers tend to have significant technical expertise about their product. However, they often must rely on designers for efficient system design, such as compressed air and steam systems. Over time, factories may need to scale production, sometimes with haphazard system accretion, making it difficult to incorporate the most efficient process design.
- Operations – To account for broken or impaired equipment, which may stop or slow production, equipment capacity is typically deliberately oversized and/or redundant, often resulting in equipment that rarely operates with optimal efficiency.
- Equipment selection – Time is money. If something fails, it might be replaced with whatever is available as quickly as possible. For planned replacement, the exact same

equipment is replaced so as not to be disruptive. Thus, whatever technology was used originally might be locked in over the long term.

- Maintenance – Some equipment must be regularly adjusted to run at peak efficiency. For example, almost all boilers can benefit from a simple manual tuning using a combustion gas analyzer.
- Cost control – Some businesses know what their energy costs are but don't know what their costs should be. Unlike new commercial buildings that have somewhat predictable usage by climate zone, factories use widely divergent amounts of energy. In addition, industrial companies do not necessarily want to benchmark or share any information about their processes with their competitors.

As this paper will discuss, most of the industrial energy efficiency programs have some level of training. Even the most prevalent form of industrial efficiency program, the industrial energy assessment, is a form of training; the assessor writes up a report that details the energy efficiency opportunities and provides a framework for evaluating the economic feasibility of implementing a given efficiency measure.

California has adopted a number of repeatable industrial process measures into their Title 24, Part 6 building energy efficiency code. Historically, efforts to increase energy code compliance and thus energy savings from codes have also relied on training programs to raise awareness around these issues and opportunities. The basis of these efforts has been that the key gap in industrial energy efficiency and code compliance is a knowledge gap. This paper recommends that program designers test this working hypothesis and collect information about what market participants perceive as the key gaps to energy efficiency, then use this data-driven approach to program design.

History of Industrial Training Programs

There are a variety of industrial training programs being offered across the country sponsored by entities including the Department of Energy (DOE), utility companies, manufacturing trade associations, and other private and non-profit institutions. This section serves to highlight these efforts and the trends among them.

The Association of Energy Engineers (AEE) surveyed 2,967 energy professionals as part of a jobs and market trends analysis. Almost 70 percent of those surveyed indicated that they believe there is currently a shortage of qualified energy management individuals (AEE 2013b). AEE also reported that almost a third of those professionals are likely to retire in the next 10 years (AEE 2013b). Fortunately, there appears to be an increasing awareness of these issues and a heightened sense of urgency around providing better training opportunities earlier in workers' careers. The DOE, specifically, identified a need for training to be incorporated into vocational schools, colleges, and universities (Kasten 2013). The DOE also identified a gap in certification associated with training. There is neither an official certification nor credentialing process for those providing the trainings or those completing the trainings. This can lead to inconsistent or incorrect information being delivered in the classroom and applied in the field (Glatt 2013). Future effort to provide accreditation of classes would not only help with quality assurance of material delivered and received, but also could incentivize more individuals to take classes.

There also appears to be an opportunity at the utility level for the development and marketing of industrial training programs. These programs could increase industrial facilities' adoption of efficient technologies and commissioning practices, as well as pave the way for future code opportunities.

Department of Energy: Process Specific Training Programs

Beginning in the mid-1990's, the DOE began to develop a series of system-based training programs centered around software tools that help facility operators and engineers identify opportunities for improvements in efficiency and system performance. Prior to the inception of this system-based curriculum, much of what was available was vendor or product specific resources. Between the mid-1990s and about 2005, the DOE invested in expanding these training programs into three specific types: (1) end-user training, (2) qualified specialist training, and (3) awareness training (Glatt 2013).

End-user training classes are designed as day-long classes for understanding system and energy implications of a given system (e.g. pumps, compressed air, steam), with some introduction to the software platforms developed for each system. Qualified specialist training classes, designed as follow-up courses to the end-user training, focus on developing expertise around each software tool. Finally, the DOE developed awareness training opportunities in the form of two-hour long presentations, serving as an introduction to the concept of whole system optimization across all system areas. Since the inception of these programs, over 50,000 individuals have participated in one or more of the three types of training (Glatt 2013).

Table 1. DOE Industrial Program Areas & Offerings

Industrial System	Activities	Partners
Compressed Air	• Software • Training • Technical Publications	DOE, Lawrence Berkeley National Lab (LBNL), CAC, Bonneville Power Authority (BPA), Oregon State University (OSU) & Washington State University (WSU)
Fans	• Software • Training • Technical Publications • Tip Sheets	DOE, LBNL, Air Movement & Control Association (AMCA), Oak Ridge National Lab (ORNL)
Motors & Drives	• Tip Sheets	DOE, LBNL, WSU
Process Heating	• Software • Training • Technical Publications • Fact Sheets	DOE, LBNL, Industrial Heating Equipment Association (IHEA)
Pumping	• Software • Training • Technical Publications • Tip Sheets	DOE, LBNL, Hydraulic Institute (HI), Europump, & ORNL
Steam	• Training • Technical Publications • Fact Sheets	DOE, LBNL, ORNL
Mechanical Insulation	• Training	DOE, National Insulation Association (NIA), and International Association of Heat and Frost Insulators and Allied Workers (IAHFI)
Data Centers	• Training	DOE, American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)

Source: LBNL 2006

Table 1 provides a high-level overview of training curriculums that have been developed for trade-organizations, manufacturers, utilities, and utility-partners to use. The topics of the industrial systems training are energy consuming services (compressed air, air movement, rotational power, etc.) common to industrial processes.

Department of Energy: Industrial Assessment Centers (IACs)

The Department of Energy sponsors the Industrial Assessment Center (IAC) Program, comprised of 24 centers and 32 participating universities across the United States, to provide small and medium-sized manufacturers with energy, waste, and productivity assessments. Teams of engineering students and faculty from these universities prepare these energy assessments, providing a valuable service to companies who cannot afford a full time energy manager while at the same time providing the students with valuable hands-on training on industrial processes and energy efficiency. Additionally, the IACs have created a host of webinars, reports, and manuals that are publicly available for use by facility operators and engineers. One of their main goals is to shorten the timeframe that new engineering graduates spend getting up to speed on applying concepts to actual practice (Kasten 2013). The IAC estimates that the average energy worker will soon be almost 10 years older than the average U.S. worker, 500,000 of which are anticipated to retire in the next 5 to 10 years (Glatt 2009). Thus, training a skilled workforce to take on the jobs of those reaching retirement will be highly critical, and has become a forefront focus of the IACs.

The IAC model is to vertically disseminate information from headquarters to each of the IAC centers; directors of those centers have the freedom to modify or change materials and training modules. The IAC developed 10 modules, which are largely based on concepts that can be completed in one day (Kasten 2013). The concepts emphasized range from how to complete audits of a specific type of facility to audits of a specific system (e.g., compressed air), with a focus on implementation.

The IAC also maintains a database of all participating students and client sites, as well as a method to track savings resulting from implemented assessment recommendations (Martin 1999). Another objective of the IAC is to extend program benefits beyond the preparation and delivery of assessments, and to keep track of these benefits (Martin 1999). The IAC database, established for these purposes, is a model example for the ways in which other training programs can and should be tracking influence on energy efficiency projects.

Utility Training Programs: Pacific Gas & Electric Company (PG&E) & Northwest Energy Efficiency Alliance (NEEA)

Pacific Gas and Electric Company (PG&E) has five main learning centers in its service territory with a handful of smaller centers that serve to provide educational and training opportunities for residential, commercial, and industrial sectors/processes. An informal needs assessment of market demand for training opportunities and topic areas is conducted bi-annually (Boswell-Barnes 2013). Coordinators at PG&E reach out to PG&E Program Managers, PG&E Core Products staff, local government entities, the California Energy Commission (CEC), and the California Public Utilities Commission (CPUC) to gain feedback and input on what should be offered in the coming month and over the next two years (Boswell-Barnes 2013). PG&E also occasionally coordinates with Southern California Edison (SCE) and cost-shares on some classes so as to augment the number of training opportunities (Boswell-Barnes 2013). These feedback loops help the California Investor Owned Utilities (CA IOUs) provide classes when and where they're needed. The IOUs recognize that additional coordination with DOE, the National Labs and utilities outside of California could enable all entities to cost-share materials, curriculums, and lessons learned.

The Northwest Energy Efficiency Alliance (NEEA) launched its industrial sector initiative in 2005, with regional training centers, offering one-day sessions for maintenance departments from manufacturing and industrial facilities (Wallner 2013). The NEEA Regional Technical Program offers on a rotating basis the DOE developed training programs including Motor Master, Air Master, Compressed Air Challenge, Steam System Assessment Tool, and Pumps Matter.

Association of Energy Engineers (AEE)

The Association of Energy Engineers is a non-profit, professional association founded in 1977 that now has over 16,000 members in 89 countries. Since its inception, more than 100,000 individuals have participated in various training programs offered or sponsored by AEE (Thumann 2013). They partner with the DOE, the Alliance to Save Energy, trade organizations, and other entities to provide, sponsor, and market training opportunities. AEE also operates the longest-standing certification program for energy managers (CEM), with 10,000 certified CEMs and over 22,000 professionals certified in specialty energy areas (AEE 2013a). This is an example of a public entity that has considerable experience and breadth of connections across industrial fields and physical localities that should be consulted and leveraged in the process of expanding the number and type of industrial training programs.

Superior Energy Performance and ISO 50001

The US DOE is leveraging the International Standards Organization (ISO) 50001:2011 *Energy Management System* standard for promoting top down energy management by industry. The US DOE, with the assistance of the U.S. Council for Energy-Efficient Manufacturing (U.S. CEEM), developed a program called Superior Energy Performance (SEP). SEP is a certification and training program for energy management with a primary focus on implementing the ISO 50001 standard and documenting energy performance improvements.

The DOE has created a certification organization Institute for Energy Management Professionals (IEnMP) to provide certifications in support of the Superior Energy Performance initiative. The Association of Energy Engineers, Georgia Tech Research Corp and UL DQS provide trainings for these certifications.

Institute for Industrial Productivity

The Institute for Industrial Productivity provides companies and governments with advice on technology, policy, and financing of industrial energy efficiency. They focus on the cement, iron and steel, and chemical sectors in China, India, and the United States. The institute has developed an Industrial Energy Efficiency Technology Database of technology options for improving processes in these areas. They also provide technology demonstrations, free software tools, guidelines, and case studies for facilities. Operating at a high level, the Institute for Industrial Productivity interacts with large manufacturers, typically with multiple facilities, and thus has the opportunity for significant global impact.

Building Energy Code Training

Implementation of IOU sponsored training programs specific to California's Building Energy Efficiency Standards Code, Title 24, Part 6, began in the late 1990's, almost two decades after Title 24's inception. As the code increased in complexity with the number of measures and the scope of coverage, participation from a wider cast of market actors was needed to assure proper code compliance. As a result, the need for energy code training became more apparent (Wylie 2013).

At first, trainings were divided into residential and nonresidential sectors and targeted only contractors and building designers for daylong sessions in which the entire code was reviewed. The utilities, California Energy Commission (CEC) and California Public Utilities Commission (CPUC), began to realize that building energy code compliance was failing at various points along the supply chain of actors, and began catering trainings to a broader range of market participants, more inclusive of all individuals involved in the process (Segerstrom 2013). While trainings were, in theory, now reaching the necessary individuals involved in compliance, the trainings were still failing in a fundamental way. Two measures, Residential Duct improvement and Lighting Controls under Skylights, had compliance as low as 27 percent and 56 percent, respectively (Marver, et al 2010). With compliance numbers this low, California was losing significant savings opportunities from its building energy code.

With these realizations, in 2007 and 2008 the California IOUs conducted a large research initiative to explore various pathways for training improvements, with the goal of increasing compliance by upwards of 30 percent across select measures. What the research team learned is that these training programs had been designed to do too much; they were trying to reach too many people with too much information in too little time (Marver, et al 2010). In 2008 and 2009, the IOUs implemented a whole new series of classes designed to build the specific knowledge base and skills that particular market actors need in order competently perform their role in ensuring code compliance. The next section discusses these concepts in greater detail.

Adult Learning Theory

To improve building energy code compliance and maximize cost-effective savings for ratepayers, PG&E redefined workforce training so that it is targeted specifically for a given market actor's unique relationship with the building code. In 2008 PG&E conducted a needs assessment study on how to increase code compliance with the Title 24 standards. (Marver et al. 2010) We think a similar approach should be applied to the industrial sector building code compliance – start with a needs assessment to determine the most promising opportunities for improving code compliance. We suggest that a performance gap analysis be conducted with the market actors included in the industrial process equipment supply chain (i.e., people involved with compressed air systems, boilers, fume hoods, etc.) to test whether the following approaches should be adopted for compliance training development for industrial process specific measures. Some of the following findings developed by Lisa McLain[2] for the 2008 PG&E study on performance gaps in residential and nonresidential energy code compliance may be transferrable to the development of an industrial training program for energy code compliance.

[2] McLain ID (Instructional Design) Consulting

Key Findings from CA IOU Study on Development of Building Code Compliance Training (Marver et al. 2010)

- *The biggest near-term impact on compliance could be achieved by equipping the market actors who kick off the compliance supply chain*—including energy consultants, plans examiners, and field inspectors—with the knowledge, skill, and tools they need to quickly and easily focus their time on important, high-value energy efficiency issues.

- *Enforcement and compliance personnel (plans examiners, building inspectors and energy consultants) are interested in participating in trainings.* Based on results from an online survey to enforcement and compliance personnel, 80 percent of responders indicated that they are able to participate in a half-to-full-day course twice annually, and that 90 percent agreed that understanding the principles and engineering behind measures helps them to perform their jobs more effectively. A carefully designed training program would try to understand what the acceptable length, frequency, and delivery type is most appropriate for different market actors.

- In follow-up interviews, the following adult learning techniques were discussed and evaluated:

  - *Emphasize hands-on training over lecture-based classes.* Interactive classes that require participants to use real plans and identify errors in faulty calculations are more effective for learning than strictly using bulleted PowerPoint slides.
  - *Keep it simple, focused, and straightforward.* Modules should be created with a central theme and focus. Information delivered during these trainings should concise and serve to help actors fulfill their roles with greater ease and accuracy.
  - *Trainings should rely on real-world examples and leverage modeling concepts related to those scenarios*. Offer modeling classes for beginners that walk students through Title 24 from beginning to end, using specific software and real plans/blueprints.
  - *Training should be designed to focus more on role-based performance requirement for key market actors,* accommodating preferred learning styles of the different market actor roles. By making classes and units modular, trainings can be more specific and tailored to experience level, role, and subject area.
  - *Trainings should provide a variety of learning activities that parallel on-the-job requirements.* Classes should provide hands-on practice and activities using real-world case scenarios. This could also entail comparing plan sets to compliance forms or using hunt/diving exercises to train individuals in finding and assessing errors more easily and quickly. Other adult learning techniques to improve retention and provide ample practice opportunities include role-play exercises and group work to prioritize time and attention. Cross-pollination is another technique in which actors in different roles can share their understanding of measure requirements and gain an appreciation of respective roles.

- *The curriculum should also utilize job aids and "quick reference" material for on-the-job support.* Partnerships with local government entities can yield a more thorough understanding of the knowledge and skill gaps, and code enforcement processes, which are needed to identify performance improvement opportunities to streamline enforcement practices and improve consistency across jurisdictions.

Using adult learning theory principles, the CA IOU Codes & Standards team began to optimize their workforce training programs to improve building code compliance. We think that the process used to develop these residential and nonresidential code compliance enhancement programs are transferrable to developing an effective code compliance program for newly added industrial measures. The following section provides an overview of adult learning theory concepts and their transferability to industrial code compliance.

Performance Improvement Needs Analysis

In addition to applying the principles of adult learning theory, performance improvement needs assessment is an integral part to maintaining up-to-date curriculums and trainings that cater to the market's changing needs. The PG&E Manager of Energy Centers stated, "There is a need to diagnose the problem first before you can prescribe an adequate solution."

The initial steps in ensuring factories are effectively implementing the building energy code include: identifying which tasks can have the biggest impact on compliance, determining what the ideal employee's performance looks like, and documenting their competencies. Competencies include those behaviors an employee must be able demonstrate to be considered proficient in their job.

Next, performance improvement specialists interview and observe how the targeted job tasks are actually being performed, how the current behavior compares to the desired behavior, which gaps exist, and why the gaps exist. For example, do the performers who are performing the targeted job tasks lack the necessary knowledge or skill they need? Are they aware of any existing inefficiencies in their facilities' operations? Is performance measured and rewarded; is there a penalty for underperformance? Do they lack the necessary tools or resources to perform effectively, etc.?

Once you understand what performance gaps exist, you can apply the appropriate performance improvement solution. For example, if one finds that knowledge or skill gaps exist, training programs may be the best intervention for this gap. If one finds that people know what to do and how to do it, ensure the proper voices of authority articulate what the desired performance looks like, and how they are going to measure performance and reward it. To this end, the authority figures must articulate the consequences for failing to perform as desired.

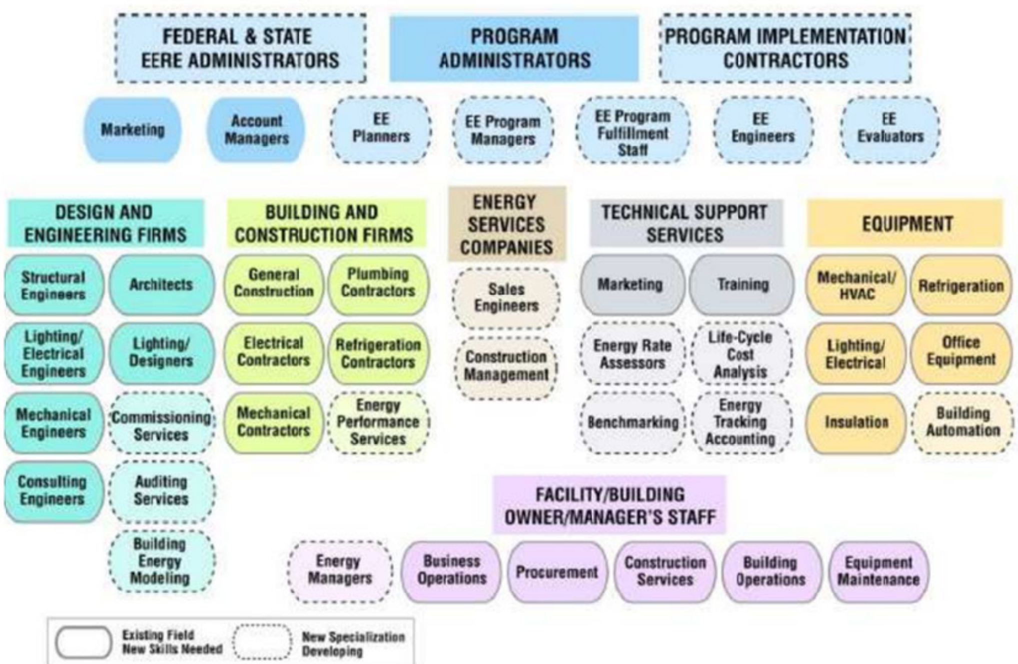
If you find that people know what they're expected to do and how to do it well, but they don't have the proper equipment to perform effectively, you must find a way to equip them with the necessary tools and resources. This can be difficult if lack of funding for employees is an issue. One performance improvement solution in this situation may be to find a way to simplify the process so that they can effectively do more with less. For example, many cities and counties have had to downsize their building departments staffing levels due to economic downturn, which puts extra stress on plans examiners, building inspectors and permit counter technicians. Remaining staff cannot afford to take much time away from their job for training and they need streamlined efficient processes to help them serve all of the contractors and building owners in their jurisdictions. In this instance, performance may be improved by:

- Bringing training directly to building department facilities at times that are convenient for them,
- Delivering short webinars on specific topics and providing factsheets that explain the code to contractors and building owners;
- Incorporating kiosks that lead contractors to the appropriate compliance forms and on-line permitting software; and,
- Developing one energy code champion that focuses on understanding the code who can serve as an expert to his or her colleagues.

Adult Learning Theory Applied to Industrial Code Compliance

The energy savings associated with the building code and industrial process measures is significant, yet compliance has fallen well short of expectations, largely due to the complex and complicated nature of both the code and market actors involved. A key difficulty in developing effective training regimes has been identifying each actor's skills and knowledge gaps, and catering directly to those needs using targeted practice. In Figure 1, Hardcastle et al. (2009) have mapped out what they believe are the key players in the industrial market in Washington State. The market is quite complex with 42 types of key market actors.

Figure 1. Industrial Market Actors



Definitions:
EE - Energy efficiency, EERE – Energy efficiency and renewable energy

Source: Hardcastle & Waterman-Hoey 2009

While not every actor plays a role in the compliance process, many affect it either directly or indirectly. Table 2 outlines the results of an interview with a subject matter expert on his perception of these actors, their roles, key decisions, and potential knowledge/skill gap. To round out his kind of scoping study of hypothesized gaps, one would interview several experts so potential issues can be identified from several perspectives.

Table 2. Key Market Actors' Roles, Decision Power, & Assessment of Knowledge Gap

Market Actor	Role	Key Decisions	Hypothesized Knowledge/Skills Gap
Energy Consultant	Acts as Code Expert; typically hired by general contractor	Helps ensure building complies with code	May not know the current code or compliance pathway (e.g. necessary permits)
General Contractor	Builds the project; Responsible for code compliance documentation for permit	Hire subs; Buys equipment and Project Manages Install/Construction	May not know the code, relies on consultant to design to code
Architect	Project initial design	What, where, who	May not know the current code; Likely to rely on engineer or energy consultant
Plant/Facility Owner	Hires architect, financial resources	Expenditure levels to attain goal	Not likely to know the code
Plant/Facility Operator	Oversees industrial process and flow of materials/labor through facility	Could stop or slow process if it impedes plant performance; optimizes plant output	May not know code; May have opposing interests to code (e.g. could disregard code, if code or certain steps for compliance are costly)
Equipment Distributor	Sells new equipment to contractor, potentially with disregard to code	Provides equipment availability and pricing	Since code has newly increased scope to industrial likely does not know about code requirements
Plan Checkers	Oversees compliance with code	Pass or fail	May not know the code
Field Inspectors	Code compliance	Pass or fail	May not know current code or have time to inspect at the rigor needed
Third Party Verification Providers	Assist the authority with compliance	Pass or fail; Suggest fixes for short falls; Test, if applicable	Could lack knowledge of complex systems and the code requirements
Builders	Build their piece of the project; Often under pressure to finish in time at low cost	Meet the owner and architect and general contractor expectations	Out of state suppliers may not know Calif. Code;
Utility Representative	Help customer with connection to the grid and general power management inquiries	Sometimes provides key information to decision-maker.	May not be aware of the code or have thorough knowledge of the facility to provide the most-informed information.
Local Government Jurisdiction	Enforce the code	Hire enough staff to assure compliance	Knowledge of complex systems and current code measures
State Government Jurisdiction	Write the code	Logical and practical code development	Knowledge of complex systems, real world practices, actual system costs, other national standards, industry standard practice, emerging technology

Source: Wylie 2013

From this table one can see that insufficient knowledge of the code and conflicting interests with respect to code compliance may be some of the largest barriers. This hypothesis has to be tested and if it is proven to be true, code compliance training should be designed for a given and specific subset of actors as a key approach for addressing the knowledge gap. As demonstrated, this has been successfully implemented in building code compliance, and would likely enhance code compliance in the industrial arena. While a conflict of interest with code compliance may be more difficult to address, penalty for non-compliance could remove some of those conflicting barriers. Recent efforts in code compliance have motivated engagement of the Contractors State Licensing Board to enforce sanctions against designers or contractors who are willfully ignoring the building codes.

Conclusions and Next Steps

Many industrial energy efficiency programs rely on training so that energy is used more effectively. Of the approximately 550 GWH/yr savings associated with each year's new construction complying with the 2013 version of the Title 24, Part 6, energy code, approximately 100 GWH/yr are saved due to process or industrial energy efficiency measures. Given the magnitude of potential energy savings that rely on process and industrial efficiency code measures, it makes sense to prepare for this new code (effective in 2014) by conducting a performance gap survey of market participants who are projected to have an impact on code compliance and develop a plan for addressing these gaps.

Earlier code compliance evaluations have found that approximately 84 percent of the potential savings associated with the nonresidential code measures have been realized (KEMA 2010). An effective program has the potential to cut this 16 percent non-compliance rate in half. Proactively addressing industrial code compliance could yield an additional 24 GWh/yr over a three year code cycle period for just the State of California.[3] The planning tools (supply chain analysis, performance gap analysis, and targeted interventions) developed for building code compliance could be fruitfully applied to this sector and yield significant savings.

Other energy codes have also started including process and industrial efficiency measures. For example, ASHREA 90.1-2010, the benchmark for future commercial energy codes has the following process measures: Data Centers, Lab Ventilation, Kitchen Ventilation, and Garage Exhaust. States like Washington, Oregon, and California have already adopted code for Data Centers. Moreover, California has adopted standards for additional industrial measures through Title 24. These include standards for industrial boilers, refrigerated warehouses, and supermarket refrigeration. As California and the northwest lead the way, the opportunity for developing code compliance programs for industrial and process energy measures is ripe for growth.

Given the huge energy savings opportunities associated with process and industrial measures, we expect that other entities will consider including process and industrial measures in their codes. However, the huge potential savings are contingent on code compliance. This paper has described a process that can be useful for other entities in developing a code compliance enhancement program.

If it turns out that technical training is identified as one of the performance gaps associated with code compliance with industrial process measures, there is wealth of information

[3] 8% x 100 GWh/yr x 3 years = 24 GWH/yr at the end of three years

that can be accessed through various sources, as indicated in Table 1, as well as the industrial energy efficiency programs that are operated by local utilities. When training is applied, past experience has indicated that it should be audience-specific and utilize a role-based approach to effectively address the code compliance activities that are specific to the targeted audience.

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