A Strategic Approach to Industrial New Construction Programs: Establishing Energy-Use Baselines in the Absence of Code

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ABSTRACT

Substantial opportunities exist in the industrial new construction and major renovation market for energy efficiency programs to intervene to promote energy performance improvements. Acknowledging this opportunity, California's utility-administered Savings By Design program provides training and awards financial incentives to industrial as well as commercial projects based on how well a proposed design outperforms a typical or "baseline" facility design. However, measuring and quantifying energy savings for new industrial projects presents a challenge because, unlike commercial facilities addressed through the program, industrial facilities are not governed by California's Title 24 new construction energy code, which sets strict energy budgets for commercial occupancies. Industrial facilities, even within the same market sector, often have unique processes and widely differing energy needs. Energy intensity per volume of production varies widely because these projects are not subject to code. In the absence of a standardized state code as an industrial program baseline, the California utilities have pursued the development of alternative baselines for industry from which to measure energy performance improvements. This paper describes the utilities' multi-tiered efforts to develop these baselines using 1) other legislated mandates, 2) industry guidelines, and 3) commonly accepted and well-documented industry practices. Where useable standards have not been available, studies have been commissioned to evaluate standard practice in unique industrial markets. Equipment and industries addressed, to date, include motors, compressed air, dairies, cleanrooms, and wastewater treatment facilities.

Introduction

Opportunities exist in the industrial new construction and renovation market for energy efficiency programs to intervene during a facility's design process and promote energy performance improvements through education and financial incentives. While specific energy efficient processes have been successfully adopted in some industries, numerous barriers still prevent technology transfer across industries, including corporate decision-making rules, lack of information, limited capital availability, shortage of trained personnel, and the "invisibility" of energy savings (ACEEE, 2001). By promoting integrated design principles, streamlined industrial processes, and the adoption of high efficiency technologies, utilities and customers can capture long-term energy savings, avoid added utility generation, and create permanent market change towards a more sustainable energy future.

California's utility-administered Savings By Design program provides design assistance and financial incentives for commercial, industrial and agricultural new construction projects to promote the adoption of energy efficiency. Design assistance is customized to the needs of each project, and financial incentives are available for both customers and design teams. Incentives for customers, available when the proposed design outperforms a standard baseline design by approximately 10% (or more), lowers the up-front incremental costs and payback periods associated with some energy efficiency options. Incentives for design teams, available when the design outperforms the baseline by 15% (or more), reward designers who meet these ambitious energy efficiency targets.

Because incentives are directly linked to the energy savings of a project beyond an established baseline, it is important to properly define baselines where they do not exist. Defined baselines form the standard by which proposed energy efficient designs are compared. They can be scaled larger or smaller to define the energy performance of a whole building, a unique system within a building, or a piece of equipment within a system. Baselines can be assigned various metrics to determine energy intensity, depending on the size and scope of what is being measured, from source energy per square foot (e.g., for system-integrated whole building analysis), to watts per square foot (e.g., for lighting energy intensity in a specialized type of room), to unit of energy per widget produced (e.g., for the efficiency of a particular production line). Due to the unique nature of different industries and their processes, standard practice baselines vary and often need to be defined on an industry-by-industry basis. Because of technology innovation and the adoption of stricter building codes and standards, standard practice baselines are also constantly in flux.

These, and other, challenges were taken into consideration when Savings By Design expanded in 2002 to address the Industrial and Agricultural markets. This paper aims to explore difficulties and share methodologies, success stories and selected results from baseline work already undertaken in the California context. The paper will focus primarily on efforts undertaken by the utilities to assess standard new construction design practices where no current energy standards or regulations exist. The first section of the paper introduces the Savings by Design program administered by the California utilities. Subsequent sections explore setting baselines for specific technologies and industries. The final section offers conclusions and discusses the potential applicability of this methodology beyond California.

Savings By Design

Savings By Design is a nonresidential new construction program that promotes energy efficiency for commercial, industrial, and agricultural new construction as well as gut-rehabilitation/renovation projects. The program is funded by California utility ratepayers and is administered by the state's four investor-owned utilities, under the auspices of the California Public Utilities Commission (CPUC). Savings By Design was developed collaboratively by the utilities in 1998 to simultaneously address two primary barriers to the adoption of energy efficiency in new construction: lack of information and real, or perceived, incremental costs. The program offers customers free design assistance and analysis services, including lifecycle costing, for projects that aim to reduce energy use below an established energy use baseline by 10% or more. Owner incentives of up to $150,000 and Design Team incentives of up to $50,000 are available.

For commercial-type buildings participating in Savings By Design, California's Title 24 new construction building code, which establishes maximum energy budgets allowable for specific types of equipment and spaces, serves as the primary baseline. The commercial building category includes spaces such as offices, retail, schools, and government buildings. However, because industrial and agricultural spaces with relatively large process loads - such as manufacturing plants, dairies, cleanrooms, biotechnology labs, and wastewater treatment plants - are not required to comply with Title 24 budgets, utilities have been required to develop alternative baselines for these industries and projects.

Savings By Design offers two program approaches: a Systems Approach and a Whole Building Approach. In the Systems Approach, the energy performance of a proposed single building system (i.e., lighting) is compared to the energy performance of the same system modeled using Title 24 baseline minimums. In the Whole Building Approach, the entire proposed building (i.e., all systems and the building envelope) is modeled with energy efficient measures included. The resulting net energy use is then measured against a run of the same building modeled using Title 24 baseline minimums. The Whole Building approach takes into account interactive effects between systems.

Historically, when faced with facilities or spaces not required to comply with Title 24 requirements, Savings By Design dealt with each such project as a unique undertaking within the Systems Approach. This has led to two major concerns for program managers; first, that baselines established on a project-by-project basis later can be construed as arbitrary, and secondly, that such an approach provides for neither in-depth understanding of energy efficiency opportunities within industries, nor cost-effective inter-industry technology transfer. The utilities have therefore undertaken the development of baselines tagged to specific technologies and industries that will both provide a consistent set of standards for analysis of project processes and will help identify opportunities to transfer successful energy efficient technologies from one industry to another.

Developing Baselines for Other Systems and Processes

For process measures not covered under Title 24, three methods are used by the utilities to determine baselines. The first choice is to apply any existing legislated mandates, such as the national minimum motor efficiency standards required under the Energy Policy Act of 1992 (EPAct). In the absence of legislated mandates, any existing industry guidelines or design protocols are applied, such as the National Electrical Manufacturers Association (NEMA) standards, or the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) application guidelines. Finally, where guidelines or standards do not apply, utility engineers or consultants investigate the standard practices for new construction within that industry. This paper will discuss all methods used but will focus primarily on the third approach, those efforts undertaken by the utilities to assess standard new construction practices that impact energy use within specific industries.

The program acknowledges a theoretical inconsistency between relying on minimum mandated standards and standard industry practice in setting baselines, but maintains that minimum standards most often reflect standard practice, and that the goal of moving the market from the status quo is achieved in either case. Lacking minimum mandated standards, market actors (vendors, designers, etc.) generally design systems according to rules of thumb, first cost, industry convention, and highest potential profit margin.

Other Systems and Processes Baseline Methodologies

Baseline Source Data	Example
1. Legislated Mandates	EPAct Motor Efficiency Standards
2. Industry Guidelines	NEMA standards
3. Design Protocols	ASHRAE application guidelines
4. Commonly accepted industry practices	Baseline-study established guidelines

Baseline Methodology Considerations

Tasked with establishing new construction baselines not covered by mandated code or industry guidelines, utilities were faced with a number of interesting methodology considerations: How is *current* standard practice defined? What level of statistical significance is required to reasonably characterize an industry for the purposes of establishing baselines? How recently should a project have been built, or rebuilt, to be considered for the new construction sample population? Similarly, how frequently does an industry baseline need to be refreshed to account for technological innovation and natural adoption and diffusion rates of emerging technologies? If an industry has not changed substantially over time, can benchmarks comparing the industry's existing stock of buildings or equipment be used to inform the new construction baseline? How does the size of an industry or facility affect its technology choices, or its tolerance for mid-to-long term payback periods? Should some industries be assigned different baselines according to customer size? At what point in the adoption curve for a technology or practice should incentives be withdrawn?

As Ernst Worrell and Lynn Price, in their paper "Policy Scenarios for Energy Efficiency Improvement in Industry" (Worrell and Price, 2001), remark about the industrial sector, "…there is no silver bullet policy; instead, an integrated policy accounting for the characteristics of technologies and target groups is needed. Acknowledging the differences between individual industries (even within one economic sector) is essential to develop an integrated policy accounting for the characteristics of technologies, conditions and target groups. Policies and measures supporting these voluntary industrial agreements should account for the diversity of the industrial sector while at the same time being comprehensive and flexible, offering a mix of policy instruments, giving the right incentives to the decision-maker at the firm level, and providing the flexibility needed to implement industrial energy efficiency measures" (Worrell, Price, 2001). This is true not only of energy efficiency policy in general, but also of the specific task of setting program baselines.

With the above considerations in mind, a number of baseline methodologies and data sources were rejected as generally inappropriate for use in a program like Savings By Design. One source of potential baseline data relied upon the results of benchmarking studies comparing, in a particular industry, metrics such as energy intensity per square foot or technology applications used. But because benchmarking typically establishes the base comparator (from which to measure each data point in the sample) as the average energy intensity for *existing* sampled equipment or facilities, industry wide, the data couldn't accurately represent *current* standard practice, even when innovation in the industry was determined to be relatively slow. The data could represent buildings of any age - fifty, twenty, or two years old. "At some point…businesses are faced with investment in new capital stock. At this decision point, new and emerging technologies compete for capital investment alongside more established or mature technologies. Even if a standard technology is chosen, it is likely to be more efficient than the equipment it is replacing" (ACEEE, 2001). Thus, this improved energy efficiency, the result of both technology innovation and design changes, needs to be accounted for in the new construction baseline and the benchmarking results are not, on their own, useful. It was also decided that for most industries (excluding the fast moving high technology sector), it would be appropriate to define new construction as having been built within the last 4 years.

Other methodologies have been rejected for calculating savings estimates and incentives. For example, past programs have taken a more customized approach to each project, measuring the improved proposed design against a baseline consisting of what the customer was going to do before the program intervened, regardless of how poor or advanced their original design was. This approach was rejected as inequitable to customers as it financially rewards (with higher energy savings and thus, higher incentives) those with the worst designs while punishing those with the better initial designs.

Savings By Design's overall baseline approach has been to balance the above-mentioned policy considerations with the reality of program administration, which includes limitations on budget, time and resources.

It was necessary to prioritize industries and technologies to create a roadmap for ongoing program development. To do so, California's major industries and technologies were assessed and placed in three general categories to determine the baseline approach to be taken:

- Crosscutting Technologies: Broadly based or used technologies where a single baseline can be applied consistently across industries
- High Priority Industries: High growth, energy intensive industries selected for immediate, targeted study
- Medium Priority Industries: Less critical industries or project types to be addressed on a case-by-case basis, as customers apply to Savings By Design, using the best information currently available

Analyzing the Industrial and Agricultural Markets

California's industrial sector, which in fact includes agricultural facilities, is extremely diverse and is comprised of 13 key sub-sectors: agriculture, mining, construction, food, paper, chemicals, glass, cement, steel, primary aluminum, petroleum refining, metals-based durables, and other manufacturing (Worrell and Price, 2001). In the territory of Pacific Gas and Electric (PG&E), one of the four utilities administering Savings By Design, industry and agriculture together consume approximately 40% of the electricity load and 59% of the gas load (BKi, 1999). A recent Xenergy study addressing California's energy efficiency potential stated that there is "a great need for more research to better understand industrial potential in California" (Xenergy, 2002), due in part to a lack of statistically representative data available to measure current energy efficiency measure saturation levels.

When PG&E set out to assess, prioritize, and categorize technologies and industries in it's territory for baseline determinations, it used industrial and agricultural potential studies conducted by consultants from 1999 to 2001. The studies prioritized the highest energy savings potential industries in the PG&E service territory by assessing energy consumed, industry growth rates, potential for high energy savings, and the existence of economically and technically proven "emerging" technologies. Qualitative data, such as the nature of existing customer relationships, PG&E's historical perspective on industry activities, and the correlation to PG&E's industrial research agenda were also considered. Studies conducted by the consultants BKi determined that the top three energy-consuming industries, consuming 37% of all electricity sales, were Food and Kindred Products, Electronic and Other Electric Products, and Industrial and Commercial Machinery and Computers. Highest growth rate industries were the Electronics, Communications, and Computer sectors. BKi then used Electric Power Research Institute (EPRI) study data to identify the five top technology categories for electric usage: motor drives for pumps, fans, compressors, etc. (averaging over 70% of energy used), process heating (approximately 10% of industrial energy use), electrolytes, lighting, and other (BKi, 1999). Applying this data, PG&E prioritized technologies and industries based on industry growth rate, energy intensity, and potential for energy savings and load reductions. Crosscutting technologies with the broadest applications were identified and prioritized first, followed by growth-industries, and then by energy-intensive specialty industries.

Crosscutting Technologies

PG&E defined crosscutting technologies as those that serve broad functions in multiple industries, for which a single consistent baseline could be established. Early in the baseline development process, it became apparent that a very small number of vendor-driven technologies had similar technology-uptake between and across industries (i.e. components, design, and installation practices remained relatively constant). The decision was made to target these crosscutting technologies first in order to capitalize on high-potential technologies at low program development cost. Motors and compressed air systems were determined to fall into this category. Because of the energy intensity and broad industrial applicability of motors and compressed air, they were already on the radar screen of national energy efficiency policy and educational efforts, and established analysis methods and tools were already in place for quantifying energy savings that could be easily adapted to the program. Wherever possible, Savings By Design has strived to incorporate existing efforts, guidelines and tools seamlessly into the program, to build upon and support existing standards and the related marketing and messaging being directed to end users.

Motors

Motors account for nearly 50% of all U.S. energy use and two thirds of all industrial energy use. Because many motors operate as much as 80 hours per week, even small increases in efficiency can yield huge energy savings (CEE Website, 2003). For its motor baseline minimums, Savings By Design has adopted the Federal minimum standards required by the Energy Policy Act of 1992 (EPAct). Savings By Design encourages customers to install National Electric Manufacturers Association (NEMA) Premium Efficiency Motors. NEMA Premium specifications are, on average, 1-2% higher than EPAct minimums. The specifications cover NEMA design A and B, three-phase, integral horsepower (hp), general purpose Open-Drip-Proof, and Totally Enclosed Fan Cooled motors (1200, 1800, and 3600 RPM) from 1-200 hp. For motors over 200 hp not covered under EPAct, and for other nonstandard motors, NEMA standard motors are used. If NEMA standards are not yet available for a particular motor, a customized baseline is developed through discussions with the designers and manufacturers. The Department of Energy's MotorMaster+ freeware is used to calculate energy savings.

Compressed Air

Compressed air is found in 19 of 20 industrial SIC codes in California and makes up between 3-30% of total facility consumption of electricity. It is estimated that 19% of the energy consumed by compressed air could be saved with energy efficiency measures (SBW, 1999). In developing the compressed air baseline, PG&E took advantage of two existing, well-branded compressed air programs developed with the Department of Energy's Office of Industrial Technology's (DOEOIT) funding: Compressed Air Challenge (CAC), an education and outreach program designed to promote energy efficiency in compressed air, and AirMaster, a compressed air modeling tool originally designed for modeling retrofit options. The CAC Best Practices was used in the development of program documents and guidelines. AirMaster is being used as a whole-system analysis tool to estimate energy savings for a project. The theoretical baseline system, modeled using baseline standards established in the program, and the proposed compressed air system, modeled with energy efficiency improvements, are compared to estimate potential energy savings and incentives for a project.

To establish the compressed air baseline which would apply to both new and rebuilt compressed air systems (that increase load or production), PG&E met and worked with compressed air vendors to evaluate standard design practice. Baseline assumptions were drafted for compressor type and efficiency, compressor sizing, use and size of system storage, leakage rate, distribution pressure, and controls. A separate baseline was established for systems being partially rebuilt, which required remaining components and measured system pressures to be modeled "as is". The baseline draft was distributed for review and comment. Reviewers included internal and external engineers, Eric Bessey (who is the developer of AirMaster), Neal Elliot at ACEEE, and compressed air service providers, among others. Comments were compiled, considered, and integrated into the baseline document. The compressed air component of the Savings By Design program was rolled out to a group of vendors in April of 2003.

High Priority Industries for Targeted Study

High priority was assigned to those high-growth industries estimated to have the greatest energy savings potentials based on the Industrial and Agricultural analysis undertaken. These industries were determined to be unique in the way in which they make capital investment decisions due to industry-specific driving forces requiring specialized design practices. In each industry selected, an opportunity for both real-time energy savings and transformation of the market existed. The first round of high priority industries studied for baseline application were dairies, wastewater treatment plants, and cleanrooms. The first round was completed as of Spring 2003. Other industries selected as high priority, such as food processing and data centers, are in various stages of evaluation and completion.

(Refrigeration baselines for supermarkets and refrigerated warehouses, established prior to 2002, will not be discussed in this paper.)

Dairies

California's sizeable dairy industry was identified early as an ideal high priority candidate for study due to its energy intensity, unique driving forces and industry growth. California leads the nation in milk production (CDRF). Dairies throughout California are both consolidating and growing (in terms of numbers of milking cows) to capture economies of scale. As farmland becomes more valuable in southern California, smaller dairies are closing down and surviving dairy producers are moving operations to more northern counties, such as Kern and Fresno. As a result, there is significant localized new construction in those counties (Canessa, 2002).

The Dairy New Construction Baseline Study was approached in three stages. First, study scope and approach were defined in a kickoff meeting attended by the consultant (Peter Canessa), the Savings By Design Industrial and Agricultural Program Manager, all assigned PG&E Dairy representatives, a leading California dairy designer, and several dairy consultants, one of whom was also a dairy producer. The team identified major dairy end uses and industry actors. The end uses identified were refrigeration, vacuum pumps, lighting, water pumping, water heating, and motors. The key industry actors included producers, vendors, manufacturers, private consultants, commodity associations, University of California Cooperative extension, the California State University (CSU) system, utilities, government, and energy management associations. The team discussed existing standards and regulations as well as ideal metrics for dairy energy measurement, including kWh/cow, kWh/cwt of milk, percent efficiency, and BTU/hour. It was determined that the study would distinguish between large and small dairies to capture possible differences between small, family owned operations and the new high-production facilities.

In the second stage, the consultant conducted a series of phone and in-person interviews with dairy producers, vendors, manufacturers, designers, electricians and technology specialists to gather general information about technology options available to dairies in the major end-uses and current industry trends. He also researched existing dairy standards, regulations, and industry guidelines that could be applied as a baseline. Finally, the consultant deployed a mail-based survey to approximately 1200 recipients, designed to gather additional feedback from the various industry actors about their design practices. The survey asked respondents to classify all areas in which they considered themselves experts in design (i.e., milking parlor, refrigeration design, lighting, etc), and to define number ranges of what they considered small and large dairies. Then, they were asked to select whether specific technologies were "Standard", a "Choice", or "Not Considered" in their design practices for both small and large dairies. 59 surveys (nearly a 5% response rate) were returned, of which 11 stated they were no longer dairies. While the remaining 48 completed surveys constituted a relatively small data set, they did allow the consultant to confirm the findings of the second stage interviews. Using the combined findings, the consultant drafted baselines for the major end uses - refrigeration, vacuum pumps, lighting, water pumping, and water heating.

Following Savings By Design baseline protocol, dairy lighting baselines were developed based on recommended lighting levels adopted from the American Society of Agricultural Engineers Engineering (ASAE) Practice EP344.2. For each dairy area, the consultant applied Title 24 equivalents that matched watts per square foot recommendations from ASAE. Few standards were found for ventilation fans, foggers, and misters used in dairies to keep the cows cool and productive during hot summer months. The exception was fan ratings conducted by the Bioenvironmental and Structural Systems Laboratory (BESS) at the University of Illinois Agricultural Engineering Department. BESS-rated dairy fans that fall into the 80th percentile or higher of rated fans are eligible for incentives. High Volume Low Speed fans (HVLS fans), which have larger diameter paddles (8-24 feet in diameter) and push more air than standard fans for less net energy, were not covered in the dairy study but are eligible for incentives based on Southern California Edison studies and savings claims.

The consultant evaluated dairy refrigeration standard practice and drafted a baseline, which was later updated by a separate refrigeration consultant who considered the dairy survey results along with extensive industry experience and "additional consideration to industry-wide refrigeration practice" (VaCom, 2003). The resulting baseline configuration assumes the use of air-cooled chillers or condensing units, which constitute the typically lowest initial-cost system.

Mixed results on the use of variable frequency drives (VFDs) on vacuum milking systems presented an interesting challenge to establishing the dairy baseline. Initial conversations with industry actors indicated that VFDs had been widely adopted in new dairy construction and should therefore be considered standard practice and, thus, not eligible for incentives. However survey results showed that only 20 out of 40 VFD responses (50%) for small dairies considered them a "standard" practice. At the same time, 27 out of 36 VFD responses (75%) for large dairies said they were standard. The resulting VFD baseline distinguishes between large and small dairies. Only small dairies (defined by surveys as roughly less than 1000 milking cows) are eligible for VFD incentives.

The results of this analysis highlight several issues applicable to all baseline studies. First, that technology adoption curves within industries may differ based on relative facility size or other differentiating factors such as location or climate. Secondly, that at a certain level of saturation for a technology, incentives become ineffective and unnecessary. Lacking the type of baseline information provided by these studies, these determinations are impossible to make and the program cost-effectiveness diminishes, at best.

Wastewater Treatment Plants

Many factors made wastewater treatment a natural choice for the high priority category. First and foremost, wastewater treatment facilities are extremely energy intensive; they are one of the largest and most intensive energy loads owned and operated by local governments, accounting for 35% of energy used by municipalities. Over the next 20 years, municipalities will need to invest billions nationally to upgrade water and wastewater systems as they face new regulatory challenges. Energy savings of 15% are readily achievable from improved efficiency in processes (ACEEE, 2001), primarily in pumping, which comprises approximately 46% of the load, and aeration, which is approximately 40% of the load (Xenergy 1998). Despite the energy intensity of wastewater treatment plants, historically energy has not been a primary concern of the industry. The principal concerns have been compliance with drinking water or discharge standards (such as those established in the Clean Water Act), reliability, capacity and costs. Wastewater treatment facilities are relatively easy for utilities to target and work with; most systems are owned and operated by local governments. Payback periods for energy efficiency improvements, often funded by long-term financial arrangements, can be longer than is typically tolerated by private business. The US EPA has recommended that the state revolving fund programs begin to offer loans for energy efficiency and co-generation technologies. In response, the EPA Energy Star program is now looking at the opportunities for a municipal water and wastewater initiative (ACEEE, date unknown).

M/J Industrial Solutions, a consultant who conducted a wastewater treatment plant (WWT) benchmarking study for PG&E in 2001, was hired by PG&E to help establish WWT baselines. To establish the baseline, the consultant built upon applicable data measured and collected in the original benchmarking study (which sampled new facilities), drew upon new data collected from a selection of recently built wastewater treatment plants, and relied upon extensive in-house expertise.

The consultant was unable to establish universally applicable baselines for a number of reasons: there is enormous variability from plant to plant in flow rates, the concentration of contaminants, type of process used, local discharge regulations, disinfection methods used, and volume of incoming wet weather flows that the system must meet. All of these characteristics affect the type of system that can be chosen to process wastewater at the site. As a result, "this lack of standardization and site-specific regulatory requirements make it impractical to establish a definitive wastewater treatment baseline in terms of a system configuration or a universal performance metric for facilities". The resulting baseline approach requires more of a case-by-case assessment of wastewater treatment facilities and requirements, and depending on facility need, the appropriate system baseline is used. The consultant provided baseline assumptions for a variety of systems and system design features:

Wastewater Treatment Plant Baseline Assumptions

Operation	Baseline Design
Influent pumping	On/Off level control and EPAct Motors
Primary Treatment	EPAct Motors
Secondary Treatment	
- Fine bubble aeration	Coarse or medium bubble aeration
-Aeration blowers	Multi-stage Centrifugal and EPAct motors
DO Control	Continuous DO monitoring with Manual Control
WAS/RAS Pumps	Timed Operation and EPAct motors
Tertiary Treatment	EPAct Motors
Sludge Processing	EPAct Motors
UV Disinfection	Medium Pressure UV lamps
Effluent Pumping	Flow Control Valves and EPAct motors

Source: PG&E Wastewater Treatment New Construction Baseline Study

Cleanrooms

Cleanrooms have become an integral part of California's new economy and are found in high tech, biotech, automotive, food, hospitals, research facilities and other industries. The buildings' HVAC systems often drive the energy consumption of these industries, estimated at 50% or more of total energy used in laboratories and cleanrooms. Lawrence Berkeley National Laboratory's (LBNL) cleanroom and lab technology roadmap envisions the potential for a 50% reduction in energy intensity in new facilities by 2012 for comparable production, while maintaining or improving productivity and safety (LBNL, Draft, 2002). While cleanroom processes and loading vary, they have many energy-intensive supporting mechanical systems in common, making them a good target for incentive-based energy efficiency programs. The five top systems include: recirculation air handling, make-up air handling, chilled water production, hot water production and compressed air production. Whole building analysis programs, such as DOE2 and Trace, are inadequate for modeling cleanroom facilities because these buildings are dominated by a wider variety of internal process loads and fan system loads. Since whole building energy use is process and facility dependant, the cleanroom baseline approach focused on system efficiency, which is generally less dependant on facility particulars and provides a more consistently transferable basis for evaluating different facilities. A systems-based approach offers a means of comparing on equal footing the energy efficiency of cleanroom systems supporting different processes (Rumsey, 2003).

Cleanrooms are defined by their particle count rating and are most typically class 10, 100, 1,000, and 10,000, where class 10 is the "cleanest". Because the class of the cleanroom has a significant impact on the energy use, the baseline distinguished between classes in its approach. To allow for an accurate comparison of efficiency levels between vastly different process loads across cleanrooms, each of the five studied systems was assigned a capacity-independent measure of its efficiency. The metric consists of the system output (CFM of filtered air, tons of cooling, etc) divided by the system input (kW or kbtu/hr of gas). To establish the baseline, the Consultant relied upon extensive industry experience as well as a series of telephone interviews with industry actors: approximately 15 cleanroom facilities personnel, 9 designers, and 5 suppliers. In the interviews, the interviewees were asked to distinguish between cleanroom classes as they described their typical design practices in designing the five primary systems. The resulting baselines, best practices and sample system calculations are ready for industry-wide dissemination.

Medium Priority Industries for Case-by-Case Study

Industries or customer types that fell out of the high priority category for any reason (i.e., savings were deemed too small to justify the cost of a study) were put in the medium priority category.

The medium priority baseline approach consists of case-by-case project analysis conducted by facility or consulting engineers. These project baselines are established with typically less intensive research than that conducted for the high priority industries, and primarily involve discussions with the project design team, various equipment manufacturers and distributors, and other relevant sources. Data collected for analysis includes the various technology and design options available for a customer to complete their given production task (from growing greenhouse to moving a certain number of widgets along an assembly line), as well as the energy costs associated with each of those options. This data, along with other information such as product availability, maturity of the technology, and incremental cost, is analyzed and used to determine both the appropriate baseline and the recommended energy-efficient options. When assessing the energy impacts of the various options, facility production is assumed to remain constant while the energy input relative to production varies. However, projects can also be assessed that increase production using the same amount of input energy. Either way, the various options provided to the customer are typically expressed in energy input/unit of product. Completed analysis and baseline results from the medium priority project/industry category will soon be entered into a statewide-accessible database for future program reference on similar projects, and for the development of future integrated studies. Projects analyzed thus far with this methodology include greenhouses, large pumping projects, and emissions control projects.

Summary

In lieu of existing standards and regulations, such as Title 24, upon which to base industrial and agricultural process baselines, the California utilities have strategically undertaken a multi-tiered approach to establishing standard practice baselines. The simple baseline approach for crosscutting technologies (motors and compressed air) was aided by significant work, tools and programs already established by the Department of Energy. Baselines for the unique and high potential high priority industries (Dairies, Cleanrooms and Wastewater Treatment Plants) were characterized by system-specific and often facility-specific baseline results, necessary because of the highly diverse nature of these industries. Medium priority industries, with smaller potential energy savings and market impacts relative to baseline study cost, are being successfully addressed on a case-by-case basis. With enough market activity and subsequent investigation, these industries may also be characterized well enough to release publishable baseline results.

Because baseline results and calculation methodologies for these technologies and industries are still in final phases of completion, or have only just recently been published, there has been little opportunity for reasonableness checks though peer review. However, such review is planned.

It is expected that the baselines will not remain static, but will continue to change, as additional or better industry information is received and as adoption rates for the various technologies accelerate. Not enough information is available to establish whether energy efficiency levels for new construction in the industrial sector of California mirror those of the nation, so the applicability of these baselines to projects outside of California remains unclear. It is likely that, while the process for the establishment of industrial new construction baselines may be valid across the nation, the baselines themselves may be highly variable and trend along industry and regional lines.

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