Industrial Sectors Market Characterization

Cement and Concrete Industry

Prepared for Pacific Gas and Electric Company and Southern California Edison Company

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Acronyms and Abbreviations

AB 32	Assembly Bill 32
ACC	autoclaved cellular concrete
ACEEE	American Council for an Energy Efficient Economy
ACI	American Concrete Institute
ACPA	American Concrete Pipe Association
AMO	Advanced Manufacturing Office
ANSI	American National Standards Institute
ARB	California Air Resources Board
ARRA	American Recovery and Reinvestment Act
BACT	best available control technology
Btu	British thermal unit
CAA	Clean Air Act
CEI	continual energy improvement
CHP	combined heat and power
CKRC	Cement Kiln Recycling Coalition
CO_2	carbon dioxide
CO_2e	carbon-dioxide equivalent
CPUC	California Public Utilities Commission
CWA	Clean Water Act
EEPS	Energy Efficiency Portfolio Standards
EPI	energy performance indicator
EPI	energy performance indicator
ESA	Endangered Species Act
F	Fahrenheit
GHG	greenhouse gas
GHG	greenhouse gas
GWh	gigawatt-hour
HSWA	Hazardous and Solid Waste Amendments
IAC	Industrial Assessment Center
IOU	investor-owned utility
ISO	International Standards Organization
ITP	Industrial Technologies Program
kWh	kilowatt-hour
LBNL	Lawrence Berkeley National Laboratory

MBtu	million British thermal unit
MECS	Manufacturing Energy Consumption Survey
NAICS	North American Industry Classification System
NRMCA	National Ready Mix Concrete Association
O&M	operations and maintenance
PABCO	Pacific Coast Building Products, Inc.
PCA	Portland Cement Association
PCA	Portland Cement Association
PG&E	Pacific Gas and Electric Company
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RPS	Renewable Portfolio Standard
RPS	renewable portfolio standard
SCE	Southern California Edison Company
SEP	Superior Energy Performance
TBtu	trillion British thermal unit
tpy	tons per year
TXI	Texas Industries Inc.
U.S.	United States
U.S. DOE	U.S. Department of Energy
U.S. EPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VSD	variable-speed drive

Summary of Findings

The cement industry (North American Industry Classification System [NAICS] prefix 32731) blends and heats limestone and other raw materials to produce clinker, and then grinds and heats the clinker into cement. This cement, in the form of finely ground gray powder, can easily be mixed with aggregate (sand and gravel), extenders (steel fly ash) and water to produce concrete slurry (NAICS 327320), or molded into concrete products such as pipes, box culverts, blocks, bricks, roof tiles, and floor and wall tiles (NAICS 327331 and 327332). PG&E and SCE customers in this segment manufacture cement, ready-mix concrete and block and brick products. The largest energy users in this sector are cement manufacturers. The industry is highly concentrated. In PG&E territory, the electric usage of five manufacturers combined represents nearly 75 percent of the total consumption for all businesses in this industry segment; in SCE territory the top five electric users consume 85 percent.

Industry Landscape and Operational Models

In California and nationally, the cement manufacturing industry is dominated by large-scale, multinational corporations with substantial sunken capital due to the extremely high capital requirements of production. This business model also applies to select concrete manufacturers. Major players operate large-scale, technologically advanced and highly automated manufacturing plants capable of producing a wide range of products. These plants are built to take advantage of economies of scale, given the size of the regional market being supplied. Less energy intensive subsectors, such as concrete products, can support a range of customer sizes and business models.

Energy Use

Manufacturers use energy to blend, heat, grind and shape industry inputs into finished products. Clinker production is the most energy-intensive stage in cement production, accounting for over 90 percent of total cement industry energy use, and virtually all of the fuel use. Natural gas consumption is concentrated in the process heating end-use or pyroprocessing in large kilns (about 90 percent of total gas consumption). Although there are only seven pyroprocessing cement plants in California, there are numerous plants devoted to preparing materials for pyropocessing, typically located onsite at limestone quarries. Manufacturers in the cement and concrete industry use electricity for machine drive end-uses associated with mixing, grinding, and crushing raw materials, and gas for kiln operation, drying and curing, and steam production.

Energy efficiency opportunities fall into four general categories:

- **Operations and maintenance (O&M)**: This includes a wide range of opportunities, from establishing a predictive maintenance system to motor and bearing lubrication, optimization of motors, fans, and compressed air systems to maximizing energy efficiency in daily operations.
- **High efficiency equipment/processes**: Some measures include premium efficiency motors; conversion of ball mills to roller mills for grinding; efficient materials transport systems; high efficiency classifiers; conversion to more efficient kilns such as vertical precalciner kilns; variable-speed drives (VSDs) for fans and other variable load drives; and compressed air system improvements.
- **Controls**: Improved process controls for clinker production and finish grinding, and operation of compressed air systems.
- **Energy Management Systems**: Leading energy efficient companies have internal programs to manage energy and/or participate in continuous energy improvement programs developed by others. Typical components of these programs are benchmark and measuring energy use; setting goals; evaluating and prioritizing energy efficiency technologies, behaviors and best practices; taking action to reduce energy consumption; followed by documentation and measurement of the effectiveness of their actions.

Drivers for Energy Decision Making

Energy cost savings is the major driver of customer participation in energy efficiency and energy management programs. Energy is one of the top priorities and the largest expense in cement production. In less energy intensive subsectors such as concrete products, energy receives less focus but cost savings achieved through energy efficiency is a key driver to program participation. Consequently, most manufacturers interviewed indicated they have already taken the most obvious steps they believe to be appropriate to reduce energy in their motors, lighting, compressed air systems and other basic industrial processes. Most of the energy used is in the process itself, such as the kiln and grinding systems. Retrofitting these systems can cost tens of millions of dollars. The focus for energy savings from these systems are more toward process optimization and best practices versus retrofits.

Manufacturers will most likely not consider major upgrades until the economy improves and they are back to full-scale production and payback periods are shorter. However, the irony often is that retrofits are undesirable when business is booming, as production is needed, but not possible to fund when production is low and business is below profit needs. However, because project planning spans multiple years, there is significant opportunity for utility representatives to engage customers now about future projects.

Overall Findings

The following findings regarding improving the adoption of energy efficiency measures in the cement and concrete industry are based on the primary and secondary research presented in this report.

- Third-party consultants are one of the most highly rated utility offerings and extend the utility's ability to reach customers and remove barriers surrounding administrative details.
- Customers are receptive and engaged in energy efficiency and other energy management projects, primarily for energy bill savings. Managing energy usage is a high priority for the largest cement manufacturers to reduce operations costs and compete more effectively in the global marketplace. Energy management is a lower priority for smaller customers engaged in concrete products, but cost savings is critical. These smaller customers lack the sophisticated energy staff to initiate and oversee programs, and rely on their utility and third-party consultants.
- Leaders in energy efficiency improvement in this industry have deep management support, energy reduction goals, and robust internal energy management systems programs to reduce energy. CEMEX and Portland Cement both reported strong corporate programs.
- Most customers interviewed rated their utility program awareness as 'high' or 'very high' but this self reported data conflicted with customers' actual program knowledge, as observed by KEMA during interviews and the industry forum meeting. It was clear that customers had some knowledge of utility programs, but their understanding of the program components may be lacking. Sources of program information were primarily utility representatives, colleagues, and vendors.
- All customers interviewed had successfully participated in rebate programs, while some had participated in demand response (for large manufacturers) and other energy management strategies. Customers widely praised programs offering rebates and prefer them to utility financing.
- The economic downturn has profoundly impacted the industry and manufacturers reported both more interest in seeking cost savings and less willingness to fund projects with paybacks over two years. These projects still do occur, but primarily to increase production capacity or replace malfunctioning equipment. Understanding the customers'

business and planning cycles is crucial if the utility is to successfully integrate energy efficiency into the less frequent larger projects.

- Collaboration between the industry and the utility on energy efficiency presents a key opportunity to expand practices and should continue. Customers expressed interest in continuing the conversation started by this study as an ongoing dialogue between utilities and this industry.

1. Project Background

The industrial sector consumes over 30 percent of the nation's energy,[1] presenting enormous opportunities for energy efficiency.[2] Many market forces beyond simple energy cost drive industrial customer decision making. Attaining a better understanding of the customer's world will assist Pacific Gas and Electric Company (PG&E) and Southern California Edison (SCE) in their design and implementation of industrial energy efficiency programs. Following upon a potential study developed in 2009 for PG&E, PG&E and SCE engaged energy-consulting firm KEMA, Inc. for a next phase to prepare market intelligence on seven key energy-intensive sub-segments.

The research objective is give PG&E and SCE staff study results to facilitate improved marketing of energy efficiency products and support face-to-face engagement of customers with those products. To address the objective of this study, the work was organized into four key elements. These include:

- Perspectives about broad trends affecting California and the nation's industrial sectors (section 2)
- Detailed in-depth, industry-specific analysis of business and process drivers developed from secondary research (section 3)
- Energy usage, target technologies and process, and energy efficiency opportunities (section 4)
- Real-time perspectives and intelligence gained from key industry insiders through interviews and Webinar/Forum group discussions (section 5)
- Recommendations (section 6)
- Utility-specific appendices containing proprietary data and customer information (Appendices).

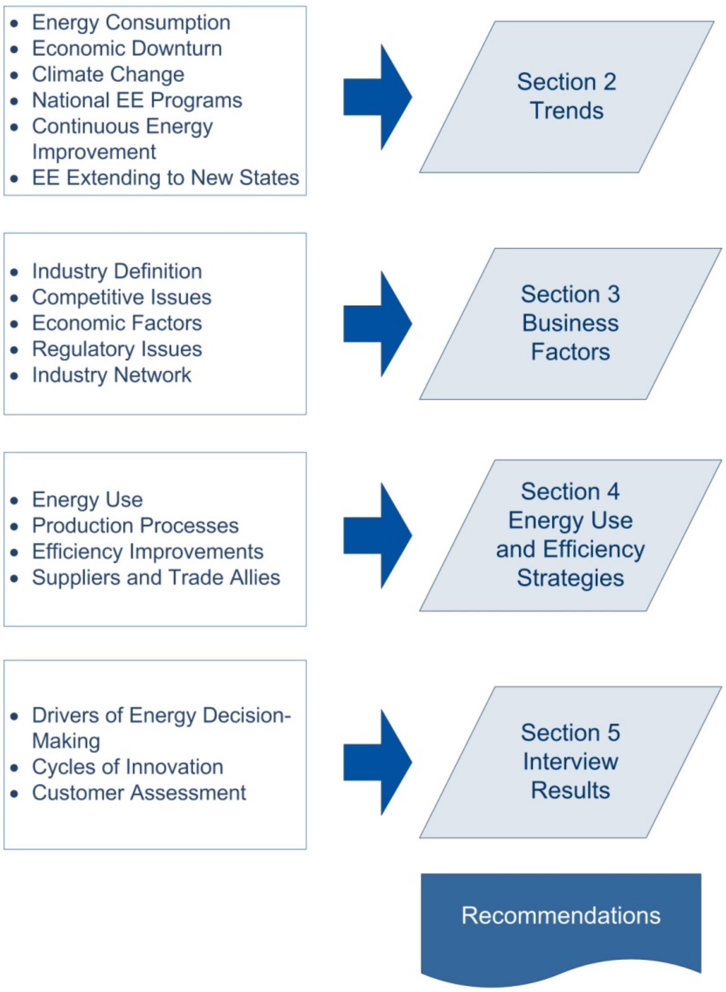
In practice, these report elements are built stepwise--broad national trends inform industry-specific secondary research and industry-specific analysis informs the primary interviews and roundtable discussions. The outcome is a thorough research report intended to provide PG&E

[1] Quinn, Jim. 2009. *Introduction to the Industrial Technologies Program*. Save Energy Now Series Webinar. January 15.
http://www1.eere.energy.gov/industry/pdfs/webcast_2009-0115_introtoitp.PDF

[2] U.S. Census Bureau, 2008.
http://www.census.gov/compendia/statab/2010/tables/10s0892.xls

and SCE staff members the breadth necessary to position their industrial energy efficiency products optimally and the depth necessary to knowledgeably engage their customers.

Figure 1: Graphic Overview of the Report



2. Trends in Industrial Energy Efficiency

The industrial sector consumes an immense amount of energy, nearly 32 percent of total U.S. consumption in 2008,[3] to produce goods and materials for wholesale and retail sales. In the past three decades, the overall energy efficiency of the industrial sector in the United States has increased dramatically. Energy efficiency potential savings have been estimated nationally at 20 percent or more by 2020.[4] It has thus been an attractive target sector for utilities and government looking to reach new levels of energy savings through efficiency.

Changing energy markets and climate change policies are driving greater interest in energy efficiency technologies. Key trends discussed are energy consumption patterns; effect of the economic downturn on manufacturing; climate change and energy legislation; thfe rise of continuous energy improvement; energy efficiency adoption outside California and national energy efficiency programs. These trends are discussed in more detail below.

2.1 Energy Consumption Trends

California ranked first in the nation in gross domestic product, at $1891.4 billion in 2009. Table 1 shows the industrial energy consumption. California ranks only third in the nation for energy use, reflecting higher efficiency levels in the industrial sector.[5]

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[3] U.S. Census Bureau, 2008. *Energy Consumption, by End-Use Sector*. http://www.census.gov/compendia/statab/2010/tables/10s0892.xls

[4] McKinsey & Co. 2009. *Unlocking Energy Efficiency in the U.S. Economy.* July. http://www.mckinsey.com/clientservice/electricpowernaturalgas/downloads/_energy_efficiency_exc_summary.PDF

[5] U.S. Department of Energy, Energy Efficiency and Renewable Energy, State and Regional Partnerships. 2011. http://www1.eere.energy.gov/industry/states/state_activities/map_new.asp?stid=CA

Table 1: Industrial Energy Consumption, California

Year	California Industrial Energy Consumption (Trillion Btu)
2009	1,770
2008	1,955
2007	1,958
2006	1,979
2005	2,001
2004	2,053
2003	1,986
2002	1,999
2001	2,137
2000	2,132

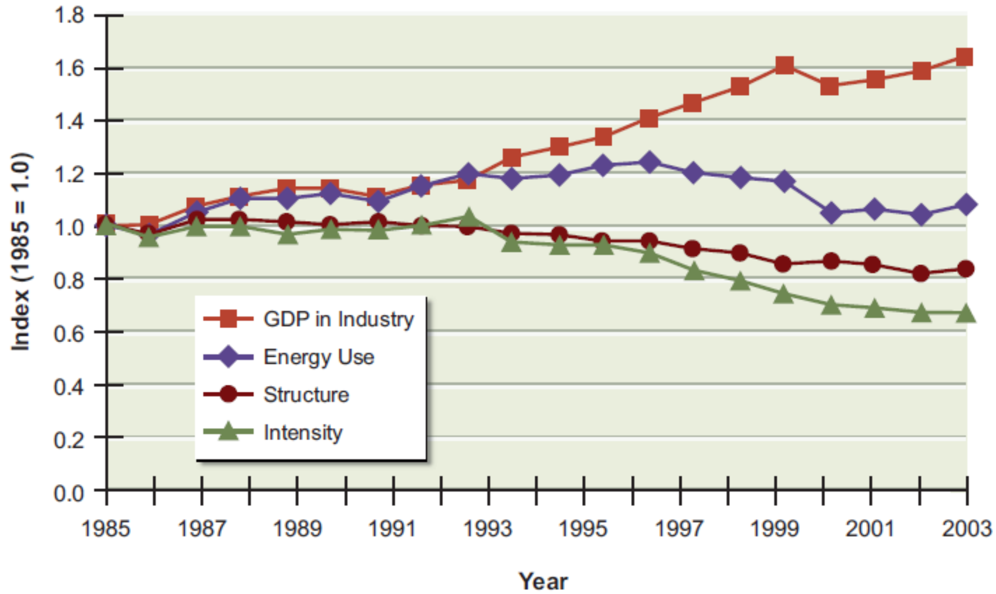
Source: Energy Information Administration[6]

Figure 2 shows U.S. trends in industrial energy intensity over time. This figure shows that there has been a general trend since 1993 toward stable or slightly decreasing energy use, even while the economy prospered. More significantly, the energy intensity, or energy per unit of production, has been steadily increasing. Thus, the industrial sector has shown consistent improvement in reducing the amount of energy required to produce manufactured goods. As shown in Figure 2, California's total energy use has continued the trend of relatively flat to gradually reducing energy consumption, similar to the national trend.[7]

[6] U.S.DOE. 2011. *State Energy Consumption Estimates 1960 through 2009*. DOE/EIA-0214(2009). June 2011. http://205.254.135.7/state/seds/sep_use/notes/use_print2009.PDF

[7] U.S. Department of Energy, Energy Efficiency and Renewable Energy, State and Regional Partnerships, Advanced Manufacturing Office Activities in California. 2011. http://www1.eere.energy.gov/industry/states/state_activities/map_new.asp?stid=CA

Figure 2: U.S. Trends in Industrial Energy Intensity Delivered Energy, 1985-2004



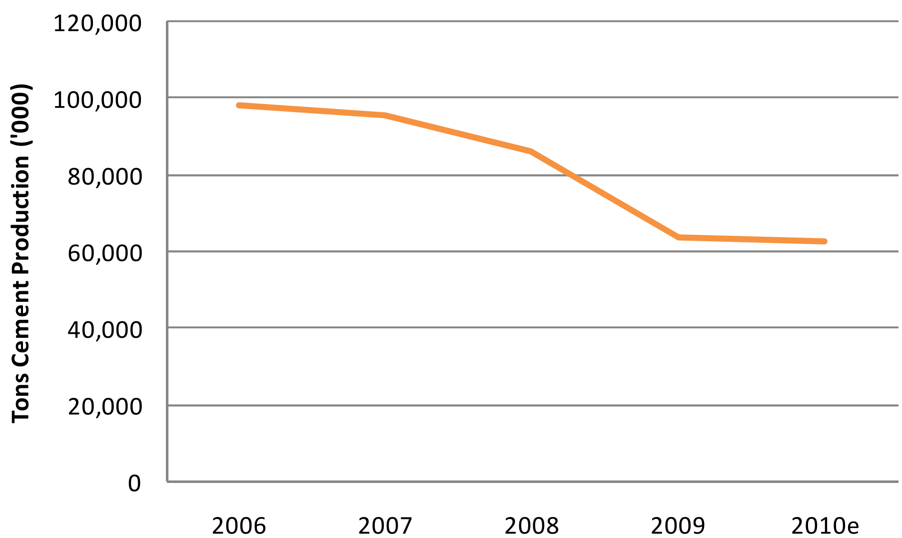
Source: National Academy of Sciences[8]

[8] National Academy of Sciences. 2010. *Real Prospects for Energy Efficiency in the United States*. National Academies Press.

2.2 Economic Downturn Effects on Industrial Production

Most U.S. industries experienced a sharp drop in production as demand for manufactured goods declined, starting in the last quarter of 2008. In 2010, U.S. cement production was the lowest since 1982 and reflected continued cement plant closures and indefinite idling.[9] United States sales volumes in 2010 were nearly 59 million tons or 45 percent below the record level of 2005. The rate of decline, however, has abated significantly since 2008, as shown in Figure 3. Imports are a significant threat in this industry, and China, the largest exporter of cement, increased production by 10 percent from 2009 to 2010.

Figure 3: U.S. Portland and Masonry Cement Production, 2006-2010



Source: USGS[10]

In California, industries that serve the housing and construction market, such as cement, have been particularly affected. For example, in 2008 there were 11 plants producing cement in California; in 2009 only 7 plants still produced cement, according to U.S. Geological Survey

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[9] U.S. Department of Energy, Energy Efficiency and Renewable Energy, State and Regional Partnerships, Advanced Manufacturing Office Activities in California. 2011. http://www1.eere.energy.gov/industry/states/state_activities/map_new.asp?stid=CA

[10] USGS. 2011. *2009 Minerals Yearbook, Cement [Advance Release]*. July 2011 http://minerals.usgs.gov/minerals/pubs/commodity/cement/myb1-2009-cemen.PDF

(USGS) data.[11] This data looks at specifics that drove manufacturing reductions, noting both changes in a few facilities and reductions in production due to reduced demand).

Another method of observing the economic downturn's effect in California is to consider trends in carbon emissions. Although multiple factors affect emissions, including energy efficiency and carbon reduction, dramatic short-term changes do indicate likely reductions in production. According to analysis by research firm Thomson Reuters Point Carbon, an overall reduction of carbon emissions of 11 percent from 2008 to 2010 was observed among the 343 California facilities that must comply with California's cap-and-trade program. Table 2 displays the CO_2 emission changes by industrial sector. Facility closures was the major driver for cement, glass, pulp and paper industries' decline while chemicals sector emissions increased largely from a new hydrogen plant in SCE's territory.

Table 2: Percentage Change in CO_2 Emissions among Largest CA Industrial Sectors, 2008-2010

CO2 Emissions 2008 vs. 2010	California Industrial Sector	Notes
+21%	Chemicals	Driven by new $80MM hydrogen facility in SCE territory
+5%	Metals	Increase in production
-34%	Cement, lime and glass	Driven by facility closures
-35%	Pulp, paper and wood	Driven by facility closures

Source: Thomson Reuters Point Carbon[12]

The economic recession is forcing businesses and governments to take a close look at initiatives that save money and do not require capital investments, such as the best practices developed by the U.S. Department of Energy's (DOE) Industrial Technologies Program (ITP), now the Advanced Manufacturing Office, and through increased energy management systems, as discussed in the following sections.

2.3 Climate Change and Energy Legislation

Industry's energy-related carbon-dioxide emissions have decreased in the last decade, while rising more dramatically in other sectors, as shown in Figure 4. This reduction is largely

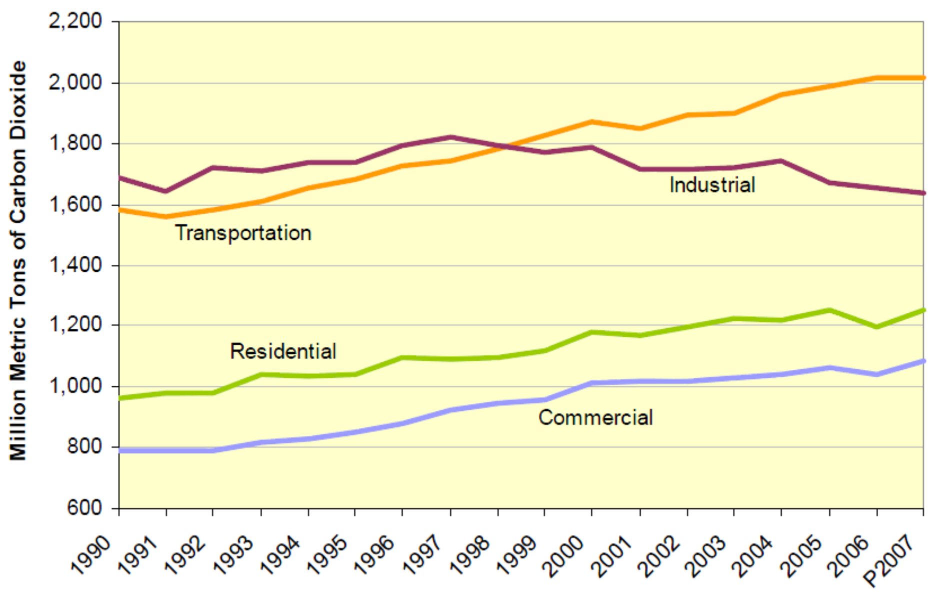
[11] USGS. 2011. *2009 Minerals Yearbook, Cement [Advance Release].* July 2011 http://minerals.usgs.gov/minerals/pubs/commodity/cement/myb1-2009-cemen.PDF

[12] Thomson Reuters Point Carbon. 2011. *California Emissions in 2010 Down by 11%.* August http://www.pointcarbon.com/aboutus/pressroom/1.1564622

attributable to U.S. industry's net decrease in energy consumption, according to the American Council for an Energy Efficient Economy[13] that resulted from a decrease in manufacturing activity as well as energy efficiency gains. Still, industry accounts for approximately 27.4 percent of total energy-related carbon-dioxide emissions in the United States.

Greater energy efficiency will almost certainly be an important component in comprehensive national—and global—strategies for managing energy resources and climate change in the future. Energy efficiency is generally acknowledged to be the lowest-cost and fastest-to-deploy resource to slow the growth of carbon dioxide emissions, and it also results in positive economic impacts. Congress is not expected to approve any policy mechanisms to reduce CO_2 emissions in the short term although legislation encouraging greater energy efficiency in the U.S. manufacturing sector is possible.

Figure 4: U.S. Energy-Related CO_2 Emissions by End-Use Sector, 1990-2007



Source: ACEEE[14]

[13] Chittum, A., R. Elliott, and N. Kaufman. 2009. *Trends in Industrial Energy Efficiency Programs: Today's Leaders and Directions for the Future*. American Council for an Energy Efficient Economy, Report IE091. September 2009.

[14] Chittum, A., R. Elliott, and N. Kaufman. 2009. *Trends in Industrial Energy Efficiency Programs: Today's Leaders and Directions for the Future*. American Council for an Energy Efficient Economy, Report IE091. September 2009.

2.4 National Programs

Typical utility programs address only a subset of the energy efficiency improvement opportunities, focusing primarily on retrofits and capital improvements. Less attention is given to behavior or maintenance. Federal, regional, and state government agencies, utilities, and others have developed a range of programs to improve industrial energy efficiency. These include providing incentives, audits and technical assistance, and continuous improvement programs.

Many of PG&E and SCE's customers participate in these programs which can yield insights and best practices to inform utility programs, such as energy assessments offered by the U.S. DOE's Advanced Manufacturing Office (AMO), formerly the Industrial Technologies Program. In California, 49 assessments were completed for small and medium facilities in 2009 through 2011 and 38 assessments for large facilities between 2006 and 2011.[15] Three cement facilities received energy assessments for large facilities:

- CEMEX – Davenport cement plant, Davenport, CA (July 17, 2007)
- CEMEX – Victorville cement plant, Victorville, CA, (May 8, 2007)
- California Portland Cement Company, Mojave, CA (Apr. 18, 2006)

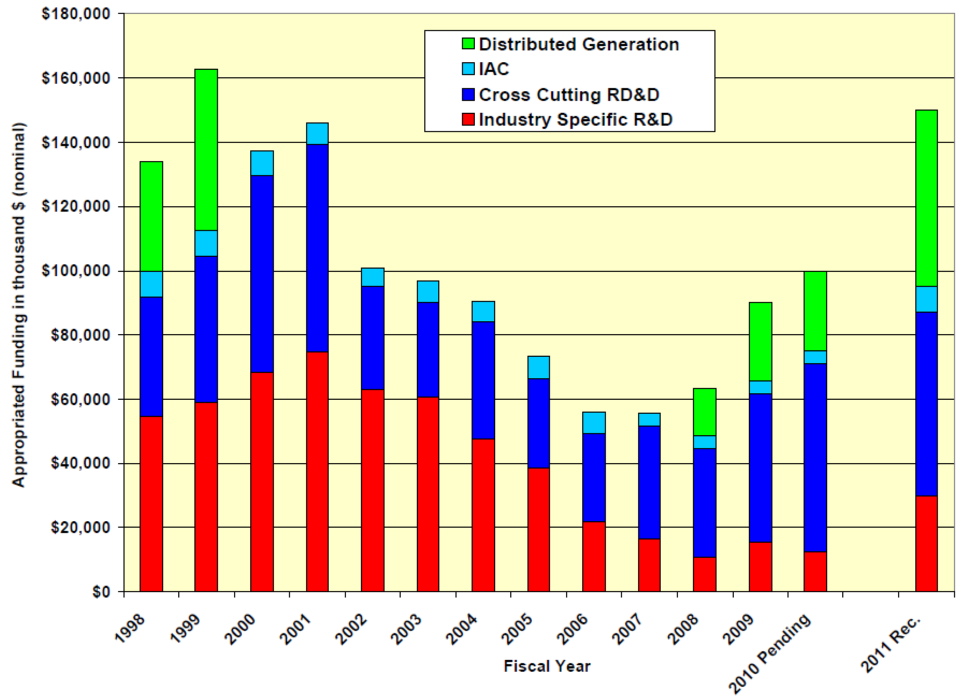
The U.S. DOE's AMO has been the primary federal entity supporting manufacturing R&D in partnership with industrial stakeholders. The AMO R&D program has been recognized as one of the most successful federal R&D efforts operating today. However, in recent years support for the program's R&D funding has faltered, particularly for the industry-specific R&D funding. This has been the most effectual initiative, considering its track record of commercializing products useful to industry. A U.S. DOE peer review report called the manufacturing R&D pipeline "largely empty."[16] This is challenging for the transformation of manufacturing because even though AMO's industry-specific R&D reaches commercialization faster than most other federal R&D, it can still take seven to ten years for results from R&D to reach a plant floor.

In addition to R&D activities (both the industry specific mentioned above and cross cutting), AMO has two technology and best practices programs: Better Plants (formerly Save Energy Now) and the Industrial Assessment Centers.

[15] U.S. Department of Energy, Energy Efficiency and Renewable Energy, State and Regional Partnerships. 2011. http://www1.eere.energy.gov/industry/states/state_activities/map_new.asp?stid=CA

[16] American Council for an Energy Efficient Economy. 2009. Barriers to energy efficiency investments and energy management in the U.S. industrial sector. October 20, 2009.

Figure 5: Industrial Technologies Program Funding, 1998-2010



Source: ACEEE[17]

Better Plants works with large industrial energy consumers to help reduce their energy intensity using audits, software tools, and best practices. The other program, Industrial Assessment Center (IAC), serves a similar function for small and mid-sized industrial facilities, and also trains the next generation of industrial energy engineers. Twenty-six centers at U.S. engineering universities train students to identify energy savings opportunities and perform no-cost assessments for small and medium industrial customers. In California, San Francisco State University and San Diego State University run IAC programs. The IAC program has a public database of recommendations dating back to 1981, a resource for customers on industrial energy efficiency improvements.

2.5 Combined Heat and Power

Combined heat and power (CHP), or cogeneration, is a significant and growing share of U.S. generation (see Figure 2-3). CHP is the concurrent production of electricity or mechanical

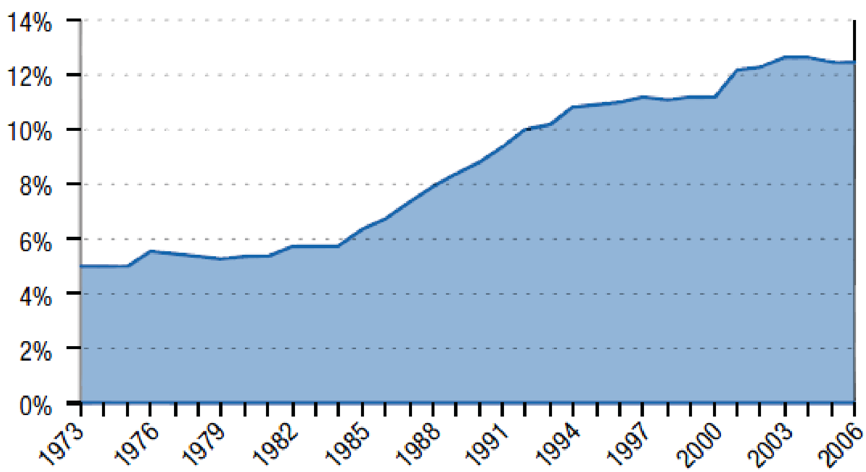
[17] American Council for an Energy Efficient Economy. 2009. *Barriers to energy efficiency investments and energy management in the U.S. industrial sector*. October 20, 2009.

power and useful thermal energy (heating and/or cooling) from a single source of energy. This technology is first and foremost an energy efficiency resource that allows users to produce needed electricity, heat, and mechanical energy while using as little fuel as possible.

Natural gas continues to be the preferred fuel for CHP systems, representing 50–80% of annual CHP capacity additions since 1990. This is primarily because natural gas is readily available at most industrial sites, is clean burning, and has historically been relatively plentiful and affordable. Since 2001, natural gas prices have been consistently volatile and relatively high. While natural gas remains an important CHP fuel, installers and technology developers are increasingly looking to "opportunity fuels" for CHP systems. Opportunity fuels are nontraditional fuels that are frequently considered waste or by-products and provide lower fuel costs.

CHP is applicable throughout the U.S., but capacity is greatest in states with the largest thermal energy-dependent industrial sectors such as the Gulf coast of Louisiana and Texas. California ranks second in largest total available CHP capacity in 2006, at 9,220 MW compared to Texas at 17,240 MW, due to large industrial demands, stringent air quality requirements, and effective policies that encourage adoption of CHP.

Figure 2-3. CHP as a Percentage of U.S. Annual Electricity Generation

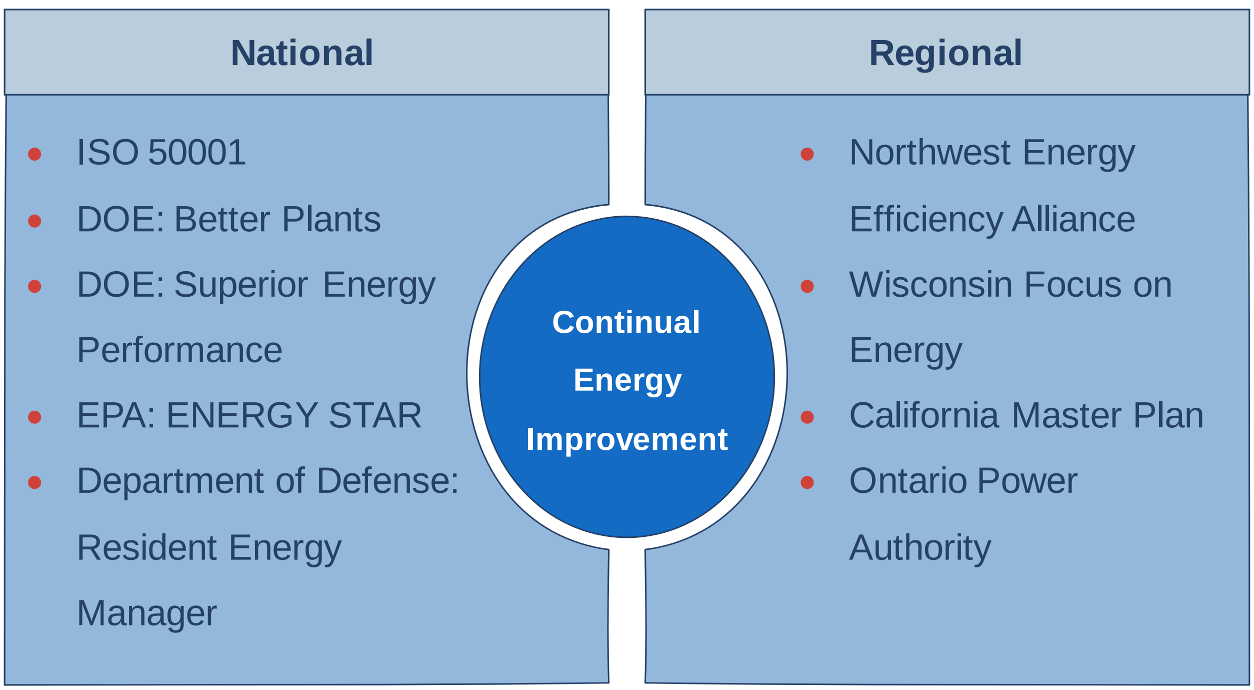


Source: ORNL, *Combined Heat and Power: Effective Solutions for a Sustainable Future*, Dec. 1, 2008.

2.6 Rise of Continual Energy Improvement

Utilities, and private organizations, and governments around the world have developed programs in the last few years that focus on setting goals and targets to achieve continual energy improvement (CEI) in industry. National programs in the United States have been developed by the U.S. DOE (Better Plants and Superior Energy Performance) and U.S. Environmental Protection Agency (EPA) (ENERGY STAR). Figure 6 displays some examples of national and regional continuous energy programs. From a business perspective, interest in energy management is increasing, as shown by the increasing number of participants in these programs.

Figure 6: Examples of National and Regional Continual Energy Improvement Programs



Two important developments in 2011 are expected to heighten interest and activity around energy management: the release of ISO 50001, a global energy management standard, and the launch of superior energy performance, a national program to support energy intensity reductions for industrial plants and commercial buildings.[18]

[18] McKane, Aimee, Lawrence Berkeley Laboratory, 2011. Presentation at the ACEEE Market Transformation Conference, Piloting Energy Management Standards for the U.S and the Globe. http://www.aceee.org/conferences/2011/mt/program

The recent work on U.S. and international energy management standards will have a significant impact on how energy is used in the industrial sector. The International Standards Organization (ISO) released an international energy management standard, ISO-50001 in June 2011.

The U.S. Department of Energy is in the process of launching the Superior Energy Performance (SEP) program to promote industrial energy management and increased energy efficiency. This voluntary program will focus on fostering an organizational culture of energy efficiency improvement in U.S. manufacturing facilities, targeting mid to larger sized plants.

Participants establish an energy management system that complies with ISO 50001 and meets other SEP program requirements, including robust measurement and verification of energy savings. Pilot programs have been launched in Texas and the Pacific Northwest, and the full SEP program is expected to begin in 2013. A California pilot is also planned within the next two years. The American National Standards Institute (ANSI) is developing companion standards to support SEP. ANSI MSE 50021 will provide the additional energy performance and management system requirements for SEP certification that goes beyond basic conformance with ISO 5000; and ANSI 50028 will provide the requirements for verification bodies for use in accreditation or other forms of recognition.[19]

Regional CEI programs have been developed under the Northwest Energy Efficiency Alliance,[20] working with the Bonneville Power Administration and the Energy Trust of Oregon. California has identified CEI as an important aspect of its strategic plan.[21] Similarly, Wisconsin's Focus on Energy employs an internally developed tool called Practical Energy Management©.[22] CEI is still in its infancy, with few CEI programs beyond the pilot stage.

2.7 Additional States Adopt Industrial Energy Efficiency

California has long been perceived as a leader in energy efficiency programs. Historically, energy efficiency trends and best practices tended to spread from California to other states involved in industrial energy efficiency. More recently, a sizable contingent of states have made

[19] U. S. Council for Energy-Efficient Manufacturing. 2010. *Superior Energy Performance.* http://www.superiorenergyperformance.net/pdfs/SEP_Cert_Framework.PDF

[20] Northwest Energy Efficiency Alliance . Continuous Improvement for Industry website. http://www.energyimprovement.org/index.html

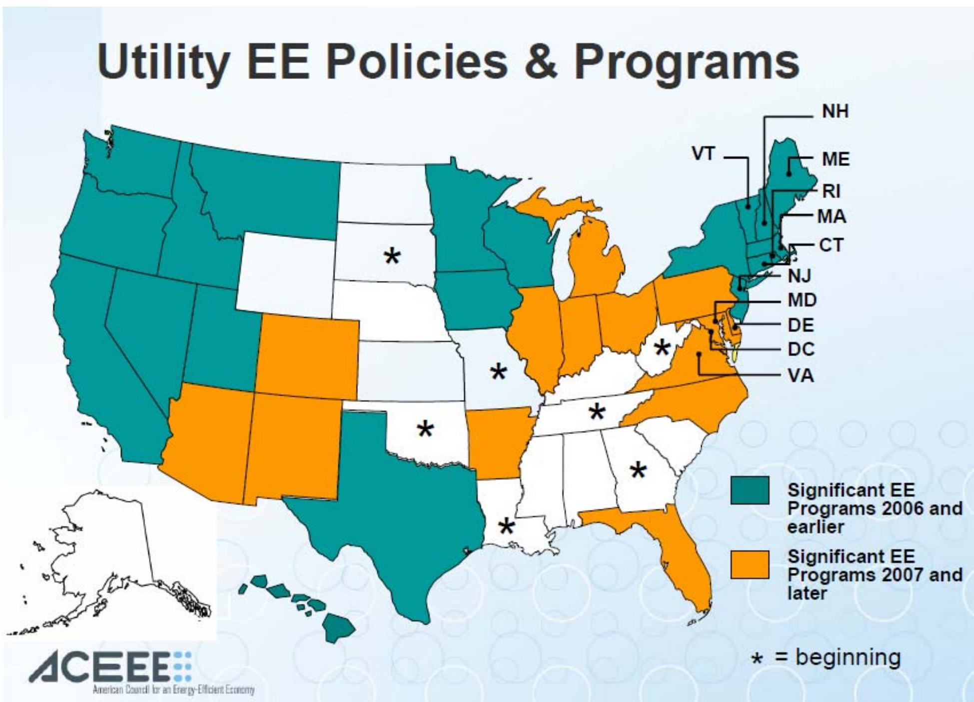
[21] California Public Utilities Commission. 2011. *CA Energy Efficiency Strategic Plan, January 2011 Update*. http://www.cpuc.ca.gov/NR/rdonlyres/A54B59C2-D571-440D-9477-3363726F573A/0/CAEnergyEfficiencyStrategicPlan_Jan2011.PDF

[22] Wisconsin Focus on Energy, Industrial Program. Practical Energy Management tool. http://www.wifocusonenergy.com/page.jsp?pageId=368

significant commitments to energy efficiency programming as shown in Figure 7. The flow of information is changing as energy efficiency programs spread to locations in the Midwest and South that typically had provided modest or little ratepayer funding for energy efficiency. Program development efforts in many of the aforementioned states are in their early stages compared to California.

These states have signaled their commitment to energy efficiency by adopting aggressive Energy Efficiency Portfolio Standards[23] (EEPS) policies[24] that exceed those in California. As shown in Table 3, California ranks number 14 for cumulative electricity savings targets by 2020, below states primarily in the Northeast and Midwest.

Figure 7: Utility Energy Efficiency Policies and Programs, 2006 vs. 2007+



Source: ACEEE[25]

[23] Covers all sectors including residential, commercial and industrial efficiency.

[24] These include: Illinois, Maryland, Michigan, New Mexico, Ohio, Pennsylvania, and Virginia (provisionally).

[25], Nadel, Steven. 2011. *Program Introduction*. (Presentation, ACEEE 2011 National Symposium on Market Transformation, Washington DC, April 10–12, Conference 2011).
http://www.aceee.org/files/pdf/conferences/mt/2011/Introduction%20-%20Steve%20Nadel.PDF

The electric EEPS targets in most of these states rise to 1–2 percent of retail sales per year within the first 5–10 years of the standard, rivaling the annual savings levels currently being achieved in only a handful of leading states. For example, North Carolina has until recently been relatively inactive in energy efficiency, but has enacted a renewable portfolio standard (RPS). Under this RPS, energy efficiency can meet up to 40 percent of the total requirements of the state's investor-owned utilities (IOU) and an unlimited amount of the publicly owned utilities' requirements.

The rise of energy efficiency policies and programs indicates that California utilities can increasingly draw on program experience in other states to inform their own experiences.

Table 3: 2020 Cumulative Electricity Savings Targets, by State[26]

State	2020 EE Target	State	2020 EE Target
Vermont	30%	Indiana	14%
New York	26%	Rhode Island	14%
Massachusetts	26%	Hawaii	14%
Maryland	25%	**California**	**13%**
Delaware	25%	Ohio	12%
Illinois	18%	Colorado	12%
Connecticut	18%	Utah	11%
Minnesota	17%	Michigan	11%
Iowa	16%	Pennsylvania	10%
Arizona	15%	Washington	10%

Source: ACEEE[27]

[26] Includes extensions to 2020 at savings rates that have been established.

[27] Nadel, Steven. 2011. *Program Introduction*. (Presentation, ACEEE 2011 National Symposium on Market Transformation, Washington DC, April 10–12, 2011). http://www.aceee.org/files/pdf/conferences/mt/2011/Introduction%20-%20Steve%20Nadel.PDF

3. Industry Characterization

The following sections describe the cement and concrete industry, including industry definition (section 3.1), description of primary energy uses (section 3.2), industry landscape in California (section 3.3), competitive issues (section 3.4), economic issues (section 3.5), regulatory issues (section 3.6), and the industry network (section 3.7).

3.1 Industry Definition

Cement manufacturers blend limestone and other raw materials; heat the raw material slurry to produce clinker; and grind and heat the clinker into cement and add gypsum. The cement, in the form of finely ground gray powder, can easily be mixed with aggregate (sand and gravel), extenders (steel fly ash) and water to produce concrete slurry (NAICS 327320), or molded to produce concrete products such as pipes, box culverts, blocks, bricks, roof tiles, and floor and wall tiles (NAICS codes 327331 and 327332).

Cement is a primary input into most building and construction markets due to its price, durability, plasticity and load-bearing capability for compressive forces. Cement and concrete are often used interchangeably, but refer to separate and distinct products. Cement is a gray, finely ground combination of minerals which, when mixed with water, sand, gravel, and other materials, forms concrete. Cement provides the chemical bonds that hold the other materials together to form a dense rock-like substance called concrete.

This report focuses primarily on four subsectors under NAICS code 3273 as shown in Table 4. Together, these four subsectors cover 90 percent or more of the electricity and gas usage of PG&E's and SCE's customers in this sector. This sector is referred to by the first four digits of the NAICS code, 3273, that is common to all codes in this sector. This report does not include similar or related industries (e.g., lime manufacturing or stone mining) and select demand and supply input industries (e.g., stone mining, sand and gravel mining).

Table 4: Cement and Concrete Manufacturing—NAICS Code 3273

327310	Cement Manufacturing
327320	Ready-Mix Concrete Manufacturing
327331	Concrete Block and Brick Manufacturing
327332	Concrete Pipe Manufacturing

Additional codes in this sector in California with 10 percent or less of the energy use include:

- 327300: Industry group, cement and concrete product manufacturing
- 327330: Concrete Pipe, Brick and Block Manufacturing
- 327390: Other Concrete Product Manufacturing

Cement production is widely dispersed across 37 states as manufacturers seek to locate both close to raw material supplies (e.g., quarries), key end markets (downstream construction and concrete product manufacturers), or bulk transportation hubs, due to the economies of transporting the final product and its raw material inputs over long distances. California ranked number two among states in terms of the volume of cement production in 2008, behind Texas. Five states (Texas, California, Pennsylvania, Michigan and Alabama) produce 48 percent of manufactured cement and related products.

The primary industry product is Portland cement, which is used to bind other minerals together to produce concrete. Portland cement accounts for approximately 95 percent of the total volume of cement produced, according to USGS data estimates. The remaining 5 percent production balance comprises mainly masonry cement for use in bricklaying and rendering, and other specialty cements.

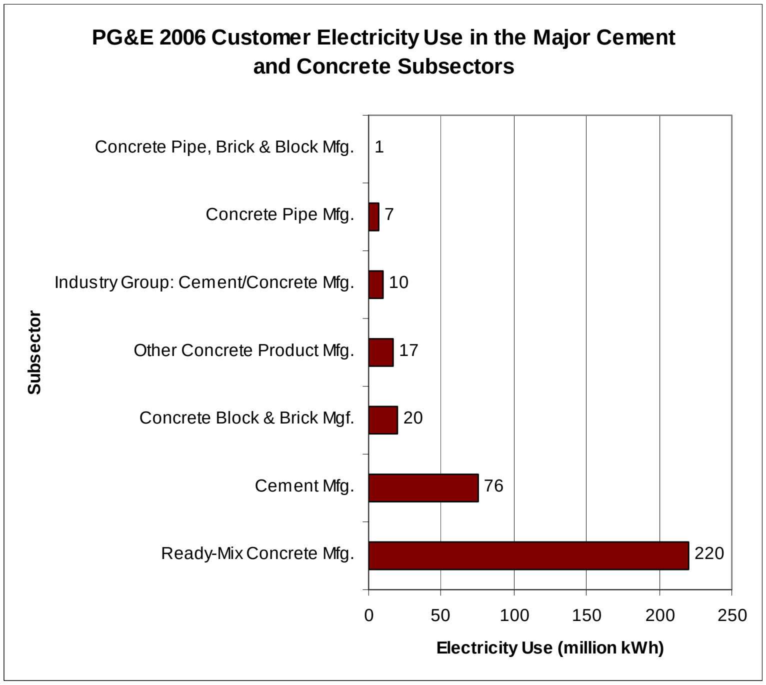
3.2 Energy Use

Figure 8 and

Figure 9 show the sub-sector breakdown by 6-digit NAICS code for electricity and gas use in PG&E's territory.

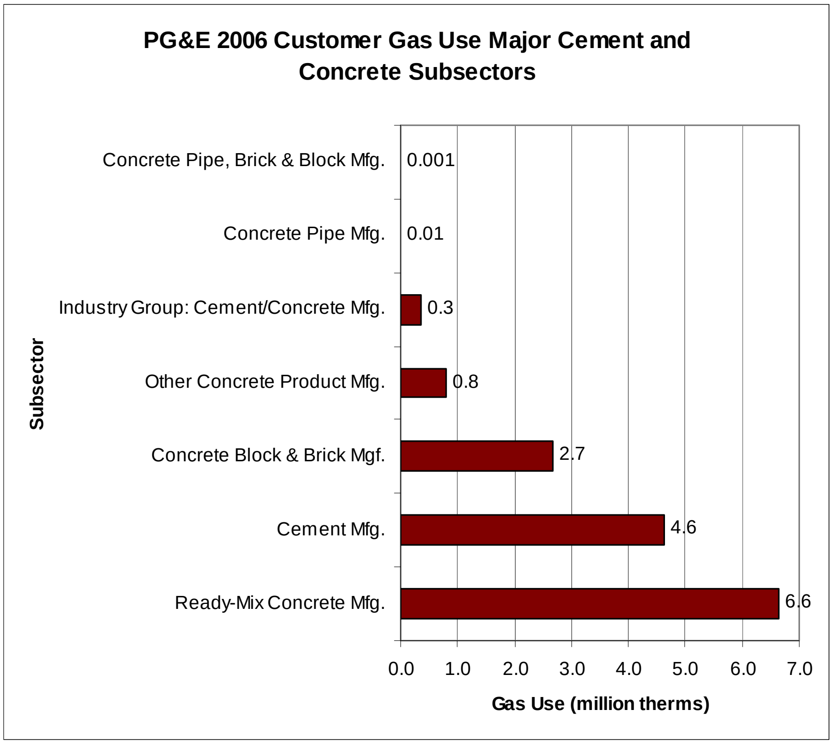
Figure 10 shows a similar breakdown in SCE's territory. In the cement and concrete industries, PG&E sells the most electricity and gas to ready-mix concrete and cement manufacturers and concrete brick and block manufacturers.

Figure 8: PG&E's Customer Electricity Use in Cement and Concrete Subsectors



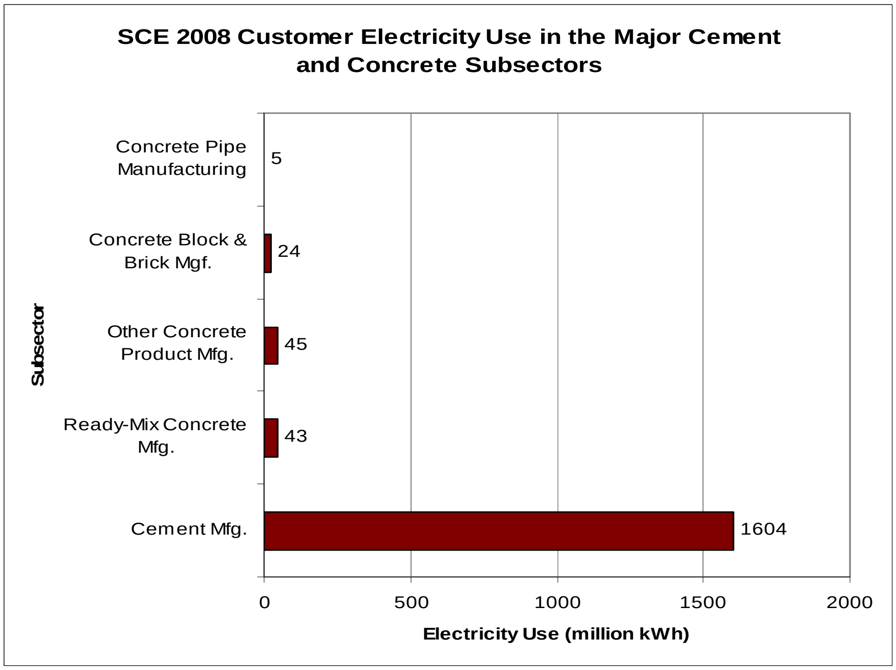
Source: KEMA, Inc and PG&E data.

Figure 9: PG&E's Customer Gas Use in Cement and Concrete Subsectors



Source: KEMA, Inc and PG&E data.

Figure 10: Cement Subsector Electricity Purchases from SCE in 2008



Source: KEMA, Inc and SCE data.

Each process along the cement/concrete supply chain has varying energy requirements. The cement/concrete supply chain is depicted in Figure 13.

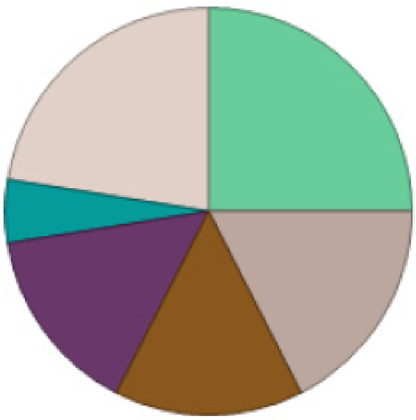
3.3 Industry Landscape

The cement manufacturing industry is highly concentrated where the top five players hold more than three-fourths market share. The top five players—CEMEX SAB de CV ADS; Holcim Inc.; HeidelbergCement AG; Lafarge North America and Texas Industries— account for 78 percent of cement sales and production. Following takeovers and acquisitions, the concentration level has risen from approximately 68 percent since 1999, according to the Portland Cement Association (PCA).

The top five U.S. cement and ready-mix concrete players and respective market shares are shown in

Figure 11 and Figure 12. All top five players in this industry are large, multinationals controlled outside the United States, with the notable exception of Dallas-based Texas Industries, Inc. The top three players (CEMEX, Holcim, HeidelbergCement) have picked up market share through strategic acquisitions of smaller rivals in the past 10 years. For example, CEMEX acquired RMC Materials, including the Davenport, California plant.

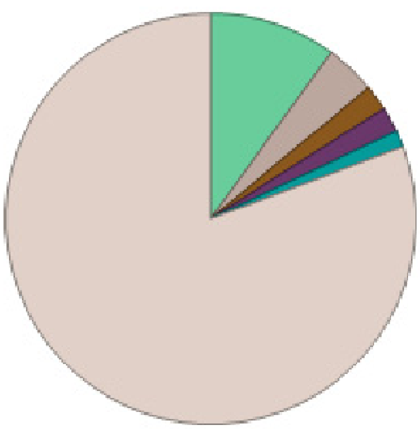
Figure 11: U.S. Cement Manufacturers Top 5 Players and Market Shares



Major Player	Market Share Range
Cemex SAB de CV ADS	25.0% (2009)
Holcim, Inc	17.5% (2008)
HeidelbergCement AG	15.0% (2009)
Lafarge North America	15.0% (2009)
Texas Industries, Inc.	5.0% (2009)
Other	22.5% (2009)

Source: IBISWorld[28]

Figure 12: U.S. Ready-Mix Concrete Manufacturers Top 5 Players and Market Shares



Major Player	Market Share Range
Cemex SAB de CV ADS	10.0% (2009)
Vulcan Materials Company	4.0% (2009)
CRH plc	2.0% (2009)
Holcim, Inc	2.0% (2009)
Hanson PLC	1.3% (2009)
Other	80.7% (2009)

Source: IBISWorld[29]

[28] IBISWorld. *IBISWorld Industry Report, Cement Manufacturing in the US: 32731*. November 2, 2009.

[29] IBISWorld. 2009. *IBISWorld Industry Report, Ready-Mix Concrete Manufacturing in the US: 32732*. July 31, 2009.

The extremely high-entry barriers have inhibited new market entrants. The main barriers are: the high capital cost of commissioning a plant; vertical integration of the existing major manufacturers; and the continued threat of import penetration, currently at approximately 20 percent. The regional domination by several large-scale operators also inhibits new competitors.

Vertically integrated producers ship cement directly to downstream operations (e.g., ready-mixed concrete production or pre-cast concrete product manufacturing) in some regional markets. Many leading cement producers also operate in the ready-mixed concrete manufacturing industry (e.g., TXI, CEMEX, and Hanson), and the concrete brick, pipe, and block manufacturing industry (e.g., Holcim and Lafarge). Many of the smaller cement manufacturers also maintain downstream concrete product manufacturing operations in regional markets.

3.3.1 Summaries of Major Manufacturers

Following are brief summaries of major cement and concrete manufacturers, most of which operate in PG&E's and/or SCE's territory. The source of the following information is the company websites of these organizations. Utility-specific information on energy use by top manufacturers, is provided in confidential Appendix A.

Basalite—a Division of Pacific Coast Building Products. Pacific Coast Building Products, Inc., or PABCO, based in Sacramento CA, manufactures a wide range of building products (including clay bricks, clay roof tiles, gypsum wallboard, waterproofing and insulation) from 30 locations spanning 10 western states. It is estimated that PABCO generates around 10 percent to 15 percent of sales revenue in the concrete pipe, brick and block industry through subsidiary Basalite Concrete Products. Basalite Concrete Products was purchased by Pacific Coast Building products in 1979 (Pacific Coast added Ocean Concrete Products, Ltd. of Surrey and Vancouver, British Columbia, Canada and Westblock of Oregon in 2003). Basalite currently operates facilities in Dixon, Tracy and Visalia, California; as well as in Nevada, Colorado, Oregon, Washington, Idaho and Canada. Basalite Concrete Products has approximately 650 employees and annual revenue of between $65 million and $70 million.

California Portland Cement produces and supplies Portland cement primarily in the western United States and Canada and also produces aggregates and ready-mixed concrete and concrete products from several locations in the western United States Originally established in 1891, privately owned CalPortland manufactures Portland cement in three cement plants located in Colton, California; Mojave, California; and Rillito, Arizona and owns 18 cement manufacturing plants in California. The company's distribution system contains the operation of five deep water international import terminals located in Wilmington, California; Stockton, California; Portland, Oregon; Seattle, Washington; and Anchorage, Alaska. Enabled by mergers and acquisitions such as Union Asphalt, CPC has expanded its line to include pre-cast manholes, redi-rock, truss pipe, corrugated pipe and fittings, catch basins, aggregates, building materials, sand, gravel, rock, asphalt, and branded insulated concrete forms.

Cemex SAB de CV ADS. Founded in Mexico in 1906, CEMEX has become a top global company supplying cement, ready-mix concrete and aggregates. Significant recent United States expansion includes acquisitions such as U.S. cement and ready-mix concrete firm Southdown Inc. for $2.8 billion (2000); RMC Group PLC worth $4.1 billion (2005); and Rinker Group Ltd for $12.8 billion (2007). Sales of concrete and cement each account for 40 percent each of company revenue. United States cement sales began to decline in 2007 due to the residential housing market downturn, and net income sharply plummeted in 2008 compared to prior years as the firm took on higher debt levels from its U.S. acquisitions, particularly Rinker Group Ltd. In 2009, CEMEX had 25 percent U.S. market share in cement manufacturing. CEMEX operates facilities in both PG&E and SCE territory.

Granite Rock Co., of Watsonville, California, is a 100-year-old family-owned and operated company with operations in a dozen locations between San Francisco and Monterey. The company quarries granite and produces concrete, asphalt, sand, and gravel. It also buys and resells such materials as brick, cinder block, and drywall, as well as masonry tools. Granite Rock is one of the smaller construction-materials companies at roughly 600–800 employees and less than $200 million annual sales. Construction-materials companies habitually compete on price, but Granite Rock, one of the smaller construction-materials companies, turns out high-quality rock and backs it up with high-quality customer service. On average, Granite Rock customers pay up to 6 percent more than they would be charged by the competition. Granite Rock operates facilities in PG&E's territory.

Holnam, Inc. (Holcim Group) is a Detroit-based company and wholly owned subsidiary of Switzerland-based Holcim Group, a leading worldwide supplier of cement, aggregates and concrete. The company significantly expanded its U.S. presence in 2005 through the takeover of Aggregate Industries in 2005 and Canadian cement manufacturer St. Lawrence Cement in 2007. Holcim (U.S.) operates as a vertically integrated manufacturer with backward integration to the quarrying of raw materials and forward integration to ready-mix concrete and other cement-based building materials. Holcim (U.S.) generates sales of approximately $1.1 billion. In 2008 as the housing crisis deepened Holcim announced cost cutting measures and plant closures in the United States. In 2009, Holnam, Inc. had a 17.5 percent U.S. market share in cement manufacturing. However, this company operates primarily in the Eastern and Midwestern United States and has no operations in California territory.

Lehigh Hanson (HeidelbergCement) is the legal entity for the North American operations of the HeidelbergCement Group, a global producer and manufacturer of aggregates, cement, concrete and building materials. HeidelbergCement integrated several North American acquisitions—global materials company Hanson (2007) and Lehigh Cement operations (1977) into three North American business lines: Aggregates and Concrete (nearly 50 percent North American group revenue); Cement (28 percent of North American revenue); and building products including concrete pipe, precast concrete, bricks, tiles and pavers (23 percent of regional revenue). In 2008, HeidelbergCement reported that the North America Group's revenue rose from approximately $4,359 million in 2007 to $5,739 million in 2008 (based on average Euro/USD exchange rates), but overall revenue actually decreased by 15.9 percent (excluding consolidation and exchange rate effects). The company has a 15 percent U.S. market share in cement manufacturing. Lehigh Hanson operates facilities in both SCE's and PG&E's territory.

Lafarge North America, based in Virginia, is a subsidiary of the French global building products giant Lafarge SA. Lafarge North America (NA) is a vertically integrated manufacturer operating 15 U.S. cement and grinding plants as well as distribution centers. United States production capacity reached 15.8 million tons in 2008. Lafarge NA cement sales have fallen in line with the residential real estate downturn and recessionary economic conditions that reduced overall construction. Lafarge North America has a 15 percent market share in cement manufacturing. Lafarge North America is not active in PG&E's or SCE's territory.

Mitsubishi Cement Corporation entered the California cement industry through its 1988 acquisition of the Cushenbury limestone quarry and industrial facility in Lucerne Valley, California. This manufacturing complex includes a limestone quarry, a heating tower, kiln, and storage and transportation facilities. Sixty percent of the plant's fuel consumption is used to prepare blended raw materials before it enter the 250 feet rotating kiln. Mitsubishi Cement Corp. is owned by Japan-based Mitsubishi Corp and operates facilities in both PG&E and SCE territory.

National Cement Company of Encino, California produces and supplies primarily concrete as well as cement in California. The company was incorporated in 1990 and is based in Encino, California. National Cement Company, Inc. operates as a subsidiary of Vicat SA.

Texas Industries Inc. (TXI) is a major cement producer in California and the largest producer of cement in Texas. Headquartered in Dallas, TXI has cement, aggregate, ready-mix and concrete product operations in six Western and Southern U.S. states. TXI cement sales have declined to $388.1 million in the year to May 2008 (from $482.4 million in FY2007 and $447.6 million in FY2006) due to the construction downturn. Texas Industries has responded to the decreased demand by idling a small kiln in Texas and its cement grinding operations at the Crestmore facility in California and by reducing companywide employment by 15 percent since December 2007. Revenue fell by 50 percent since the company spun off its Chaparral Steel segment (a top U.S. producer of structural steel and steel bar products from recycled steel scrap). TXI has since resumed revenue growth. Texas Industries has a 5 percent market share in cement manufacturing. Texas Industries Inc. is not a significant energy user in PG&E's territory, but has become a major player in SCE's territory after acquiring Riverside Cement Company in 1997.

Vulcan Materials Company. Alabama-based Vulcan Materials Company is the largest producer of construction aggregates (crushed stone, crushed rock, gravel, sand etc.) in the United States and a significant player in the ready-mix concrete manufacturing industry, with 26 ready-mixed concrete plants operating primarily in markets within the states of Arizona, California, New Mexico, and Texas. The firm's Construction Materials division includes the production of aggregates, asphalt and ready-mix concrete. In 2007, the company acquired Florida Rock Industries for $4.6 billion, consisting of 29 aggregates production facilities, 15 aggregates sales yards, 108 concrete plants, 1 cement plant, 1 calcium products plant and 3 cement grinding facilities located in the southeastern and mid-Atlantic states. As the housing crisis evolved and the credit crisis became evident Vulcan noted significant declines in volumes. However, Vulcan has maintained revenue growth largely as a result of improved pricing but also as a result of the successful integration of Florida Rock. Ready-mix concrete sales more than doubled with the Florida Rock acquisition. In 1998, Vulcan acquired CalMat, which had major operations in the PG&E territory.

3.4 Competitive Issues

Cement is generally marketed on the basis of price, quality, and product differentiation to downstream manufacturers, and to wholesale and retail customers. Competition in this industry is high and likely to remain so due to the dominance of a relatively few technologically advanced producers and due to foreign competition.

These large cement-manufacturing players may have both backward vertical integration as well as forward vertical integration. The backward vertical integration into quarrying restricts new entrants from accessing raw materials required for cement production. Forward vertical integration into the ready-mixed concrete and other concrete product markets by the existing major players limits penetration of these markets by newcomers. New entrants are likely to have restricted access to available resource deposits since the existing players hold leases on the most economically efficient quarries.

Similarly, the few large-scale multinational firms which dominate the national concrete pipe and precast product market generally adopt sophisticated production processes which are unlikely to be matched by new entrants, and maintain a high degree of vertical integration, owning cement quarries through to end product distribution network. This vertical integration provides a competitive advantage when sourcing inputs and distributing final product.

While cement is an internationally traded commodity, the U.S. cement manufacturing industry is subject to substantial import competition but exports only around 1 percent to 2 percent of production. Import penetration is estimated at around 25 percent volume of domestic consumption. There is limited room for U.S. cement manufacturers to export sufficient product to offset the continued penetration of imports.

The industry has a heavy dependence on the cyclical fluctuations in the downstream building and construction markets. Concrete and cement manufacturing firms have been heavily impacted in California, where the cyclical real estate downturn, starting in 2005, has been particularly severe. Firms with diversified customer bases outside real estate (such as bridge and highway sales) and large operations are able to secure a competitive advantage and better weather the downturn than less diversified rivals.

Competitive pressures fluctuate between regional markets based on variations in construction trends. During a peak building boom in 2004–2005, the Portland Cement Association (PCA) noted 35 states with supply shortages. During these short-term shortfalls in supply, competitive conditions are likely to ease in these regions and allow prices to rise. However the tendency for producers with excess production capacity in neighboring regions to capture a share of the markets experiencing shortages, adds to competitive pressures when demand conditions normalize.

3.4.1 Operational Models

There exists a substantial degree of vertical integration between the cement manufacturing industry and key downstream building product industries. Many of the leading cement producers are also leading players in the ready-mixed concrete manufacturing industry (e.g., TXI, CEMEX, and Hanson), and the concrete brick, pipe, and block manufacturing industry (e.g., Holcim and Lafarge). The vertical integration between cement and downstream concrete production ensures a captive market, and guarantees that each operator is less influenced by the actions of other companies. Many of the smaller cement manufacturers also maintain downstream concrete product manufacturing operations in regional markets.

The cement manufacturing industry is dominated by several large-scale multinational corporations with substantial sunken capital due to the extremely high capital requirements of production. For example, to produce $1 in annual sales of Portland Cement requires $3 of capital investment. Each of the major players operates large-scale technologically advanced and highly automated manufacturing plants capable of producing a wide range of products. Plants are built to take advantage of economies of scale, given the size of the regional market being supplied.

Similarly, most of the large-scale players in concrete pipe, brick and block manufacturing (e.g., U.S. Concrete, Florida Rock, and Hanson North America) are vertically integrated and own cement quarries through to end product distribution networks. There has been substantial consolidation of ownership within this industry over the past decade with several of the large-scale multinational construction materials companies selectively acquiring small-scale regional establishments in order to exploit economies of scale in technology, financing and marketing, and capture market share across several of the faster growing regions.

Unlike cement, the ready-mix concrete manufacturing industry has a highly fragmented structure as the perishable nature of the product restricts manufacturers to supplying within a narrow geographic market since most operate within a 25-mile radius from the batching plant. There is virtually no international trade in ready-mix concrete. The industry also has a low concentration of ownership with the five largest companies accounting for around 15 percent of annual industry revenue. Key players include CEMEX Corporation, Vulcan Materials Company, Holcim, Inc, CRH plc, and Lehigh Hanson, most of which also are cement manufacturers. All but Vulcan Materials are majority foreign owned. There is virtually no international trade in ready-mix concrete as the bulky and perishable nature of the product and relatively low unit value precludes transport over long distances.

There has been substantial consolidation of ownership within this industry over the past decade with several of the large-scale multinational construction materials companies selectively acquiring small-scale regional establishments. This strategy allows the companies to add capacity without the heavy investment needed for building from the ground and waiting for demand to reach scale. It also provides ready access to technology and captures market share across several of the faster growing regions.

3.4.2 Cost Structure

Cement and concrete manufacturing has a high level of capital intensity. The minimum investment required for constructing and commissioning a new plant is estimated at around $250 to $300 million. Given the high level of sunken capital in this industry, a substantial share of the gross operating surplus is absorbed by financing costs and depreciation. Capital expenditure on new buildings, plant and equipment accounted for around 5 percent of the total value of shipments in 2009, according to the U.S. Bureau of the Census's Annual Survey of Manufacturers.[30] Plant maintenance costs also represent a significant cost burden for this industry, reflecting the high level of fixed capital. For example, in the concrete manufacturing industry, 7 percent of annual industry revenue is due to other business costs, including contract labor, repair and maintenance, communications and legal costs, according to IBISWorld.

Aside from new plant expenses, the major industry expenses are raw materials and utilities. Material purchases are the largest expense in U.S. cement manufacturing, at 17.5 percent of cost for cement, 45 percent of cost for ready-mix concrete, and 30 percent of cost for concrete products. These materials mainly comprise: quarry materials such as crushed rock, limestone, other aggregate, gypsum, and industrial sand; water; blending additives; and extenders (e.g., slag and fly ash). Utilities take a close second at 15 percent of cement manufacturing cost, but only 2.5 percent of ready-mix and 2 percent of concrete products costs. The high-energy kiln process represents the bulk of utility costs for cement. Furnaces or kilns are typically fired by coal, oil, natural gas and electricity, but environmental and climate change concerns are changing fuel mixes. For example, the Mitsubishi Cement plant in Lucerne Valley, California implemented a wood waste recovery system in 2009, enabling it to use both coal and biomass in its cement kilns. Approximately half the industry's energy and utility expenses represent the cost of purchased fuels, and the balance represents the cost of purchased electricity. Cartage costs, notably outward freight, are a small but notable industry expense, reflecting the bulky nature of the raw material inputs and the final product.

3.4.3 Technology Development

The cement manufacturing industry is subject to a substantial degree of technological change, principally associated with the production process. Over the past two decades the industry has boosted efficiency by concentrating new capital investment in plants that use the dry kiln

U.S. Census Bureau. *2010. American Fact Finder, 2009 Annual Survey of Manufacturers*. December 3, 2010. http://factfinder.census.gov/servlet/IBQTable?_bm=y&-_skip=600&-ds_name=AM0931GS101&-_lang=en

(preheated) process of production and by phasing out operations that rely on the more energy-intensive wet process.

These and other technological advancements during the last three decades of the 20th century have seen the cement industry reduce the amount of energy needed in cement production by almost 30 percent. This improved energy efficiency resulted from the closure of small, inefficient plants (often the energy-intensive wet production processes) and the modernizing and automation of remaining plants. By the end of 2009, only 22 plants used the wet-kiln technology, out of 103 total plants in the United States. The USGS reports 11 cement plants in California in 2008, all of which are dry kilns. During the recent economic downturn, the wet kiln plants were more likely to be idled.[31] In 2009, USGS reported only 7 cement plants in California. The dry kiln process uses more electrical energy than the wet kiln process, because of the need for fans and blowers.[32]

The ready-mix concrete manufacturing industry has been subject to substantial technological development over recent decades though on a smaller scale than the cement manufacturing industry. The technological advancements in the end product have occurred on two levels: durability and strength, and these advancements have ensured that concrete continued to capture a greater share of the total construction materials market.

Concrete products designed to improve energy efficiency in buildings are also reaching the market. For example, autoclaved cellular concrete (ACC), which has a lightweight cellular quality, weighs about one-quarter that of conventional concrete. It is recyclable and both economical to produce and energy efficient. Widely used in the European market for the past 50 years however, it was introduced to the United States in the past two decades. ACC is mixture of cement, lime, water, sand, and aluminum powders. Due to the materials lightweight, it has lower labor cost associated with it as well as lower product cost. It must be cured in an autoclave using high-pressure steam. Also, the greater thermal resistive properties of the material (R-10 for ACC versus R-1 for conventional concrete masonry units) produces lower energy costs in the buildings where it is used.[33]

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[31] USGS. 2011. *2009 Minerals Yearbook, Cement [Advance Release].* July 2011 http://minerals.usgs.gov/minerals/pubs/commodity/cement/myb1-2009-cemen.PDF

[32] Hanle, L., K. Jayaraman and J. Smith. *CO_2 Emissions Profile of the U.S. Cement Industry.* U.S. EPA. http://www.epa.gov/ttnchie1/conference/ei13/ghg/hanle.PDF

[33] Portland Cement Association, Cement & Concrete Basics, accessed 2011. http://www.cement.org/basics/concreteproducts.asp

Carbon negative cement has emerged as a potential new technological advancement. In typical cement production the calcination stage of pyroprocessing creates a direct emission of roughly 0.14 metric tons of $C0_2$ for every ton of cement produced. A number of companies, notably Los Gatos, California-based Calera Corp., have developed prototype cement manufacturing techniques that result in a negative net carbon footprint. Calera is developing a low energy kiln process that uses carbonates of calcium and magnesium rendered from sequestered $C0_2$ as a raw ingredient. By Calera's estimate their process absorbs half a ton of $C0_2$ per ton of produced cement. Calera employs 100 people and is currently working on a pilot plant. The London based firm Novacem is developing a type of cement that uses magnesium oxide in a low energy kiln process to produce a cement that absorbs CO_2 as it sets. Novacem is also in the process of building a pilot plant.

3.4.4 Supply Chain Management

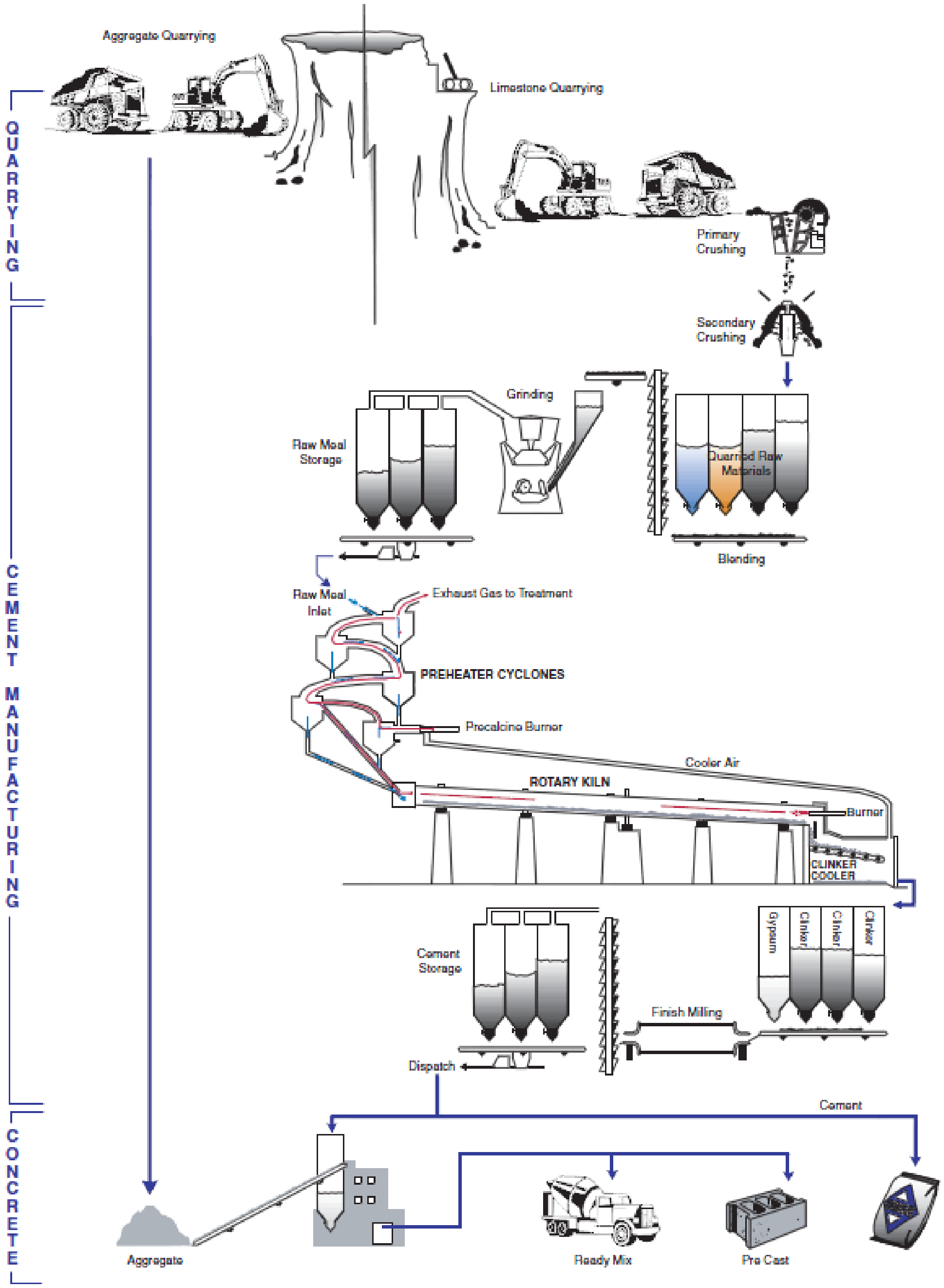
Cement production requires raw material input primarily of limestone and secondary raw materials include amounts of silica, alumina and iron oxide. Quarries are typically owned by the cement-manufacturing companies, and it is not uncommon for the raw materials to be transferred to the cement plant via conveyer belt.

Raw materials arriving at the cement plant are stored in dry sheds or silos prior to processing. Grinding raw materials for cement manufacturing consumes about 2 percent of the on-site energy associated with cement manufacturing and are electrically driven processes. Pyroprocessing in large rotating furnaces or kilns to produce clinker (unfinished raw material used to make cement) represents the major technical process common to all cement plants. It is also the most technically complex and energy-intensive operation from quarrying to concrete placement.

Cement is stored at the cement manufacturing facility or a cement terminal until it is shipped to a customer. Storage of bulk cement is in watertight bins or silos as cement is very moisture-sensitive and must be stored in a dry environment. About 40 percent of manufactured cement is shipped by rail and barge directly to terminals but the majority of cement that is shipped directly to consumers is by truck. The total U.S. market for concrete pipes, bricks and blocks is predominantly met by local production and heavily skewed towards regions in close proximity to raw materials (cement and aggregates) as the bulk and weight of the product tends to preclude transport over long distances. Ready-mix concrete facilities convey products to end-use customers via trucks for transport to a job site.

Figure 13 shows the stages of supply chain management from quarrying to cement manufacturing to concrete production to transport.

Figure 13: Cement Industry Supply Chain



Source: U.S. DOE[34]

[34] U.S. Department of Energy, Energy Efficiency and Renewable Energy, Industrial Technologies Program. 2003. *Energy and Emission Reduction Opportunities for the Cement Industry*. December 29, 2003. http://www1.eere.energy.gov/industry/imf/pdfs/eeroci_dec03a.PDF

3.4.5 Product Development and Roll-out

The principal factor supporting industry expansion is the continuous development of new products and new markets by the downstream concrete product manufacturing industries. Concrete products have taken an increasing share of the total building and construction materials market during the past thirty years, and the continued market penetration by concrete products (albeit at a slower pace) will remain an important source of expansion in demand for cement.

The presence of large-scale vertically and horizontally integrated building material manufacturers in this industry enhances the rapid adoption and spread of new technologies in product design and attributes. For example, concrete corrosion resulting from exposure to salt air has long been a disincentive to build with concrete in coastal environments. By developing additives which reduce the incidence of cracking during drying or limit the porosity of concrete finishes, manufacturers have been able to improve the durability of ready-mixed concrete. Improved use of concrete extenders, including fly ash and steel slag, have enabled manufacturers to strengthen the final product and improve its application on projects where builders demand a high level of strength (e.g., slim concrete office columns to save on floor space).

Developments in building technology have contributed greatly to a long-term trend of substitution by concrete-based products of alternative materials (e.g., timber, ceramic, asphalt, and steel), resulting from product developments in existing markets and entry into new markets. This trend has dissipated during the 2000s as concrete penetration into the construction materials market approaches saturation point. Product variations developed to expand existing markets, include: concrete housing; pre-cast modular paving stones; pre-stressed concrete railroad ties to replace wood ties; continuous-slab rail-support systems for rapid transit and heavy-traffic intricate rail lines; and concrete bridges, tunnels and other structures for rapid transit systems. New markets that have opened for ready-mixed concrete include highway median barriers, highway sound barriers, paved shoulders to replace less permanent and increasingly costly asphalt shoulders, parking lots providing a long-lasting and aesthetically pleasing urban environment, and colored pavements to mark entrance and exit ramps and lanes of expressways.

The penetration of low-cost cement imports from Asia (notably Thailand and China), Mexico, and South America threaten the U.S. cement and concrete manufacturing companies. However, in the concrete bricks and blocks segment, product differentiation is limited as the products tend to have standardized attributes and are of a commodity nature. The weight and bulky nature of this industry's products severely limits where products can be sold. Prohibitively high transport costs constrain establishments to supplying relatively narrow regional markets. It is therefore vitally important for manufacturers to establish and maintain a strong position within regional markets on the basis of availability of delivery and standard quality, rather than entering into price wars. However, the recent concrete industry trend is towards greater market penetration of cement-based building products (e.g., concrete pipes, concrete blocks etc.), and technological advances in the production of concrete products using other blended materials (aggregates, extenders, steel reinforcement etc.).

3.4.6 Value Chain

A value chain shows how materials and processes turn out a final product that contains more value after undergoing these activities. The final product value is higher than the cost of what is sold. This idea was developed to explain how a company is more than a random compilation of machinery, equipment, people and money. Combined, these all work together to create higher value in the product. In this section, we evaluate the value that each activity adds to the company’s products.

In the cement and concrete industry value chain, the business model and operations create the highest value, particularly for the top players. Most of the large-scale players in this industry (e.g., U.S. Concrete, Florida Rock, and Hanson North America) are vertically integrated, owning cement quarries through to end product distribution networks. These large-scale, vertically integrated manufacturers have access to raw material quarrying activities and proximity to customers. Hence, the value-added between quarrying and sale of final cement product is substantial since the vertically integrated company may control a substantial amount of activities needed to mine raw materials and turn them into final cement and concrete products.

3.4.7 Pricing

Historically, the value, volume and price of U.S. cement experiences short term volatility with fluctuations up to 20 percent between peaks, due to the cyclical fluctuations in downstream construction markets. During 2005 and 2006, rising energy costs and high demand due to a construction and housing boom caused cement prices to rise. The U.S Geological Service estimates the average price per ton of Portland cement rose 14.5 percent in 2005, and to a record $104.0 per ton in calendar year 2007. The price fell to $99/ton in 2009.[35]

Profit margins are declining with the collapse in housing construction. Yet profit margins have held in the non-housing construction markets (e.g., foundations, sidewalks and drives). The industry is also seeing a contraction in employee compensation (i.e., payroll costs and fringe benefits), down around 1.5 percent per year over the five years to 2009.

Faced with the recent surge in energy prices which trimmed profitability, some U.S. cement producers have shifted to coal-fired kilns as the principal energy source although the passage of AB 32 inhibits this shift in California (see Section 3.6.2). These firms will also have to invest in emission control technology to comply with stricter regulatory controls.

In some regional markets, the downstream dominance of the vertically integrated manufacturers enables them to act as *price makers* when sourcing cement from an independent producer or internalize costs when sourcing cement internally. The USGS estimates that ready-mixed concrete producers consume three quarters of total U.S. cement production and hence vertical integration provides relatively competition free access to the largest market segment.

3.5 Economic Factors

3.5.1 Business Cycles

The cement industry depends heavily on the cyclical demand of many building industries. However, the industry is somewhat guarded from the extremes of these business cycles since cement may likely be needed by one of the construction industry segments at any given time. Demand is also highly seasonal: two thirds of cement consumption occurs in the six months between May and October, attributed to construction during seasons of warmer weather when it is more advantageous to build.

The current recession has slowed the construction market significantly, particularly in California, and severely impacted the cement industry. Following the accelerated growth during the early to mid 2000s, which coincided with the cyclical growth of key construction markets, the industry is now experiencing a contraction. This contraction in both production and revenue corresponds with the slump in demand from the housing construction market and, to a lesser extent, the

[35] USGS. 2010. *Cement Statistics*. December.
http://minerals.usgs.gov/ds/2005/140/cement.PDF

recession-induced decline in commercial building investment. California has been particularly affected since it was one of four states (Nevada, Arizona, and Florida) that saw the sharpest rise in housing construction.

The U.S. recession and further deterioration in the housing construction market resulted in continued contraction in the industry's performance in 2009. The value of total housing construction is estimated to decline by 17.3 percent, and the number of new housing starts is estimated to fall to 650,000 units, or almost 70 percent below the record peak in 2005 (2,068,300 starts). In addition, the demand for cement has contracted sharply in the commercial building market during 2009 associated with the current recessed conditions in the U.S. economy (rising unemployment and falling profits), and the global shortage of investment funds. The continued solid growth in construction activity for highways and bridges, and the institutional building market, has helped cushion the industry from the full impact of the deterioration in demand in the housing and commercial building markets. Infrastructure programs that are a part of the stimulus package have increased revenue for the cement and concrete industries.

3.5.2 Availability of Capital and Credit

The cement manufacturing industry has not been immune from the deteriorating global credit market starting in 2008. In its fourth quarter 2008 earnings report,[36] CEMEX reported that "overall construction activity weakened further as economic conditions continued to worsen and credit availability became very scarce." Although conditions have improved, the 2010 CEMEX annual report still refers to the business environment as challenging.[37]

An enormous financial investment is required to construct a new or maintain an existing plant. Research firm IBISWorld estimates a new plant can cost up to $300 million and major modernization of existing premises more than $50 million. These costs are typically secured through long or short-term debt, and, less frequently, through working capital or cash transactions available to the largest multinational competitors. Characterized as mature, the cement industry does not attract venture capitalists who typically invest in high growth potential businesses. The high level of fixed capital required to establish and maintain operations at an efficient scale is likely to be a significant barrier to most new entrants, even global players, as credit is more difficult to obtain and terms may not be as attractive as during the 2000's boom years.

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[36] CEMEX 2008. Fourth Quarter Results. http://www.cemex.com/InvestorCenter/files/2008/CXING08-4.pdf
[37] CEMEX 2010. Annual Report. http://www.cemex.com/MediaCenter/AnnualReports.aspx

As the pace of acquisitions picked up in the past 10 years, some of the larger players (e.g., CEMEX and others) had taken on higher debt levels to finance these acquisitions and subsequently have retrenched. CEMEX has subsequently embarked on a program to create greater cash flow and financial flexibility, selling select operations in Europe.

3.6 Regulatory Issues

Regulatory issues facing the cement and concrete industries are detailed below.

The cement and concrete production industry is subject to a myriad of environmental regulations on federal, state, and local levels. The following sections describe the regulatory issues facing the cement and concrete production industry.

3.6.1 Environmental

The cement and concrete production must comply with the following environmental laws:

- The Clean Air Act (CAA) regulates air emissions from stationary and mobile sources. The pollutants are defined as particle pollution (often referred to as particulate matter), and include ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, and lead. Regulated sources are stationary sources or group of stationary sources that emit or have the potential to emit 10 tons per year or more of a hazardous air pollutant or 25 tons per year or more of a combination of hazardous air pollutants.
- The Clean Water Act (CWA) establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. Under the CWA, the U.S. EPA has implemented pollution control programs such as setting wastewater standards for industry. The CWA made it unlawful to discharge any pollutant from a point source into navigable waters, unless a permit was obtained.
- The Resource Conservation and Recovery Act (RCRA) gives the U.S. EPA the authority to control hazardous waste from the cradle-to-grave. This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of non-hazardous solid wastes. The 1986 amendments to RCRA enabled EPA to address environmental problems that could result from underground tanks storing petroleum and other hazardous substances. HSWA—the federal Hazardous and Solid Waste Amendments—are the 1984 amendments to RCRA that focused on waste minimization and phasing out land disposal of hazardous waste as well as corrective action for releases.

Responsibility for enforcing environmental laws is distributed between the federal government (usually the EPA), state agencies, counties and municipalities. In California, regional air districts are charged with developing and enforcing air quality regulations that are more stringent than federal standards. In general, facilities in the cement and concrete production industry are long accustomed to complying with existing environmental regulations as part of their normal course of business.

3.6.2 Climate

California Global Warming Solutions Act

In 2006, Assembly Bill 32, the Global Warming Solutions Act (AB 32) became the first U.S. legislation signed into law to establish mandatory limits on greenhouse gas emissions (GHG). The California Air Resources Board (ARB) was designated as the lead agency tasked with developing the regulatory structure to achieve emissions reductions targets for carbon dioxide (CO_2) and other greenhouse gases.[38]

In January 2009, ARB adopted a Scoping Plan that provides the blueprint for achieving the reductions through a mix of incentives, direct regulatory measures, and market-based compliance mechanisms.

Key elements of the Scoping Plan include:

- Expanding and strengthening existing energy efficiency programs, as well as building and appliance standards
- Developing a California cap-and-trade program that links with other Western Climate Initiative partner programs to create a regional market system
- Establishing targets for transportation-related emissions for regions throughout California, and pursuing policies and incentives to achieve those targets.

The cement production industry in California is likely to be affected in the proposed cap-and-trade program. Cap and trade would require large emission sources to surrender emissions permits equal to their actual emissions in any given year. The amount of total available permits declines over time, thereby making it more and more expensive to emit GHGs. Emissions permits are tradable among market actors and emissions reductions from non-capped sectors, known as offsets, can also be used for low-cost compliance purposes.

[38]These gasses include methane (CH4), nitrous oxide (N2O), hydro-fluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride(SF6). Since each of these gases' unique physical properties causes them to have varying heat trapping effects, they are normalized into carbon-dioxide equivalents. For example, one metric ton of methane is equivalent to 21 metric tons of CO_2 equivalents (CO_2e).

The implementation of the cap-and-trade under AB 32 has been delayed to 2013, although the state plans to develop the regulatory framework in 2012. Starting in the first compliance period of 2013, all large industrial facilities that emit over 25,000 metric tons CO_2e per year (including cement plants) will be required to acquire and hold emissions permits. Starting in the second compliance period of 2015, industrial fuel combustion at facilities with emissions at or below 25,000 metric tons CO_2e per year will be included.

Eleven cement plants will be affected, according to the California Air Resources Board. Four are in PG&E's territory and five in SCE's territory as listed below. The remaining two plants affected are served the Los Angeles Department of Public Works.

- Affected plants in PG&E territory:
  - Mitsubishi Cement, Lucerne Valley, California
  - Lehigh Southwest Cement, Cupertino, California
  - Lehigh Southwest Cement, Redding, California
  - CEMEX, Davenport, CA
- Affected plants in SCE territory
  - CEMEX, Black Mountain Quarry, Victorville, California
  - Lehigh Southwest Cement Co., Tehachapi, California
  - California Portland Cement - Mohave, Glendora, California
  - California Portland Cement – Colton Plant, Glendora, California
  - TXI Riverside Cement (Oro Grande plant), Oro Grande, California

For some energy-intensive industrial sources, stringent requirements in California, either through inclusion in a cap-and-trade program or through source specific regulation, have the potential to create a disadvantage for California facilities relative to out-of-state competitors unless those locations have similar requirements. If production shifts outside of California in order to operate without being subject to these requirements, emissions could remain unchanged or even increase. This is referred to as *leakage*.

The cement sector is an example of a sector that may be susceptible to this type of leakage, and the Draft Scoping Plan included consideration of a measure to institute an intensity standard at concrete batch plants that would consider this type of life-cycle emissions. While this measure is not recommended in this Proposed Scoping Plan, ARB will evaluate whether this type of intensity standard could be incorporated into the cap-and-trade program or instituted as a complementary measure during the cap-and-trade rulemaking.

EPA Mandatory Reporting

The U.S. EPA requires mandatory GHG emissions reporting from large sources in the United States. The rule, which took effect on December 29, 2009, established EPA's program to collect accurate and comprehensive emissions data to inform future policy decisions. Facilities that emit 25,000 metric tons or more of GHG emissions per year to submit annual reports to the U.S. EPA. Approximately 85–90 percent of total national U.S. GHG emissions, from approximately 13,000 facilities, are covered by the rule. The U.S. EPA estimates the average cost of reporting under this proposed rule would be approximately $0.04 per metric ton. Large cement manufacturing plants have sizeable enough emissions that they are required to monitor and report them to the EPA.

EPA Regulation of GHG under the Clean Air Act

Greenhouse gas emissions are now regulated in the United States under the Clean Air Act. According to the Tailoring Rule,[39] GHG permitting requirements will cover for the first time new construction projects that emit GHG emissions of at least 100,000 tons per year (tpy). Modifications at existing facilities that increase GHG emissions by at least 75,000 tpy will be subject to permitting requirements, even if they do not significantly increase emissions of any other pollutant. By 2016, the EPA may lower the threshold to 50,000 tpy.

Under the EPA rulemaking for New Source Review proposed emissions sources will be required to install best available control technology (BACT). Typically, this means installing energy efficiency equipment. Large sources permitted through the Title V program may have emissions limits on GHG emissions in the future.

3.7 Industry Network

Major cement and concrete producers such as Holcim, LaFarge North America, and CEMEX belong to the industry's leading group, the Portland Cement Association. Other specialty associations serve the specialized interests of its members, such as concrete manufacturers.

- Portland Cement Association (PCA, http://www.cement.org)—Conducts research and development; and promotes the industry's interest in codes and standards. Represents cement companies in the United States and Canada. The essential function of the Portland Cement Association (PCA) is the promotion of cement and concrete with an

[39] Federal Register. 2010. *Environmental Protection Agency: Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule*. Vol. 75, No. 106, June 3, 2010. http://www.gpo.gov/fdsys/pkg/FR-2010-06-03/pdf/2010-11974.pdf#page=1

emphasis on market development. The PCA has a special arm directed at joining cement suppliers and paving contractors, and another arm aimed at protecting concrete interests in national building code organizations.

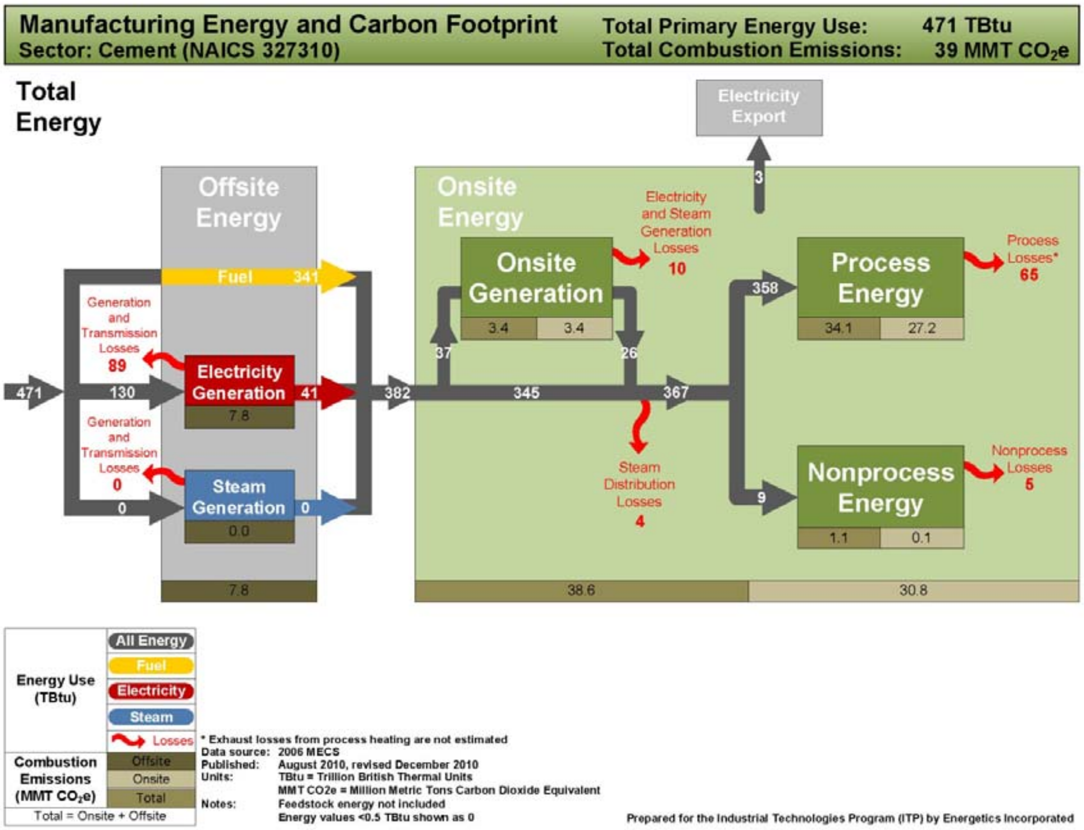
- National Ready Mix Concrete Association (NRMCA, www.nrmca.org)—Has partnership agreements with state associations on regulatory and promotional issues. The NRMCA lobbies for the interests of the ready-mix concrete industry and also sponsors trade shows and other promotional efforts for ready-mix concrete.
- American Concrete Pipe Association (ACPA, www.concrete-pipe.org)—Acts as national advocate for the concrete pipe industry. Established quality assurance standards that members follow.
- American Concrete Institute (ACI, www.concrete.org)—Non-profit authority on concrete technology. Releases publications on concrete technology. Conducts seminars and provides a standard certification program for the industry.
- Cement Kiln Recycling Coalition: The Cement Kiln Recycling Coalition (CKRC) is a trade association with member companies that recover energy from hazardous-waste derived fuels (http://www.ckrc.org/). CKRC and its member companies support standards, regulations, policies and procedures related to the use of waste-derived fuels.

4. Target Technologies / Processes and Energy Efficiency

Similar to other manufacturing industries, cement and concrete manufacturers tend to view their individual processes as proprietary. Thus, the improvement potential of any particular manufacturer cannot be precisely predicted. This section focuses on energy usage and energy efficiency opportunities for PG&E and SCE territory customers, as available, and more generally in California and the United States

Extremely high operating temperatures up to 2,700° F needed for cement manufacturing make it an energy-intensive process. The average energy input required to make one ton of cement is 4.65 million Btu, excluding quarrying for raw materials. Figure 14 shows the industry processes and related energy uses. In the cement and concrete industries, the greatest efficiency gains are in the cement industry's most energy intensive process called pyroprocessing. Concrete production is much less energy intensive, involving mixing, curing, and transporting the final product. Both the cement and concrete industry offer opportunities to improve energy efficiency.

Figure 14: Cement Industry Total Energy Input



Source: U.S. DOE[40]

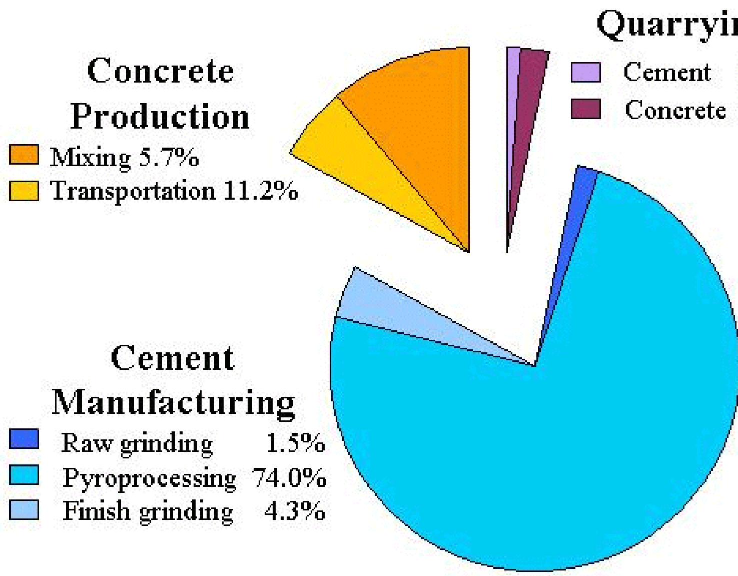
4.1 Energy Use

Figure 15 shows the proportion of the more than 550×10^{12} Btu (0.55 quad) that were consumed in 2000 for U.S. quarrying, cement manufacturing, and concrete production. Cement manufacturing requires very high temperatures to initiate the reactions and phase changes necessary to form the complex mineral compounds that give cement its unique properties. Pyroprocessing in large rotary kilns dominates the energy consumption associated with the manufacture of cement and use of concrete and accounts for 74.2 percent of the industries'

[40] U.S. DOE, Energy Efficiency and Renewable Energy, Advanced Manufacturing Office. 2010. *Manufacturing Energy and Carbon Footprints: Cement Footprint.* http://www1.eere.energy.gov/industry/pdfs/cement_footprint.pdf

energy consumption. Concrete production accounts for 16.9 percent of the industries' energy consumption for use in mixing and transportation.

Figure 15: Energy Use Distribution for Quarrying, Cement Manufacturing and Concrete Production



Source: U.S. DOE [41]

The cement industry in California consists of 31 sites, according to the 2000 U.S. Census Bureau, which combined consume large amounts of energy, annually: 1,600 GWh of electricity, 22 million therms of natural gas, 2.3 million tons of coal, 0.25 tons of coke, and smaller amounts of waste materials, including tires, according to USGS data. Although 11 cement plants were operating in California in 2008, according to USGS, only seven of sites were involved in full-scale cement production in 2009. The remainder of the facilities provides grinding and mixing operations only. There are numerous plants devoted to preparing materials for pyropocessing, typically located onsite at limestone quarries. Figure 16 shows the location of and relative size of cement and concrete plants in California.

[41] U.S. DOE, Energy Efficiency and Renewable Energy, Industrial Technologies Program. 2003. *Energy and Emission Reduction Opportunities for the Cement Industry*. December 29, 2003. http://www1.eere.energy.gov/industry/imf/pdfs/eeroci_dec03a.PDF

Figure 16: Cement Plants in California

Source: California Air Resources Board[42]

The cement/concrete sector energy consumption is comprised of energy used for raw material preparation, clinker production, grinding/milling, mixing and transportation. In California, coal accounts for approximately two-thirds total cement and concrete industry energy consumption, according to 2002 USGS data. However, reducing coal use is a top industry priority, according to the PCA. Kilns are ideally suited to recycling alternate/wastes for recovering their energy value because of the intense heat of pyroprocessing. The cement industry has steadily increased its use of waste materials to fuel cement kilns, and currently relies on the combustion of waste materials for 8.2 percent of its energy needs. Cement plants can burn many household and industrial wastes, including waste solvents, scrap tires, used motor oils, surplus printing

[42] California Air Resources Board. Cement Plants in California.
http://www.arb.ca.gov/cc/ccei/presentations/cementmap_4_3_07.PDF

inks, dry-cleaning solvents, paint thinners, petroleum sludge, and agricultural wastes such as almond shells and rice hulls. Because of strict product quality demands, the cement produced from kilns using alternative materials or fuels must be equal in quality to cement from kilns using conventional materials or fuels. The remaining energy use is primarily natural gas and electricity, which is used in the machine drive end use, associated with grinding, crushing, and materials transport.

Clinker production is the most energy-intensive stage in cement production, accounting for over 90 percent of total industry energy use, and virtually all of the fuel use. Natural gas consumption is concentrated in the process heating end use or pyroprocessing in large kilns (about 90 percent of total gas consumption). However, in most cases natural gas is used as a supplemental fuel to coal. Only one relatively small plant in California, which produces white cement, uses gas as a primary kiln fuel. The remainder of the natural gas usage is associated with boiler and machine drive end uses.

For the cement and concrete sectors, grinding/milling and mixing are electrically driven processes. Cooled clinker, combined with approximately 3 percent to 6 percent gypsum, is ground/milled into an extremely fine gray powder called cement. Electricity use for raw meal and finish grinding depends strongly on the hardness of the material (limestone, clinker, pozzolana extenders) and the desired fineness of the cement as well as the amount of additives. Clinker milling uses the same general type of equipment as raw meal grinding. However, the final product is much finer and requires almost three times the energy.

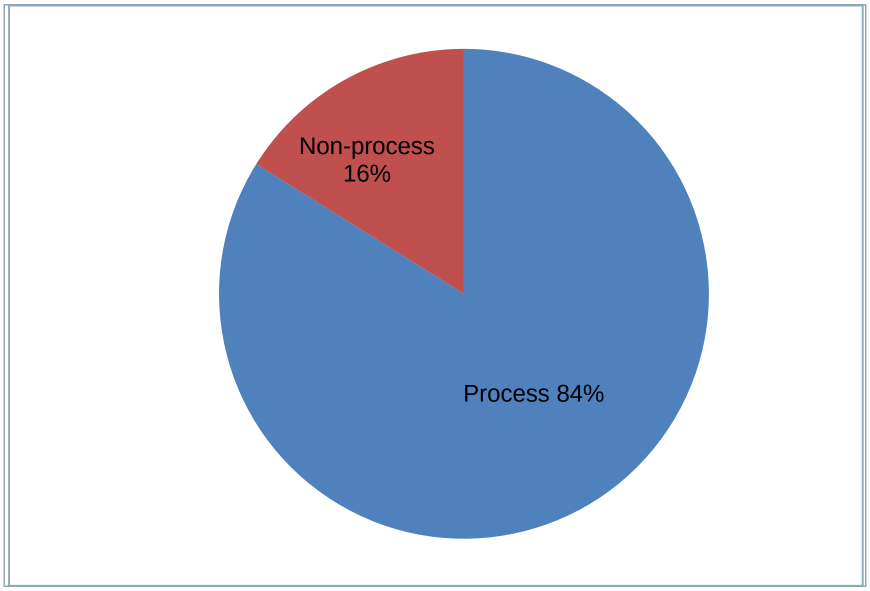
Product transportation requires a variety of fuels such as gasoline, natural gas, diesel and others, depending on the method. Most concrete block and brick manufacturers typically ship in raw materials by rail or inland water transport, and later freight the finished product to distribution facilities close to the end market. Ready-mix cement producers transport the final product in mixer trucks.

4.2 Energy Consumption by End Use

Cement manufacturing accounts for nearly 80 percent total cement and concrete industry energy used, primarily for pyroprocessing. This process is predominantly fueled by coal and coke, but increasingly supplanted by agricultural and other waste materials, and supported by natural gas usage. The other processes—quarrying (3 percent) and concrete production (17 percent)—primarily use electricity to power the grinders, rollers, and other machinery to move the raw materials through the cement manufacturing process.

The energy consumption associated with major end use was estimated using national industry data from the 2006 Manufacturing Energy Consumption Survey (MECS).

Figure 17: Cement Industry National Electric Consumption



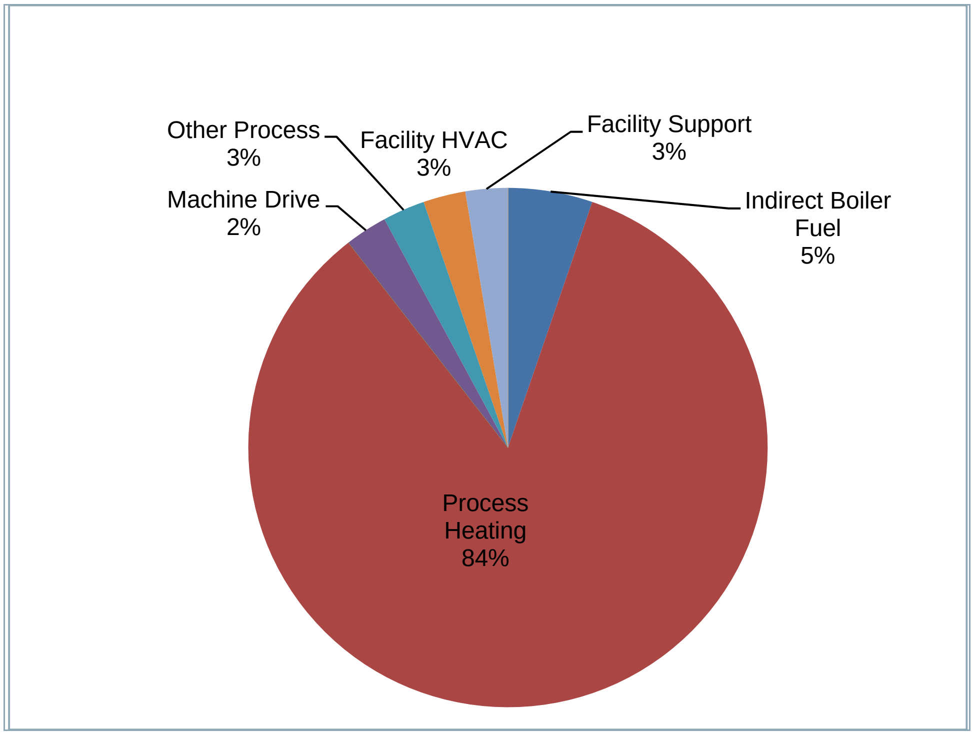
Source: 2006 Manufacturing Energy Consumption Survey[43]

Figure 17 and **Error! Reference source not found.** display electricity consumption in the cement industry (NAIC 327310) based on MECS data. MECS does not provide sufficient information for a breakdown of the concrete industry.

Figure 17 reinforces the findings that the majority of energy consumption (84 percent) driven by cement production. While most energy consumption is related to cement production, the remaining 16 percent still presents opportunity for addressing energy efficiency via non-process use such as lighting, non-process plug loads, and HVAC.

[43] U.S. Energy Information Administration. 2009. *2006 Energy Consumption by Manufacturers*. June 2009. http://www.eia.gov/emeu/mecs/mecs2006/2006tables.html

Figure 18: Cement Industry Gas Consumption by End Use

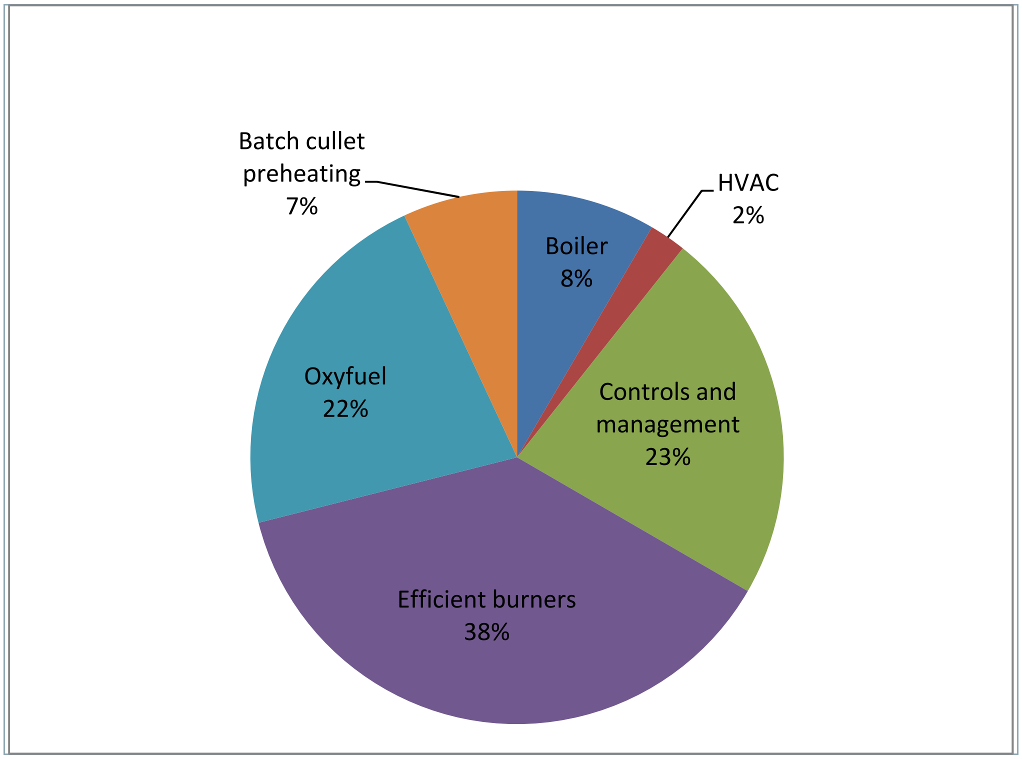


Source: 2006 Manufacturing Energy Consumption Survey[44]

Figure 18 breaks down the end use consumption of natural gas for the cement industry. The overwhelming majority of natural gas is used for process heating, which represents the kiln primarily (84 percent).

[44] Ibid.

Figure 19: Non-Metallic Mineral Products Gas Energy Efficiency Potential



Source: 2006 Manufacturing Energy Consumption Survey[45]

Figure 19 displays the energy efficiency potential related to natural gas use within the non-metallic mineral products industrial sectors (NAICS 327), of which cement and concrete manufacturers are a part. Efficient burners (38 percent of total potential) and oxy-fuel (22 percent) represent the largest opportunity to save natural gas. These technologies are appropriate for operations with furnaces and kilns, such as glass and cement plants. For concrete products, controls and management and boiler improvements are the largest opportunities.

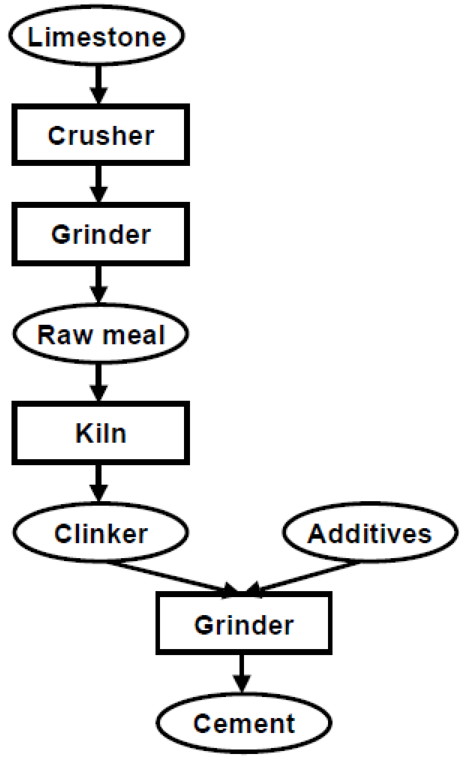
4.3 Production Processes

Figure 20 displays a simplified cement and concrete making process, from raw materials, quarrying and crushing, cement manufacturing and concrete production blending and mixing. The manufacturing and production process can be broken down as follows:

[45] Ibid.

1. **Grinding and Processing**. Virgin raw materials—limestone and secondary materials including silicon, aluminum oxides, and iron oxides materials—are blended to a specific chemical composition that account for the addition of combustion fuel ash and the use of extenders, and are then fed through grinding mills. Grinding mill equipment includes ball mills, tube mills, compound mills, ring roll mills, and impact mills.
2. **Pyroprocessing.** The blended raw materials are fed into a kiln, a long rotating tube with a hot end and a cool end. Raw materials are fed into the cool end of the kiln and move down at a speed dependant on the kiln's rate of rotation. As the raw materials move down the kiln they under go four stages of pyroprocessing in the following order: drying, pre heating, calcination, and sintering at approximately 2,700° F. The heat causes the materials to turn into a new marble-sized substance called clinker.
3. **Portland cement production.** Clinker is taken to grinding mills where is processed into Portland cement. In this stage the clinker is mixed with gypsum, additives, and extenders. The mixture is then fed to ball mills or vertical roller mills to reduce the size to the fineness desired for Portland cement. Portland cement is then packaged for shipment to downstream markets.
4. **Concrete production**. Portland cement is blended and mixed with sand, crushed stone, water, and small amounts of chemicals called admixtures which control setting time and plasticity. Pre-cast concrete products are molded onsite into commonly used building materials, which are then stored and shipped to end users.

Figure 20: Simplified Schematic Process for Cement Making



Source: PG&E[46]

4.4 Current Practices

Although the basic technologies in cement production are well-established, recent innovations have focused on increasing the efficiency and quality of cement manufacturing operations and developing better-performing cements.

Estimated potential energy savings in California is about 32 kWh/short ton of cement and potential fuel savings of about 0.7 MBtu/short ton of clinker, according to a 2005 Lawrence Berkeley National Laboratory report. Given the 2002 production of 11,166,000 short tons of cement and 11,187,000 short tons of clinker in California, the technical potential electricity savings are about 360 GWh and fuel savings are about 7.8 TBtu.

[46] Pacific Gas & Electric. 2005. *Industrial Case Study: The Cement Industry*. CALMAC Study ID: PGE0251.01 Prepared by KEMA, Inc. September 2005.

Beginning in the mid 1990s, the industry strengthened its commitment to minimize emissions, waste, energy consumption and the use of raw materials. Working with the U.S. EPA, members of the Portland Cement Association (which accounts for close to 95 percent of cement manufacturing capacity in the United States) adopted in 2003 the goal of reducing carbon-dioxide emissions per ton of product by 10 percent from 1990 levels by the year 2020. Most recently, the industry successfully advocated a change in the U.S. Portland cement manufacturing standard (ASTM C 150) to permit the use of up to 5 percent ground limestone, which will provide key environmental benefits such as reducing carbon dioxide emissions by approximately 2.6 percent per ton of cement produced, with an annual reduction of 2.5 million tons.

The U.S. cement industry is currently implementing a three-part program to achieve reduced emissions through the cement manufacturing process, product formulation, and product application. The steps include: reduction of emissions through increased efficiency, decreased fuel use, greater use of alternative fuels and raw materials; formulating cements using a lower portion of calcined material; and the promotion of the use of energy-efficient concrete buildings, homes, and highways. CEMEX, for example, received recognition from the EPA for reducing energy by 2.2 percent in 2009, by adopting an energy management systems approach.

4.4.1 Efficiency Improvements

Over the past two decades, the cement manufacturing industry has boosted efficiency by concentrating new capital investment in plants that use the dry-kiln (preheated) process of production and by phasing out operations that rely on the more energy-intensive wet process. However, the cement/concrete industry operates at less than 40 percent thermal efficiency. This low figure suggests that significant opportunities still exist to improve energy efficiency.

Table 5 shows a comprehensive assessment of all energy efficiency measures in the cement industry, according to the Lawrence Berkeley National Lab. Not all measures will apply to all plants. Applicability will depend on the current and future situation in individual plants. For example, expansion and large capital projects are likely to be implemented only if the company has about 50 years of remaining limestone reserves onsite. Plants that have a shorter remaining supply are unlikely to implement large capital projects and would more likely focus on minor upgrades and energy management measures.

To improve the industry’s energy efficiency, Portland Cement Association member companies partnered with the U.S. EPA to develop an Energy Performance Indicator (EPI). The tool is intended to help cement plant operators identify opportunities to improve energy efficiency, reduce GHGs, conserve conventional energy supplies, and reduce production costs.

In California, energy efficiency opportunities fall into four general categories:

- Operations and maintenance (O&M): Motor and bearing lubrication, motor belt replacement, fan blade cleaning, fan wheel balancing, and compressed air system maintenance. The opportunity is to shift focus on keeping equipment operating to maximize production to energy efficiency.
- High efficiency equipment/processes: premium efficiency motors; conversion of ball mills to roller mills for grinding; efficient materials transport systems; high efficiency classifiers; conversion to more efficient kilns such as vertical precalciner kilns; VSDs for fans and other variable load drives; and compressed-air system improvements.
- Controls: Improved process controls are applicable to all processes, including clinker production, grinding, and operation of compressed air systems.
- Energy Management Systems: Leading energy efficient companies have internal programs to manage energy and/or participate in continuous energy improvement programs developed by others. Typical components of these programs are benchmark and measuring energy use; setting goals; evaluating and prioritizing energy efficiency technologies, behaviors and best practices; taking action to reduce energy consumption; followed by documentation and measurement of the effectiveness of their actions.

In addition, new cement and concrete formulas, such as incorporating fly ash—a byproduct of burning coal—and/or slag cement in concrete or increasing limestone content in cement, reduce the amount of energy needed in manufacturing.

Table 5: Energy Efficient Practices and Technologies in Cement Production

Raw Materials Preparation
Efficient transport systems (dry process)
Slurry blending and homogenization (wet process)
Raw meal blending systems (dry process)
Conversion to closed circuit wash mill (wet process)
High-efficiency roller mills (dry process)
High-efficiency classifiers (dry process)
Fuel Preparation: Roller mills

Clinker Production (Wet)	Clinker Production (Dry)
Energy management and process control Seal replacement Kiln combustion system improvements Kiln shell heat loss reduction Use of waste fuels Conversion to modern grate cooler Refractories Optimize grate coolers Conversion to pre-heater, pre-calciner kilns Conversion to semi-dry kiln (slurry drier) Conversion to semi-wet kiln Efficient kiln drives Oxygen enrichment	Energy management and process control Seal replacement Kiln combustion system improvements Kiln shell heat loss reduction Use of waste fuels Conversion to modern grate cooler Refractories Heat recovery for power generation Low-pressure drop cyclones for suspension pre-heaters Optimize grate coolers Addition of pre-calciner to pre-heater kiln Long dry kiln conversion to multi-stage pre-heater kiln Long dry kiln conversion to multi-stage pre-heater, pre-calciner kiln Efficient kiln drives Oxygen enrichment
Finish Grinding	
Energy management and process control Improved grinding media (ball mills) High-pressure roller press High efficiency classifiers	
General Measures	
Preventative maintenance (insulation, compressed air system, maintenance) High efficiency motors Efficient fans with variable speed drives Optimization of compressed air systems Efficient lighting	
Product & Feedstock Changes	
Blended Cements Limestone cement Low Alkali cement Use of steel slag in kiln (CemStar®) Reducing fineness of cement for selected uses	

Source: Lawrence Berkeley National Laboratory[47]

[47] Lawrence Berkeley National Laboratory. 2008. *Energy Efficiency Improvement and Cost Saving Opportunities for Cement Making, An ENERGY STAR® Guide for Energy and Plant Managers*. LBNL-54036-Revision. March 2008.

In the concrete industry, the trend toward new building materials designed to meet sustainability goals offers opportunities for energy efficiency.

5. Market Intervention

This section presents the results from primary research conducted in two phases: an industry leader meeting via Webinar and one-on-one interviews conducted with industry stakeholders. Industry leader meeting attendees included vice presidents and other executives, trade association directors energy managers from various manufacturers, and representatives from KEMA, ACEEE, and PG&E. KEMA also conducted six one-on-one interviews with major energy users in the PG&E and SCE service territory to solicit input from those unable to attend the industry leader meeting and confirm feedback from the meeting. Interviewees included corporate energy managers and plant operations staff. KEMA focused primarily on the largest customers in this sector; more than 50 percent of the top 10 customers from both PG&E and SCE were interested in participating in the research. This response rate is higher than KEMA observed in other sectors.

KEMA asked questions on relative importance of energy, key drivers and barriers for energy efficiency investment, and energy investment decision-making process. A summary of their responses is included in this section. The interview guide is provided as an attachment to this report.

Our insights and conclusions are presented below.

5.1 Effective Utility Programming

Respondents were very supportive of utility energy efficiency programs and services. They especially appreciated the expertise provided by utility-sponsored third party consultants. The following provides more details on these findings.

- *Third-party Consultants*. Customers interviewed cited high satisfaction with third-party consultants. They appreciate the flexibility to outsource rebate paperwork, calculations and other administrative details and the reduced burden on staff time. Promoting this option more broadly may bring more customers to participate in utility programs.
- *Existing Utility Programs.* Many respondents participated in incentive programs as well as demand response and enthusiastically supported the utility's efforts to assist in energy efficiency. While utility programs will not *make or break* the decision for large capital projects, continuing to offer rebate programs will help overcome barriers to small- to medium-sized projects.

5.2 Drivers of Energy Decision-Making

The following sections describe cement and concrete manufacturers' approach to energy efficiency projects, including planning, financing and decision-making criteria.

5.2.1 Energy Efficiency Planning

Cost savings is the single largest driver of energy efficiency projects among customers interviewed. Cement manufacturers reported spending up to 50 percent of variable production costs on energy due to the energy-intensive kiln process and continue to seek ways to reduce this cost. For concrete, aggregates and asphalt manufacturers, energy costs comprise from 10–20 percent total production costs. However, during the existing economic downturn, the importance of energy costs has increased for all manufacturers interviewed as businesses seek to reduce variable costs.

Table 6 displays manufacturers' self-reported ability to undertake energy efficiency practices or investments. Most companies rated themselves number 2, meaning they have already implemented many energy savings retrofits and practices. Two companies reported decreased sales volumes hindered their ability to advance identified projects. One cement manufacturer constructed a new plant in the past few years, and was the only respondent that self-rated at number 1, meaning they aggressively pursue energy efficiency. These results indicate that companies have knowledge of and interest in energy efficiency opportunities but recognize additional steps can be taken.

Table 6: Self Reported Manufacturer's Ability to Undertake Energy Efficiency Investments, Using Scale 1–5[48]

Manufacturer Type	Self-Reported Rating: EE Projects Undertaken	Notes
Cement Manufacturer	#2	Many improvements already made ('low hanging fruit)
Ready-Mix Concrete	#2	Pursuing energy efficiency savings, but limited by business model in DR savings
Concrete, aggregates & asphalt	#2	2-year long planning process underway but sales decline limiting ability to undertake projects.
Asphalt, concrete, limestone quarrying	#2	Many projects undertaken using Lockheed Martin
Cement Manufacturer	#1	Step changes only since entirely new plant constructed
Cement Manufacturer	#3	Numerous projects identified, but only funding <$200,000 or 18 month payback
Cement Manufacturer	#2.5	Only considering projects < 18 month payback

Source: KEMA, Inc

Energy efficiency planning varies among companies, but larger firms have more resources to devote. For example, one larger customer mentioned five staff members devoted to energy management and they aggressively seek opportunities for energy savings through all mechanisms, including employee behavioral changes and retrofitting existing equipment. This firm had the resources to monitor and influence employee's energy using behavior. For example, they conducted day-long *treasure hunt* assessments at individual facilities to help to manage costs and allow brainstorming of ideas. Smaller companies rarely devote this level of resources to energy efficiency. For these customers, energy efficiency generally is a low priority compared business operations and cost factors such as labor, raw material sourcing, and product transport.

Utility representatives initiate many energy efficiency projects by engaging customers, particularly smaller or less energy efficiency savvy companies with fewer resources and staff, into investigating opportunities. Larger and/or more sophisticated energy users tend to develop projects internally, and then investigate utility program incentives.

Corporate or management involvement is essential to moving projects forward. Recognition by managers of the value of energy efficiency makes an enormous difference. For example, one company stressed the importance of executives' presence at energy meetings, since knowing

[48] Scale: 1 = your company invests heavily in energy efficiency. 5= energy efficiency is a low priority

the CEO may attend creates better accountability for the staff. Regular meetings on energy use leads to focusing on improvement.

The larger the project, the further up the management chain it will need to go for approval.

Typically, the plant operations staff will review the proposed project and the financial returns. If it meets the company's criteria (e.g., project size, payback, funding availability, etc.), additional analysis will be conducted and the purchasing department will become involved. At this point, the process of requesting financing will start. Approval for small projects (e.g., < $50,000) likely occurs at the plant level if the payback period is sufficient. The largest projects require decision-making at executive levels.

5.2.2 Investment Priorities

The most important investment priority criteria reported are project payback length and impact on operations. The standard two- to three-year payback has decreased during the economic downturn as shown in Table 7. One factor driving the shorter paybacks is lower equipment operation time when product demand is down. Energy efficiency projects with paybacks over two or three years are difficult to approve. This applies to energy-intensive cement customers as well as less intensive users (e.g., concrete producers). Other important criteria are: impact on operations, particularly for demand response programs; and staff availability to pursue projects, particularly at manufacturers that lack dedicated energy management staff. Table 7 shows specific responses by customers regarding payback periods required for energy efficiency projects.

Table 7: Payback Periods, by Manufacturer Type

Manufacturer Type	Payback
Cement Manufacturer	As short as possible
Ready-Mix Concrete	2 year max but considers major capital projects up to 4 years
Concrete, aggregates & asphalt	2-3 years (formerly 5-6 years)
Asphalt, concrete, limestone quarrying	1-2 years
Cement Manufacturer	Less than 3 (formerly 3-5 years)
Cement Manufacturer	<12-18 months (formerly 2-3years)
Cement Manufacturer	Variable - depends on savings

Source: KEMA, Inc

Some customers interviewed voiced interest in onsite renewable energy projects to ease rising and volatile energy costs, especially where they can use available company land. However, no one interviewed stated that they have taken more than initial, exploratory research steps.

For large capital projects, incentives are the *icing on the cake* for some customers but can pose a real challenge for utilities regarding cost effectiveness. For example, a cement manufacturer recently installed a new grinding mill, which cost tens of millions of dollars. While energy savings were substantial, the company implemented the project to rapidly add more production capacity. The incentive had no bearing on the decision and evaluators would probably consider the project a free rider and potentially disallow the substantial savings in energy that occurred due to the project.

5.2.3 Project Financing

Project financing overall has become more difficult in the economic downturn. The cement and concrete industry is heavily dependent on housing and construction industries, which saw sharp downturns in California. As payback length increases, so does the difficulty of securing funding.

Easier access to capital depends on project cost and a shorter payback period. The shorter the payback period, the fewer barriers a company will have in place towards accessing project financing. Companies reported financing smaller projects through operating budgets and larger projects require capital budgets. None of the respondents took out loans or other alternative methods to raise capital, and there was little interest among participants in utility sponsored financing options.

5.3 Cycles of Innovation

Companies that set goals for sustainability or carbon reduction are more open to innovate with technology or energy management systems. Many of the companies with these goals are based in Europe or other countries outside the United States. Companies with sustainability or energy efficiency goals are also more likely to participate in government and utility forums that focus in these areas. Both the California Air Resources Board and U.S. EPA have forums for the cement industry. In California, ARB meets with industry groups to achieve compliance with AB 32.

Several customers interviewed noted that California stands out as the leading center of energy efficiency and innovation. It was widely agreed that if it succeeds in California, it will succeed anywhere.

Current innovative practices include sophisticated controls that can provide operators with real time energy information to allow reaction to process discrepancies, and web-based real-time energy monitoring and control systems so that remote viewers can view plant operations and fuel usage. These systems may be added to an existing operation but more commonly occur as part of a major upgrade.

Industry process technologies are relatively mature, and major rebuilding or retooling occurs primarily when customers need increased production capacity, switch product lines, or replace worn or broken equipment. Newly constructed cement plants in California are uncommon due to the hundreds of millions of dollars required and environmental and regulatory permitting. In the concrete industry, green codes and requirements are expected to drive innovation. Concrete products with a lower carbon footprint may drive market innovation, as new construction seeks to meet sustainability or energy efficiency goals.

Existing plants require ongoing maintenance and replacements to remain operational. Recent projects cited include: upgrading/replacing lighting and heating systems; installing variable frequency drive controls on motors and fans; insulating systems to improve heat transfer; and replacing worn or outdated process equipment. These recent projects indicate that companies have not addressed all low-hanging fruit, and new energy efficiency projects can be found.

Companies consider vendors as the true experts for innovative products. As such, the vendors are in a *market power* position for determining what technologies will help them optimize their processes. Vendors have overwhelmed companies with claims to have new energy efficient technologies, and it is difficult for companies to distinguish the real advancements from the *snake oil* sellers. Company interest in new technology is real, although they are cautious about actual results that can be achieved. Utilities can provide customers value by providing or sponsoring a clearinghouse of vetted ideas and including relevant technologies in its Emerging Technologies programs. This can help re-balance the market power for determining which energy efficient innovation customers should pursue.

5.4 Customer Assessment

Squeezed by low-cost imports and decreased product demand, customers stated they will look into any program that may meet their needs and saves on energy costs. The following sections describe customers’ rating of utility program awareness, experience, and satisfaction.

5.4.1 Utility Program Awareness

Company representatives we interviewed generally indicated either "high" or "very high" awareness of utility programs for their industry. This self-reported awareness conflicted with customers' actual program knowledge as demonstrated during the industry leader meeting and one-on-one interviews. At least one customer cited low awareness of utility programs as a barrier. From our observations, we noted that customers interviewed did have some knowledge of utility programs, but may not understand program details and components. One large, sophisticated customer noted that they work with about 40 utilities, making it difficult to know about all the offerings. For the large companies with multiple facilities and central energy managers, keeping up with specific offerings is challenging

Customers reported sources of program information were primarily utility representatives colleagues, and vendors. Typically, utility representatives call or visit six or more times per year, although frequency of contact varied, depending on customer needs. When undertaking a large capital project, for example, one customer met with the utility representative several times per month. According to many customers interviewed, they expect the utility reps to be proactive and to make frequent contact. Customers stated they almost always involve the utility well in advance when planning large capital projects involving changes to their kilns or grinding equipment. They regard utility reps as responsive and helpful, and willing to adjust their contact schedules when needed or requested.

5.4.2 Customers' Experience

Customers uniformly praised California utilities' industrial programs. However, because they invest through the public goods funds, companies want to recoup these funds. According to customers interviewed, the utility programs meet expectations in terms of cost and energy savings.

Participants especially praised third-party help with rebate applications and savings estimations as well as audits and project identification. In fact, we heard from several customers who suggested expansion of the pool of auditors, possibly tapping the U.S. DOE resources. Customers noted strong interest in rebate programs, not utility financing, since they use capital or operational budgets to finance their projects.

However, we did hear some criticism of the programs such as customers encouraging utility reps to understand the company's financial situation before proposing energy efficiency projects. Some customers are planning to add plant capacity, while others struggle to stay in business. The former company will be receptive to longer term, large-scale projects while the latter company will be most receptive to extremely short-term projects (e.g., payback as short as possible) or other energy management controls or systems that show savings rapidly.

Customers reported a need to have energy experts with knowledge and expertise of the cement and concrete industry. Audits and energy assessments can address the unique needs of the sector when the auditor has knowledge of the major process unit operations.

6. Next Steps and Recommendations

This investigation has revealed that cement industry customers are willing to consider new approaches, including a comprehensive approach to addressing their energy needs, beyond simply retrofitting equipment. Some suggested elements of that approach are presented below, and additional research focused on the feasibility of each of these recommendations would be prudent. Two key components of a successful effort are the participation of regulatory staff in the development of the options and CPUC recognition of the utilities' role in changes to a customer's policies and procedures regarding energy.

Our research suggests a number of opportunities for both program implementation and program evaluation.

6.1 Program Implementation

1. **Build on Customer's Internal Goals and Programs.** The most sophisticated customers, such as CEMEX and Portland Cement, have established strong internal energy efficiency programs. Utility offerings that further enable the energy-savvy customers to achieve savings have low market barriers. For example, utilities could offer technical and management assistance for companies seeking to achieve ISO 50001 certification.
2. **Identify Planned Upgrades and Document Associated Efficiency Opportunities.** Companies will continue to invest in plants where long-term markets are perceived. Major upgrades may be infrequent, possibly only every 10 years. As utilities are aware of the customer's long-term plans, they can encourage the addition of energy efficiency. Early and complete documentation of the utility's involvement will assist in appropriate net-to-gross evaluations for energy efficiency projects.
3. **Increase Promotion of Third-party Providers.** Customers universally praised third-party providers for simplifying the program process and removing barriers such as lack of staff time and paperwork requirements. A large energy user reported this was the most beneficial utility offering: "We have limited staff, and it's worked extremely well for us to have someone being reimbursed by the utility or state to identify projects, follow up with applications for incentives, and implement the projects."
4. **Avoid "utility speak."** Customers reported that utilities often do not express the program ideas in ways that the CEO, or most employees outside of the energy management group, can understand.

5. **Encourage Low-cost Improvements.** In this economic climate, companies are most receptive to projects with the shortest possible payback. Programs that focus on low- and no-cost items, such as improving reliability through a predictive and preventative maintenance programs, can engage customers with limited financial options.
6. **Integrate Energy Efficiency with Permits and Regulatory Requirements**. As part of large-scale projects, utilities may consider partnering with permitting specialists (consultants or regulators) to help move energy efficiency projects forward. Environmental permitting can be a significant barrier for new construction, or large capital projects that substantially change plant operations. Utility support to help to overcome this barrier would be well received.

6.2 Evaluation

1. **Build on Existing Support.** Customers interviewed praised PG&E's energy programs and are interested in continuing the conversation. These customers recognized the benefits of energy and cost savings, and access to utility representatives, which is key since many rely on the utility to learn about new programs. Companies also appreciate when utilities reach out to trade associations and speak at their meetings.
2. **Develop Innovative Pilots to Suit Differing Customer Needs.** Highly sophisticate customers like CEMEX and Cal Portland are potential candidates for programs leading to certification under ISO 50001 or U.S. DOE's Superior Energy Performance. Other firms that are less engaged may be receptive to shorter term programs like the Energy Trust of Oregon's *Kaizen Blitz*. This program offers audits and one year of technical assistance, but requires the participants to set goals and implement fast payback options.
3. **Develop 'Clearinghouse' Program for New Product Innovation.** Customers interviewed would appreciate help re-balancing the market power of vendors of new technologies. A government or utility clearinghouse program that aggregates information that vets emerging technologies would help to verify vendor's claims. Existing programs are available, such as PG&E's and SCE's Emerging Technologies Program, ENERGY STAR industry guidelines, and the California Energy Commission's Public Interest Energy Research program, but are not widely known or used, among customers interviewed. California utilities could support the industry's needs by provide a forum for non-competitive communication about energy efficiency and successful technologies. Trade organizations also help members understand new technologies and utility reps are encouraged to speak at industry events or conferences to explain new technologies and highlight their programs.

4. **Engage the Uninterested in Measurement.** One of the biggest challenges in the industrial sector is getting participation. The cement and concrete sector has such a high level of concentration that there are many facilities that are owned by only a few companies. In our research we found a high participation among these companies, approximately 50 percent. One opportunity for engaging the less sophisticated customers is to focus on the measurement of their utility use, and assist them in breaking down their bill to specific operations. This can then highlight energy efficiency opportunities.

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A. Appendices

Cement and Minerals Industrial Research Forum Question Set

Introduction:

- Introduce KEMA
- Go over the project and the objectives
- Go around the room or make introductions via telephone. Tell us about your job. How do you contribute to the decisions around energy in your organization?

Section 1: What drives decision-making for energy? Who initiates ideas for projects?

How does energy fit in with key priorities in your industry? **(For KEMA forum leader: list priorities identified in each report here and prompt discussion as required. Typically, priorities are safety, quality, meeting regulations, cost, competition.**

1. Where does energy rank in the management and operations of your business? Would your executive management agree with this ranking of importance?
    a. In your knowledge of the industry, is energy efficiency an integral part of strategic planning and risk assessment? Why or why not? If yes, in what ways? If not, what are other factors that are more important?
    b. Generally speaking, what proportion are energy costs relative to your operating costs? Do you see this proportion increasing in the future? By how much?
2. How have energy use patterns changed over the past 10 years? What drives the growth of energy use?
3. What drives investment in energy efficiency in the **cement** industry? In the concrete industry? What are the key differences between them?
4. What drives investment in energy efficiency in the minerals industry?
5. What are the main opportunities for your organizations to save energy?

a. Behavioral, operations? (i.e., Management systems, preventative/predictive maintenance, Smart Mfr. – use of sensors, controls, , EMS, process optimization including EE)

b. Retrofits and equipment upgrades? (Heat recovery, efficient motors,

c. Process upgrades? (major changes, such as new kilns, major equipment conversion)

6. What are the primary barriers to adoption of these opportunities?

7. Regarding capital and maintenance investments at your organization (i.e. major capital projects of any type, including mid-sized retrofits):

    a. How is energy efficiency financed? Operating budget vs. capital budget.

    b. How difficult is it to acquire capital for investment? Does the industry have alternative or innovative ways of raising capital? (i.e., private partnerships)

    c. How aware are you of IOU programs to help you manage your energy? Their technical support? Their incentives?

8. Would you say it is typical or not for firms to solicit input from employees at various levels and departments into investment decision making? If not typical, does it happen at all? If so, in what way(s)?

9. For major investment decisions, what is the typical process and timing from idea to start of implementation?

10. How are investment priorities determined?

    a. What are your investment criteria? What is the typical and shortest payback period needed to make an efficiency upgrade that requires capital investment attractive?

    b. How do you determine which project to invest in? How does management determine a project is worthwhile? What are the key deciding criteria to move forward on a project? (e.g. regulatory, safety, cost, increased production capacity, improved quality, new products, etc). How would you rank these criteria in terms of influencing how projects are prioritized?

    c. If the project could include energy efficiency improvements, do you involve your utility?

11. How has the recession/recovery affected your energy use? More, less or about the same? Any shift in types of fuels used?

Section 2: Cycle of innovation. What kinds of changes or innovations would cause you to retool or rebuild? Examples?

(For KEMA forum leader: Factors of innovation in cement and minerals include

changes in kiln technology; regulations; white cement, “green cement” - Mineralization via Aqueous Precipitation (Calera Process), high pressure grinding rolls, cone crushing).

12. How mature is the industry infrastructure in regards to age of equipment and systems? Do you foresee a need for substantial upgrades in the future? About how long? Near-term? Long-term?
13. What types of efficiency investments have been popular in the past ten years?
    a. Energy Management Systems and process control optimization
    b. Process and product optimization – feeds, rates, heat input, combustion process, etc
    c. New products or processes
    d. Steam projects- efficient boilers, dryers, kilns, leak repairs
    e. Electric loads: VFDs, efficient motors
    f. Heat recovery
    g. Air compressor optimization
14. What do you foresee the trend will be (regarding efficiency investments) in the future?
15. What organizations would you point to as particularly innovative? Why do you see these organizations as innovative, what are they doing that makes them innovative? (i.e. vendors? Utility engineers, consultants?)
16. What internal needs are shaping innovation?
    a. New products, Product improvements,
    b. New processes,

   c. Quality, cost, reliability, safety

17. What external factors drive innovation that effect energy use?
    a. Fuel prices
    b. Carbon trading
    c. Regulations and legal issues

18. (for companies operating in California) Do you foresee the implementation of AB-32 or other upcoming regulations will make a difference in your operations? Do you see that this will change how you manage energy?

19. How do your organizations access the latest information on energy efficiency technology?

20. If not mentioned, probe for comments on the following:
    a. Do you foresee more efforts to increase self-generation to service your own electricity demand?
    b. Validate the trends in innovation in operations such as; storage to facilitate load-shifting; plant optimization; improvements in optimization technology beyond SCADA

Section 3: Experience with Utility Programs and Networks of Expertise

21. What roles do others (e.g. contractors, consultant, etc.) play in moving EE projects forward?

22. Do you partner with the utility? Do you see the utility as a partner? What kind of resources and assistance do you look for from the utility? Is there more they could be doing to help you manage your energy use? What else should they be doing?

23. Have you participated in any energy efficiency or management programs offered by either the Department of Energy or your utility? Why or why not? Did the program address your needs? Would you participate again? Why or why not?

24. What would encourage your company's management to sign up for energy efficiency or demand response programs? Any past examples of either participation or non-participation and why?

Interview Guide

Section 1: Introduction

Hello. My name is [Interviewer Name] calling from KEMA Inc., an energy consulting firm. Your utility [Pacific Gas & Electric or Southern California Edison] has hired KEMA to conduct research to improve their industrial energy efficiency programs in the cement sector. You have been identified as someone knowledgeable at your company about energy efficiency decisions and participation in utility energy efficiency programs. Is this correct? [If no, ask for a colleague referral. If yes, start the interview questions below.]

First, I'd like to ask you about what drives decision-making in energy efficiency first, then ask about your thoughts on your utility's energy efficiency programs. Your responses are confidential. This interview will take approximately 30 minutes.

Section 2: What Drives Energy Efficiency Decision-Making?

1. What does energy efficiency mean at your company?
2. On a scale of one to ten, with 1 being the highest and 5 being the lowest, How would you describe your company's commitment to implementing energy efficiency practices or investments? (where 1 = invests heavily in energy efficiency or your company has taken all or nearly all cost-effective actions to reduce energy costs, 5 = only replace equipment on burnout)
3. Where does energy rank in terms of your business operation decisions?
   (Not a priority * low priority * medium priority * high priority * very high priority)
   a. What factors drive that ranking? i.e., need energy reliability for production/will pay any costs; energy costs in top 10 operating costs/huge impact on variable costs; or both?
4. What are the primary energy efficiency improvements that your company plans to make over the next…
   a. 2-5 years?
   b. 5-10 years?
5. How short of a payback does your company require to invest in energy efficiency measures?
6. How does your company typically pay for energy efficiency investments?
   a. What are the challenges involved with access to capital?
   b. How can the utility help with those barriers?
7. What other barriers are there to investment in energy efficiency in this industry?

Section 3: Utility Programs Communications

1. Please describe the typical process at your organization, from how you hear about energy efficiency programs offered by your utility to the final decision to participate or not.
    a. Who is involved?
    b. Who needs to participate in the decision-making process?
2. Are you familiar with the energy efficiency programs offered by your utility?
    a. How do you hear about utility sponsored programs? e.g. vendors, utility rep, colleagues, other?
3. Do you feel you have enough knowledge about the energy efficiency programs your utility offers? If no,
    a. Why not?
    b. How do you gather information to make an informed decision?
4. How often do you speak or meet with your utility representative?
    a. Would you prefer to meet: *more/less or the same?*
    b. How would you prefer to meet? *1-on-1, group, seminar?*

Section 4: Utility Programs Experience

5. What are the major factors your company considers when deciding whether to participate in a utility-sponsored program?
6. 2. What type of utility sponsored program(s) are you most likely to participate? Least likely? Has this shifted over time? If so, why?
7. Does your utility offer energy efficiency and/or energy management programs that address your important energy concerns?
    a. If not, what is missing?
8. Has your company participated in any utility sponsored energy efficiency program recently (e.g. past 2-3 years)?

If NO,

a. What factors have contributed the most to your decision not to participate in an energy efficiency program?
b. What would encourage you to participate? i.e. different type of program offerings; better/more communication about program opportunities; business need; other?

If YES,

c. What is the most effective and beneficial energy efficiency program you have participated in? Please explain what you found beneficial.
d. What led to your company's decision to participate i.e., how did you learn about the program, who at your company spearheaded the decision to participate?
e. Did participating meet your expectations?
    i. If yes, how?
    ii. If not, why not?
f. Would you participate in this program again? Why or why not?

Would you mind if I contacted you again as needed?

Thank you for your participation.